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Studies on combining ability in okra through line x tester analysis

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Abstract
Assessment of combining ability in okra (*Abelmoschus esculentus* (L.) Moench) was done in the current investigation using a line x tester mating design. From 11 female lines and 3 testers, 33 cross combinations were made using the LxT mating design, and enough F_1 seeds were produced in the summer of 2021. The F_1 were planted in kharif 2021 to evaluate the effectiveness of various crosses with three checks. The experiment was conducted at the Breeder Seed Production Unit, VNMKV Parbhani. The best male parents in the current investigation were found to be IC-45800 and Parbhani Kranti. The best general combiner was found to be lines EC-305613, EC-305675, and VROR-159 when the GCA effect was taken into account. To distinguish transgressive segregants from succeeding generations of segregating individuals, these lines can be used in transgressive breeding programmes. EC-305653 x IC-45800, EC-305612 x Parbhani Kranti, EC-305741 x IC-45800, EC-305652 x Parbhani Kranti, and EC-305664 x IC-45800 were the top five crosses for the particular combining ability effect. Among the thirty-three crosses, these nine were found to be the best in terms of desirable specific combining ability effect and high per se performance for fruit yield.

Keywords: Combining ability, GCA, SCA, fruit yield, okra, line x tester

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is an annual herbaceous plant that is classified as an amphidiploid with a somatic chromosome number of 2n=130 and is a member of the family Malvaceae in the order Malvales. Okra was first produced in the Hindustani region, primarily in India, Pakistan, and Burma (Zeven and Zhukovsky, 1975) [20]. Another name for okra is "Queen of Vegetables." In various regions of the world, okra is known by a variety of regional names. For instance, gumbo is a dish that is popularly known as Bhindi in America, lady's finger in England, and in India. Its fruits are rich in vitamins, calcium, potassium, and other minerals, and they have a high nutritional, medicinal, industrial, and export potential. Mature pods and stems contain crude fibre that is used by the paper industry. It contains a lot of nutrients, including iodine (Benchasri, 2012) [3]. The okra's green, tender fruits are a good source of calcium, potassium, and other minerals as well as carbohydrates, protein, vitamins A, B, and C.

Combining ability helps in the identification of superior cross combinations that may be used for commercial exploitation of heterosis, in the selection of suitable parents for hybridization, and in the evaluation of inbreds in terms of their genetic value. When choosing parents for improved hybrid production, understanding the relative importance of general combining ability and specific combining ability for yield and its component traits is extremely helpful. In order to estimate GCA and SCA variances and to comprehend the nature of gene action involved in the expression of various quantitative traits, Kempthorne's (1957) [5] line x tester technique has been widely used among the various biometrical methods available for studying the inheritance pattern of combining ability and heterosis.

Materials and Methods

At Breeder Seed Production Unit V.N.M.K.V. Parbhani during summer (crossing) and kharif 2021, the current investigation for combining ability studies in okra (*Abelmoschus esculentus* (L.) Moench) was carried out. On a bed of black cotton soil, the experiment was carried out. For the experimental material of the proposed work, three testers and 11 exotic okra lines were obtained from NBPGR New Delhi. Fifty genotypes, including 33 crosses, eleven exotic lines, and three testers. The Line x Tester (11x3) crossing was impacted, resulting in a total of 33 crosses. This material was then assessed using a Randomized Block Design with two replications. There was a total of 18 observations, including characters that contributed to yield and yield.

The average value of all the treatments for the investigated characters was calculated. The formula was used to determine the standard error and critical difference at the 1 and 5% level of significance (Panse and Sukhatme (1985) [9]. The genetic analysis was earned out adopting line x tester mating design as suggested by Kempthorne (1957) [5]. Combining ability analysis and the testing of the significance of different genotypes was based on the procedure given by Kempthorne (1957) [5].

Results and Discussion

Finding superior parents and specific cross combinations that can be used for various breeding goals is made easier with knowledge of combining ability. 33 hybrids were created in the current study using 11 lines and 3 testers as the female and male parents, respectively. Line x-tester analysis was performed on the information gleaned from the crosses and parental lines. For all characters except fruit diameter, the variance resulting from crosses, lines and testers, and line x testers was highly significant. However, all characters except for yield per plant (4716.50) and fruit weight had higher variance of lines (10.83). Table 1 displays the analysis of variances (lines x testers) for fruit yield and the traits that influence it.

With the help of 11 lines and 3 testers in a L x T design, the GCA effect and SCA effects were estimated for a total of 18 characters. Tables 2 and 3 present the findings of the estimates of general and specific combining ability effects for yield and yield-contributing traits. Table 2 provides the estimates of the effects of gender on general combining ability (GCA).For this trait, the female line EC-305675 (15.25) showed positive GCA effects, and the highest significant negative GCA effect was shown by EC- 305653 (-18.42), followed by EC- 305652(-8.63). The tester VROR-159 (-1.88) and Parbhani Kranti both showed significant negative GCA effects, with the tester IC-45800 (2.55) exhibiting a positive GCA effect (-0.67). Similar results of significant and positive GCA were also obtained by Patil *et al*. (1996) [11], Thippeswamy *et al*. (2001) [18], Akansha *et al*. (2015) [2] and Khanpara *et al*. (2009) [6]. It suggests that additive gene action is a key factor in the expression of plant height in important lines and testers.

Out of the eleven female lines, EC-305652 (0.13) and EC-305612 (0.10) both demonstrated the highest significant positive GCA effects, while EC-305672 (-0.15) and EC-305741 (-0.14) demonstrated the highest significant negative GCA effects. However, none of the tested had a discernible impact. For the number of branches per plant, Tiwari *et al*. (2016) [19] have also identified effective general combiners. Out of 11 females, line EC-305613 (-0.72) had the highest significant negative GCA effect, followed by lines EC-305672 (-0.40), EC-305741 (-0.28), and line EC-305716 (0.70), which had the highest significant positive GCA effect, before line EC- 305685. (0.53). The highest significant negative GCA effect was recorded for testers by Parbhani Kranti (-0.13). Good general combiners for the quantity of nodes per plant were identified. The highest significant negative GCA effect was shown by the female line EC-305653 (-01.10), followed by EC-305716 (-0.40). While Parbhani Kranti (-0.13) expressed the highest significant negative GCA effect, EC-305613 (1.27) and EC-305675 (0.75) both recorded significant GCA effects. Good general combiners for the number of nodes per plant were also identified by Akansha *et al*. (2015) [2] and Tiwari *et al*. (2016) [19].

Out of 11 females, line EC-305716 (-2.58), line EC-305714 (-1.58), line EC 305652 (-1.24), and line EC-305664 (2.92) recorded the highest significant negative GCA effect and the highest significant positive GCA effect, respectively (2.42). For the number of days until the first harvest. Among the studied lines, EC-305675 (1.89) demonstrated a notable positive GCA effect. Two lines with a significant negative GCA effect for this trait were found to be EC-305653 (-1.96) and EC-305664 (-1.766). VROR-159 (0.38) showed the highest positive GCA effect among the testers, and Parbhani Kranti demonstrated significant negative GCA effects. Lines EC-305741 (1.21) and EC-305685 (1.09) showed a positive GCA effect, whereas lines EC-305672 (-1.72) and EC-305716 (-0.66) showed a significant negative GCA effect. VROR-159 demonstrated the greatest positive effects of GCA among the testers (0.50). Similar results obtained by Rewale *et al*. (2003) [14], Sateesh *et al*. (2013) [15] and Kalaiselvan and Anuja (2021) [4].

The female line EC-305685 (1.82), followed by EC-305741, demonstrated the highest significant positive GCA effect (1.12). As opposed to lines EC-305664 (-2.01) and EC-305672 (-1.44), which both showed a significant negative GCA effect. VROR-159 (0.33) recorded the highest significant positive GCA effect for fruit length among the testers. The highest significant negative GCA effect was shown by the female line EC-305652 (-0.12), followed by EC-305685 (-0.09). While Parbhani Kranti (0.01) expressed the highest significant positive GCA effect among testers, EC-305714 (0.10) and EC- 305612 (0.09) recorded the highest significant positive GCA effect. Female lines EC-305613 (-13.03) and EC-305652 (-9.16) demonstrated the highest significant negative GCA effect, while male lines EC-305653 (14.49) and EC-305612 (14.06) demonstrated the highest significant positive GCA effect, and tester lines Parbhani Kranti (0.50) demonstrated the highest significant positive GCA effect. Similar findings obtained by Pal and Hossain (2000) [8] and Sharma and Singh (2012) [17].

Lines EC-305653 (2.92) and EC-305664 showed the positive GCA effect. Lines EC-305716 (-2.58) and EC-305714 (-1.58), however, showed a significant negative GCA effect. EC-305653 (2.34) had the highest significant positive GCA effect of the eleven female lines, followed by EC-305741 (0.72), and two lines, EC-305612 (-0.133) and EC-305664 (-0.88), had significant negative GCA effects. For fruit yield per plant, the line EC-305675 (31.39) showed the highest positive GCA effect, followed by EC-305613 (30.09), and the line EC-305664 (-38.41) showed the highest negative significant GCA effect. The highest positive GCA was recorded by tester VROR-159 (12.44), but Parbhani Kranti also experienced significant negative GCA effects (-12.99). Similar result were reported by Satish *et al*. (2017) [16], Reddy and Sridevi (2018) [13] and Abinaya *et al*. (2020). Effects of general combining abilities aid in identifying the good parent. Effects of 14 parents' GC on 18 characters (11 lines, 3 testers). The EC-305613 was found to be a good general combiner for plant height, inter-nodal length, fruit weight, leaf area, and yield per plant, according to the general combining ability result.

Table 3 shows the estimates of the effects of 33 cross combinations' specific combining abilities on fruit yield and other yield-contributing traits. The cross EC-305714 x

Parbhani Kranti (0.27) and EC-305664 x Parbhani Kranti were the two that showed the highest positive SCA effects (0.26). For the trait number of branches per plant, nine crosses showed positive SCA effects, while 12 crosses showed negative SCA effects. a good specific cross combination for the quantity of branches per plant was also identified. Similar results obtained by Thippeswamy *et al*. (2001) [18], Pithiya *et al*. (2020) [12] and Patel *et al*. (2021) [10]. Eleven of the 33 studied crosses showed adverse SCA effects for internodal length. Significantly negative SCA effects were expressed by the cross of EC-305672 x VROR-159 (-0.96) and significant positive SCA effects were displayed by the cross of EC-305675 x VROR-159 (0.98). 10 crosses, however, showed favourable SCA effects. Also discovered some effective general combiners for internode length. Similar findings regarding internodal length were also made by Sharma and Singh (2012) [17] and Sateesh *et al*. (2013) [15].

The cross between EC-305685 and VROR-159 (4.14), followed by EC-305741 and VROR-159, showed the highest positive SCA effects (2.02). For the trait number of days until first harvest, three crosses showed positive SCA effects, while three crosses showed negative SCA effects. Nine of the 33 studied crosses had negative SCA effects on the number of fruits produced per plant. Significantly negative SCA effects were expressed by the cross of EC-305685 x IC-45800 (-2.13) and significant positive SCA effects were displayed by the cross of EC-305612 x VROR-159 (3.29). Seven crosses, however, showed favourable SCA effects. Two crosses, EC-305741 x Parbhani Kranti (3.28), and EC-305741 x IC-45800 (3.13), both showed a significant increase in fruit weight as a result of the SCA. Nine crosses displayed a negative SCA effect, while seven crosses expressed a positive SCA effect. Out of 33 crosses studied, the highest positive SCA effect was expressed in cross EC-305675 x Parbhani Kranti (3.13) followed by EC-305685 x Parbhani Kranti (2.13). The ten crosses expressed positive SCA effects and eight showed negative SCA effect for fruit length. Crosses EC-305685 x VROR-159 and EC-305741 x VROR-159 had the highest positive SCA effects out of the 33 crosses examined (0.21 and 0.21, respectively) (0.16). Ten crosses revealed the favourable SCA effect for this trait. Negative SCA was seen for fruit diameter in twelve crosses. Nimbalkar *et al*. (2017) [7], Pithiya *et al*. (2020) [12], and Patel *et al*. (2021) [10] discovered similar outcomes for sca effects on fruit diameter.

The cross of EC-305741 x VROR-159 (23.89) and EC-305685 x IC-45800 showed the highest positive SCA effects (18.07). 17 crosses showed favourable SCA results. The trait number of seeds per fruit, however, showed negative SCA effects in sixteen crosses. The cross between EC-305685 and VROR-159 (4.14), followed by EC-305741 and VROR-159, showed the highest positive SCA effects (2.02). For the trait Days required to marketable fruit, three crosses showed positive SCA effects, while three crosses showed negative SCA effects. The cross EC-305741 x IC-45800 (-1.09) and EC-305716 x VROR-159 (-0.94) showed notable negative SCA effects out of the 33 crosses examined. The three crosses for this trait showed the negative SCA effects. Out of the two crosses that showed positive SCA effects, EC-305685 x VROR-159 (1.58) and EC-305714 x IC-45800 (1.25) both showed notable positive SCA effects for YVMV Incidence. Nine of the 33 crosses showed appreciable positive SCA effects, in terms of fruit yield per plant, the cross EC-305653 x IC-45800 (65.13) demonstrated the highest significant positive SCA effect, followed by EC-305612 x Parbhani Kranti (62.79) and EC-305741 x IC-45800 (58.71). Significantly detrimental SCA effects were seen in nine crosses. For these traits, the crosses EC-305714 x Parbhani Kranti (-68.03), EC-305664 x IC-45800 (-67.91), and EC-305741 x VROR- 159 (-48.43) showed the highest significant negative SCA effects. Satish *et al*. (2017) [16], Reddy and Sridevi (2018) [13], and Abinaya *et al*. (2018) [1] all came to similar conclusions (2020). Significant SCA effects were observed for yield per plant in the crosses EC-305653 x IC-45800, EC-305612 x Parbhani Kranti, and EC-305741 x IC-45800. This shows that non-additive types of gene action predominate in their performance and that heterosis can be used to develop hybrids. These results are harmony with Nimbalkar *et al*. (2017) [7], Reddy and Sridevi (2018) [13], Pithiya *et al*. (2020) [12] and Patel *et al*. (2021) [10].

Table 1: ANOVA Line x Tester

Source	DF	Plant Height	No of Branches	No of Nodes per Plant	Inter-nodal Length	Number of Ridges per Fruit	Days for 50% flowering	Number of days to first harvest	Number of fruits per plant	Fruit Weight
REPLN	1	50.08	0.01	0.08	0.14	0.12	0.38	0.52	0.75	0.46
GENO	46	408.98**	0.07**	1.43**	1.51**	3.85**	11.55**	11.61**	8.39**	10.63**
CROSS	32	426.52**	0.06**	1.59**	1.51**	4.07**	13.11**	12.98**	9.16**	10.81**
LINE(c)	10	546.08**	0.06**	1.22**	2.45**	1.37**	20.32**	19.68**	10.58**	4.79**
TEST(c)	2	115.15**	0.01**	0.27**	0.44**	0.20**	0.97**	0.55**	6.32**	4.20**
LXT (c)	20	397.88**	0.06**	1.91**	1.14**	5.81**	10.72**	10.88**	8.73**	14.48**
PARENT	13	396.33**	0.07**	0.84**	1.58**	3.60**	6.73**	7.07**	7.04**	9.80**
ERROR	46	13.73	0.01	0.03	0.05	0.06	1.45	1.50	0.35	0.38
Source	**DF**	**Fruit Length**	**Fruit Diameter**	**Leaf Area**	**Number of Seeds Per Fruit**	**100 Seed Weight**	**Days required to marketable fruit**	**Pod Borer Infestation (%)**	**Incidence of YVMV (%)**	**Yield/Plant**
REPLN	1	0.22	0.00	0.04	0.63	0.01	0.52	20.04	0.02	459.81
GENO	46	6.91**	0.03	234.55**	477.44**	3.49**	11.61**	49.39**	2.79**	5152.11**
CROSS	32	8.03**	0.03	251.57**	470.77**	3.70**	12.98**	49.59**	3.22**	4716.50**
LINE(c)	10	8.15**	0.03	271.42**	644.06**	6.02**	19.68**	62.79**	6.32**	3933.47**
TEST(c)	2	1.84**	0.00	207.83**	4.60**	0.79**	0.55**	5.37**	0.82**	3559.72**
LXT (c)	20	8.58**	0.03	246.03**	430.74**	2.83**	10.88**	47.41**	1.92**	5223.70**
PARENT	13	4.70**	0.04	175.67**	450.52**	3.20**	7.07**	35.51**	1.95**	6073.49**
ERROR	46	0.14	0.00	0.28	0.14	0.04	1.50	7.42	0.32	193.37

*and **, significant at 5and 1 per cent level, respectively

Table 2: Estimates of general combining ability (GCA) of lines and testers in for eighteen characters in okra

SN	Genotypes	Plant Height	No of Branches	No of Nodes per Plant	Inter-nodal Length	Number of Ridges per Fruit	Days for 50% flowering	Number of days to first harvest	Number of fruits per plant	Fruit Weight
	Lines									
1	EC-305613	12.92 **	-0.07 NS	-0.72 **	1.27 **	-0.38 **	-1.52 **	-0.91 NS	1.52 **	0.24 NS
2	EC-305652	-8.63 **	0.13 **	-0.17 *	-0.50 **	-0.03 NS	-1.02 *	-1.24 **	1.16 **	-0.49 NS
3	EC-305653	-18.42 **	-0.02 NS	-0.28 **	-1.10 **	0.33 **	2.98 **	2.92 **	-1.96 **	1.03 **
4	EC-305664	-3.03 NS	-0.07 NS	-0.05 NS	-0.18 NS	-0.40 **	2.48 **	2.42 **	-1.76 **	-0.71 *
5	EC-305672	-3.89 *	-0.15 **	-0.40 **	-0.07 NS	-0.13 NS	-1.52 **	-1.58 **	-0.68 **	-1.72 **
6	EC-305675	15.25 **	0.13 **	0.50 **	0.75 **	0.00 NS	-0.35 NS	-0.41 NS	1.89 **	0.06 NS
7	EC-305685	4.44 *	-0.00 NS	0.53 **	0.03 NS	0.43 **	0.48 NS	0.59 NS	0.86 **	1.09 **
8	EC-305612	0.63 NS	0.10 **	0.33 **	-0.12 NS	-1.03 **	1.98 **	1.92 **	-0.06 NS	-0.21 NS
9	EC-305714	5.86 **	0.06 NS	-0.18 *	0.47 **	0.57 **	-1.52 **	-1.58 **	-1.46 **	0.16 NS
10	EC-305716	-0.98 NS	0.03 NS	0.70 **	-0.40 **	0.13 NS	-2.52 **	-2.58 **	0.17 NS	-0.66 *
11	EC-305741	-4.15 *	-0.14 **	-0.28 **	-0.15 NS	0.50 **	0.48 NS	0.42 NS	0.32 NS	1.21 **
	Testers									
12	Parbhani Kranti	-0.67 NS	-0.01 NS	-0.13 **	0.02 NS	0.05 NS	-0.12 NS	-0.09 NS	-0.61 **	-0.29 *
13	VROR-159	-1.88 *	0.03 NS	0.05 NS	-0.15 **	0.06 NS	0.24 NS	0.18 NS	0.38 **	0.50 **
14	IC-45800	2.55 **	-0.02 NS	0.08 NS	0.13 *	-0.11 NS	-0.12 NS	-0.09 NS	0.24 *	-0.22 NS
	S.E± (Lines)	2.37	0.05	0.11	0.14	0.15	0.64	0.65	0.24	0.38
	CD @ 5% (Lines)	4.78	0.10	0.23	0.28	0.30	1.28	1.30	0.48	0.76
	CD @ 1% (Lines)	6.37	0.14	0.31	0.38	0.40	1.71	1.74	0.64	1.02
	S.E± (Testers)	1.24	0.03	0.06	0.07	0.08	0.33	0.34	0.13	0.20
	CD @ 5% (Testers)	2.50	0.05	0.12	0.15	0.16	0.67	0.68	0.25	0.40
	CD @ 1% (Testers)	3.33	0.07	0.16	0.20	0.21	0.89	0.91	0.34	0.53

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

SN	Genotypes	Fruit Length	Fruit Diameter	Leaf Area	Number of Seeds Per Fruit	100 Seed Weight	Days required to marketable fruit	Pod Borer Infestation (%)	Incidence of YVMV (%)	Yield/Plant
	Lines									
1	EC-305613	0.92 **	-0.04 **	6.85 **	-13.03 **	-1.35 **	-0.91 NS	-0.89 NS	0.32 NS	30.09 **
2	EC-305652	-0.54 **	-0.12 **	-1.61 **	-9.16 **	0.41 **	-1.24 **	2.48 *	0.39 NS	13.20 *
3	EC-305653	0.71 **	0.06 **	-0.35 NS	14.49 **	0.73 **	2.92 **	5.73 **	2.34 **	-18.80 **
4	EC-305664	-2.01 **	0.01 NS	-1.67 **	11.54 **	-1.04 **	2.42 **	0.16 NS	-0.88 **	-38.51 **
5	EC-305672	-1.44 **	-0.03 *	-7.80 **	-10.86 **	-0.97 **	-1.58 **	0.29 NS	0.32 NS	-31.81 **
6	EC-305675	0.29 *	-0.02 *	0.97 **	-8.81 **	-0.22 *	-0.41 NS	-5.19 **	-0.60 **	31.39 **
7	EC-305685	1.82 **	-0.09 **	4.52 **	7.01 **	1.20 **	0.59 NS	1.69 NS	-0.70 **	27.64 **
8	EC-305612	-0.86 **	0.09 **	-1.16 **	14.06 **	-0.27 **	1.92 **	2.61 *	-1.33 **	-0.61 NS
9	EC-305714	0.44 **	0.10 **	12.24 **	-3.76 **	-0.82 **	-1.58 **	-3.67 **	-0.86 **	-23.03 **
10	EC-305716	-0.46 **	-0.02 *	-12.87 **	-3.84 **	0.66 **	-2.58 **	-3.79 **	0.27 NS	-6.88 NS
11	EC-305741	1.12 **	0.06 **	0.88 **	2.36 **	1.68 **	0.42 NS	0.59 NS	0.72 **	17.34 **
	Testers									
12	Parbhani Kranti	-0.22 **	0.01 *	-2.34 **	0.50 **	-0.20 **	-0.09 NS	0.31 NS	0.14 NS	-12.99 **
13	VROR-159	0.33 **	-0.01 NS	3.48 **	-0.39 **	0.18 **	0.18 NS	0.26 NS	0.08 NS	12.44 **
14	IC-45800	-0.11 NS	-0.01 NS	-1.14 **	-0.12 NS	0.03 NS	-0.09 NS	-0.57 NS	-0.22 NS	0.55 NS
	S.E± (Lines)	0.19	0.02	0.31	0.23	0.12	0.65	1.53	0.31	7.09
	CD @ 5% (Lines)	0.38	0.03	0.62	0.47	0.25	1.30	3.07	0.63	14.26
	CD @ 1% (Lines)	0.50	0.04	0.83	0.63	0.33	1.74	4.09	0.84	19.01
	S.E± (Testers)	0.10	0.01	0.16	0.12	0.06	0.34	0.80	0.16	3.70
	CD @ 5% (Testers)	0.20	0.02	0.32	0.25	0.13	0.68	1.60	0.33	7.45
	CD @ 1% (Testers)	0.26	0.02	0.43	0.33	0.17	0.91	2.14	0.44	9.93

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

Table 3: Estimates of specific combining ability (SCA) of crosses for eighteen characters in Okra

SN	Genotypes	Plant Height	No of Branches	No of Nodes per Plant	Inter-nodal Length	Number of Ridges per Fruit	Days for 50% flowering	Number of days to first harvest	Number of fruits per plant	Fruit Weight
1	EC305613 x Parbhani kranti	-5.95 *	-0.08 NS	-0.45 **	-0.16 NS	1.43 **	-0.55 NS	-0.48 NS	-0.98 *	-1.13 *
2	EC305652 x Parbhani kranti	5.33 *	0.10 *	-0.06 NS	0.38 *	-0.80 **	0.55 NS	0.52 NS	-0.28 NS	0.50 NS
3	EC-305653 x Parbhani kranti	0.62 NS	-0.03 NS	0.51 **	-0.22 NS	-0.63 **	0.00 NS	-0.03 NS	1.25 *	0.63 NS
4	EC-305664 x Parbhani kranti	-1.89 NS	0.26 **	-0.08 NS	-0.09 NS	1.99 **	0.45 NS	0.35 NS	0.12 NS	-0.83 NS
5	EC-305672 x Parbhani kranti	-12.38 **	-0.16 **	-0.05 NS	-0.76 **	-0.83 **	-0.45 NS	-0.15 NS	0.12 NS	0.25 NS
6	EC-305675 x Parbhani kranti	14.28 **	-0.09 NS	0.13 NS	0.85 **	-1.16 **	0.00 NS	-0.20 NS	-0.25 NS	0.58 NS
7	EC-305685 x Parbhani kranti	-1.28 NS	-0.18 **	-0.05 NS	-0.07 NS	2.63 **	0.62 NS	0.68 NS	-1.31 **	2.24 **
8	EC-305612 x Parbhani kranti	-5.14 *	-0.10 NS	-0.41 **	-0.14 NS	-1.30 **	-2.29 *	-2.32 *	3.24 **	0.26 NS
9	EC-305714 x Parbhani kranti	6.42 *	0.27 **	0.46 **	0.21 NS	-1.33 **	1.67 NS	1.64 NS	-1.93 **	-2.50 **
10	EC-305716 x Parbhani kranti	3.21 NS	-0.04 NS	0.33 **	0.06 NS	-1.57 **	1.62 NS	1.68 NS	-0.03 NS	-0.90 *
11	EC-305741 x Parbhani kranti	11.65 **	0.04 NS	1.12 **	0.24 NS	0.90 **	0.71 NS	0.68 NS	-0.13 NS	3.28 **
12	EC-305613 x VROR- 159	-14.86 **	0.01 NS	-1.45 **	-0.30 *	0.67 **	-2.33 *	-2.36 *	0.15 NS	-2.38 **
13	EC-305652 x VROR- 159	6.72 **	-0.04 NS	-0.58 **	0.76 **	-0.87 **	-0.05 NS	0.02 NS	-0.68 NS	1.47 **
14	EC-305653 x VROR- 159	11.06 **	-0.06 NS	1.25 **	0.09 NS	-1.10 **	-0.95 NS	-0.98 NS	0.12 NS	0.10 NS
15	EC-305664 x VROR- 159	-17.78 **	0.11 *	-0.67 **	-0.85 **	1.97 **	1.00 NS	0.97 NS	0.55 NS	-1.57 **
16	EC-305672 x VROR- 159	-10.44 **	0.12 *	0.65 **	-0.96 **	-1.21 **	-3.38 **	-3.32 **	1.12 *	-0.98 *
17	EC-305675 x VROR- 159	13.44 **	0.00 NS	-0.21 *	0.98 **	-1.43 **	-0.79 NS	-0.82 NS	0.82 NS	-1.20 **
18	EC-305685 x VROR- 159	-3.00 NS	-0.13 *	-0.44 **	-0.02 NS	2.64 **	4.17 **	4.14 **	-1.95 **	2.18 **
19	EC-305612 x VROR- 159	0.32 NS	-0.21 **	-0.70 **	0.31 *	0.13 NS	-0.88 NS	-0.82 NS	3.29 **	-0.15 NS
20	EC-305714 x VROR- 159	-3.74 NS	0.27 **	0.79 **	-0.56 **	-0.00 NS	1.71 NS	1.68 NS	-1.96 **	0.93 *
21	EC-305716 x VROR- 159	3.42 NS	-0.06 NS	-0.09 NS	0.25 NS	-0.13 NS	-0.83 NS	-0.86 NS	-1.33 **	-0.78 NS
22	EC-305741 x VROR- 159	-15.48 **	0.12 *	-0.37 **	-0.84 **	0.73 **	1.95 *	2.02 *	-2.06 **	-0.90 *
23	EC-305613 x IC-45800	8.03 **	0.00 NS	0.17 NS	0.44 **	0.60 **	-1.45 NS	-1.48 NS	0.99 *	0.38 NS
24	EC-305652 x IC-45800	7.45 **	-0.13 *	0.20 *	0.40 **	-1.33 **	-0.50 NS	-0.53 NS	1.07 *	0.52 NS
25	EC-305653 x IC-45800	15.67 **	-0.26 **	0.73 **	0.64 **	-1.11 **	-0.21 NS	-0.15 NS	1.61 **	2.29 **
26	EC-305664 x IC-45800	-12.59 **	0.12 *	-1.08 **	-0.32 *	2.07 **	0.88 NS	0.85 NS	-1.19 *	-3.09 **
27	EC-305672 x IC-45800	-3.09 NS	0.14 **	0.35 **	-0.32 *	-0.96 **	-0.67 NS	-0.70 NS	-0.41 NS	0.80 NS
28	EC-305675 x IC-45800	18.10 **	0.22 **	0.42 **	0.96 **	-1.34 **	-0.21 NS	-0.15 NS	0.17 NS	-0.73 NS
29	EC-305685 x IC-45800	-12.29 **	-0.10 NS	-0.40 **	-0.61 **	2.43 **	1.88 *	1.85 *	-2.13 **	1.35 **
30	EC-305612 x IC-45800	-5.81 *	-0.13 *	-0.02 NS	-0.35 *	-1.09 **	-1.67 NS	-1.70 NS	1.95 **	-0.62 NS
31	EC-305714 x IC-45800	-8.97 **	0.09 NS	0.10 NS	-0.62 **	-0.81 **	0.62 NS	0.18 NS	-1.26 *	-0.38 NS
32	EC-305716 x IC-45800	-3.38 NS	-0.13 *	-1.11 **	0.26 NS	-0.53 **	0.21 NS	0.18 NS	0.39 NS	-2.75 **
33	EC-305741 x IC-45800	12.35 **	0.04 NS	1.01 **	0.36 *	1.34 **	-0.83 NS	-0.36 NS	0.87 NS	3.13 **
	S.E± (sca)	4.12	0.09	0.20	0.25	0.26	1.11	1.12	0.42	0.66
	CD @ 5% (sca)	8.28	0.18	0.40	0.49	0.52	2.22	2.26	0.84	1.32
	CD @ 1% (sca)	11.04	0.24	0.53	0.66	0.70	2.96	3.01	1.11	1.76

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

SN	Genotypes	Fruit Length	Fruit Diameter	Leaf Area	Number of Seeds Per Fruit	100 Seed Weight	Days required to marketable fruit	Pod Borer Infestation (%)	Incidence of YVMV (%)	Yield/Plant
1	EC305613 x Parbhani kranti	-0.45 NS	0.04 *	-2.72 **	-10.90 **	-0.48 **	-0.48 NS	2.87 NS	-0.55 NS	-33.05 **
2	EC305652 x Parbhani kranti	-0.18 NS	0.01 NS	-2.19 **	1.85 **	-0.96 **	0.52 NS	-1.15 NS	-0.31 NS	2.96 NS
3	EC-305653 x Parbhani kranti	0.63 *	-0.05 *	4.91 **	9.04 **	1.45 **	-0.03 NS	-1.72 NS	0.86 NS	30.09 **
4	EC-305664 x Parbhani kranti	-1.55 **	0.14 **	-2.52 **	-4.31 **	-0.55 **	0.35 NS	-4.42 *	0.01 NS	-11.72 NS
5	EC-305672 x Parbhani kranti	-1.58 **	-0.06 **	11.87 **	4.59 **	0.92 **	-0.15 NS	6.02 **	0.31 NS	7.09 NS
6	EC-305675 x Parbhani kranti	3.13 **	-0.07 **	-9.35 **	-0.27 NS	-0.37 *	-0.20 NS	-1.60 NS	-0.32 NS	4.62 NS
7	EC-305685 x Parbhani kranti	2.13 **	0.03 NS	6.76 **	16.77 **	0.50 **	0.68 NS	-0.97 NS	0.46 NS	5.23 NS
8	EC-305612 x Parbhani kranti	-0.05 NS	0.07 **	-15.64 **	-11.48 **	0.37 *	-2.32 *	6.47 **	-0.34 NS	62.79 **
9	EC-305714 x Parbhani kranti	-2.08 **	-0.10 **	8.88 **	-5.29 **	-0.87 **	1.64 NS	-5.50 **	-0.12 NS	-68.03 **
10	EC-305716 x Parbhani kranti	-2.20 **	-0.05 **	0.40 NS	12.87 **	-0.98 **	1.68 NS	2.32 NS	-0.24 NS	-9.90 NS
11	EC-305741 x Parbhani kranti	0.87 **	0.08 **	4.29 **	14.02 **	0.54 **	0.68 NS	-1.10 NS	0.16 NS	39.41 **
12	EC-305613 x VROR- 159	1.33 **	-0.03 NS	-4.70 **	-26.89 **	0.45 **	-2.36 *	-1.22 NS	0.08 NS	-29.51 **
13	EC-305652 x VROR- 159	1.03 **	0.02 NS	19.04 **	-5.55 **	-1.22 **	0.02 NS	0.12 NS	-0.40 NS	10.62 NS
14	EC-305653 x VROR- 159	0.25 NS	-0.05 *	-3.70 **	2.10 **	1.20 **	-0.98 NS	-0.55 NS	0.39 NS	4.33 NS
15	EC-305664 x VROR- 159	-1.28 **	0.02 NS	-15.35 **	3.44 **	0.01 NS	0.97 NS	0.43 NS	0.01 NS	-14.94 NS
16	EC-305672 x VROR- 159	-2.12 **	-0.08 **	-15.47 **	-5.31 **	-0.00 NS	-3.32 **	3.98 *	-0.69 NS	8.05 NS
17	EC-305675 x VROR- 159	1.65 **	-0.13 **	-9.58 **	-6.01 **	-0.93 **	-0.82 NS	-3.98 *	-0.89 *	-0.14 NS
18	EC-305685 x VROR- 159	0.47 NS	0.21 **	25.05 **	11.33 **	0.93 **	4.14 **	-0.00 NS	1.58 **	-7.91 NS
19	EC-305612 x VROR- 159	1.23 **	0.04 NS	-6.15 **	-9.93 **	2.02 **	-0.82 NS	6.35 **	0.10 NS	46.03 **
20	EC-305714 x VROR- 159	-1.00 **	-0.01 NS	16.88 **	-1.63 **	0.09 NS	1.68 NS	-5.51 **	0.84 NS	-16.21 NS
21	EC-305716 x VROR- 159	-0.23 NS	-0.03 NS	-10.72 **	11.56 **	-2.10 **	-0.86 NS	-0.84 NS	-0.94 *	-29.83 **

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

SN	Genotypes	Fruit Length	Fruit Diameter	Leaf Area	Number of Seeds Per Fruit	100 Seed Weight	Days required to marketable fruit	Pod Borer Infestation (%)	Incidence of YVMV (%)	Yield/Plant
22	EC-305741 x VROR- 159	-0.42 NS	0.16 **	5.25 **	23.89 **	0.70 **	2.02 *	1.32 NS	-0.05 NS	-48.43 **
23	EC-305613 x IC-45800	0.35 NS	-0.08 **	-7.58 **	-16.91 **	0.17 NS	-1.48 NS	1.25 NS	-0.46 NS	22.98 *
24	EC-305652 x IC-45800	0.07 NS	-0.08 **	2.33 **	-6.97 **	-0.87 **	-0.53 NS	-2.57 NS	0.51 NS	25.46 *
25	EC-305653 x IC-45800	1.36 **	0.03 NS	-2.38 **	1.87 **	0.05 NS	-0.15 NS	-4.25 *	0.78 NS	65.13 **
26	EC-305664 x IC-45800	0.34 NS	0.06 **	1.65 **	-5.43 **	-0.83 **	0.85 NS	-3.16 NS	-0.22 NS	-67.91 **
27	EC-305672 x IC-45800	-1.70 **	-0.09 **	0.73 NS	3.56 **	0.78 **	-0.70 NS	7.41 **	-0.56 NS	2.77 NS
28	EC-305675 x IC-45800	0.13 NS	-0.28 **	2.62 **	-13.48 **	-0.72 **	-0.15 NS	-5.33 **	-0.67 NS	-6.23 NS
29	EC-305685 x IC-45800	0.15 NS	0.14 **	3.92 **	18.07 **	0.35 *	1.85 *	-1.10 NS	0.68 NS	-22.32 *
30	EC-305612 x IC-45800	-0.28 NS	0.15 **	-6.54 **	-4.59 **	0.36 *	-1.70 NS	6.43 **	-0.01 NS	28.56 *
31	EC-305714 x IC-45800	0.86 **	-0.05 *	-4.84 **	-5.91 **	0.70 **	0.18 NS	-1.98 NS	1.25 **	-25.73 *
32	EC-305716 x IC-45800	-0.81 **	-0.03 NS	0.08 NS	0.84 **	-0.93 **	0.18 NS	2.80 NS	-0.16 NS	-32.97 **
33	EC-305741 x IC-45800	-0.05 NS	0.08 **	4.75 **	5.08 **	0.23 NS	-0.36 NS	-0.82 NS	-1.09 *	58.71 **
	SE± (sca)	0.32	0.03	0.53	0.41	0.21	1.12	2.65	0.54	12.29
	CD @ 5% (sca)	0.65	0.05	1.07	0.82	0.43	2.26	5.32	1.09	24.70
	CD @ 1% (sca)	0.87	0.07	1.43	1.09	0.57	3.01	7.09	1.45	32.93

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

Conclusion

Male parent IC-45800 and Parbhani Kranti were determined to be the best male parents in the current investigation. Lines EC-305613, EC-305675, and VROR-159 were discovered to be the best general combiner when the GCA effect was taken into account. These lines can be used in transgressive breeding programmes to separate transgressive segregants from subsequent generations of segregating individuals. The best five crosses for the specific combining ability effect were EC-305653 x IC-45800, EC-305612 x Parbhani Kranti, EC-305741 x IC-45800, EC-305652 x Parbhani Kranti, and EC-305664 x IC-45800. These nine crosses were found to be superior among the thirty-three crosses in terms of desirable specific combining ability effect along with high per se performance for fruit yield. These crosses could be recognised for additional heterosis breeding to create hybrid okra varieties.

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