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Research Article

Combining Ability Estimates of Various Morphological and Quality Traits of Okra

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ABSTRACT

Okra (*Abelmoschus esculentus* L. Moench) is one of important summer vegetable of Pakistan. In the present study GCA effects of parents and SCA effects of crosses were estimated by using line × tester analysis. Five lines i.e. Clean strawless, Sanura, Okra Malka, 0019221, Krishna and three testers Sabz pari, Perbhani selection, Ikra-03 were crossed to develop 15 F_1 hybrids. The parents along with their hybrids were evaluated in RCBD in three replications in the field during 2019. The GCA and SCA mean squares for plant height, number of fruits, number of leaves, Stem diameter, Fruit diameter, Protein content, Fiber content, Ascorbic acid, Ash content, internodal distance and Pubesence were significant. Among lines Clean strawless, Okra malka and Sanura whereas among testers Sabz pari and Ikra-03 were proved to be good general combiners for most of the traits. These parents suggested to be used in future programs for fixing the desirable traits. Among crosses Clean strawless × Sabz pari, Sanura × Perbhani selection, Sanura × Sabz pari, were proved to be best specific combiners for most of the characters. Whereas Okra malka × Sabz pari, Sanura × Ikra-03, Krishna× Ikra-03, 0019221 × sabz pari had significant mid and better parent heterosis for most of the traits under study. So these cross combinations may be used in the development of hybrid okra or in the improvement of different quality traits of okra.

Key words: Okra, GCA, SCA

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an economically important vegetable crop that belongs to the Malvaceae family and liked by the people of the sub-continent. In Pakistan, the production of okra is stagnant from years and is not enough to fulfill the demand of the increasing population. The average production of okra was around 2.7 million tons during previous years. (Pakistan Bureau of Statistics, 2019). It originated from North-Eastern African countries i.e. Sudan and Ethiopia. It is the crop being cultivated from ages and its distribution is from Asia to Africa, North America and Southern Europe (Oyelade *et al.*, 2003).

Its major growing zones are tropical and subtropical regions. It is prone to frost, chilling, water deficit and water logging conditions (Oyetunde *et al.*, 2015). Okra has annual growth habit with 2n=130 chromosomes. Cultivars from different countries have acquired certain distinguished characters from the country to which they belong. It is a multi-purpose crop, consumed in several ways but mostly its green tender fruits are consumed as a vegetable. Its fruits are a good source of calcium, vitamins, magnesium and other mineral nutrients. The mature seed of okra is a rich source of protein and oil and some important micro and macronutrients. The oil obtained from its seed is a rich source of fatty acids including linoleic acid, which is a good source of nutrition for humans (Savello *et al.*, 1980). Okra is commonly known as "bhindi "in Pakistan. Okra fruit has nutritional value as it has 88% water, 1.52 g protein, 5.76 g carbohydrate, 13.1 mg ascorbic acid, 0.4 mg Ca, 36.5 µg folic acid, 46 mg and 2g dietary fiber, which lowers blood cholesterol level, reduces the chances of cardiac arrest and lethal cancer especially colorectal (Saleem *et al.*, 2018).

Most okra verities are adapted to high temperature. Minimum temperature requirement for okra germination is 16 °C and for excellent growth night temperature should not be less than 13 °C. Okra cultivars grows on range of soil types but well drained, fertile substrates with adequate amount of organic matters are ideal (Shivaramegowda *et al.,* 2016). In field okra harvests twice a year, early and late are sown yearly. The best time for early sowing is mid of

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March. The late harvest is sown in July. In slop okra is grown in April – July (More *et al.*, 2017). The area under okra has increased from 14,601 acres in 2016 to 14658 acres in 2017 in Punjab due to good economic return to the growers while production has increased from 67,058 tons in 2016 to 68,056 tons in 2017 in Punjab due to favorable environmental conditions (Anonymou, 2016-2017).

Okra is also beneficent in medical industry such as Mucilage which is present in okra, is used for washing away toxic substances and bad cholesterol. It's used for the remedy of ulcer and healthiness of joints (Kumar *et al.,* 2013). Biometrical techniques like Line × tester and diallel are very useful breeding tools (Zafar *et al*., 2020). The choice of parents is the pre-requisite for a successful breeding program. SCA and GCA effects are foundation of a successful breeding programme.

Objectives of research study were;

I)   to evaluate the performance of 8 accessions of Okra and their F_1offsprings for desired characters

ii)   To estimate general combining ability (GCA) and specific combining ability (SCA)

iii) To estimate mid and better parent heterosis

iv) To find out inheritance pattern and heritability in parents and hybrids

MATERIALS AND METHODS

Germplasm Development

A field experiment consisting of eight lines and $15F1_s$ of okra was conducted in the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during crop season of 2018-2019. The germplasm of okra was collected from Plant genetic resource institute NARC, Islamabad. All crosses were made to obtain F_1 seed following Line x tester analysis design. Care was taken to avoid contamination of breeding material during emasculation and pollination.

Experimental Site

This research was conducted at experimental area of Plant Breeding and Genetics Department University of Agriculture Faisalabad.

Soil

The soil of experimental area was loamy having good drainage and uniform texture.

Experimental Material

The experimental material used in this research work comprised of 8 parents and 15 F_1 crosses.

Observations

Thirteen yield and nutrition related traits of okra were recorded.

1. Plant height (inches)
2. Internodal distance (inches)
3. Fruit length (cm)
4. Fruits per plant
5. Leaves per plant
6. Ridges per fruit
7. Fruit diameter (cm)
8. Stem diameter (cm)
9. Fruit weight (g)
10. Protein content (%)

Table 1: Detail of genotypes used in this study

Sr. No	Genotypes (parents)
1	Clean Strawless
2	Sanura
3	Okra Malka
4	Sabz Pari
5	0019221
6	Perbhanikaranti
7	Ikra-03
8	Karishna

Sr. No	Genotypes (F₁ Crosses)
1	Clean strawlessx IKRA-03
2	Sanurax IKRA-03
3	Okra Malka x IKRA-03
4	0019221 x IKRA-03
5	Karishna x IKRA-03
6	Clean strawless x Perbhani selection
7	Sanura x Perbhani selection
8	Okra MalkaxPerbhani selection
9	0019221 x Perbhani selection
10	Karishnax Perbhani selection
11	Clean strawlessxSabz Pari
12	Okra Malka x Sabz Pari
13	Sanura x Sabz Pari
14	0019221 x Sabz Pari
15	Krishna x Sabz Pari

The quality of a fruit can be determined through its protein percentage. The percentage of protein was provided by the equation:

$$P / T \times 100$$

Where,

"P" is the number of calories that come from protein & "T" is the total number of calories in the food.

11. Fiber content (%)

The amount of dietary fiber was determined using NIR.

12. Ash content (%)

Ash content of okra genotypes were determined using NIR (Near infrared refractometer).

13. Ascorbic acid (mg/g)

Ascorbic acid or vitamin C content of okra was determined by using Lime juice vitamin C content determination method.

Statistical analysis

Data from experiment were subjected to analysis of variance by using the approach proposed by Steel *et al.* (1997) to see genotypic differences. Traits that showed significant differences were further analyzed through for estimation of combining ability effects by Kempthorne (1957).

RESULTS AND DISCUSSION

Plant Height

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for plant height (Table 2). Among lines Krishna showed positive and highly significant GCA value (24.67) that showed it is a poor general combiner followed by Okra Malka which has GCA value (11.78), whereas Clean straw less has negative and highly significant (-11.89**) so it is a good general combiner for plant height followed by Sanura which has negative and significant GCA value (-13.11). In the testers

Table 2: ANOVA for yield related traits of maize genotypes and their crosses

SOV	Df	PH	NOL	FL	ID	SD	NOF	FD	Pub	PC	AC	AA	FC	NOR
Replication	2	1.63	4.84	0.07	0.12	0.00	0.13	0.01	0.01	0.01	0.02	0.00	0.00	0.00
Genotype	22	955.25	77.71	7.70	3.14	0.16	38.50	0.17	0.69	20.85	5.55	0.03	0.81	0.07
Cross	14	925.05	100.17	7.74	3.43	0.21	37.90	0.14	0.59	27.92	6.98	0.05	0.95	0.10
Line (C)	4	2702.61	140.69	7.48	2.49	0.65	25.19	0.12	1.02	96.98	19.57	0.06	2.52	0.20
Tester (C)	2	293.07	261.49	19.95	0.70	0.03	0.20	0.05	0.82	0.37	1.65	0.06	0.10	0.07
Line × Tester (C)	8	194.26	39.57	4.81	4.58	0.03	53.67	0.16	0.32	0.27	2.02	0.35	0.37	0.07
Parent	7	891.71	17.51	8.72	2.27	0.10	23.50	0.13	0.64	7.36	3.19	0.00	0.13	0.00
Line (P)	4	1196.67	13.56	4.13	2.50	0.12	18.93	0.18	0.60	8.59	3.71	0.00	0.08	0.00
Tester (P)	2	488.44	19.44	19.26	2.81	0.10	2.33	0.01	1.00	6.84	0.73	0.01	0.14	0.00
Line × Tester (P)	1	478.40	29.47	5.98	0.29	0.00	84.10	0.14	0.10	3.84	6.01	0.00	0.29	0.00
Cross vs Parent	1	1822.85	184.80	0.15	5.16	0.00	152.04	1.05	2.44	16.25	1.89	0.01	3.65	0.07
Error	44	2.82	0.87	0.68	0.04	0.00	1.33	0.02	0.04	0.04	0.02	0.00	0.02	0.03

Table 3: GCA for yield related traits of maize genotypes

Parents

Lines	PH	NOL	FL	ID	SD	NOF	FD	Pub	PC	AC	AA	FC	NOR
Clean strawless	-13.89**	-3.76**	-.86**	0.54**	-0.06**	-2.76**	0.04ns	0.36**	-.47**	-1.16**	-0.01ns	-0.30**	-0.07ns
Sanura	-13.11**	-1.09**	-0.75**	0.0ns	-0.12**	0.36ns	0.14**	0.36**	-0.36**	-0.28**	0.13**	-0.24**	0.27**
Okra Malka	11.78**	6.58**	1.01**	0.47**	-0.16**	1.13**	-.11**	-.31**	4.91**	1.96**	-0.10**	0.86**	-0.07ns
19221	-9.44**	-1.98**	0.94**	-0.72**	-0.13**	1.47**	-0.13**	-0.09**	0.23**	1.03**	-0.01ns	0.13**	-0.07ns
Krishna	24.67**	.24 ns	-0.33**	-0.29**	0.48**	-0.20ns	0.07ns	-0.31	-4.31	-1.54	-0.01ns	-0.46	-0.07ns
Testers													
Sabzpari	-5.078**	-3.68*	-1.22*	0.23*	0.01ns	-0.07ns	-0.05ns	0.22	-0.06ns	0.38*	-0.03*	0.08ns	-0.07ns
Perbhani selection	1.96**	-.91**	0.14**	-0.19**	0.04**	-0.07ns	0.07ns	-0.24	-0.12*	-0.23**	-0.04**	-0.08**	-0.07ns
Ikra-03	3.07*	4.56**	1.08**	-0.04	-0.05	0.13ns	-0.02ns	0.02ns	0.18**	-0.15**	0.08**	0.01ns	0.07ns

Experimental Conditions during crop season 2019.
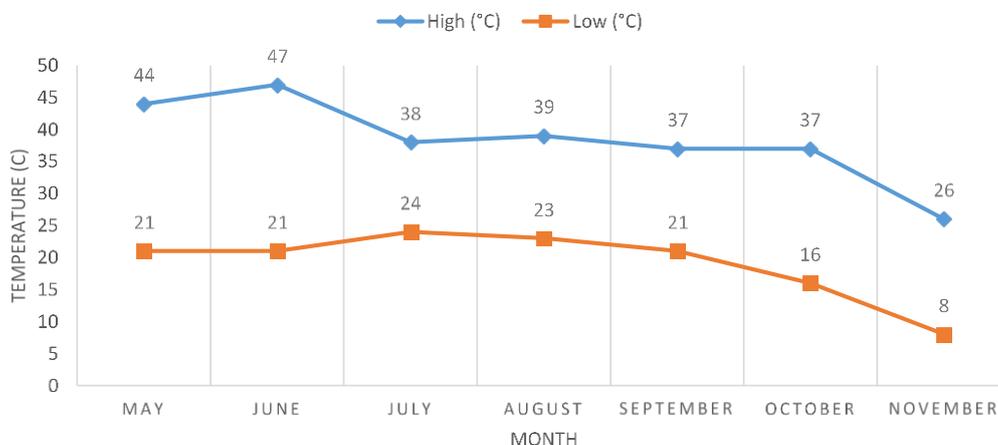
Fig. 1: Temperature during crop season 2019

IKRA-03 has highly significant GCA value (3.07) followed by Perbhani selection which has GCA value (1.96) and Sabz Pari showed negative and highly significant GCA value (-5.078) which indicated that it is a good general combiner for plant height (Table 3).

Crosses Clean strawless× IKRA-03, OKRA MALKA × IKRA-03,0019221 X PERBHANI Selection and KRISHNA × IKRA-03 indicated positive and Highly significant specific combining ability values (3.90), (3.58), (2.79) and (3.86) respectively so they are poor specific combiners for plant height, whereas cross Clean strawless × sabz pari, Sanura x sabz pari and Okra malka × sabz pari revealed negative and highly significant specific combining ability values (-6.35), (-2.04) and (-2.43) respectively which revealed that these combinations are good specific combiner for plant height (Table 4).

Sanura × Perbhani selection showed negative and highly significant value (-14.43) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-21.10) for better parent heterosis it means F₁ will also showed good performance from better parent from Sanura and Perbhani selection. Whereas Okra Malka × sabz pari showed highly significant and positive value for mid parent heterosis and better parent heteorsis (64.45) and (56.31) respectively it means hybrid from these two parents is not desirable for plant height (Table 5).

GCA and SCA effects were estimated which revealed that Varsha upher, Hisarunnat, N0-315 and Kahi pragati were found good general combiner for most of the traits. Varsha was found good general combiner for fruit weight and plant height. Hisar unnat was also found good general combiner for plant height (Raju *et al.*, 2017).

Number of leaves

Among lines Okra Malka showed positive and highly significant GCA value (6.58) that showed it is a poor

Table 4: SCA of crosses for yield related traits of maize

Cross	PH	NOL	FL	ID	SD	NOF	FD	Pub	PC	AC	AA	FC	NOR
Clean strawless × Ikra-03	3.90**	3.09**	1.38**	2.24**	0.11**	0.96ns	0.38**	-0.22ns	0.03ns	0.22**	0.07**	-0.03ns	-0.07ns
Clean strawless x Perbhani selection	0.63ns	0.02ns	-2.34**	-0.83**	-0.04**	-1.71**	-0.35**	-0.24ns	0.25ns	0.12ns	-0.02ns	0.10ns	0.0ns
Clean strawless × Sabz pari	-6.35**	-3.11**	0.96**	-1.42**	-0.06**	0.76ns	-0.03ns	-0.02ns	-0.28*	0.10**	-0.05*	-0.06ns	0.07ns
Sanura × Ikra-03	1.82ns	-1.24**	-0.06ns	-1.32**	-0.03**	-4.16**	0.06ns	0.22ns	0.15ns	1.66**	-0.10**	0.23**	0.27*
Sanura × Perbhani selection	-2.04*	-1.64*	-0.42*	0.67*	-0.05*	-2.16*	0.03ns	0.24ns	0.07ns	-0.79*	-0.11**	0.10ns	0.0ns
Sanura× Sabz pari	-2.66**	2.89**	-1.03**	0.65**	0.08**	6.31**	-0.09ns	0.02ns	-0.22	-0.88**	0.21**	0.14ns	0.07ns
Okra Malka × Ikra-03	3.58**	-4.58**	-0.71**	0.18ns	-.10**	-2.60**	-0.09ns	0.11ns	-0.35**	-0.55**	0.06**	0.20**	0.0ns
Okra Malka×Perbhani selection	1.12ns	0.36ns	0.31**	-0.40**	-0.06**	5.07**	0.01ns	-0.09ns	-0.10ns	0.30**	-0.01ns	-0.06ns	0.07ns
Okra Malka × Sabz pari	-2.43*	4.22**	-0.82**	0.22ns*	0.04**	-2.47**	0.08ns	-0.02ns	0.44**	0.25**	-0.07**	0.14ns	-0.07
Krishna × Ikra-03	-0.76ns	-1.36	0.82**	-1.03**	-0.04**	4.73**	-0.20**	-0.11ns	0.23ns	-0.31**	-0.02ns	0.70**	0
Krishna ×Perbhani selection	3.86**	-.56ns*	-0.01ns	0.56**	0.13**	1.27ns	0.24*	-0.31ns	-0.32*	0.23**	0.06*	-.30**	0.07**
Krishna × Sabzpari	-0.67ns	4.09**	0.52**	0.47**	-0.09**	-3.47**	-0.03ns	0.42**	0.09ns	0.08ns	-0.04**	-0.40**	-0.40**
0019221 × Ikra-03	0.57ns	-0.64ns	0.32**	-0.07ns	0.05**	1.07ns	0.07ns	0.44**	-0.06	-0.58**	-0.02ns	0.24**	0.07**
0019221×Perbhani selection	2.79**	-3,44	0.33*8	-0.01ns	0.08**	0.07ns	0.08ns	-0.09ns	-0.09ns	0.13ns	0.06*	0.05ns	0.00ns
0019221× Sabzpari	-1.09ns	-1.09ns	-0.84**	0.07ns	0.03**	-1.13ns	-1.13ns	-0.36**	-0.03**	0.45ns	-0.04*	0.19*	0.07*

Table 5: Mid-parent heterosis for yield related traits of maize

Cross	PH	NOL	FL	ID	SD	NOF	FD	Pub	PC	AC	AA	FC	NOR
Clean strawless× Ikra-03	10 **	7.69ns	-2.24	59.01**	0.12ns	-7.69ns	27.62**	100**	11.30**	-33.55**	5.26ns	10.98**	0.0ns
Clean strawless x Perbhani selection	-6.74**	-15**	-25.46**	12.27**	-11.56**	-31.91**	-2.72ns	100**	4.25**	-43.63**	-24.32**	13.10**	0.0ns
Clean strawless×Sabz pari	7.50**	9.33**	22.18**	0.36ns	-8.03**	0.0ns	26.02*	00ns	1.86*	-38.02	15.15ns	2.76ns	0.0ns
Sanura × Ikra-03	-14.93**	-6.25ns	-11.35**	-21.76**	-9.54**	9.09ns	31.74**	100**	19.55**	20.00**	2.86ns	4.55ns	13.33**
Sanura × Perbhani selection	-14.43	-6.33**	-6.09ns	25.44**	-12.41**	71.43**	22.09**	100**	9.60**	-44.21**	0.0ns	7.85**	6.67**
Sanura× Sabz pari	-9.65	81.08**	12.76**	25.60**	2.67**	244.83**	4.46ns	0.0ns	9.6	-39.94**	186.67**	13.45**	0.00ns
Okra Malka × Ikra-03	44.78**	40.98**	-13.17**	7.56**	-13.78**	38.89**	17.68**	66.67**	8.47**	21.43**	-12.50ns	9.78**	0.00ns
Okra Malka × Perbhani selection	33.19**	73.68**	-0.91ns	6.58*	-3.66*	209.68**	18.43**	0.0ns	40.59	15.82**	-3.70ns	47.37**	0.00ns
Okra Malka × Sabz pari	64.45**	164.79**	20.81**	19.35**	1.68ns	62.50**	-0.28	-33.33	31.14	25.40**	-16.67*	55.42**	0.00ns
Krishna × Ikra-03	2.46**	-10ns	-6.06ns	-31.62**	-7.26**	152.63**	32.20**	66.67**	3.20**	32.27**	8.57ns	49.72*	0.00ns
Krishna × Perbhani selection	10**	20**	5.79ns	4.03ns	-3.29ns	81.82**	13.76**	0.0ns	-0.19ns	17.99**	29.03**	49.71**	0.00ns
Krishna × Sabzpari	37.09*	54.29**	27.18**	3.29ns	-7.13**	41.18**	-2.65ns	0.0ns	3.76**	27.56**	-16.67*	12.94**	0.00ns
0019221 × Ikra-03	39.77*	31.58**	-1.94ns	12.11**	23.71**	45.45**	14.91**	100**	-30.94**	-34.14**	8.57ns	4.92ns	0.00ns
0019221 × Perbhani selection	20.61*	-3.30ns	-2.22ns	27.97**	12.86**	48.72**	12.74**	0.0ns	-30.43	-38.46	1.16ns	-7.61*	0.00ns
0019221× Sabzpari	30.86**	20,93*	15.78*	30.58*	28.44*	30.00*	30.00*	-33.33*	-29.57*	-22.89**	29.03**	0.0ns	0.0ns

general combiner followed by Krishna which has GCA value (0.24), whereas Clean strawless has negative and highly significant (-3.76) so it is a good general combiner for Number of leaves followed by 0019221 which has negative and significant GCA value (-1.98). In the testers Ikra-03 has highly significant GCA value (4.56) and Sabz pari showed negative and highly significant GCA value (-3.68) which indicated that it is a good general combiner for number of leaves (Table 3).

Crosses 0019221 × Perbhani selection, Sanura × sabz pari and Clean strawless x Ikea-03 indicated positive and Highly significant specific combining ability values (4.22), (4.09) and (3.09) respectively so they are poor specific combiners for Number of leaves, whereas cross Sanura x Perbhani selection , 0019221 × Sabz pari and Okra Malka × Ikra-03 revealed negative and highly significant specific combining ability values (-4.58), (-3.44) and (-3.11) respectively which revealed that these combinations are good specific combiner for Number of leaves (Table 4).

Sanura × Ikra-03 showed negative and highly significant value (-15) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-15) for better parent heterosis it means F_1 will also showed good performance

from better parent from Sanura and Ikra-03. Whereas 0019221 × Perbhani selection showed highly significant and positive value for mid parent heterosis and better parent heteorsis (164.79) and (65) respectively it means hybrid from these two parents is not desirable for number of leaves (Table 5).

Same kind of study was conducted by Reddy *et al.* (2012) to know the combining ability effects and gene action. Results revealed that IC45732, IC89819 and IC89976 were found good general combiner for yield and related traits. Among crosses IC2919 X IC 89976 and IC 89976 X IC111443 were found good general combiner for number of fruits and number of leaves.

Fruit Length

Among lines Okra malka showed positive and highly significant GCA value (1.01) that showed it is a poor general combiner followed by 0019221 which has GCA value (0.94), whereas Clean strawless has negative and highly significant (-0.86) so it is a good general combiner for fruit length followed by Sanura which has negative and significant GCA value (-0.75). In the testers Ikra-03 has highly significant GCA value (1.08) followed by Perbhani selection which has GCA value (0.14) and Sabz pari showed negative and highly significant GCA value (-1.22)
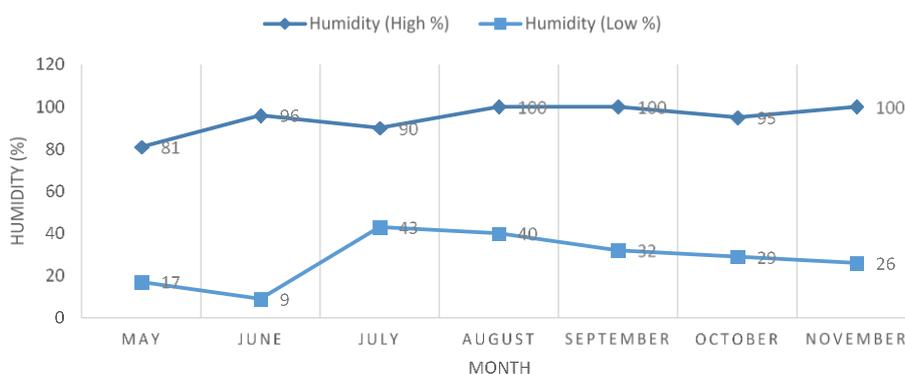
Fig. 2: Humidity during crop season 2019
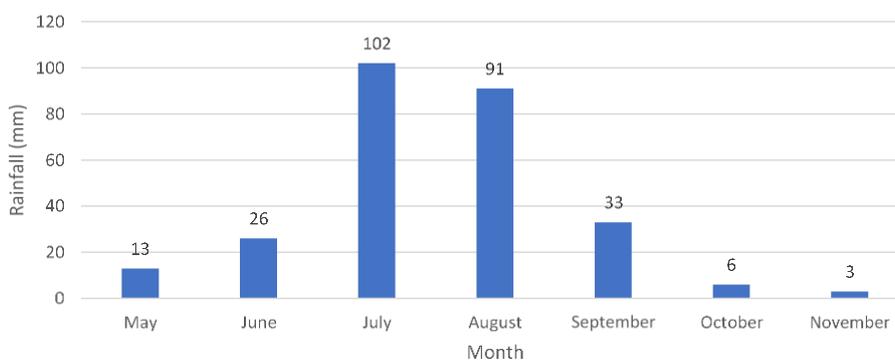
Fig. 3: Average Rainfall during Crop Season 2019

which indicated that it is a good general combiner for Fruit length (Table 3).Clean strawless × Ikra-03 and okra Malka × ikra-03 indicated positive and Highly significant specific combining ability values (1.38) and (0.96) respectively so they are poor specific combiners for fruit length, whereas cross Sanura × Ikra-03, Clean strawless × perbhani selection and 0019221 × perbhani selection revealed negative and highly significant specific combining ability values (-2.34), (-1.03) and (-0.82) respectively which revealed that these combinations are good specific combiner for fruit length (Table 4).

Sanura × Ikra-03 showed negative and highly significant value (-25.46) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-20.55) for better parent heterosis it means F_1 will also showed good performance from better parent from Sanura and Ikra-03. Whereas Okra Malka × Ikra-03 showed highly significant and positive value for mid parent heterosis and better parent heteorsis (22.18) and (8.78) respectively it means hybrid from these two parents is not desirable for fruit length (Table 5,6).

Internodal Distance

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for internodal distance (Table 2). Among lines Clean strawless showed positive and highly significant GCA value (0.54) that showed it is a poor general combiner followed by Okra Malka which has GCA value (0.47), whereas 0019221 has negative and highly significant (-0.72) so it is a good general combiner

for internodal distance followed by Krishna which has negative and significant GCA value (-0.29). In the testers Sabz pari has highly significant GCA value (0.23) and Perbhani selection showed negative and highly significant GCA value (-0.19) which indicated that it is a good general combiner for internodal distance (Table 3).

Crosses Clean strawless × Ikra-03,Krishna × Ikra-03 and Clean strawless × perbhani selection indicated positive and Highly significant specific combining ability values (2.24), (0.67) and (0.65) respectively so they are poor specific combiners for internodal distance, whereas cross Okra Malka × Ikra-03, 0019221 × Ikra-03 and Krishna × perbhani selection revealed negative and highly significant specific combining ability values (-1.42), (-1.32) and (-1.03) respectively which revealed that these combinations are good specific combiner for internodal distance (Table 4).

Krishna × Perbhani selection showed negative and highly significant value (-31.62) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-6.93) for better parent heterosis it means F_1 will also showed good performance from better parent from Krishna and Perbhani selection. Whereas Krishna × sabz pari showed highly significant and positive value for mid parent heterosis and better parent heteorsis (30.58) and (13.53) respectively it means hybrid from these two parents is not desirable for internodal distance (Table 5,6).

Stem Diameter

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, and crosses for stem diameter (Table 2).

Table 6: Better-parent heterosis for yield related traits of maize

Cross	PH	NOL	FL	ID	SD	NOF	FD	Pub	PC	AC	AA	FC	NOR
Clean strawless × Ikra-03	-1.94ns	-12-40**	-4.16**	37.63**	-1.38ns	-33.33	19.31**	100**	4.61**	-34.39**	5.25ns	7.87ns	0.00ns
Clean strawless x Perbhani selection	-9.78**	-15*	-20.55*	11.03*	-13.79**	-55.56**	-10.05**	100**	2.93**	5**	-26.32**	6.74ns	0.00ns
Clean strawless × Sabz pari	-13.95**	2.50ns	8.78ns	-.72ns	-16.82**	-33.33**	0.78ns	0.0ns	-0.38ns	-47.22**	0.0ns	1.09ns	0.00ns
Sanura × Ikra-03	-31.19**	-0.89ns	-13.39**	-28.49**	-12.11**	5.88ns	25.45**	100**	20.50**	-38.22	-5.26ns	0.0ns	13.33**
Sanura × Perbhani selection	-21.10**	-23.08	-0.23ns	16.88**	-18.16**	41.18*	30.78*	100**	2.54**	18.22**	-5.26ns	5.43ns	6.67*
Sanura× Sabz pari	-24.16**	-7.50**	-0.0ns	19.48**	-3.27**	194.12**	19.31**	0.0ns	0.57ns	-47.78**	168.75**	9.78**	0.00ns
Okra Malka × Ikra-03	44.06**	71.79**	7.85**	3.23ns	-19.71	25.00ns	3.61ns	-33.33**	29.98**	-40.13**	-26.32**	44.83**	0.00ns
Okra Malka ×Perbhani selection	14.86**	19.44**	13.63**	-5.26ns	-13.71**	140**	17.24**	-16.67**	31.14**	20.65**	-38.89**	48.28**	0.00ns
Okra Malka × Sabz pari	56.31**	65**	17.32**	8.19**	0.0ns	30*	16.25	-50	34.67**	7.78**	-7.14ns	45.65**	0.00ns
Krishna × Ikra-03	1.96ns	161.1**	-6.93**	-6.93**	-13.54**	188.88**	-3.79ns	0.0ns	3.20**	25.00**	-21.05*	43.96**	0.00ns
Krishna × Perbhani selection	-4.35**	-22.86**	13.86**	-35.486**	-7.22**	36.36**	29.02**	100**	-0.19**	8.50**	5.66**	5.49ns	0.00ns
Krishna × Sabzpari	31.75**	12.50**	14.55**	-6.06**	-8.79**	9.09ns	12.79**	0.0ns	3.76**	-8.89**	17.65ns	4.35ns	0.00ns
0019221 × Ikra-03	14.56**	54.29**	-6.47	-4.85ns	13.21	14.09ns	-12.41**	0.0ns	-30.94**	3.85**	-21.05**	-15**	0.00ns
0019221 × Perbhani selection	12.79**	-1.96ns	1.62ns	-12.90**	7.30**	3.57ns	2.31ns	0.0ns	-30.43	-47.07**	5.56ns	-11**	0.00ns
0019221× Sabzpari	11.39**	-13.73**	0.00ns	13.53**	8.68**	-7.14ns	-1.01ns	50**	-29.57**	-38.46**	42.86**	-4ns	0.00ns

Among lines Okra malka showed positive and highly significant GCA value (1.01) that showed it is a poor general combiner followed by 0019221 which has GCA value (0.94), whereas Clean strawless has negative and highly significant (-0.86) so it is a good general combiner for stem diameter followed by Sanura which has negative and significant GCA value (-0.75). In the testers Ikra-03 has highly significant GCA value (1.08) followed by perbhani selection which has GCA value (0.14) and Sabz pari showed negative and highly significant GCA value (-1.22) which indicated that it is a good general combiner for stem diameter (Table 3).

Crosses Clean strawless × Sabz pari, Clean strawless × Ikra-03 and 0019221× Sabz pari indicated positive and Highly significant specific combining ability values (0.13), (0.11) and (0.08) respectively so they are poor specific combiners for stem diameter, whereas cross Sanura × perbhani selection, Sanura × Sabz pari and Okra malkax Ikra-03 revealed negative and highly significant specific combining ability values (-0.10), (-0.8) and (-0.6) respectively which revealed that these combinations are good specific combiner for stem diameter (Table 4).

Sanura × Perbhani selection showed negative and highly significant value (-13.78) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-19.71) for better parent heterosis it means F_1 will also showed good performance from better parent from Sanura and Perbhani selection. Whereas Krishna × Sabz pari showed highly significant and positive value for mid parent heterosis and better parent heteorsis (28.44) and (8.68) respectively it means hybrid from these two parents is not desirable for stem diameter (Table 5,6). The results of present study are in conformity to the findings of Arti and Sood (2015) and and Kumar and Reddy (2016).

Number of Fruits

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for Number of fruits (Table 2). Among lines 0019221 showed POSITIVE and highly significant GCA value (1.47) that showed it is a poor general combiner followed by Okra malka which has GCA value (1.13), whereas Clean strawless has negative and highly significant (-2.76) so it is a good general combiner for number of fruits followed by Krishna which has negative and significant GCA value (-0.20). In the testers were nonsignificant GCA value (0.13) for stem diameter and sabz pari showed negative and nonsignificant GCA value (-0.07) which indicated that it is a good general combiner for number of fruits (Table 3).

Crosses Clean strawless × Perbhani selection, Okra malka × Perbhani selection and Krishna × Perbhani selection indicated positive and Highly significant specific combining ability values (6.31), (5.07) and (4.73) respectively so they are poor specific combiners for number of fruits, whereas cross 0019221 × Ikra-03, Sanura × Sabz pari and Sanura × Perbhani selection revealed negative and highly significant specific combining ability values (-4.16), (-2.47) and (-2.16) respectively which revealed that these combinations are good specific combiner for number of fruits. (Table 4).

Sanura × Ikra-03 showed negative and highly significant value (-31.91) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-55.56) for better parent heterosis it means F_1 will also showed good performance from better parent from Sanura and Ikra-03. Whereas Clean strawless × Perbhani selection showed highly significant and positive value for mid parent heterosis and better parent heteorsis (244.83) and (194.12) respectively it means hybrid from these two parents is not desirable for plant height (Table 5,6).

Fruit Diameter

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for Fruit diameter (Table 2). Among lines Sanura showed positive and highly significant GCA value (0.14) that showed it is a poor general combiner followed by Krishna which has GCA value (0.07), whereas 0019221 has negative and highly significant (-0.13) so it is a good general combiner for fruit diameter followed by okra malka which has negative and significant GCA value (-0.11). In the testers all have nonsignificant GCA value (0.07) (Table 3).

Crosses Clean strawless × Ikra-03, Krishna x Ikra-03 and Clean strawless × sabz pari selection indicated positive and Highly significant specific combining ability values (0.38), and (0.24) respectively so they are poor specific combiners for fruit diameter, whereas cross Sanura × Ikra-03, 0019221 × Ikra-03 and Krishna x perbhani selection revealed negative and highly significant specific combining ability values (0.35) and (-0.20) respectively which revealed that these combinations are good specific combiner for fruit diameter (Table 4).

0019221 × perbhani selection showed negative and highly significant value (-0.28) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (16.25) for better parent heterosis it means F_1 will also showed good performance from better parent from 0019221 and perbhani selection. Whereas 0019221 × Ikra-03 showed highly significant and positive value for mid parent heterosis and better parent heteorsis (31.74) and (25.45) respectively it means hybrid from these two parents is not desirable for fruit diameter (Table 5,6).

Pubescence

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for pubescence (Table 2).

Among lines Clean strawless showed positive and highly significant GCA value (0.36) that showed it is a poor general combiner followed by Sanura which has GCA value (0.36), whereas Krishna has negative and highly significant (-0.31) so it is a good general combiner for plant height followed by Okra malka which has negative and significant GCA value (-0.31). In the testers Sabz pari has highly significant GCA value (0.22) and Perbhani selection showed negative and highly significant GCA value (-0.24) which indicated that it is a good general combiner for pubescence (Table 3).

Crosses Okra Malka × Sabz pari, Sanura × Sabz pari and Krishna × Ikra-03 indicated positive and Highly significant specific combining ability values (0.44), (0.42) and (0.24) respectively so they are poor specific combiners for pubescence, whereas cross Clean strawless × sabz pari, Krishna × sabz pari revealed negative and highly significant specific combining ability values (-0.36), and (-0.31) respectively which revealed that these combinations are good specific combiner for pubescents (Table 4).

Sanura × perbhani selection showed negative and highly significant value (-33) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-50.00) for better parent heterosis it means F_1 will also showed good performance from better parent from Sanura and Perbhani selection. Whereas Clean strawless × Ikra-03 showed highly significant and positive value for mid parent heterosis and better parent heteorsis (100) and (100) respectively it means hybrid from these two parents is not desirable for pubescence (Table 5,6).

Protein Content

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for protein content (Table 2).

Among lines Okra malka showed positive and highly significant GCA value (4.91) that showed it is a poor general combiner followed by 0019221 which has GCA value (0.23), whereas Krishna has negative and highly significant (-4.31) so it is a good general combiner for plant height followed by Sanura which has negative and significant GCA value (-0.36). In the testers Ikra-03 has highly significant GCA value (0.18) and Perbhani selection showed negative and highly significant GCA value (-0.12) which indicated that it is a good general combiner for protein content (Table 3).

0019221 × perbhani selection indicated positive and Highly significant specific combining ability values (0.44) so they are poor specific combiners for protein content, whereas cross Sanura x perbhani selection, Clean strawless × Sabz pari and okra malka × Ikra-03 revealed negative and highly significant specific combining ability values (-0.38), (-0.32 and (-0.28) respectively which revealed that these combinations are good specific combiner for protein content (Table 4).

Okra malka × Sabz pari showed negative and highly significant value (-30.94) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-30.94) for better

parent heterosis it means F₁ will also showed good performance from better parent from okra malka and Sabz pari. Whereas okra malka × perbhani selection showed highly significant and positive value for mid parent heterosis and better parent heteorsis 40.59) and (31.14) respectively it means hybrid from these two parents is not desirable for protein content (Table 5,6).

Ash Content

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for Ash content (Table 2). Among lines okra malka showed positive and highly significant GCA value (1.96) that showed it is a poor general combiner followed by 0019221 which has GCA value (1.03), whereas Krishna has negative and highly significant (-1.54) so it is a good general combiner for plant height followed by Clean strawless which has negative and significant GCA value (-1.16). In the testers Sabz pari has highly significant GCA value (0.38) and perbhani selection showed negative and highly significant GCA value (-0.23) which indicated that it is a good general combiner for Ash content (Table 3).

Crosses Sanura ×Ikra-03, okra malka × perbhani selection and okra malka × sabz pari indicated positive and Highly significant specific combining ability values (1.66), (0.30) and (0.23) respectively so they are poor specific combiners for Ash content, whereas cross Sanura × perbhani selection, Sanura × sabz pari and 0019221 × ikra-03 revealed negative and highly significant specific combining ability values (-0.88), (-0.79) and (-0.58) respectively which revealed that these combinations are good specific combiner for ash content (Table 4).

Krishna × Ikra-03 showed negative and highly significant value (-44.21) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (18.22) for better parent heterosis it means F₁ will also showed good performance from better parent from Krishna and Ikra-03. Whereas Krishna × perbhani selection showed highly significant and positive value for mid parent heterosis and better parent heteorsis (32.27) and (25.00) respectively it means hybrid from these two parents is not desirable for ash content (Table 5,6).

Ascorbic Acid

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for Ascorbic acid (Table 2). Among lines Sanura showed positive and highly significant GCA value (0.13) that showed it is a poor general combiner whereas Okra Malka has negative and highly significant (-0.10) so it is a good general combiner for ascorbic acid. In the testers Ikra-03 has highly significant GCA value (0.08) and perbhani selection showed negative and highly significant GCA value (-0.04) which indicated that it is a good general combiner for ascorbic acid (Table 3).

Crosses Sanura × Sabz pari, Okra Malka × Ikra-03 and 0019221× perbhani selection indicated positive and Highly significant specific combining ability values (0.21), (0.06) and (0.06) respectively so they are poor specific combiners

for ascorbic acid, whereas cross Sanura× perbhani selection, Sanura× Ikra-03 and Okra Malka × sabz pari revealed negative and highly significant specific combining ability values (-0.11), (-0.10) and (-0.06) respectively which revealed that these combinations are good specific combiner for ascorbic acid (Table 4).

Sanura × Ikra-03 showed negative and highly significant value (-24.32) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-26.32) for better parent heterosis it means F₁ will also showed good performance from better parent from Sanura and Ikra-03. Whereas Clean strawless × Perbhani selection showed highly significant and positive value for mid parent heterosis and better parent heteorsis (186.85) and (168.75) respectively it means hybrid from these two parents is not desirable for ascorbic acid (Table 5,6).

Fiber Content

Analysis of variance for line × tester Showed significant differences between genotypes, parents, lines, testers, crosses, and line × tester for fiber content (Table 2). Among lines Okra Malka showed positive and highly significant GCA value (0.86) that showed it is a poor general combiner followed by 0019221 which has GCA value (0.13), whereas Krishna has negative and highly significant (-0.46) so it is a good general combiner for fiber content followed by Sanura which has negative and significant GCA value (-0.24). In the testers sabz pari selection has non-significant GCA value (0.08) followed by ikra-03 which has GCA value (0.01) which indicated that it is a good general combiner for fiber content (table 3).

Crosses Krishna × Ikra-03, 0019221 × Ikra-03 and Sanura× Ikra-03 indicated positive and Highly significant specific combining ability values (0.70), (0.24) and (0.23) respectively so they are poor specific combiners for fiber content, whereas cross Krishna × sabz pari , Krishna × perbhani selection and okra Malka × sabz pari revealed negative and highly significant specific combining ability values (-0.40) and (-0.30) respectively which revealed that these combinations are good specific combiner for fiber content (Table 4).

0019221 × sabz pari showed negative and highly significant value (-7.61) for mid parent heterosis it mean hybrid of both parents will show better results as compare to mean value of parent performance while It also showed negative and highly significant value (-11) for better parent heterosis it means F₁ will also showed good performance from better parent from 0019221 and sabz pari. Whereas 0019221 × perbhani selection showed highly significant and positive value for mid parent heterosis and better parent heteorsis (55.42) and (45.65) respectively it means hybrid from these two parents is not desirable for fiber content (Table 5,6).

Conclusion

Among the lines Clean straw less proved to be a good general combiner for protein content. Sanura proved to be a good general combiner for ascorbic acid and protein content. Okra Malka proved to be a good general combiner for number of fruits, number of leaves. proved to be a good

general combiner for plant height and pubescence. Among the testers perbhani selection proved to be a good general combiner for ascorbic acid, ash content and fibre content. Sabz pari also proved to be a good general combiner for fiber content, plant height, number ridges and number of fruits. Perbhani selection also proved to be a good general combiner for number internodal distance.

Those cross combinations which indicated good specific combining ability are Clean strawless× sabz pari and Sanura × sabz pari for plant height, 0019221 × perbhani selection and Sanura× sabz pari for number of leaves Clean strawless × perbhani selection0019221 × perbhani selection for fruit length. The cross okra malka × Ikra-03 and Krishna × perbhani selection proved to be a good specific combiner for internodal distance the cross Sanura x perbhani selection and Krishna x sabz pari proved to be good general combiner for number of fruits. Selection must be delayed in breeding populations because non additive genes have low heritability. The parents which have good general combining ability for specific traits and the cross combinations with good specific combining ability are supposed to be used in future breeding programs for the improvement of these traits in cotton.

REFERENCES

Arti V and S Sood, 2015. Gene action studies on yield and quality traits in okra (Abelmoschus esculentus (L.) Moench). African Journal of Agricultural Research, 10(43), 4006-4009.

Anonymous, 2016-2017. Pakistan Economic Survey, Economic Adviser's Wing, Finance Devision, Government of Pakistan, Islamabad.

Kempthorne O, 1957. An introduction to genetic statistics. John Wiley and Sons, New York. pp: 408-415.

More SJ, KN Chaudhari, GB Vaidya and SL Chawla, 2017. Estimation of hybrid vigour for fruit yield and quality traits of okra [Abelmoschus esculentus (L.) Moench] through line x tester analysis carried over environments. International Journal Current Microbiology App. Science 6(7), 4101-4111.

Kumar A, P Kumar and R Nadendla, 2013. A review on: Abelmoschus esculentus (Okra). International Research Journal of Pharmaceutical and Applied Sciences, 3(4), 129-132.

Kumar S and MT Reddy, 2016. Correlation and path coefficient analysis for yield and its components in okra (Abelmoschus esculentus (L.) Moench). Advances in Agricultural Science, 4(4), 72-83.

Oyelade OJ, BIO Ade-Omowaye and VF Adeomi, 2003. Influence of variety on protein, fat contents and some physical characteristics of okra seeds. Journal of Food Engineering, 57(2), 111-114.

Pakistan Bureau of Statistics, 2019. Pakistan Statistical Year Book 2019.

Oyetunde OA and OJ Ariyo, 2014. Genetics of seed yield and related traits in biparental crosses of okra, Abelmoschus esculentus (L.) Moench. Nigerian Journal of Genetics, 28(2), 8-14.

Raju CV and A Selvam, 2017. Combining ability studies in bhendi [Abelmoschus esculentus (L.) Moench]. Plant Arch 17(2), 1431-1434.

Reddy MT, K Haribabu, M Ganesh, KC Reddy, H Begum, R Subbararama Krishna Reddy and J Dilip Babu, 2012. Genetic analysis for yield and its components in okra (Abelmoschus esculentus (L.) Moench). Songklanakarin Journal of Science & Technology, 34(2).

Saleem AM, M Amjad, K Ziaf and ST Sahi, 2018. Characterization of okra (Abelmoschus esculentus) genotypes for fruit firmness, other horticultural traits and heritability studies. International Journal Agriculture Biology 20, 345-352.

Savello PA, FW Martin and JM Hill, 1980. Nutritional composition of okra seed meal. Journal of Agricultural and Food Chemistry, 28(6), 1163-1166.

Shivaramegowda KD, A Krishnan, YK Jayaramu, V Kumar and HJ Koh, 2016. Genotypic variation among okra (Abelmoschus esculentus (L.) Moench) germplasms in South India. Plant Breeding and Biotechnology, 4(2), 234-241.

Steel RGD, JH Torrie and DA Dickey, 1997. Principles and procedures of statistics a biometrical approach. 2 Ed. McGraw Hill Book Co. Inc., Singapore, 172-177.

Zafar MM, A Razzaq, MA Farooq, A Rehman, H Firdous, A Shakeel, H Mo, M Ren, M Ashraf and Y Youlu, 2020. Genetic Variation Studies of Ionic and within Boll Yield Components in Cotton (Gossypium Hirsutum L.) Under Salt Stress. Journal of Natural Fibers.1-20.