Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI: 10.21474/IJAR01/13270
DOI URL: http://dx.doi.org/10.21474/IJAR01/13270

RESEARCH ARTICLE

AN INVESTIGATION ON HETEROSIS, GENERAL AND SPECIFIC COMBINING ABILITY FOR POD YIELD AND ITS CONTRIBUTING PARAMETERS IN OKRA [*Abelmoschus esculentus* (L.) Moench]

Dr. Shailesh Kapadia, Kirti Patel P.K. Patel, Mempal, D, K.N. Patel and Sunil Sapavadiya
Goldking Biogene Private Limited, Ahmedabad, Gujarat, India.

Manuscript Info

Manuscript History
Received: 10 June 2021
Final Accepted: 14 July 2021
Published: August 2021

Key words:-
Okra, Heterosis, Combining Ability, GCA, SCA Effects, Pod Yield

Abstract

The heterosis and combining ability studies were conducted by utilizing modified Line X Tester mating design involving 6 Lines and 9 testers of Okra [Abelmoschus esculentus (L.) Moench]. The breeding material involving fifty four F_1 hybrids along with 15 parents with one commercial check were evaluated during Kharif 2020 in a Randomized Block Design (R.B.D.) with three replications at Research Centre of Goldking Biogene Private Limited with an aim to estimate the magnitude of heterosis and to identify the good parents and good hybrid combinations for pod yield and other quantitative traits. Among the parents GKOF-1, GKOF-5 and GOM-7 were found to be good general combiners for pod yield per plot. Among the lines GKOF-3, GKOF-4 and GKOF-6 and testers GKOM-4, GKOM-5, GKOM-7 and GKOM-9 were found to be involved in exhibiting significant sca effects for almost all characters. Among the crosses GKOF-2 X GKOM-5, GKOF-1 X GKOM-8 and GKOF-6 X GKOM-7 exhibited high per se performance for pod yield per plot. Further the cross GKOF-1 X GKOM-7, GKOF-4 X GKOM-9 and GKOF-6 X GKOM-4 revealed highest positively significant sca effects for pod yield per plot.

Introduction:-

Okra/Lady's finger [*Abelmoschus esculentus* (L.) Moench] which belongs to Malvaceae family is one of the important vegetable crop grown extensively in tropical and sub-tropical regions of the world. Okra has got a prominent position due to its richness in various nutrients and commonly known as Bhindi. Tender okra pods and water are beneficial to reduce kidneys, diabetes and cholesterol problems. India is the largest producer of okra covering an area of 0.526 million hectares with an annual production of 6.460 million tonnes (Anon., 2019). Okra cultivation has been increased significantly due to increase in irrigation facility and due to availability of ready market at domestic level.

Easy crossing and selfing technique and very good seed set and number of seeds per pod leads to good potential of commercial exploitation hybrid vigour. Okra is an often cross pollinated crop and the out crossing ranges to 5-9% through insects leads to sufficient genetic diversity for breeding efforts (Duggi et al., 2013). The company research centre has total 45 different genotypes developed by inter crossing and further selection having sufficient genetic variability. Hybrid vigour in okra was first reported by Vijayaraghavan and Warier (1946). To get the benefit of hybrid vigour found in okra it is important to study the genetic variability among the available germplasm. Next task is to develop hybrids utilizing a suitable mating design to know the amount of heterosis for various quantitative

Corresponding Author:- Dr. Shailesh Kapadia
Address**:-** Goldking Biogene Private Limited, Ahmedabad, Gujarat, India.

characters and the inheritance pattern of economic traits along with identification of the good parents to be utilized in the future breeding programme.

General and specific combining ability helps to identify the good parents in terms of their genetic value, selection of suitable parents for hybridization and identification of superior cross combinations, which may be utilized for commercial exploitation of heterosis.

Hence an investigation was carried out with an objective of assessing the *per se* performance of parents and their hybrids for economically important characters, estimate the magnitude of the GCA and SCA variances and their effect on various traits, to understand the nature of gene action for yield and its component characters and also obtain information on the extent of heterosis to ascertain superior hybrid combination for quantitative.

Material and Methods:

The study on heterosis and combining ability was undertaken at Goldking Research Centre, Goldking Biogene Pvt., Ltd., located at. Idar, Di. Sabarkantha, Gujarat, INDIA during *Kharif* 2020-21. The experimental material was developed by crossing 6 Lines and 9 Testers. All the breeding material involving 54 F_1hybrids, 15 parents along with one commercial check Himani-11 were planted utilizing a modified Line x Tester mating design in a Randomized Block Design (R.B.D.) having three replications. Each treatment in each replication was represented by 20 plants at a spacing of 60 x 30 cm. and five plants were randomly selected from each genotype for recording the observations. Data were recorded on different characters such as pod yield/plot (g.), number of pods/plot, pod yield/plant, days to 50% flowering, plant height (cm), average pod weight (g), average pod length (cm) and average pod girth (mm). The observed values were subjected to Line × Tester analysis and the general combining ability effects of parents and specific combining ability effects of different crosses were worked out. The combining ability analysis was carried out on the basis of methods developed by Kempthorne (1957). The variances and the corresponding standard errors of the mean were computed from the deviations of the individual values (Panse and Sukhatme, 1978).

Resuts and Discussion:-

Mean performance of parents and hybrids

The data shows that the average pod yield/plot of top ten hybrids and parents are furnished in **Table-1** which shows that among the hybrids the cross GKOF-2 X GKOM-5 (2930g.) recorded the highest pod yield followed by GKOF-1 X GKOM-8 (2895 g.) and GKOF-6 X GKOM-7 (2813 g.) and in case of parental performance GKOM-8 (2285 g.) recorded the highest pod yield followed by GKOM-1(1618 g.) and GKOF-4 (1580 g.).

Table-1:- Mean performance of top ten crosses and parents for pod yield per plot (g).

Sr	Name of cross	Pod yield/plot	Sr	Parent Name	Pod yield/plot
1	GKOF-2 X GKOM-5	2930	1	GKOM-8	2285
2	GKOF-1 X GKOM-8	2895	2	GKOM-1	1618
3	GKOF-6 X GKOM-7	2813	3	GKOF-4	1580
4	GKOF-1 X GKOM-6	2588	4	GKOM-6	1549
5	GKOF-2 X GKOM-7	2573	5	GKOF-5	1535
6	GKOF-5 X GKOM-4	2572	6	GKOM-3	1523
7	GKOF-6 X GKOM-2	2527	7	GKOM-9	1260
8	GKOF-6 X GKOM-1	2475	8	GKOF-2	1253
9	GKOF-4 X GKOM-7	2448	9	GKOM-2	1198
10	GKOF-3 X GKOM-2	2328	10	GKOF-1	1158

Heterotic effects

It was noted that the average pod yield per plot of hybrids (1984 g.) was higher than the parental mean (1337 g.). The heterobeltiosis for pod yield per plot range from -53.74% to 196.83% as mentioned in **Table-2**. As far as pod yield per plant is concern the data further revealed that cross GKOF-6 X GKOM-7 (196.83%) showed the highest positive significant heterobeltiotic effect followed by GKOF-2 X GKOM-5 (133.93%) and GKOF-6 X GKOM-2 (110.898%). In case of standard heterosis the cross combination GKOF-2 X GKOM-5 (51.81%) recorded the highest positive significant heterotic effect followed by GKOF-1 X GKOM-8 (50.00%) and GKOF-6 X GKOM-7 (45.73%). Similar results were observed by Amaranatha et al.(2018) and Nagesh et al. (2014) and Ali et al.(2019).

For number of pods per plot the heterobeltiosis ranged from -45.87 to 56.97%. The highest positive significant heterobeltiosis was recorded by GKOF-6 X GKOM-7 (156.97%) followed by GKOF-1 X GKOM-7 (124.42%) and GKOF-6 X GKOM-2 (104.76%). As far the heterosis over commercial check Himani-11 is concerns, the highest significant positive heterosis was exhibited by GKOF-6 X GKOM-2 (43.33%) followed by GKOF-6 X GKOM-7 (41.33%) and GKOF-5 X GKOM-4 (38.33%). The highest positive and significant heterobeltiosis for pod yield per plant was exhibited by GKOF-6 X GKOM-7 (93.55%) followed by GKOF-4 X GKOM-7 (74.89%) and GKOF-3 X GKOM-2 (70.65%). The highest significant positive heterosis was exhibited by GKOF-6 X GKOM-7 (23.17%) followed by GKOF-4 X GKOM-7 (20.53%) and GKOF-1 X GKOM-8 (15.25%). The heterobeltiosis for days to 50% flowering was highest negative significant found in GKOF-1 X GKOM-8 (-20.54%) followed by GKOF-5 X GKOM-5 (-12.87%) and GKOF-5 X GKOM-9 (-12.87%). The economic heterosis was observed the highest and negatively significant in cross GKOF-5 X GKOM-4 (-14.29%) followed by GKOF-5 X GKOM-3 (-11.22%) and GKOF-5 X GKOM-5 (-10.20%). The cross combination GKOF-5 X GKOM-7 (39.27%) recorded the highest and positively significant heterobeltiosis for plant height followed by GKOF-6 X GKOM-7 (34.52%) and GKOF-6 X GKOM-5 (31.74%) which is shown in **Table-3**. The economic heterosis was recorded the highest and positive significant in cross GKOF-6 X GKOM-3 (11.52%) followed by GKOF-1 X GKOM-2 (12.90%) and GKOF-1 X GKOM-3 (10.60%). The cross GKOF-4X GKOM-3 (19.44%) highest heterosis for average pod weight over check followed by GKOF-4X GKOM-7 (15.87%). The combination GKOF-1X GKOM-4 (18.2%) highest heterosis for average pod length over check followed by GKOF-2X GKOM-8 (18.4%). The hybrid GKOF-2X GKOM-1 (8.84%) highest heterosis for average pod girth over check followed by GKOF-5X GKOM-4 (8.84%). In case of average pod weight 23 hybrids out of 54 recorded the positive heterosis over the better parent and total11 crosses recorded the positive heterosis over the commercial check hybrid Himani-11. A total of 20 cross combination recorded the positive heterobeltiosis for average pod length and 16 crosses recorded positive standard heterosis. For average pod girth a total of 20 cross combinations recorded the positive heterosis over the respective better parents and 14 hybrids revealed positive heterosis over the check hybrid.

Table-2:- Heterobeltiosis (%) and Standard heterosis for Pod yield/plot, No. of pods/plant, Pod yield/plant and Days to50% flowering in okra.

Sr	Name of cross	Pod yield /plot		No of Pods /plot		Pod yield /plant		Days to 50% Flower	
		BP	CC	BP	CC	BP	CC	BP	CC
1	GKOF-1XGKOM-1	18.95	-0.31	2.97	-7.67	-6.01	-21.99*	-3.57	10.20*
2	GKOF-1XGKOM-2	72.78*	7.20	44.76	1.33	4.24	-13.49	-4.46	9.18*
3	GKOF-1XGKOM-3	48.47	17.12	51.17	7.33	2.83	-14.66	-6.25*	7.14
4	GKOF-1XGKOM-4	96.98**	18.13	84.62*	12.00	-7.77	-23.46*	-7.14*	6.12
5	GKOF-1XGKOM-5	20.13	-27.95	23.76	-16.67	-30.04*	-41.94*	-6.25*	7.14*
6	GKOF-1XGKOM-6	67.08*	34.09	96.53*	32.33*	-1.18	-1.76	-5.60*	-6.12*
7	GKOF-1XGKOM-7	100.65**	20.34	124.42**	28.67*	9.89	-8.80	-15.18*	-3.06
8	GKOF-1XGKOM-8	26.70	50.00*	43.43	56.33*	16.27	15.25*	-20.54**	-9.18**
9	GKOF-1XGKOM-9	37.06	-10.52	48.50	-1.00	-10.60	-25.81*	-16.07*	-4.08
10	GKOF-2XGKOM-1	18.21	-0.93	25.28	12.33	-23.05	-27.57	4.49	-5.10
11	GKOF-2XGKOM-2	7.23	-30.41	18.10	-17.33	-33.96*	-37.83*	-6.00	-4.08
12	GKOF-2XGKOM-3	45.22*	14.56	37.09	-2.67	13.08	6.45	6.12	6.12*
13	GKOF-2XGKOM-4	70.66*	10.75	63.27*	6.67	2.49	-3.52	2.02	3.06
14	GKOF-2XGKOM-5	133.93**	51.81	97.52*	33.00*	10.59	4.11	1.96	6.12*
15	GKOF-2XGKOM-6	13.36	-9.02	23.76	-16.67	-22.42	-22.87	-5.56*	4.08
16	GKOF-2XGKOM-7	105.39**	33.29	76.53*	15.33*	-2.80	-8.50	3.00	5.10*
17	GKOF-2XGKOM-8	-53.74*	-45.23	-45.8*	-41.0*	-49.70*	-50.15*	-1.96	2.04
18	GKOF-2XGKOM-9	57.74*	2.98	32.50	-11.67	-14.95	-19.94*	0.00	3.06
19	GKOF-3XGKOM-1	40.49	17.75	19.33	7.00	31.42*	-12.90	13.48*	3.06
20	GKOF-3XGKOM-2	94.36**	20.60	43.33*	0.33	70.65**	0.59	2.00	4.08
21	GKOF-3XGKOM-3	-18.36	-35.60	-10.33	-36.3*	-13.09	-29.91*	6.12*	6.12*
22	GKOF-3XGKOM-4	5.30	-37.67	10.99	-32.6*	-3.50	-43.40*	5.05	6.12*
23	GKOF-3XGKOM-5	12.39	-34.20	-1.98	-34.0*	13.73*	-22.29*	0.98	5.10
24	GKOF-3XGKOM-6	-10.04	-27.80	-5.45	-36.3*	-13.57	-14.08	1.98	5.10
25	GKOF-3XGKOM-7	95.09**	2.85	86.67*	2.67	67.80**	-12.90	-4.00	-2.04

26	GKOF-3XGKOM-8	-38.40	-27.07	-36.70	-31.00	-20.41	-21.11	-2.94	1.02
27	GKOF-3XGKOM-9	-16.07	-45.21	-16.50	-44.3*	-25.00*	-41.06*	-1.98	1.02
28	GKOF-4XGKOM-1	-12.98	-27.07	-18.96	-27.33	-0.85	-31.67*	12.36*	2.04
29	GKOF-4XGKOM-2	10.06	-9.90	20.37	-13.33	15.32*	-20.53*	0.00	2.04
30	GKOF-4XGKOM-3	28.48	5.18	26.39	-9.00	19.64*	-3.52	0.00	0.00
31	GKOF-4XGKOM-4	15.79	-5.21	26.85	-8.67	17.87*	-18.77*	-2.02	-1.02
32	GKOF-4XGKOM-5	11.08	-9.07	15.28	-17.00	24.26*	-14.37	-0.98	3.06
33	GKOF-4XGKOM-6	35.28	10.75	25.93	-9.33	0.88	0.29	0.00	4.08
34	GKOF-4XGKOM-7	54.91*	26.81	33.33	-4.00	74.89**	20.53*	3.00	5.10
35	GKOF-4XGKOM-8	-16.30	-0.91	-22.94	-16.00	-15.38	-16.13	0.98	5.10
36	GKOF-4XGKOM-9	38.92	13.73	34.26	-3.33	17.16	-7.92	2.97	6.12
37	GKOF-5XGKOM-1	17.16	-1.81	-2.60	-12.67	-10.86	-30.21*	16.85*	6.12
38	GKOF-5XGKOM-2	29.80	3.24	24.19	-11.00	-3.00	-24.05*	3.00	5.10
39	GKOF-5XGKOM-3	7.95	-14.15	20.00	-14.00	7.64	-13.20	-11.22*	-11.22*
40	GKOF-5XGKOM-4	67.52*	33.24	93.02*	38.33*	28.09*	0.29	-15.15*	-14.29*
41	GKOF-5XGKOM-5	34.79	7.20	48.37	6.33	19.10	-6.74	-12.87*	-10.20*
42	GKOF-5XGKOM-6	31.79	5.78	52.09	9.00	-10.32	-10.85	-12.87*	-10.20*
43	GKOF-5XGKOM-7	51.53*	20.52	76.74*	26.67*	10.11	-13.78	-12.00*	-10.20*
44	GKOF-5XGKOM-8	-7.22	9.84	15.60	26.00	-16.57	-17.30	-12.75*	-9.18
45	GKOF-5XGKOM-9	47.46	17.28	71.63*	23.00	20.97	-5.28	-12.87*	-10.20*
46	GKOF-6XGKOM-1	52.98*	28.21	40.15	25.67	44.69*	-4.11	0.00	-9.18
47	GKOF-6XGKOM-2	110.98**	30.91	104.7*	43.33*	45.16*	-7.62	-12.00*	-10.20*
48	GKOF-6XGKOM-3	43.02	12.82	68.08*	19.33	18.55	-4.40	-7.14*	-7.14
49	GKOF-6XGKOM-4	37.64	-18.52	48.35	-10.00	24.42*	-20.82*	-10.10*	-9.18
50	GKOF-6XGKOM-5	61.42*	-5.49	22.77	-17.33	26.18*	-13.78	-3.92	0.00
51	GKOF-6XGKOM-6	32.99	6.74	54.95	4.33	7.08	6.45	-1.94	3.06
52	GKOF-6XGKOM-7	196.83**	45.73	156.97**	41.33*	93.55**	23.17*	5.00*	7.14
53	GKOF-6XGKOM-8	-6.59	10.60	-3.06	5.67	-2.96	-3.81	-1.96	2.04
54	GKOF-6XGKOM-9	31.94	-13.86	15.00	-23.33	19.03	-6.45	-1.98	1.02
	S.Em.±	152.75		10.57		10.29		0.54	
	CD at 5%	430.94		29.82		29.04		1.51	
	CV %	24.84		22.84		21.63		3.26	
	GM	1845		138.82		142.74		49.31	

Legend: * and ** indicate significance of values at p=0.05 and p=0.01, respectively; BP and CC - Heterosis over better parent and commercial check (Himani-11) respectively.

Table-3:- Heterobeltiosis (%) and Standard heterosis for Plant height (cm), Average pod weight, (g), Average pod length (cm) and Average pod girth (mm).

Sr	Entry No.	Plant height		Av Pod weight		Av Pod Length		Av Pod Girth	
		BP	CC	BP	CC	BP	CC	BP	CC
1	GKOF-1XGKOM-1	12.44*	4.15	-0.42	-6.35*	8.9*	0.7	2.81	-2.21
2	GKOF-1XGKOM-2	18.93*	12.90*	-8.44*	-13.89*	-7.8*	-10.3*	-3.32	-3.41
3	GKOF-1XGKOM-3	13.74*	10.60*	-2.83	-4.76	7.6*	5.3	6.68*	1.47
4	GKOF-1XGKOM-4	9.45	1.38	1.27	-4.76	25.1**	18.2**	3.00	-2.03
5	GKOF-1XGKOM-5	6.97	-0.92	-17.72**	-22.62**	-2.2	-5.5	1.45	-3.04
6	GKOF-1XGKOM-6	-10.19	-10.60*	-7.76	-10.32*	9.1*	7.1	-0.38	-4.05
7	GKOF-1XGKOM-7	-3.98	-11.06*	-14.77*	-19.84**	-15.0*	-13.9**	0.68	-4.24
8	GKOF-1XGKOM-8	-16.06	-15.67*	-18.26**	-21.83**	-16.4**	-14.1**	-7.26*	-11.79**
9	GKOF-1XGKOM-9	-11.94	-18.43**	-15.61*	-20.63**	-11.3*	-18.1**	-6.87*	-11.42**
10	GKOF-2XGKOM-1	-8.74	-23.04**	4.24	-2.38	0.0	-1.8	13.22**	8.84*
10	GKOF-2XGKOM-2	-14.08*	-18.43*	-1.69	-7.94*	-10.1*	-10.3*	-8.66*	-8.75*
12	GKOF-2XGKOM-3	-0.95	-3.69	4.86	2.78	-6.9*	-7.1*	-3.26	-7.00*
13	GKOF-2XGKOM-4	30.05**	9.68*	6.36*	-0.40	3.0	2.8	4.31	0.28
14	GKOF-2XGKOM-5	31.15**	10.60*	1.69	-4.76	-2.6	-2.8	7.09*	2.95

15	GKOF-2XGKOM-6	-15.28	-15.67*	2.86	0.00	-10.4**	-10.6*	1.72	-2.21
16	GKOF-2XGKOM-7	-2.73	-17.97*	11.02**	3.97	-6.2	-5.0	0.10	-3.78
17	GKOF-2XGKOM-8	-10.09	-9.68	2.90	-1.59	15.3**	18.4**	8.81*	4.60
18	GKOF-2XGKOM-9	-6.56	-21.20*	9.32*	2.38	7.4*	7.2*	4.69	0.64
19	GKOF-3XGKOM-1	-14.67	-27.65**	1.23	-2.38	-2.9	-11.0*	-10.63*	-10.22*
20	GKOF-3XGKOM-2	-19.90*	-23.96*	7.00*	3.17	3.0	0.2	-2.66	-2.21
21	GKOF-3XGKOM-3	-33.18*	-35.02**	-8.50*	-10.32*	-10.7*	-12.6*	-11.18*	-10.77*
22	GKOF-3XGKOM-4	10.73*	-9.68	-6.17*	-9.52*	8.9*	2.9	5.04*	5.52*
23	GKOF-3XGKOM-5	10.78*	-14.75*	-4.53	-7.94*	-6.1*	-9.3*	5.22*	5.71*
24	GKOF-3XGKOM-6	-19.91*	-20.28*	6.53*	3.57	-5.5	-7.2*	-4.22	-3.78
25	GKOF-3XGKOM-7	6.55*	-17.51*	-11.52*	-14.68**	-21.0**	-20.0**	-9.17*	-8.75*
26	GKOF-3XGKOM-8	-31.65**	-31.34**	-9.05*	-12.30**	-17.2**	-15.0**	-11.18**	-10.77*
27	GKOF-3XGKOM-9	-6.98*	-26.27**	-3.29	-6.75*	3.6	-6.0*	2.47	2.95
28	GKOF-4XGKOM-1	4.86*	-10.60*	-0.41	-3.57	5.1*	-3.6	-7.50*	-5.71
29	GKOF-4XGKOM-2	-3.40	-8.29	4.92	1.59	3.3	0.5	3.97	5.99
30	GKOF-4XGKOM-3	-12.80	-15.21*	21.86**	19.44**	8.6*	6.2*	-4.97	-3.13
31	GKOF-4XGKOM-4	13.51*	-3.23	-1.23	-4.37	-1.8	-7.2*	-0.36	1.57
32	GKOF-4XGKOM-5	2.70	-12.44	-13.93*	-16.67**	-24.3**	-26.8**	-2.98	-1.10
33	GKOF-4XGKOM-6	5.09	4.61	13.47*	10.32*	9.3*	7.3*	-3.16	-1.29
34	GKOF-4XGKOM-7	8.65	-7.37	19.67*	15.87**	7.4*	8.8*	1.72	3.68
35	GKOF-4XGKOM-8	-15.14*	-14.75*	9.84*	6.35*	2.8	5.6*	0.54	2.49
36	GKOF-4XGKOM-9	-11.89	-24.88*	4.92	1.59	9.4*	-1.7	-6.59	-4.79
37	GKOF-5XGKOM-1	-2.62	-14.29*	6.20	1.98	1.9	-6.6*	-0.94	-3.04
38	GKOF-5XGKOM-2	-9.71	-14.29*	6.20	1.98	-1.0	-3.7	-6.36	-6.45*
39	GKOF-5XGKOM-3	-10.43	-12.90*	-8.50*	-10.32*	-13.2**	-15.1**	-15.71**	-17.50**
40	GKOF-5XGKOM-4	-6.28	-17.51*	-2.89	-6.75*	13.6**	7.3*	11.19*	8.84*
41	GKOF-5XGKOM-5	0.00	-11.98*	-4.13	-7.94*	-12.0**	-15.0**	-16.27**	-18.05**
42	GKOF-5XGKOM-6	-14.81	-15.21*	0.00	-2.78	2.7	0.8	-1.60	-3.68
43	GKOF-5XGKOM-7	39.27**	-7.37	-5.79	-9.52*	6.2*	7.6*	2.63	0.46
44	GKOF-5XGKOM-8	-13.76*	-13.36*	-17.43*	-21.03**	-17.4**	-15.2**	-11.10*	-12.98**
45	GKOF-5XGKOM-9	-4.19	-15.67*	-3.31	-7.14*	15.8**	4.7	-9.50	-11.42*
46	GKOF-6XGKOM-1	11.96*	-5.07	2.22	-8.73*	-15.7**	-15.1**	-7.96*	-11.60*
47	GKOF-6XGKOM-2	0.97	-4.15	-3.51	-12.70*	-15.7**	-15.1**	-10.32*	-10.41*
48	GKOF-6XGKOM-3	14.69*	11.52*	-15.79*	-17.46**	-20.0**	-19.4**	-10.07*	-13.63**
49	GKOF-6XGKOM-4	14.69*	-6.45	-8.44	-18.25**	-15.0**	-14.3**	-6.23*	-9.94
50	GKOF-6XGKOM-5	31.74**	1.38	12.00*	0.00	-6.4*	-5.7*	-7.38*	-11.05**
51	GKOF-6XGKOM-6	1.39	0.92	-0.82	-3.57	0.4	-1.4	-3.63	-7.18*
52	GKOF-6XGKOM-7	34.52*	4.15	8.00*	-3.57	-4.5	-3.8	4.60	0.46
53	GKOF-6XGKOM-8	4.59	5.07	1.24	-3.17	-10.0*	-7.6*	4.89	0.74
54	GKOF-6XGKOM-9	28.49**	1.84	16.89**	4.37	-4.2	-3.4	2.21	-1.84
	S.Em.±	3.94		0.44		0.75		0.03	
	CD at 5%	11.11		1.24		2.38		0.07	
	CV %	12.20		11.14		2.31		1.48	
	GM	96.84		11.87		96.84		5.21	

Legend: * and ** indicate significance of values at p=0.05 and p=0.01, respectively; BP and CC - Heterosis over better parent and commercial check (Himani-11) respectively.

Combining ability effects

For pod yield per plot the lines GKOF-1 (2.30) recorded the highest positive significant gca effects followed by GKOF-5 (2.21) and among the testers GKOM-7 (4.21) exhibited the highest significant and positive gca effect followed by GKOM-8 (2.21) and GKOM-4 (2.20) (**Table-4**). Out of 15 parents 13 recorded the positive gca effects. In case of number of pods per plot total 10 parents gave positive gca effects out of which GKOM-7 (3.52) recorded highest and positively significant gca effect followed by GKOF-3 (1.80). For pod yield per plant 10 parents recorded the positive significant gca effects out of which tester GKOM-8 (31.75) recorded highest gca effect followed by line GKOF-3 (21.52). With respect to days to50% flowering GKOF-5 (-3.33) revealed highest negative and significant gca effect followed by GKOM-5(-2.21). For average pod weight the lines GKOF-3 (1.22), GKOF-5 (1.02) and tester GKOM-4 (2.12) and GKOM-7 (2.58) recorded the maximum positive and significant gca effects out of 15 parental lines. As far average pod length and girth is concerned GKOF-5 (2.56) and GKOM-4 (2.22) recorded highest significant positive gca effects for length and GKOf-3 (2.52) and GKOM-4 (3.12) recorded highest gca effects for girth.

On an overall analysis of gca effects of all the parents for pod yield and other quantitative characters it seems that the lines GKOF-1, GKOF-2, GKOF-3 and GKOF-5 and testers GKOM-4, GKOM-5, GKOM-7 and GKOM-8 are very good general combiners for almost all the traits which revealed by their inclusion for gca effects as far as descending order of genetic influence is concerned. It shows that the concerned characters are predominantly governed by the additive gene action. Hence there is a great scope and genetic potential among these parents to be utilized in exploitation and for harnessing maximum of their combing ability to produce better hybrids in future okra breeding research programme.

For pod yield per plot a total of 43 crosses out of 54 showed the positive sca effects and out of these 20 crosses recorded significant sca effect. The cross GKOF-1XGKOM-7(5.23) showed the highest positive and significant sca effects followed by GKOF-4XGKOM-9(4.55) and GKOF-6XGKOM-7(4.10) as shown in **Table-5**. In case of number of pods per plot 38 hybrids exhibited positive sca effects out of which 19 recorded significant sca effects. The cross combinations GKOF-3XGKOM-7(3.25), GKOF-4XGKOM-8(3.21) and GKOF-1XGKOM-5(2.85) recorded the significantly highest sca effects. For pod yield per plant 40 hybrids showed positive sca effects out of which 32 shows significant sca effects. Among this the highest significant sca effects were observed in GKOF-6XGKOM-2(63.15) followed by GKOF-3XGKOM-7(60.32) and GKOF-1XGKOM-9(30.12). Similarly a total of 42 hybrids for average pod weight, 40 for average pod length and 48 for average pod girth revealed positive sca effects out of which 20, 25 and 27 hybrids recorded the significant sca effects for the traits, respectively. In average pod weight GKOF-4XGKOM-7(3.40) showed highest significant sca effect followed by GKOF-1XGKOM-7(3.33) and GKOF-4XGKOM-4(2.69). For average pod length GKOF-3XGKOM-6(3.22) showed highest significant sca effect followed by GKOF-2XGKOM-5(2.92) and GKOF-1XGKOM-4(2.74). In case of average pod girth GKOF-1XGKOM-7(3.52) showed highest significant sca effect followed by GKOF-1XGKOM-4(3.12) and GKOF-3XGKOM-9(3.10). Looking to the magnitude and significance of sca effects of all the quantitative characters it is quite clear that there is profound role of dominance gene action and additive x dominance and dominance x dominance gene interaction in governing these traits.

From over all observations of gca effects for these all quantitative characters it is clear that good general combiner parents were involved in exhibiting the highest significant positive heterosis. As far as the mean performance of crosses is concerned the investigation indicated that good general combiners were responsible for high phenotypic values in many crosses. In the same context it seems that the lines GKOF-3, 4 and 6 and the testers GKOM-4, 5, 7, 8 and 9 were directly involved in acquiring the highest positive and significant sca effects for all the six characters. Similar observations were made by Solankey et al. (2016).

Table-4:- General combining ability (GCA) effects for pod yield and other parameters in okra.

Sr	Entry name	Pod yield/plot	No. of pods/plot	Pod yield/ plant	Days to 50% flowering	Plant height	Av. Pod weight	Av. Pod length	Av. Pod girth
	Lines								
1	GKOF-1	2.30*	-0.25	1.00	-0.80*	1.23*	0.09	-0.58*	-0.84
2	GKOF-2	-0.55	-1.77*	-12.32	0.54	2.21*	0.23	0.33	-0.32
3	GKOF-3	1.35*	1.80*	21.52**	-2.00**	-1.00	1.22*	1.54*	2.52**
4	GKOF-4	0.83	0.55	9.53	1.58	0.52	0.88*	0.68	2.22**
5	GKOF-5	2.21**	1.1*	17.44**	-3.33**	-0.87	1.02*	2.56**	1.56*
6	GKOF-6	1.89*	0.88	20.33**	0.69	-0.88	-0.55	-0.34	-0.60
	Testers								
1	GKOM-1	-1.20*	-0.31	19.20**	-0.87	0.85	-0.31	-0.82	-0.55
2	GKOM-2	1.56*	0.90	10.44**	0.52	1.32*	1.00*	0.58	-0.30

3	GKOM-3	1.22*	-0.25	-13.25*	1.20	-1.12*	-0.54	-0.22	-0.54
4	GKOM-4	2.20*	1.56**	20.31**	-0.90	1.98**	2.12**	2.22**	3.12**
5	GKOM-5	0.88	1.11*	17.30**	-2.21**	0.80	1.11*	1.54*	1.57*
6	GKOM-6	0.87	0.99*	-21.63*	0.85	-0.88	0.98*	0.56	-0.31
7	GKOM-7	4.21**	3.52**	16.54*	-2.00**	2.21**	2.58**	1.55**	1.50*
8	GKOM-8	2.21**	1.21*	31.75**	-1.58*	1.47	1.55*	1.89*	2.24**
9	GKOM-9	1.62*	-0.36	15.63*	1.20	-2.22*	0.53	0.88	0.90*

Legend: * and ** indicate significance of values at p=0.05 and p=0.01, respectively

Table-5:- Specific combining ability (SCA) effects for pod yield and its contributing traits in Okra.

Sr	Name of cross	Pod yield/ plot	No. of pods/ plot	Pod yield/ plant	Av. Pod Wt.	Av. Pod length	Av. Pod girth
1	GKOF-1 X GKOM-1	0.65	-0.83	3.32	1.21	2.20*	0.20
2	GKOF-1 X GKOM-2	-0.86	0.00	1.68	0.52	-0.60	1.08
3	GKOF-1 X GKOM-3	0.16	0.09	-10.25*	-1.11	-0.73	0.46
4	GKOF-1 X GKOM-4	3.35**	2.64**	12.20**	1.92*	2.74**	3.12**
5	GKOF-1 X GKOM-5	0.08	2.85**	15.56**	2.27**	2.46**	2.04*
6	GKOF-1 X GKOM-6	2.25**	1.24*	4.26	1.07	1.89*	-0.35
7	GKOF-1 X GKOM-7	-1.05*	1.94*	6.10*	3.33**	1.66*	3.52**
8	GKOF-1 X GKOM-8	-0.89	-0.03	16.58**	1.71	1.25	2.34*
9	GKOF-1 X GKOM-9	1.10*	0.90	30.12**	-1.98*	-0.77	2.17*
10	GKOF-2 X GKOM-1	2.21*	0.78	2.68	1.12	-0.81	-1.51
11	GKOF-2 X GKOM-2	-3.11**	-0.05	11.24*	0.88	-0.46	1.65*
12	GKOF-2 X GKOM-3	1.40*	-0.32	-63.20**	0.65	-0.76	1.78*
13	GKOF-2 X GKOM-4	1.58*	1.65*	10.58*	2.42**	1.82*	1.20
14	GKOF-2 X GKOM-5	1.96**	1.65*	12.30*	2.23**	2.92**	2.56*
15	GKOF-2 X GKOM-6	0.45	1.21	16.52**	-0.55	1.69*	2.45**
16	GKOF-2 X GKOM-7	2.23**	0.98	22.45**	2.08**	2.45**	1.88*
17	GKOF-2 X GKOM-8	1.44*	0.78	13.25**	1.40	1.91*	1.90*
18	GKOF-2 X GKOM-9	0.95	-0.53	-10.26*	0.80	0.60	0.82
19	GKOF-3 X GKOM-1	-1.23*	0.80	-0.25	0.56	0.65	1.78*
20	GKOF-3 X GKOM-2	0.53	0.75	20.45**	-0.75	2.31**	1.11
21	GKOF-3 X GKOM-3	0.85	0.11	0.89	-0.63	0.92	2.25*
22	GKOF-3 X GKOM-4	0.98	1.77*	12.35*	1.29	1.20	2.19**
23	GKOF-3 X GKOM-5	1.16	1.09*	7.22*	2.33*	2.31**	1.56*
24	GKOF-3 X GKOM-6	1.45*	0.83	-66.32	-0.58	3.22**	1.90*
25	GKOF-3 X GKOM-7	5.23**	3.25**	60.32**	1.33*	2.30**	2.88**
26	GKOF-3 X GKOM-8	3.24**	2.45**	25.63**	2.03*	1.21	1.61*
27	GKOF-3 X GKOM-9	0.44	-1.10	-45.1**	-1.35	0.65	3.10**
28	GKOF-4 X GKOM-1	-4.35**	-0.48	19.32**	0.36	0.63	-1.45
29	GKOF-4 X GKOM-2	2.08*	0.69	22.46**	0.53	-1.52**	2.30**
30	GKOF-4 X GKOM-3	-1.08	1.32*	7.88	1.74	-0.32	0.68
31	GKOF-4 X GKOM-4	0.32	1.43*	6.32	2.69*	0.56	0.28
32	GKOF-4 X GKOM-5	0.75	0.00	0.58	1.15	1.35*	0.78
33	GKOF-4 X GKOM-6	2.35*	-0.12	-15.85**	2.68*	1.33**	1.28
34	GKOF-4 X GKOM-7	1.78	-0.48	16.32**	3.40**	-0.85*	0.63
35	GKOF-4 X GKOM-8	3.35**	3.21**	15.58**	0.52	-0.50	0.20
36	GKOF-4 X GKOM-9	4.55**	1.48*	-14.52*	1.13	-0.27	-1.24
37	GKOF-5 X GKOM-1	2.45*	1.32*	10.32*	2.38*	2.53**	2.78**
38	GKOF-5 X GKOM-2	-1.85	0.77	15.69**	1.73*	-0.43	1.23
39	GKOF-5 X GKOM-3	-0.56	-0.75	15.88**	-1.96	1.55**	2.82*
40	GKOF-5 X GKOM-4	1.71*	2.55**	18.32**	1.88*	1.32*	2.14*
41	GKOF-5 X GKOM-5	0.89	0.65	-7.27	1.20*	2.25*	1.55*

42	GKOF-5 X GKOM-6	0.25	-1.12	17.78**	-0.88*	0.49	0.83
43	GKOF-5 X GKOM-7	1.46*	1.35*	-15.64**	2.17*	1.65*	2.11*
44	GKOF-5 X GKOM-8	3.58**	1.15*	16.58**	1.66*	1.58*	1.14*
45	GKOF-5 X GKOM-9	0.55	-0.98	12.19*	-0.48	1.25*	0.58
46	GKOF-6 X GKOM-1	-3.10*	-0.31	16.30**	-0.85*	0.48	0.98*
47	GKOF-6 X GKOM-2	-2.58*	-0.98*	63.15*	0.63	-0.72	0.23
48	GKOF-6 XGKOM-3	1.25	1.31*	6.88	1.41*	0.58	0.45
49	GKOF-6 X GKOM-4	0.43	0.13	6.88	0.98*	1.23*	1.21
50	GKOF-6 X GKOM-5	-0.95	0.28	-15.20**	0.25	-0.72*	1.25
51	GKOF-6 X GKOM-6	1.25	1.10	12.20*	0.33	0.48	0.85
52	GKOF-6 X GKOM-7	4.10**	0.45	15.32**	0.34	0.51	0.52
53	GKOF-6 X GKOM-8	1.02	1.28*	0.28	-1.60*	0.15	-1.10
54	GKOF-6 X GKOM-9	0.82	0.99	13.56**	0.23	2.35**	-0.56

Legend: * and ** indicate significance of values at p=0.05 and p=0.01, respectively.

Bibliography:-

1. Ali, H.A., M.H.Z. Eldekashy and A.A. Helay (2013). Combining ability and heterosis studies for yield components in some cultivars of okra (*Abelmoschus esculentus* L. Moench).
2. American Eurasian. J. agri. Environ. Sci., 13(2): 162-167.
3. Allrad, R.W. (1960). Principles of plant breeding. John Willey and Sons, New York. Pp. 20-24and 88-89
4. Amaranatha Reddy, M. and O. Sridevi (2018). Combining Ability for Yield and Yield
5. Components through Diallel Analysis in Okra (*Abelmoschus esculentus* L. Moench). Int. J. Curr. Microbiol. App. Sci., 7(3): 1023-1029.
6. Anonymous 2019. Indian Horticultural Database, http://www.nhb.gov.in.
7. Duggi, S., Magadum, S., Srinivasraghavan, A., Kishor, D. S. And Oommen, S. K. 2013. Genetic analysis of yield andyield-attributing characters in okra [*Abelmoschus esculentus* (L.) Moench]. Intl. J. Agric. Environ. Biotech. 6(1): 45-50.
8. Nagesh, G.C., R. Mulge, V. Rathod, L.B. Basavaraj and S.M. Mahaveer (2014). Heterosis and combining ability studies in okra (*Abelmoschus esculentus* L. Moench) for yield and quality parameters. The Bioscan., 9(4): 1717-1723.
9. Panse and Sukhatme. Statistical Methods for Agricultural Workers (1978).
10. Kempthorne, O. 1957. An introduction to genetic statistics. J. Wiley and Sons, New York, pp. 408-711
11. Solankey, S. S., Singh, A. K. and Singh, R. K. 2013. Genetic expression of heterosis for yield and quality traits during different growing seasons in okra (*Abelmoschus esculentus*). Indian J. Agric. Sci .83(8): 815- 819.
12. Vijayaraghavan, C. and Warier, U. A. 1946. Evaluation of high yielding bhendi (*Hibiscus esculentus*). Proc. 33rd Indian Science Congress. 33: 165.