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Relationship Among Mean, Combining Ability and Standard Heterosis in Bhendi (*Abelmolschus esculentus* L.)

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ABSTRACT

The present investigation was carried out in bhendi involving six parents and fifteen hybrids. Six parents viz., Arka Anamika (P_1), Thanvi 66 (P_2), Villupuram Local (P_3), Dhaanya (P_4), Ankur 41 (P_5) and Varsha Uphar (P_6) were crossed in half-diallel fashion at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University. The observations were made on characters namely, days to first flowering, plant height at maturity, number of primary branches per plant, number of nodes per plant, number of fruits per plant, number of seeds per fruit, fruit length, fruit girth, single fruit weight and fruit yield per plant on single plant basis. Considering the mean performance of all the parents P_1, P_6 and P_4 were considered as the best parents for fruit yield per plant and its component traits. Among the hybrids, $P_1 \times P_6$ and $P_2 \times P_4$ were rated as best hybrids followed by $P_3 \times P_4$ and $P_2 \times P_5$ were better hybrids for exploitation of heterosis based on mean performance. Considering the *gca* effects of parents, P_1 was adjudged as the best source as it had significant desirable *gca* effects for number of fruits per plant, fruit girth, fruit weight and fruit yield per plant. The parent P_6 exhibited significant desirable *gca* effects for days to first flowering, fruit length, fruit weight and fruit yield per plant. Based on the *sca* effects, the hybrid $P_1 \times P_6$ considered as the best followed by crosses $P_2 \times P_4$ and $P_3 \times P_4$ considered as the better hybrids. Based on the standard heterosis, the hybrid, $P_1 \times P_6$ was adjudged as the best hybrid for the exploitation of fruit yield per plant and its component traits, followed by P_2 x P_4 and P_3 x P_4 were considered as the best for the character fruit yield per plant along with days to first flowering, number of primary branches per plant, number of nodes per plant, number of fruits per plant and number of seeds per fruit. Based on *per se* of hybrids, *sca* effects and standard heterosis, the hybrid P_1 x P_6 may prove as a good source for commercial exploitation of heterosis for fruit yield per plant and other yield components in bhendi.

Key words: *Abelmolschus esculentus*, Combining ability, Heterosis

In recent years, we are just experiencing a marginal surplus production in cereals leading to self-sufficiency. However, shortage in the production of vegetables has drawn the attention for increased cultivation of vegetables to provide food and nutritional security. Among the vegetables, India is one of the largest producers and consumers of bhendi in the world. In India bhendi is cultivated in area of 528 lakh ha with a production of 61 mt and productivity is 11.60 mt/ha [1]. In Tamil Nadu it is cultivated in area of 12.78 lakh ha with a production of 88.07 mt and productivity is 6.89 mt/ha [2]. It is popularly known as ladies finger or okra is one of the most important vegetable crop grown in tropical and subtropical regions of the world and it is native of tropical Africa. It is commercially grown in Indian states of Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Bhendi (*Abelmoschus esculentus* (L.) Moench) is an important member of the family Malvaceae with chromosome number 2n=130. A further increase in okra productivity needs intensive research in genetics and plant breeding. The *per se* performance of the parents themselves does not always give a correct indication of their breeding potentialities. Breeders need to examine whether productivity is enhanced mainly by genes favoured by heterozygosity or homozygosity, crop improvement through hybridization will be effective, if the information on the genetic architecture of the experimental population is available. The quantitative characters which are controlled by a large number of genes, which exerts very small effect, cannot be easily deciphered through simple biometrical techniques.

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Even the choice of parents based on *gca* should be cautiously done, since a parent possessing favourable genes for one character may also possess genes governing unfavourable expression for some other traits [3]. Only those parents which possess favourable *gca* effects for different characters should be used in crossing programmes so that segregants can be obtained with superior performance for all the traits through recombination [4]. According to Sharma and Chauhan [5], the *per se* performance and *gca* effects of the parents were directly related to each other. Hence, it is necessary to consider both *per se* performance and *gca* effects for the crop improvement of any character. Evaluation of hybrids for heterosis breeding is based on (i) Mean performance, (ii) sca effect and (iii) magnitude of heterosis (standard heterosis). The selection of hybrids based on the combination of three criteria namely mean, sca and heterosis will be meaningful than either alone. Richariz and Singh [6] stressed that the selection criterion for good cross is that it should have high sca and high per se performance. The hybrids with high mean values and sca effects coupled with heterosis would be highly advantages for heterosis breeding.

MATERIALS AND METHODS

The present investigation was carried out at the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalainagar. Six parents of bhendi viz., Arka Anamika (P_1), Thanvi 66 (P_2), Villupuram Local (P_3), Dhaanya (P_4), Ankur 41 (P_5) and Varsha Uphar (P_6) which were received from the Indian Institute of Horticultural Research, Bangalore, National Bureau of Plant Genetic Resources, Thrissur and from Villupuram local area. These parents were crossed in half-diallel fashion in the Plant Breeding Farm, Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University resulting in fifteen hybrids. The seeds obtained from the crossing block were sown to raise the hybrids. Six parents and fifteen hybrids were raised in a randomized block design with three replications. The seeds of each entry were sown in a single row of 3m long ridges with a spacing of 45cm × 30 cm and uniform population of 10 plants were maintained. A total of 21 ridges were formed in a plot size of 9.5m × 9m. Cultural and agronomic practices were followed as per the standard recommendation and need based plant protection measures were taken up to maintain healthy crop stand. The biometrical observations like days to first flowering, plant height at maturity, number of primary branches per plant, number of nodes per plant, number of fruits per plant, number of seeds per fruit, fruit length, fruit girth, single fruit weight and fruit yield per plant were taken.

The general combining ability effects of parents and specific combining ability effects of different crosses were worked out. The parents or cross combinations which showed significant positive *gca* or *sca* effects were given the score +1. The parents or cross combinations which recorded significantly negative *gca* effects were given the score -1. The parents or cross combinations which registered non-significant *gca* or *sca* were given the score 0. For days to 50 per cent flowering and plant height at maturity, negative significant *gca* or *sca* effects were given the score +1 and positive significant *gca* or *sca* effects were given the score -1. The genotype, which exhibited a total score more than +1 was considered as a good combiner. The genotype, which scored a total score of -1 was considered as a poor combiner. The genotype, which scored a total score of 0, was considered as an average combiner. The F_1 hybrid performance was calculated as the estimates of heterosis over standard parent [7] and their significance of heterosis was tested using the formula suggested by Wynne *et al*. [8].

RESULTS AND DISCUSSION

The variance due to genotypes was significant for all the characters studied. The result of the present study indicated that existence of significant differences among the parents. Therefore, further analyses were appropriate (Table 1).

Table 1 Analysis of variance for ten characters

Source	Df	Days to first flowering	Plant height at maturity	No. of primary branches per plant	No. of nodes per plant	No. of fruits per plant	No. of seeds per fruit	Fruit length	Fruit girth	Single fruit weight	Fruit yield per plant
Replication	2	-0.02	0.01	-0.01	2.57	-0.01	-0.03	0.01	0.01	0.01	-1.24
Genotypes	20	26.00**	61.88**	0.49**	14.51**	17.87**	75.29**	11.24**	0.70**	18.69**	22168.13**
Error	40	0.01	0.01	0.01	0.33	0.01	0.01	0.02	0.01	0.01	0.03

**Significant at 1 per cent level*Significant at 5 per cent level

Among the parents, P_1 had superior *per se* performance for the characters viz., days to first flowering, fruit length, number of branches per plant, number of fruits per plant, fruit weight, fruit yield per plant. P_6 showed better performance for the characters, namely plant height at maturity, number of nodes per plant, number of fruits per plant, number of seeds per fruit, fruit girth, single fruit weight, fruit yield per plant, P_5 for the plant height at maturity, number of branches per plant, number of fruits per plant, number of seeds per fruit, fruit girth [9-12]. It is obvious that parents P_1, P_6 and P_5 were found to be good for the most of the traits. Hence, it would be desirable to have multiple crosses involving the parents viz., P_1, P_5 and P_6 make selection in the segregating generations to isolate superior genotypes. Considering the performance of all the parents for different characters, the parents P_1, P_5 and P_6 were adjudged as best parents. This showed that the above-mentioned parents might be useful for the incorporation of the respective characters in hybridization programme.

Among the crosses, based on *per se* the hybrid $P_1 \times P_6$ and $P_2 \times P_4$ were considered as the best for the character fruit yield per plant along with days to first flowering, number of primary branches per plant, number of nodes per plant, number of fruits per plant and number of seeds per fruit.

Even the choice of parents based on gca should be cautiously done, since a parent possessing favourable genes for one character may also possess genes governing unfavourable expression for some other traits [13]. Only those parents which possess favourable gca effects for different characters should be used in crossing programmes so that segregants can be obtained with superior performance for all the traits through recombination [14]. In the present investigation, P_1 and P_6 were rated as best parents, since they possessed high mean and gca for fruit yield per plant. Similarly, P_5 was the next best parent. Therefore, it could be concluded that crosses involving P_1, P_5 and P_6 would result in the identification of superior segregants with favourable genes for for fruit yield per plant and its component characters.

The contribution of individual parents to hybrid performance was accomplished by comparing the general combining ability effects. When the parents were assessed for their overall combining ability, the parents namely, P_1 found out as good general combiner followed by P_2 and P_6. The high *per se* performance coupled with high *gca* effects in the parents viz., P_1 and P_6 indicated that these genotypes have enormous amount of additive genetic variability. When the cross combinations were assessed for their overall specific combining ability effects, the cross combinations viz., $P_1 \times P_3$ and followed $P_4 \times P_6$ and $P_1 \times P_6$ scored maximum.

Eight out of 15 hybrids exhibited positive significant standard heterosis for this fruit yield per plant. It was maximum with $P_1 \times P_6$ followed by $P_2 \times P_4$ and $P_4 \times P_6$. The observed direction and magnitude of standard heterosis for this trait added scope for inclusion of this trait in heterosis breeding programme [15].

Most of the cross combinations which exhibited high *sca* effects had both the parents with high *gca* effects. However, in some crosses, atleast one of the parents of the cross combination which exhibited high *sca* effects, had high *gca* effects too. Most of the cross combinations which portrayed high standard heterosis were endowed with high mean performance and *sca* effects. Hence *sca* effects could well be utilized as a biometrical marker in heterosis breeding of rice.

The *per se* performance and *gca* effects were related with each other which reflects the breeding behavior of individual genotype [16]. The *per se* performance of the parent might not always serve as an index of their genetic nicking ability. The combining ability has an equal importance to indicate the genetic behavior of the parent material enabling the breeder to select upon and utilize it for further exploitation [17]. The *per se* performance of the parents may not necessarily correspond with the *gca* effect as evident from the finding of the rice workers [18-19]. Therefore, the knowledge on combining ability coupled with mean performance of parents would be of great importance in selecting the suitable parents for hybridization [20].

The *gca* effects itself is considered to be due to the presence of large number favourable genes in parents for traits concerned [21]. As the aforementioned lines and testers had additive gene action, their ability to transmit desirable characters to the progeny could be predicated on the basis of their phenotypic performance. For an autogamous crop like rice, additive gene effects could be efficient to use by hybridization and selection. It mainly involves crossing of two or more diverse genotypes and then selecting in the segregating generations to fix the additive genetic variance [22].

The selection of hybrids based on the contribution of the criteria namely mean, sca and standard heterosis will be meaningful than either alone. The consistency between *gca* and *sca* effects might be due to complex interaction of genes as suggested by [23].

For days to first flowering, the *per se* performance among the three best hybrids ranged from (35.45) to (36.77) days and *sca* effects ranged from (-1.53) to (-4.65). Plant height at maturity exhibited per se performance ranging from (133.58) to (134.80) cm and their sca effects ranged from (-3.31) to (-4.09). Number of primary branches per plant had per se performance ranging from (3.44) to (3.44) numbers and their sca effects ranged from (0.33) to (0.55). The per se performance for number of nodes per plant ranged from (28.19) to (29.23) numbers and its sca effects ranged from (2.74) to (2.92). The mean performance for number of fruits per plant ranged from (21.07) to (22.81) numbers and its sca effects ranged from (3.14) to (3.68).The mean performance for number of seeds per fruit ranged from (61.00) to (66.73) numbers and its sca effects ranged from (3.50) to (7.38).The mean performance for fruit length ranged from (18.30) to (18.90) numbers and its sca effects ranged from (2.16) to (2.55).The mean performance for fruit girth ranged from (5.98) to (6.23) numbers and its sca effects ranged from (0.21) to (0.33).The mean performance for single fruit weight ranged from (20.47) to (21.65) numbers and its sca effects ranged from (2.84) to (3.53).The mean performance for fruit yield per plant ranged from (431.30) to (493.84) numbers and its *sca* effects ranged from (109.80) to (143.69).

Based on *gca* effects the parents P_1 and P_2 registered maximum total score (+6) followed by P_6 (+4). Least score was found for P_3 (-6) (Table 2).

Table 2 Scoring based on gca effects

	Days to first flowering	Plant height at maturity	No. of primary branches per plant	No. of nodes per plant	No. of fruits per plant	No. of seeds per fruit	Fruit length	Fruit girth	Single fruit weight	Fruit yield per plant	Total
P_1	+1	-1	+1	+1	+1	-1	+1	0	+1	+1	+5
P_2	+1	+1	-1	+1	-1	+1	+1	-1	+1	+1	+4
P_3	-1	+1	-1	-1	-1	-1	-1	+1	-1	-1	-6
P_4	+1	-1	0	+1	+1	+1	-1	-1	+1	+1	+3
P_5	-1	-1	+1	-1	-1	+1	-1	+1	-1	-1	-4
P_6	-1	-1	+1	+1	+1	-1	+1	+1	+1	+1	+4

+1 = Positive significant 0 = Non-significant -1 = Negative significant

Table 3 Scoring based on *sca* effects

	Days to first flowering	Plant height at maturity	No. of primary branches per plant	No. of nodes per plant	No. of fruits per plant	No. of seeds per fruit	Fruit length	Fruit girth	Single fruit weight	Fruit yield per plant	Total
$P_1 \times P_2$	+1	-1	-1	+1	+1	+1	-1	+1	-1	+1	+2
$P_1 \times P_3$	+1	-1	+1	+1	+1	+1	+1	+1	+1	+1	+8
$P_1 \times P_4$	-1	-1	+1	0	-1	-1	+1	+1	-1	-1	-3
$P_1 \times P_5$	-1	+1	+1	-1	+1	-1	+1	-1	+1	+1	+2
$P_1 \times P_6$	+1	-1	+1	+1	+1	+1	+1	-1	+1	+1	+6
$P_2 \times P_3$	-1	-1	+1	+1	-1	+1	+1	-1	-1	-1	-2
$P_2 \times P_4$	-1	-1	+1	+1	+1	+1	+1	-1	+1	+1	+4
$P_2 \times P_5$	+1	-1	-1	+1	+1	+1	+1	-1	+1	+1	+4

$P_2 \times P_6$	+1	+1	+1	-1	-1	-1	-1	-1	-1	-1	-4
$P_3 \times P_4$	+1	-1	-1	+1	+1	-1	-1	-1	+1	+1	0
$P_3 \times P_5$	-1	-1	-1	-1	+1	+1	-1	-1	+1	+1	-2
$P_3 \times P_6$	-1	-1	+1	-1	-1	-1	+1	+1	-1	-1	-4
$P_4 \times P_5$	+1	+1	+1	-1	-1	-1	-1	+1	-1	-1	-2
$P_4 \times P_6$	+1	+1	+1	+1	+1	+1	+1	-1	+1	+1	+8
$P_5 \times P_6$	-1	+1	+1	+1	-1	-1	0	-1	-1	-1	-1

+1 = Positive significant 0 = Non-significant -1 = Negative significant

Based on *sca* effects, among 15 crosses, the cross combinations $P_1 \times P_3$ and $P_4 \times P_6$ were on top by scoring +8 followed by $P_1 \times P_6$ with +6. Minimum score of -4 was achieved by $P_2 \times P_6$ and $P_3 \times P_6$ (Table 3).

Table 4 Relationship among mean, combining ability and standard heterosis

Character	*per se* of hybrids	*gca* effect	*sca* effect	Standard heterosis
Days to first flowering	$P_4 \times P_5$ (35.45*)	P_4(-1.24**) × P_5 (1.51**)	$P_4 \times P_5$ (-4.65**)	$P_5 \times P_6$ (26.95**)
	$P_2 \times P_6$ (36.01*)	P_2(-0.55**) × P_6(0.47**)	$P_2 \times P_6$ (-3.75**)	$P_3 \times P_6$ (24.80**)
	$P_1 \times P_2$ (36.77*)	P_1(-1.93**) × P_2(-0.55**)	$P_1 \times P_6$ (-1.53**)	$P_3 \times P_5$ (23.33**)
Plant height at maturity	$P_1 \times P_5$ (133.58)	P_1(0.67**) × P_5(0.30**)	$P_1 \times P_5$ (-4.09**)	$P_1 \times P_6$ (11.11**)
	$P_1 \times P_3$ (134.41)	P_1(0.67**) × P_3(-3.07**)	$P_4 \times P_6$ (-4.04**)	$P_2 \times P_5$ (5.64**)
	$P_4 \times P_5$ (134.80)	P_4(0.07**) × P_5(0.30**)	$P_2 \times P_6$ (-3.31**)	$P_3 \times P_4$ (5.26**)
Number of primary branches per plant	$P_1 \times P_5$ (3.44**)	P_1(0.11**) × P_5(0.17**)	$P_4 \times P_6$ (0.55**)	$P_4 \times P_6$ (24.19**)
	$P_4 \times P_6$ (3.44**)	P_4(-0.06**) × P_6(0.06**)	$P_1 \times P_4$ (0.39**)	$P_5 \times P_6$ (24.19**)
	$P_5 \times P_6$ (3.44**)	P_5(0.17**) × P_6(0.06**)	$P_4 \times P_5$ (0.33**)	$P_1 \times P_5$ (24.19**)
Number of nodes per plant	P_1 x P_6 (29.23**)	P_1(0.47**) × P_6(0.28**)	$P_1 \times P_6$ (2.92**)	$P_1 \times P_6$ (14.60**)
	P_2 x P_3 (28.45**)	P_2(1.16**) × P_3(-1.01**)	$P_3 \times P_4$ (2.81**)	$P_2 \times P_3$ (11.54**)
	P_2 x P_4 (28.19**)	P_2(1.16**) × P_4(0.25**)	$P_2 \times P_3$ (2.74**)	$P_2 \times P_4$ (10.51**)
Number of fruits per plant	P_1 x P_6 (22.81**)	P_1(1.06**) × P_6(0.16**)	$P_1 \times P_6$ (3.68**)	$P_1 \times P_6$ (29.16**)
	P_2 x P_4 (21.62**)	P_2(-0.04**) × P_4(0.57**)	$P_2 \times P_4$ (3.18**)	$P_2 \times P_4$ (22.42**)
	P_4 x P_6 (21.07**)	P_4(0.57**) × P_6(0.16**)	$P_3 \times P_4$ (3.14**)	$P_4 \times P_6$ (19.31**)
Number of seeds per fruit	$P_2 \times P_4$ (66.73**)	P_2(0.31**) × P_4(1.88**)	$P_2 \times P_4$ (7.38**)	$P_2 \times P_4$ (25.27**)
	$P_1 \times P_2$ (64.40**)	P_1(-0.39**) × P_2(0.31**)	$P_1 \times P_2$ (7.32**)	$P_1 \times P_2$ (20.89**)
	$P_4 \times P_6$ (61.00**)	P_4(1.88**) × P_2(-0.34**)	$P_2 \times P_3$ (3.50**)	$P_4 \times P_6$ (14.51**)
Fruit length	$P_1 \times P_6$ (18.90**)	P_1(0.63**) × P_6(0.48**)	$P_2 \times P_4$ (2.55**)	$P_2 \times P_4$ (25.10**)
	$P_2 \times P_4$ (18.48**)	P_2(0.53**) × P_4(-0.29**)	$P_4 \times P_6$ (2.42**)	$P_1 \times P_6$ (27.94**)
	$P_4 \times P_6$ (18.30**)	P_4(-0.29**) × P_6(0.48**)	$P_3 \times P_6$ (2.16**)	$P_1 \times P_5$ (17.99**)
Fruit girth	$P_4 \times P_5$ (6.23**)	P_4(-0.06**) × P_5(0.22**)	$P_4 \times P_5$ (0.33**)	$P_4 \times P_5$ (7.60**)
	$P_3 \times P_6$ (6.05**)	P_3(0.05**) × P_6(0.05**)	$P_1 \times P_4$ (0.29**)	$P_3 \times P_6$ (4.55**)
	$P_1 \times P_4$ (5.98**)	P_1(0.01**) × P_4(-0.06**)	$P_1 \times P_2$ (0.23**)	$P_1 \times P_4$ (3.28**)
Single fruit weight	$P_1 \times P_6$ (21.65**)	P_1(1.04**) × P_6(0.18**)	$P_1 \times P_6$ (3.53**)	$P_1 \times P_6$ (23.57**)
	$P_2 \times P_4$ (21.10**)	P_2(0.41**) × P_4(0.95**)	$P_2 \times P_5$ (2.99**)	$P_2 \times P_4$ (20.43**)
	$P_4 \times P_6$ (20.47**)	P_4(0.95**) × P_6(0.18**)	$P_2 \times P_4$ (2.84**)	$P_4 \times P_6$ (16.84**)
Fruit yield per plant	$P_1 \times P_6$ (493.84**)	P_1(36.59**) × P_6(6.95**)	$P_1 \times P_6$ (143.69**)	$P_1 \times P_6$ (59.61**)
	$P_2 \times P_4$ (456.18**)	P_2(6.32**) × P_4(-40.98**)	$P_2 \times P_4$ (115.22**)	$P_2 \times P_4$ (47.44**)
	$P_4 \times P_6$ (431.30**)	P_4(-40.98**) × P_6(6.95**)	$P_3 \times P_4$ (109.80**)	$P_4 \times P_6$ (39.40**)

*Significant at 5 per cent level; **Significant at 1 per cent level

In general, many of the cross combinations which registered high mean had also possessed high *sca* and standard heterosis. Most of the cross combinations which exhibited high sca effects also had either both the parents atleast one parents with high *gca* effects. The selection of hybrids based on the combination of three criteria namely mean, *sca* and heterosis will be meaningful than either alone. The hybrids with high mean values and *sca* effects coupled with heterosis would be highly advantages for heterosis breeding [24]. In the present study, the combinations satisfying the above three criteria were $P_1 \times P_6$ for number of fruits per plant, fruit length, fruit girth, fruit weight and fruit yield per plant, the cross $P_2 \times P_4$ for plant height, fruit length and number of nodes per plant and crosses $P_4 \times P_6$ and $P_2 \times P_5$ for number of branches per plant, number of fruits per plant and number of seeds per fruit. The cross $P_3 \times P_4$ satisfying days to first flowering, plant height and fruit weight and cross $P_1 \times P_4$ for number of branches per plant, number of fruits per plant and fruit girth.

CONCLUSION

From the above investigation it may be concluded that the hybrid Arka Anamika × Varsha Uphar ($P_1 \times P_6$) followed by Thanvi 66 × Dhaanya ($P_2 \times P_4$) and Dhaanya × Varsha Uphar ($P_4 \times P_6$) were suitable for heterosis breeding to improve fruit yield per plant and other yield component characters.

LITERATURE CITED

1. Anonymous. 2017. Food and Agriculture Organization (FAO) of the United Nations. https://www.fao.org/statistics/en/.
2. Anonymous. 2017. Annual Reports of National Horticulture Board 2017-18. http://nhb.gov.in/annual_report.aspx?enc.
3. Aswani Kumar DK, Baranwal, Aparna J, Srivastava K. 2013. Combining ability and heterosis for yield and its contributing characters in okra (*Abelmoschus esculentus* (L.) Moench*). Madras Agric. Journal* 100(1/3): 30-35.
4. Nagesh GC, Mulge R, Rathod LB, Basavaraj, Mahaveer SM. 2014. Heterosis and combining ability studies in okra (*Abelmoschus esculentus* (L.) Moench), for yield and quality parameters. *Int. Quart. Journal of Life Science* 9(4): 1717-1723.
5. Sharma RL, Chauhan BPS. 1985. Combining ability in Sesame. *Indian Jr. Genetics* 45(1): 45-59.
6. Richaria AK, Singh RS. 1983. Heterosis in relation to *per se* performance and effect of general combining ability in rice. *In:* Pre congress. meeting on genetics and improvement at heterosis systems. *Thesis,* Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu, India.
7. Fonesca S, Peterson FL. 1968. Hybrid vigour in a seven parent diallel cross in common winter wheat. *Crop Science* 8: 85-88.
8. Wynne JC, Emery DA, Rice DW. 1970. Combining ability estimates in *Arachis hypogea* L. II yield performance of Fi hybrids. *Crop Science* 19(6): 713-715.
9. Medagam TR, Kadiyala HB, Mutyala G, Begum H. 2011. Relationship between combining ability and per se performance for yield and yield components in okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Plant Breeding* 5(2): 137-140.
10. Jaiprakashnarayan RP, Prashanth SJ, Mulge R, Madalgeri MB. 2008. Prediction of combining ability effects through per se performance in okra (*Abelmoschus esculentus* (L.) Moench). *The Asian Journal of Horticulture* 3(1): 95-97.
11. Kerure P, Pitchaimuthu M, Srinivasa V, Venugopalan R. 2019. Heterosis for yield and its components in okra (*Abelmoschus esculentus* L. Moench). *Int. Jr. Curr. Microbiol. App. Science* 8(01): 353-367.
12. Tippeswamy S, Pitchaimuthu M, Dutta OP, Kumar JSA, Ashwini MC. 2005. Heterosis studies in okra (*Abelmoschus esculentus* (L.) Moench) using male sterile lines. *Journal of Asian Horticulture* 2(1): 9-15.
13. Yogini D, Saravanan KR. 2020. Estimation of combining ability for yield and its components through diallel mating system in bhendi [*Abelmoschus esculentus* L. Moench.]. *Plant Archives* 20(1): 1008-1012.
14. Solankey SS, Singh AK. 2010. Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench]. *The Asian Journal of Horticulture* 5(1): 49-53.
15. Singh AK, Singh MC, Pandey S, 2012. Line x tester analysis for combining ability in okra [*Abelmoschus esculentus* (L.) moench]. *Agriculture Science Digest* 32: 91-97.
16. Rao AM, Ramesh S, Kulkarni RS, Savithramma DL, Madhusudhan. 1996. Heterosis and combining ability in rice. *Crop Improvement* 23: 53-56.
17. Sood BC, Gartan SL. 1991. Combining ability analysis in black gram. *Indian Jr. Pulses Research* 4(2): 155-157.
18. Kavimani. 2004. Genetic analysis of thermo sensitive genic male sterile (TGMS) lines and its utilization in heterosis breeding of rice *(Oryza sativa* L.). *Ph. D., Thesis,* Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu, India.
19. Faiz FA, Sabar M, Awan TH, Ijaz M, Manzoor Z. 2006. Heterosis and combining ability analysis in basmati rice hybrids. *Journal Anim. Plant Science* 16(1/2): 56-59.
20. Tiwari DS, Singh V, Shukla PS, Singh V. 1993. Combining ability studies in mungbean (*Vigna radiata* (L.) Wilczek). *Indian Jr. Genetics and Plant Breeding* 53(4): 395-398.
21. Ullah Zaid I, Tang W, He J, Ullah Khan S, Hong D. 2018. Association analysis uncovers the genetic basis of general combining ability of 11 yield-related traits in parents of hybrid rice. *AoB Plants* 11(1): ply077.
22. Satheesh Kumar P, Saravanan K, Sabesan T. 2010. Combining ability for yield and yield contributing characters in rice (*Oryza sativa* L.). *Elect. Jr. Plant Breeding* 1(5): 1290-1293.
23. Matzinger DF, Kempthorne D. 1954. The modified diallel table with partial inbreeding and interaction with environment. *Genetics* 41: 822-833.
24. Fasahat P, Rajabi A, Rad JM. 2016. Principles and utilization of combining ability in plant breeding. *Biom. Biosta.t Int. Journal* 4(1): 1-22.