Indian Journal of Agricultural Sciences **93** (2): 127–132, February 2023/Article
https://doi.org/10.56093/ijas.v93i2.132161

Exploitation of combining ability and heterosis potential for improvement in okra (*Abelmoschus esculentus*) genotypes

KALPANA YADAV[1], S K DHANKHAR[1]*, DAVINDER SINGH[1], UDAY SINGH[1], AMIT[1] and YOGITA[2]

Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana 125004, India

Received: 10 January 2023; Accepted: 26 January 2023

ABSTRACT

The present investigation was undertaken with the objective to carry out combining ability and heterosis for 13 fruit yield and its attributing traits in 14 parents and their 24 crosses in okra (*Abelmoschus esculentus* (L.) Moench) at vegetable research farm, CCS Haryana Agricultural University, Hisar, Haryana during spring-summer season 2019–20 and rainy (*kharif)* season 2020–21. Four crosses, viz. HB-20-3-4 × Hisar Naveen (HN), Hisar Mutant (HM)-1 × Hisar Unnat (HU), HBMS-1 × Hisar Unnat (HU) and HB-76-2-4 × Hisar Naveen (HN) showed highly significant positive economic heterosis for yield and its contributing traits.Parents HB-20-3-4 and HM-1 were found to be the best general combiner for most of the economic traits. While, cross HB-60-1 × HN followed by HBMS-1 × HU, HB-20-3-4 × HN, HM-1 × HU and HB-96-2 × HU demonstrated strong SCA effects for yield and its attributes. The ratio of general combining ability (σ^2GCA) and specific combining ability variances (σ^2SCA) was less than one for all the quantitative traits indicating the non-additive gene effects predominated in determining the expression of all these characters and demonstrates variability in genotypes, which provide ample scope for improvement of yield and its contributing traits in okra. Line HB-60-1 when crossed with Hisar Naveen, and HBMS-1 with Hisar Unnat gave superior hybrids as compared to other crosses. Hence, these parents can be exploited for further genetic improvement programmes and isolation of desirable segregants in okra.

Keywords: *Abelmoschus esculentus,* GCA, Hybridization, SCA, Standard heterosis

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the important vegetable crops grown in India belongs to the family Malvaceae and having chromosome number 2n =130. Originating in Ethiopia, okra spread to North Africa and to India by 12th century BC. It prefers a temperature range from 18–35°C for better growth and development. Thus, it can be cultivated throughout the tropical and subtropical regions of the world for its immature edible fruits (Gemede *et al.* 2015).

Worldwide, India ranks first in annual production of okra with 6.40 mMT from 0.53 million hectares area having productivity of 12.2 tonnes/ha (Indiastat 2020). Gujarat is the leading producer of okra followed by West Bengal. The fresh fruits of okra contain a good amount of minerals like calcium, potassium, phosphorus, and vitamins. Consumption of its fruits is also good for the control of goitre due to its high iodine content. Okra is a valuable source of soluble fibres, which reduce the risk of heart diseases by lowering the serum cholesterol level and insoluble fibres, which helps in maintaining a healthy intestinal tract and reduces certain types of cancer (Gemede *et al.* 2015).

Okra's often cross-pollinated nature leads to generation of substantial genetic diversity for different traits, which is further essential for genetic improvement (Mishra *et al.* 2021). Crop improvement involves strategies to improve yield, quality of the crop and resistance against biotic and abiotic stresses. The most common approach to select parents based on *per se* performance does not necessarily lead to fruitful results. The selection of best parents for hybridization must be based on the complete genetic transformation and prepotency of potential parents. The heterosis and combining ability studies of any crop are prerequisites to provide the desired information regarding the best parents and crosses for further genetic improvement. The present study was carried out with the objective to assess the combining ability and heterosis for morpho-horticultural, yield parameters and to identify the superior hybrids.

MATERIALS AND METHODS

The present study was carried out at the research farm of Chaudhary Charan Singh Haryana Agricultural University (CCS HAU), Hisar, Haryana during spring-summer 2019–20 and rainy season 2020–21. The experimental material

---

[1]Chaudhary Charan Singh Haryana Agricultural University, Hisar; [2]Maharana Pratap Horticultural University, Karnal. *Corresponding author email: dhankharsk@gmail.com

comprised of 14 genotypes of okra involving 12 lines and 02 testers provided by department of vegetable science, CCS HAU, Hisar. The parents were sown in spring-summer 2019–20 at 60 cm × 30 cm spacing to attempting 24 crosses. The seeds of 14 parental genotypes and 24 F_1 hybrids were harvested from the first season crop and sown along with standard check HBH-142 during *kharif* 2020–21 in Randomized Block Design with 3 replications at spacing of 60 cm × 30 cm. The data were recorded for 13 yield and its contributing characters. Five plants from each entry per replication were selected randomly and tagged. The data except fruit yield were recorded from tagged plants.

Statistical analysis: The analysis of variance (ANOVA) for Randomized Block Design was carried out as per Panse and Sukhatme (1985).The mean value of each character was calculated by dividing the total value by the corresponding number of observations. Heterosis was calculated as the percentage increase or decrease in mean of F_1 performance over the standard check (SC). Heterosis was estimated as (Fonseca and Patterson 1968):

$$\text{Standard heterosis} = \frac{F_1 - SC}{SC} \times 100$$

where F_1 and SC, denote mean performance of F_1 hybrid and standard check, respectively and significance test was ascertained with the help of standard error using T-test (Wynne *et al.* 1970). The combining ability analysis was carried out as detailed by Griffing (1956). The statistical data were analysed by using the computer program Window stat 8.0.

RESULTS AND DISCUSSION

The scrupulous study of analysis of variance among 38 genotypes for different quantitative characters revealed highly significant differences among the parents, crosses and commercial check. The total variance from the combined ANOVA of line × tester was divided into variances owing to lines, testers, lines vs. testers, crosses and parents vs. crosses. Parents vs. crosses except for internodal length, petiole length, fruit diameter and weight showed prominent variation in all the traits examined. Koli *et al.* (2020) also observed high genetic variability for yield and its component traits in okra.The average mean performance of parents, their crosses and control are presented in Fig 1.

Heterosis studies: The highest significant negative heterosis for days to 50% flowering over standard check was observed in the cross HM-1 × HU followed by cross HM-1 × HN and HB-98-1 × HN (Table 1). These results were consistent with Hadiya *et al.* (2018) and Koli *et al.* (2020). Maximum negative standard heterosis recorded from HBMS-1 × HN for first fruiting node while, significant positive heterosis by HBMS-1 × HN for number of branches per plant. Negative hetrosis for first fruiting node and positive hetrosis for number of branches per plant were obtained by Patel *et al.* (2015), Gavint *et al.* (2018) and Koli *et al.* (2020) respectively. Negative heterosis for internodal length is desirable, as shorter internodal lengths result in more nodes per plant resulting in higher fruit yield. Crosses HM-3 × HU and HM-1× HU showed significant negative heterosis for internodal and petiole length. The results agreed with the findings of Hadiya *et al.* (2018) and Koli *et al.* (2020).

Fruit size is an important yield characteristic influenced by the fruit length and diameter. The cross HB-96-1× HN showed highly significant heterosis for fruit length and diameter ranging from -8.16 to 6.80% over standard check. Gavint *et al.* (2018) and Hadiya *et al.* (2018) observed similar results for fruit length and diameter. The maximum standard heterosis for number of fruits per plant was exhibited by the cross HM-1 × HU while, HB-10-2-5 × HU gave same results for average fruit weight.

The crosses HB-98-1 × HN and HBMS-2 × HN showed highest positive heterosis for test weight and average number of seeds per pod, which was supported by Patel *et al.* (2015) and Koli *et al.* (2020), respectively. The highest significant positive economic heterosis for fruit yield was observed in the cross HB-20-3-4 × HN. The results for fruit yield were in close conformity with findings of Patel *et al.* (2015), Singh *et al.* (2016), Hadiya *et al.* (2018), Chowdhury and Kumar (2019), Pithiya *et al.* (2019) and Rynjah *et al.* (2020).

General combining ability: Evaluation of general combining ability (GCA) and specific combining ability (SCA) is necessary to identify and select inbred lines and

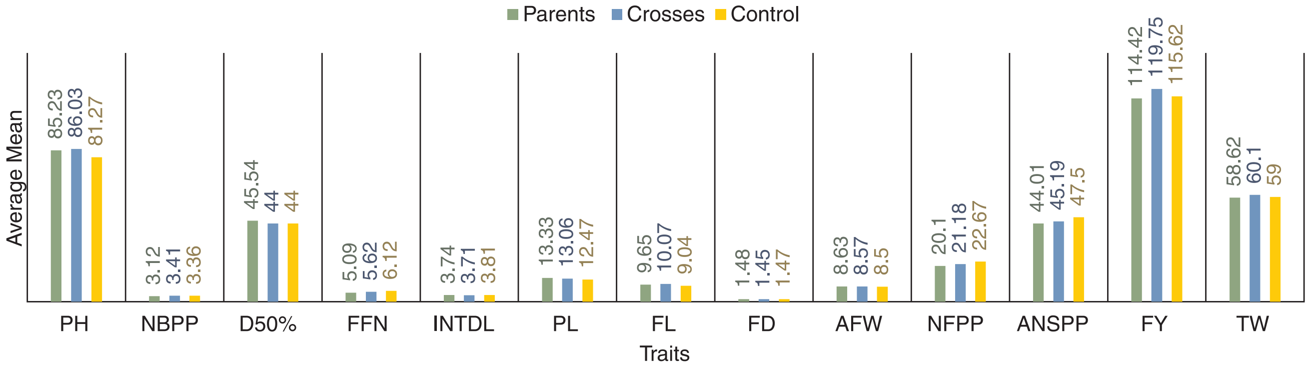

Fig 1 Average mean values of parents, crosses and control.
[PH, Plant height at final harvest (cm); NOB, Number of branches per plant; DF50%, Days to 50% flowering; FFN, First fruiting node; INTDL, Internodal length (cm); PL, Petiole length (cm); FL, Fruit length (cm); FD, Fruit diameter (cm); FW, Average fruit weight (g); NFPP, Number of fruits per plant; ANSPP, Average number of seeds per plant; TW, Test weight (g)].

Table 1 Estimation of standard heterosis (%) in line × tester set of okra

Hybrid	Plant height at final harvest (cm)	Number of branches per plant	Days to 50% flowering	First fruiting node	Internodal length (cm)	Petiole length (cm)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruits per plant	Average number of seeds per plant	Fruit yield (q/ha)	Test weight (g)
HB-96-2 × HN	1.85	2.38	-3.48	-2.78	-10.5	0.8	26.88**	-0.68	-1.41	-20.60**	-2.8	-13.97*	1.69
HB-96-2 × HU	2.87	5.06	-2.5	-1.96	-8.4	-5.13	0.88	-0.68	3.65	-2.96	-9.12*	10.66	2.83
HB-98-1 × HN	-5.22*	-3.87	-1.82	-4.74	-9.45	-3.77	24.56**	-0.68	-2.82	-10.32	-9.12*	-3.88	6.78*
HB-98-1 × HU	0.16	5.06	5.75	2.45	-14.17*	-10.18	17.92*	4.08	-4.35	-2.96	-3.52	2.25	4.53
HB-11-3-4 × HN	3.64*	1.49	4.39	2.45	-0.79	-1.36	12.17*	-8.16*	-2.94	-2.96	-17.89**	3.99	-1.14
HB-11-3-4 × HU	0.41	-6.55	-4.25	4.08	-2.1	2.89	14.38*	-2.04	1.06	-16.19*	-17.54**	-6.8	-1.14
HB-76-2-4 × HN	6.64**	-3.87	-4.55	-24.02*	-4.46	-1.92	18.58*	6.80	-5.06*	7.32	2.11	11.98*	-2.83
HB-76-2-4 × HU	-0.91	-9.82	10.30*	-17.81*	-3.67	7.22	3.98	5.44	-1.88	-10.32*	-14.38*	-3.12	5.08*
HB-96-1 × HN	2.13	-8.93	-0.45	-11.44	15.22*	4.25	27.65**	-5.44	3.29	-17.64*	-1.05	-6.38	3.39
HB-96-1 × HU	7.05**	-1.19	-1.66	-11.76	1.05	14.43*	10.29	-2.72	2.12	-8.82	-6.67	2.47	1.14
HB-20-3-4 × HN	6.60**	-9.52	-2.8	-9.64	5.51	5.61	16.81*	0	3.29	14.69	1.75	29.89**	5.08*
HB-20-3-4 × HU	12.87**	8.93	4.84	2.94	-4.72	14.11*	24.23**	-1.36	4.24	-4.41	-11.22*	9.64	0
HM-1 × HN	-1.13	-3.57	-8.93*	-19.61*	-2.62	5.85	16.70*	2.04	0.71	-8.82	-4.91	0.97	1.14
HM-1 × HU	6.40**	6.85	-9.50*	-16.99*	-16.27*	5.85	7.85	2.04	2.24	11.73*	4.57	25.65**	2.83
HM-3 × HN	5.14*	0	-4.55	-0.98	-2.62	7.7	3.1	2.72	-2.82	-2.96	4.57	3.75	4.53
HM-3 × HU	-3.99*	-3.87	6.66	-11.76	-11.55	-1.52	-0.77	0.68	2.35	-1.5	1.75	10.69	-0.56
HB-60-1 × HN	1.86	-14.29	5	8.66	10.76	13.47*	10.40*	-2.04	3.29	-4.41	-3.52	8.55	-1.69
HB-60-1 × HU	18.28**	-7.14	10.30*	2.94	2.62	15.48*	0.55	-0.68	4.35	-33.83**	-1.05	-24.01**	1.14
HB-10-2-5 × HN	44.70**	-2.68	6.66	-7.03	1.57	12.83*	13.38*	-3.4	3.88	-8.82	-3.52	4.23	2.83
HB-10-2-5 × HU	11.01**	-8.33	-1.98	3.1	4.46	15.48*	13.05*	-1.36	5.06*	-10.32*	-3.52	3.64	0
HBMS-1 × HN	3.85*	34.82*	-7.57*	-18.3	-1.05	-5.61	-5.2	-6.12	-2.71	-14.73*	-13.68*	-8.92	1.69
HBMS-1 × HU	6.07**	29.46*	-3.41	-16.18*	-5.51	2.65	0	2.04	0.59	8.82	-12.27*	20.45*	2.83
HBMS-2 × HN	3.52*	14.29	3.8	-19.93*	2.36	2.09	12.06*	-8.16*	2	-11.78*	8.42*	-0.99	1.69
HBMS-2 × HU	6.64**	11.9	0	-28.10**	-6.04	12.27*	3.65	-7.48*	1.41	-5.91	-4.27	4.96	2.83

*and ** significant at 5% and 1% level, HN, Hisar Naveen; HU, Hisar Unnat.

Table 2 Estimates of GCA for 13 characters in line × tester set of okra

Parent	Plant height at final harvest (cm)	Number of branches per plant	Days to 50% flowering	First fruiting node	Internodal length (cm)	Petiole length (cm)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruits per plant	Average number of seeds per plant	Fruit yield (q/ha)	Test weight (g)
HB-96-2	-2.84**	0.074	-1.32	0.356	-0.265*	-0.859*	0.23	0.01	-0.023	-1.18	-0.519	-6.04	0.236
HB-98-1	-6.81**	-0.031	0.86	0.431	-0.355**	-1.459 **	0.89**	0.04	-0.372**	-0.01	-0.686	-5.07	2.236**
HB-11-3-4	-3.11**	-0.136	0.03	0.698*	0.042	-0.493	0.17	-0.06	-0.15	-0.68	-6.103**	-5.76	-1.764*
HB-76-2-4	-2.43**	-0.281	1.26	-0.780*	-0.06	-0.259	-0.01	0.11	-0.363**	1.15	-0.603	0.99	-0.431
HB-96-1	-1.03	-0.219	-0.47	-0.21	0.409**	0.574	0.69*	-0.04	0.162	-1.51*	0.481	-6.39	0.236
HB-20-3-4	3.16**	-0.062	0.45	0.295	0.112	0.641	0.83**	0.01	0.253*	2.65**	0.064	18.72**	0.403
HM-1	-2.62**	0.001	-4.06**	-0.619*	-0.261*	0.141	0.08	0.05	-0.055	1.82**	2.231	11.26**	0.069
HM-3	-4.28**	-0.117	0.46	0.11	-0.175	-0.203	-0.92**	0.04	-0.09	0.99	3.814**	4.22	0.069
HB-60-1	3.43**	-0.412	3.36**	0.856**	0.349**	1.214**	-0.53	-0.01	0.255*	-2.85**	1.231	-13.06**	-1.264
HB-10-2-5	17.89**	-0.237	1.03	0.383	0.209	1.174**	0.17	-0.02	0.313*	-0.68	0.647	0.419	-0.264
HBMS-1	-0.73	1.031**	-2.42*	-0.552*	-0.031	-0.776	-1.26**	-0.01	-0.16	0.82	-3.853**	2.54	0.236
HBMS-2	-0.63	0.389	0.83	-0.969**	0.025	0.307	-0.32	-0.10**	0.0.72	-0.51	3.297*	-1.83	0.236
Hisar Naveen	0.23	-0.034	-0.53	-0.047	0.108	-0.175	0.31*	-0.01	-0.078	-0.04	0.744	-1.31	0.042
Hisar Unnat	-0.23	0.034	0.53	0.047	-0.108	0.175	-0.31*	0.01	0.078	0.04	-0.744	1.31	-0.042

*and ** significant at 5% and 1% level.

F_1 crosses with superior performance. Genotypes HM-1 followed by HBMS-1 for days to 50% flowering and HBMS-2 followed by HB-76-2-4 for first fruiting node presented high significant negative GCA effects and found to be good general combiners for earliness (Table 2). Vekariya *et al.* (2020) and Shwetha *et al.* (2021) also noticed earliness in okra genotypes. Lines HB-10-2-5, HB-60-1 and HB-20-3-4 represented the highest GCA effects for average fruit weight and the results were in agreement with Padadalli *et al.* (2019). In general, line HB-10-2-5 expressed the highest significant GCA effects for plant height and petiole length. Kumar and Reddy (2016) have their consonance with the results of plant height. Line HB-20-3-4 showed significant GCA for fruit length, number of fruits per plant and fruit yield. Javiya *et al.* (2020) also presented the same results for different fruit yield traits. Genotype HB-20-3-4 and HM-1 registered the maximum positive GCA effects for fruit yield. Parent HB-20-3-4 and HB-10-2-5 were found to be best general combiners for most of the traits under study. Similar, outcomes for GCA were obtained by Vani *et al.* (2020) and Arvind *et al.* (2021).

Specific combining ability: It is the relative performance of a cross that is related to non-additive gene activity, which is mostly contributed by dominance, epistasis or genotype-environment interaction effects. Cross HB-10-2-5 × HN was recognized as the best for plant height and HB-76-2-4 × HN for days to 50% flowering (Table 3). Four crosses, viz. HB-60-1 × HN followed by HBMS-1 × HU, HB-20-3-4 × HU and HB-96-2 × HU displayed significant positive SCA effects for number of fruits per plant. The cross HB-60-1 × HN which was closely accompanied by HBMS-1 × HU and HB-20-3-4 × HN reported highly significant positive SCA effects and was found to be the best cross combinations for fruit yield. The result of SCA analysis was in harmony with Vani *et al.* (2020) and Arvind *et al.* (2021). The ratio of magnitude of variances due to GCA (σ^2GCA) to SCA (σ^2SCA) was less than unity for all the quantitative traits indicating the non-additive gene effects predominated in determining the expression of all these characters. The results agreed with Obiadalla *et al.* (2013) and Koli *et al.* (2020).

The selected okra genotypes showed noteworthy variability with respect to all the traits examined in the research. The primary goal of this research was to evaluate the importance of GCA and SCA effects in okra in order to develop novel F_1 hybrids with high fruit yield. The improvement of okra should largely continue even though significant progress has been done. In the current study, combining ability and heterosis analysis has effectively located good parents and crosses that may serve as guideposts in the development of a coherent strategy for okra improvement. Among parents, line HB-20-3-4 and HM-1 observed to be good general combiners while cross HB-60-1 × Hisar Naveen and HBMS-1 × Hisar Unnat exhibited highest significant SCA effects and standard heterosis for most of the traits. The prominence of non- additive gene in inheritance of traits indicating that heterosis breeding will be beneficial to obtain accelerated improvements in the

Table 3 Estimates of SCA for 13 characters in line × tester set of okra

Hybrid	Plant height at final harvest (cm)	Number of branches per plant	Days to 50% flowering	First fruiting node	Internodal length (cm)	Petiole length (cm)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruits per plant	Average number of seeds per plant	Fruit yield (q/ha)	Test weight (g)
HB-96-2 × HN	-0.64	-0.014	0.31	0.022	-0.15	0.542	0.87*	0.01	-0.138	-1.96*	0.76	-12.92*	-0.375
HB-96-2 × HU	0.64	0.014	-0.31	-0.022	0.15	-0.542	-0.87*	-0.01	0.138	1.96*	-0.76	12.92*	0.375
HB-98-1 × HN	-2.41*	-0.119	-1.14	-0.17	-0.02	0.575	-0.01	-0.02	0.143	-0.79	-2.08	-2.23	0.625
HB-98-1 × HU	2.41	0.119	1.14	0.17	0.02	-0.575	0.01	0.02	-0.143	0.79	2.08	2.23	-0.625
HB-11-3-4 × HN	1.09	0.166	2.43	-0.003	-0.09	-0.092	-0.4	-0.03	-0.09	1.54	-0.83	7.55	-0.042
HB-11-3-4 × HU	-1.09	-0.166	-2.43	0.003	0.09	0.092	0.4	0.03	0.09	-1.54	0.83	-7.55	0.042
HB-76-2-4 × HN	2.84*	0.131	-2.74*	-0.141	-0.12	-0.392	0.35	0.02	-0.06	2.04	3.17	10.04	-2.375*
HB-76-2-4 × HU	-2.84	-0.131	2.74*	0.141	0.12	0.392	-0.35	-0.02	0.06	-2.04*	-3.17	-10.04	2.375*
HB-96-1 × HN	-2.23*	-0.097	0.8	0.055	0.16	-0.458	0.48	-0.01	0.13	-0.96	0.59	-3.8	0.625
HB-96-1 × HU	2.23*	0.097	-0.8	-0.055	-0.16	0.458	-0.48	0.01	-0.13	0.96	-0.59	3.8	-0.625
HB-20-3-4 × HN	-2.78*	-0.277	-1.15	-0.34	0.08	-0.358	-0.64	0.02	0.04	-2.21*	2.34	13.02*	1.458
HB-20-3-4 × HU	2.78*	0.277	1.15	0.34	-0.08	0.358	0.64	-0.02	-0.04	2.21*	-2.34	-13.02*	-1.458
HM-1 × HN	-3.29**	-0.141	0.66	-0.036	0.15	0.175	0.1	0.01	0.02	-2.30*	-2.99	-12.95*	-0.542
HM-1 × HU	3.29**	0.141	-0.66	0.036	-0.15	-0.175	-0.1	-0.01	-0.02	2.3	2.99	12.95	0.542
HM-3 × HN	3.48**	0.101	-1.94	0.375	0.07	0.752	-0.13	0.03	-0.14	-0.13	-0.08	-2.7	1.458
HM-3 × HU	-3.48**	-0.101	1.94	-0.375	-0.07	-0.752	0.13	-0.03	0.14	0.13	0.08	2.7	-1.458
HB-60-1 × HN	-6.90**	-0.084	-0.64	0.222	0.05	0.048	0.14	0.01	0.03	3.38**	-1.33	20.14**	-0.875
HB-60-1 × HU	6.90**	0.084	0.64	-0.222	-0.05	-0.048	-0.14	-0.01	-0.03	-3.38**	1.33	-20.14**	0.875
HB-10-2-5 × HN	13.46**	0.131	2.43	-0.261	0.17	0.008	-0.29	-0.002	0.03	0.21	-0.74	1.65	0.792
HB-10-2-5 × HU	-13.46**	-0.131	-2.43	0.261	-0.17	-0.008	0.29	0.002	-0.03	-0.21	0.74	-1.65	-0.792
HBMS-1 × HN	-1.12	0.126	-0.39	-0.02	-0.03	-0.342	-0.54	-0.05	-0.07	-2.63**	-1.08	-15.66**	-0.375
HBMS-1 × HU	1.12	-0.126	0.39	0.02	0.03	0.342	0.54	0.05	0.07	2.63**	1.09	15.66**	0.375
HBMS-2 × HN	-1.49	0.078	1.36	0.297	0.05	-0.458	0.08	0.01	0.1	-0.63	2.27	-2.13	-0.375
HBMS-2 × HU	1.49	-0.078	-1.36	-0.297	-0.05	0.458	-0.08	-0.01	-0.1	0.63	-2.27	2.13	0.375

*and ** significant at 5% and 1% level, HN, Hisar Naveen; HU, Hisar Unnat.

okra. Transgressive segregants may also be produced by the promising hybrids in the early segregating generations. Hence, these crosses can be exploited for heterosis breeding and lines can be used in future breeding programmes to isolate desirable segregants in okra.

REFERENCES

Arvind K, Gaurav S S and Shiri T. 2021. Combining ability studies in okra (*Abelmoschus esculentus* (L.) Moench) through diallel analysis for yield and yield attributing characters. *Pharma innovation* **10**: 480–85.

Chowdhury S and Kumar S. 2019. Exploitation of heterosis for yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Communication Systems* **7**(4): 853–57.

Fonseca S and Patterson F. 1968. Hybrid vigour in seven parent diallel crosses in common winter wheat (*Triticum aestivum* L.). *Crop Science* **8**: 85–95.

Gavint K N, Vadodariya K V and Bilwal B B. 2018. To study the nature and magnitude of heterosis for fruit yield and yield attributes in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of pharmacognosy and phytochemistry* **7**: 2583–87.

Gemede H F, Ratta N, Haki G D, Woldegiorgis A Z and Beyene F. 2015. Nutritional quality and health benefits of okra (*Abelmoschus esculentus*): A review. *Journal of food processing technology* **6**: 458.

Griffing B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences* **9**: 463–93.

Hadiya D N, Mali S C, Gamit A M and Sangani J L. 2018. Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of pharmacognosy and phytochemistry* **7**: 2525–28.

Indiastat. 2020. Available online: https://www.indiastat.com/table/agriculture/area-production-productivity-okra-india-1987-1988-/14905. (Accessed on Jan 1, 2022).

Javiya U R, Mehta D R, Sapovadiya M H and Pansuriya D J. 2020. Selection of parents and breeding methods based on combining ability and gene action for fruit yield and its contributing characters in okra (*Abelmoschus esculentus* L. Moench). *Journal of Pharmacognosy and Phytochemistry* **9**(5): 1936–39.

Koli H K, Patel A I, Vshai J M and Chaudhari B N. 2020. Study of heterosis for fruit yield and its component traits in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Current Microbiology and Applied Sciences* **9**: 1930–37.

Kumar S and Reddy M T. 2016. Combining ability of inbred lines and half-diallel crosses for economic traits in okra (*Abelmoschus esculentus* (L.) Moench). *Jordan Journal of Agricultural Sciences* **12**(2): 479–98.

Mishra G P, Seth T, Karmakar P, Sanwal S K, Sagar V, Singh P M and Singh B. 2021. Breeding strategies for yield gains in okra (*Abelmoschus esculentus* L.). *Advances in Plant Breeding Strategies*: *Vegetable Crops*, pp. 205–33. Al-Khayri J M, Jain S M and Johnson D V(Eds). Springer, Cham, New York.

Obiadalla-Ali H A, Eldekashy M H Z and Helaly A A. 2013. Combining ability and heterosis studies for yield and its components in some cultivars of okra (*Abelmoschus esculentus* (L.) Moench). *American-Eurasian Journal of Agricultural and Environmental Science* **13**: 162–67.

Padadalli S, Satish D, Babu A G, Chittapur R, Prabhuling G and Peerjade D. 2019. Studies on combining ability in okra [*Abelmoschus esculentus* (L.) Moench] through Line × Tester analysis for productivity and quality traits. *Journal of Pharmacognosy and Phytochemistry* **8**(4): 639–43.

Panse V G and Sukhatme P V. 1985. *Statistical Methods for Agricultural Workers*, ICAR, New Delhi.

Patel H, Bhanderi D R, Patel A I, Tank R V and Kumar A. 2015. Magnitude of heterosis for pod yield and its contributing characters in okra (*Abelmoschus esculentus* (L.) Moench). *BioScan* **10**: 939–42.

Pithiya D J, Pithiya K R, Jethava A S, Sapovadiya M H and Vachhani J. H. 2019. Heterosis studies in okra [*Abelmoschus esculentus* (L.) Moench]. *The International Journal of Communication Systems* **8**(12): 461–65.

Rynjah S, Arumugam T, Mohankumar S and Kannan K A. 2020. Exploitation of heterosis for yield and yield related traits in okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Communication Systems* **8**(4): 886–93.

Shwetha A, Mulge R and Raju K K. 2021. Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench] for growth and earliness parameters. *Journal of Pharmacognosy and Phytochemistry* **10**(2): 1313–16.

Singh B, Goswami A and Sharma A K. 2016. Estimation of heterosis in okra (*Abelmoschus esculentus*) for fruit yield and its components using line × tester mating design. *Indian Journal of Agricultural Sciences* **86**: 1613–20.

Vani V M, Singh B K and Singh S R A K. 2020. GCA and SCA for plant and pod parameters of okra [*Abelmoschus esculentus* (L.) Moench]. *Journal of pharmacognosy and phytochemistry* **6**: 332–38.

Vekariya R D, Patel A I, Modha K G, Kapadiya C V, Mali S C and Patel A A. 2020. Estimation of heterosis, gene action and combining ability over environments for improvement of fruit yield and its related traits in okra [*Abelmoschus esculentus* (L.) Moench]. *International Journal of Current Microbiology and Applied Sciences* **9** (9): 866–81.

Wynne J C, Emery D A and Rice P W. 1970. Combining ability estimation in *Arachis hypogea* II field performance of F_1 hybrids. *Crop Science* **10**: 713–15.