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RESEARCHARTICLE

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Estimation of Genetic Potential and Mode of Inheritance in F_1 Hybrids of Upland Cotton for Seed Cotton Yield and Fiber Quality Attributes

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Abstract
Cotton is essential fiber and cash crop in Pakistan and known as “King of fiber” due to its worldwide prompting qualities in agricultural and textile sector. Climatic variability along with the advent of new epidemic diseases induced yield loss in last few years. Biotic and abiotic stress considerably reduced the performance and yield potential of cotton. Suitable breeding strategies are essential to generate useful genetic variations and to identify desired traits. Genetic variability is beneficial tool for the plant researchers to exploit and produce advanced genetic hybrids for high yield and better quality. Hence this research experiment was conducted to investigate the genetic inheritance pattern of morphological and phenological parameters of earliness and seed cotton yield related traits in upland cotton at university of agriculture Faisalabad. A complete diallel cross pattern was used to evaluate the five parental lines along with their all F1 crosses in an experimental field under randomize complete block design (RCBD) with two replications. Statistical analysis showed significant variation among all the evaluated parameters. Mean square estimate of GCA exhibited significant difference in almost all the traits except plant height, internodal distance, seed index, node number of first sympodial branch and total number of bolls picked, whereas SCA mean square was found significant in plant height, earliness index, GOT% and seed cotton yield. However combining ability analysis manifested that SCA variance was higher for plant height, seed cotton yield, earliness index, days to first flowering, GOT% which indicated the preponderance of non-additive gene action. Whereas GCA variance was higher for total number of nodes, boll maturation period and number of sympodial branches per plant which showed the prevalence of additive type of gene action. The parent KZ-189 was reported as prominent general combiner for seed cotton yield, parent C-26 for boll maturation period and Kehkshan for GOT% and many other earliness parameters. However specific cross combinations C-26×FH-313 was found prominent specific combiner for boll weight and seed cotton yield.

KEYWORDS
Earliness index, Inheritance pattern, Seed cotton yield, Genetic variability.

1 | INTRODUCTION

Cotton is imperative cash and fiber crop of Pakistan hence known as “King of fiber” due to its worldwide prompting qualities in agricultural and textile sector. Cotton is regarded as the key pillar of economy because it holds a large portion of Pakistan agricultural exports (Ali et al. 2019). Moreover it imparts fiber for textile sector, cellulose contents from its lint and ample amount of protein and oil form its seeds(Kumar et al. 2014). It shares about 1.4 percent in agriculture value addition and 0.3 percent in the GDP. During 2022-23, floods affected the large area of crop in Sindh and Balochistan hence the overall production decreased 4.910 million bales as compare the previous year 8.329 million bales. This crop faced decline in its productivity due to number of biotic (white fly and pinkballworm) and abiotic factors (heat and rainfall). Moreover, cotton crop has to combat a lot of different challenges such as competing with different crops especially sugarcane and world wide fluctuations in cotton price (GOP, 2021-22).

Overall duration of cotton’s vegetative growth lies between 135-150 days. Development of early maturing and high yield varieties are the main stream focus of all the cotton breeders now days, as these cultivars managed to escape from all the sudden adverse biotic and abiotic catastrophes. Such early maturing cultivars demands less quantity of fertilizer, water and other essentials moreover it also helps the farmers to increase the wheat production by facilitating the ideal time and environmental conditions for wheat sowing (Zafar et al. 2022) and (Solongi et al. 2019).

Early maturing cotton cultivars are considered to have the following earliness indicators such as decreased node number of first sympodial branch and first effective ball, short flowering period, short ball maturation period i.e. 120-150 days after seed sowing (Ramdan, 2021). By acquiring early node number of first fruiting branch one can get early yield of cotton by 4-7 days, moreover days to first flower is very curial attribute which helps the breeder to distinguish the early maturing cultivars(Rani et al. 2020), (Rehman et al. 2020). By cumulating the data of above attributes in tabulated form will provide insight and valuable information regarding the early production of cotton crop (Giri et al. 2020a), (Soomro et al. 2021).

Cotton crop is mainly cultivated in kharif season in Pakistan and it is a member of genus Gossypium of Malvaceae which comprised of almost 45 diploid species and 5 tetrapoloid species. Among all these species only four varieties were cultivated globally and classified as Old World diploid species (G. arboreum L. and G. herbaceum L) and New World allotetrapoloid species (G. hirsutum and G. barbadense). Cotton is not only famous for its fiber but it is second important crop regarding its edible oil seed production in tropical and subtropical areas of the world (Ali et al. 2016). As wheat and cotton are sown in rotated pattern hence delay in the sowing of wheat ultimately causes late maturity and poor yield production of all fiber related attributes of cotton (Shavkiev et al. 2021).

Knowledge of complex gene actions and transmission of favorable genes from parents to their offspring is essential for plant breeders because it facilitate the selection of best cross combinations (Zhang et al. 2017).Combining ability is very efficient analytical tool which is used in hybridization program and it provide information regarding nature and magnitude of different kinds of genes contribute in the expression of quantitative traits. Combining ability term mainly deal with two concepts, general combining ability (GCA) and specific combing ability (SCA) however sometimes it also gave some value insight through maternal effects (Fasahat et al. 2016). This analysis also assures the accumulation of advantageous fixable and non-fixable genetic effects (Chikuta et al. 2017).

The performance and adaptability of high yielding hybrid cultivars can be estimated through their specific combining ability. However on the basis GCA estimates best parental cross combination can be selected for development of high yield cultivars. Diallel crossing technique is most frequently used biometrical analysis by plant researchers to identify the gene action that either it is additive or dominant, of various quantitative traits which contribute indirect or directly in the seed cotton yield (Griffing, 1956). Current investigation was carried out to get valuable information about the genetic attributes of earliness regarding traits, seed cotton yield and fiber quality parameters via 5x5 complete diallel analysis.

2 MATERIALS AND METHODS

Collection of Breeding Material, Crossing, Sowing in the Experimental Area

The current investigation was carried out to estimate the combining ability and gene action for several earliness parameters, fiber quality traits, yield and its related components in Gossypium hirsutum L. genotypes. This research study comprised of five distinct genotypes namely CRS-2007, KZ-189, C-26, Kehkashan and FH-313 issued by Cotton Research Division of Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad. These five experimental genotypes were grown in glass house under controlled temperature, light and humidity for appropriate germination of seedlings in earthen pots. The five parental lines crossed in all possible combinations with complete diallel mating design generated five self, ten direct, ten reciprocal crosses. All the necessary safety measures were applied to avoid the contamination and irregularities of the breeding germplasm. (1)Flowers were selected one day before its opening for their emasculation(2)In evening, candle shaped buds were emasculated and protected with soda tube and the next morning these emasculated buds were pollinated with the pollens of competent and desired parent and again covered after pollination. (3) Female part was kept safe during emasculation process. Many crosses were made in order to develop sufficient number of F0 hybrid seeds. Some buds of the parental varieties were retained without being pollinated to produce self-seed. During kharif season 2020-2021, the F0 seeds of five parental genotypes along with 20 cross combinations were grown with two replications under randomized complete block design (RCBD) in an experimental area. The parental seeds and their combinations were planted in a row comprised of ten plants and maintained with 30cm plant to plant distance and 75 cm row to row distance. Thinning was done after two weeks of sowing. All agronomic exercises from sowing to harvesting were performed on timely basis. At maturity, data of earliness, yield and fiber quality traits were recorded and cotton from the successful crosses was picked and ginned to collect the seeds.

Experimental Material

Genetic material was comprised of 5 above mentioned parents and their 20 direct and indirect hybrids CRS-2007x KZ-189, CRS-2007×C-26, CRS-2007×Kehkshan,CRS-2007×FH-313, KZ-189×C-26, KZ-189×Kehkshan, KZ-189×FH-313, C-26×Kehkshan, C-26×FH-313, Kehkshan×FH-313, indirect crosses KZ-189×CRS-2007,C-26×CRS-2007, C-26×KZ-189, Kehkshan×CRS-2007, Kehkshan×KZ-189, Kehkshan× C-26, FH-313×CRS-2007, FH-313×KZ-189, FH-313×C-26, FH-313×Kehkshan. For the collection of data ,10 tagged plants of each genotype from both the replication were selected and data was recorded for earliness, yield regarding traits and fiber quality attributes viz plant height (PH), number of sympodial branches per plant (NSB), seed cotton yield (SCY), boll maturation period (BMP), days to first ball open (DFBO), Days to first flowering (DFF), earliness index (E.I), ginning out turn (GOT), lint index (L.I), lint weight (L.W), seed index (S.I), node number of first sympodial branch (NNFSB), node number of first effective ball (NNFEB), total number of nodes (TNN), total ball picked (TBP), boll weight (BW), internodal distance (IND), fiber length (FL), fiber strength (FS), fiber uniformity (FU) and fiber fineness (FF) in upland.

Statistical Analysis

The genetic variability of 5 parents and their 20 F1 hybrids were analyzed by utilizing the mean values of above-mentioned parameters in two replications as proposed by Steel and Torrie (1997). Combining ability analysis of above-mentioned parameters was conducted by using the (Griffing 1956) combining ability techniques. The estimate of GCA and SCA ratio provide information that whether that particular parameter governed by additive or non-additive gene action which was measured by calculating the mean square values of GCA and SCA (Elhousary, 2023). Moreover, the graphical representation of mean performance of parents and hybrids depicted that which parent and hybrid could be used as best general and specific combiner respectively in upcoming breeding programs.

3 RESULTS

Analysis of Variance

Collected data of all the experimental genotypes was subjected to analysis of variance which exhibited considerable variation as depicted in the Table 1 for plant height, no of sympodial branches, seed cotton yield, boll maturation period, earliness index, days to first flowering, days to first ball open, Ginning out turn, lint index, lint weight, seed index, node number of first sympodial branch, node number of first effective boll, total number of nodes, total boll picked, boll weight, internodal distance fiber length, fiber strength, fiber uniformity and fiber fineness. However, number of seeds per boll and number of monopodial branches per plant manifested non-significant variability due to the implication of environmental effects hence restricted for further analysis.

Table 1: Mean squares of All Earliness, Yield and Fiber Regarding Parameters of Upland Cotton

SOV	Replication	Genotypes	Error
D.f	1	24	24
PH	219.03 ns	130.68*	55.33
NSB	4.703 ns	4.47*	2.2
SCY	27.23 ns	379.12*	173.42
BMP	4.99 ns	25.38*	11.97
DFBO	8.49 ns	18.99*	8.8
DFF	26.50 ns	23.41*	10.77
E.I	790.85 ns	471.90*	199.31
GOT	2.48 ns	47.92*	23.69
L.I	3.14 ns	2.180*	1.001
L.W	3.43 ns	38.68*	15.9
S.I	0.01 ns	0.17*	0.07
NNFSB	0.01 ns	3.02*	1.28
NNFEB	0.89 ns	4.17*	1.94
TNN	15.31 ns	23.44*	10.63
TBP	63.39 ns	35.81*	16.81
BW	0.24ns	0.20*	0.07
IND	0.36 ns	0.26*	0.11
FL	1.96 ns	3.81*	1.76
FS	14.47ns	21.28*	8.66
FU	0.27 ns	2.27*	0.93
FF	0.70ns	0.56*	0.22
NMB	0.37ns	0.14ns	0.53
NSPB	242.73 ns	246.90 ns	309.19

Combining Ability Analysis
General Combining Ability

For the estimation of genetic variability, above mentioned significant parameters were subjected to Griffing 1956 combining ability analysis utilizing its Method II, model II. Combining ability estimates revealed that mean square estimates for GCA was significant in almost all the characters excluding plant height, internodal distance, lint weight, seed index, node number of first sympodial branch and total number of bolls picked as demonstrated in Table 2.

Specific Combining Ability

SCA mean square was found significant for plant height, earliness index, lint weight, seed cotton yield and all fiber quality traits as demonstrated in Table 2.

Table 2: Genetic Analysis of All Earliness, Yield and Fiber Regarding Parameters of Upland Cotton

SOV	MS GCA	MS SCA	GCA σ 2	SCA σ 2	GCA σ 2/SCA σ 2	VA	VD	VA/VD
PH	16.97 ns	74.86*	-1.05	47.2	-0.02	-2.11	47.2	-0.04
NSB	3.57*	1.22 ns	0.25	0.13	1.96	0.49	0.13	3.92
SCY	330.74*	234.02*	24.4	147.31	0.16	48.8	147.31	0.33
BMP	33.22*	5.91 ns	2.72	-0.08	-35.05	5.45	-0.08	-70.1
DFBO	12.48*	9.33*	0.81	4.93	0.16	1.62	4.93	0.33
DFF	42.41*	1.13 ns	3.7	-4.25	-0.87	7.4	-4.25	-1.74
E.I	355.81*	228.03*	25.62	128.38	0.2	51.23	128.38	0.4
GOT	52.79*	25.07 ns	4.09	13.22	0.31	8.19	13.22	0.62
L.I	2.19*	1.09 ns	0.17	0.59	0.29	0.33	0.59	0.57
L.W	9.79 ns	28.66*	0.18	20.71	0.01	0.37	20.71	0.02
S.I	0.08 ns	0.11*	0.004	0.07	0.06	0.009	0.07	0.13
NNFSB	0.91 ns	0.91 ns	0.03	0.27	0.1	0.05	0.27	0.2
NNFEB	2.88*	0.93 ns	0.19	-0.04	-4.36	0.38	-0.04	0.34
TNN	30.02*	6.32 ns	2.5	1.29	1.94	4.1	1.29	3.89
TBP	20.21 ns	20.51*	1.18	12.11	0.1	2.36	12.11	0.19
BW	0.13*	0.07 ns	0.009	0.03	0.27	0.019	0.03	0.55
IND	0.04 ns	0.15*	-0.0021	0.09	-0.02	-0.004	0.09	-0.05
FL	3.50*	2.16*	0.26	1.28	0.2	0.52	1.28	0.41
FS	22.84*	11.56*	1.85	7.24	0.26	3.7	7.24	0.51
FU	1.47*	0.99 ns	0.1004	0.52	0.19	0.2	0.52	0.39

Genetic Parameters

Genetic variance for SCA was higher in magnitude than the GCA for almost all the traits like PH(47.20), SCY (147.31), DFBO(4.93), E.I (128.38), GOT% (13.22), L.I(0.59), L.W (20.71), S.I(0.07), NNFSB (0.27),TBP (12.11), BW (0.034), IntD (0.09), F.L (1.28), F.S (7.24), F.U (0.52), F.F (0.18) as mentioned in the Table 2. Whereas GCA variance was higher for TNN (2.50), NNFEB (0.19), BMP (2.72), DFF (3.70), NSB (0.25). Moreover, the value of GCA and SCA variance is lower than unity for plant height, seed cotton yield, days to first ball open, days to first flowering, earliness index, GOT%, lint index, lint weight, seed index, node number of first sympodial branch, total ball picked, ball weight, internodal distance, fiber length, fiber strength, fiber uniformity and fiber fineness.

Mean Performance

Parent Kehkshan showed favorable values of mean performance for DFBO (92.3), DFF (53.1), NNFSB (7.3), S.I (6.7), L.I (6.0) and NNFEB (8.3), parent KZ-189 showed higher mean performance for SCY (58.3), BMP (37.4) and PH (98.3) and parent FH-313 showed good mean performance of SCY(53.3), NNFEB(6.7), F.S (24.9), TBP (33.2) . Specific cross combination Kehkshan×CRS-2007 and its reciprocal cross exhibited good mean performance for different earliness characters such as PH (98.4), DFF (59.2), S.I (6.7), NNFSB (6.8), NNFEB (7.2) and GOT% (54.1) whereas C-26×KZ-189 displayed preferable values of mean performance for SCY (79.9), BMP (32.4), BW (3.0) TNN (32.2) and FU (83.8) as depicted in Table 3.

Genetic Effects

General Combining Ability Effects

Table 4 proposed that parent CRS-2007 was found with positive and higher GCA effects for fiber length FL (0.75), total number of nodes TNN (2.38), and node number of first effective boll NNFB (0.73). The parent KZ-189 was reported as prominent general combiner for seed cotton yield SCY (8.35) total number of bolls picked TNBP (1.82) and fiber uniformity (0.55. Kehkshan showed highly significant and positive results for GOT% (3.08), earliness index E.I (8.01) and lint index L.I (0.54) however, it showed highly significant GCA effect but with negative values for days to first flowering DFF (-2.30), days to first boll open DFBO (-1.71), node number of first sympodial branch NNFSB (-0.36). Parent C-26 was found predominant for fiber strength FS (2.11) and fiber uniformity FU (-0.42) and lowering boll maturation period BMP (-2.98)

Specific Combining Ability Effects

However cross combination C-26×FH-313 was found good specifically for and seed cotton yield SCY (12.26), boll maturation period BMP (-2.93), days to first boll open DFBO (-3.63), lint weight LW (4.51), fiber fineness FF (0.6400) and seed index SI (0.3233). CRS-2007×Kehkshan for boll weight (0.36), seed index (0.36), lint index (1.46) and GOT% (4.97) whereas C-26×Kehkshan for fiber length FL (1.21) (Table 4).

Table 3: Mean Performance of All the Earliness, Yield and Fiber Regarding Parameters of Upland Cotton

Parents	PH	NSB	SCY	BMP	DFBO	DFF	EI	GOT	L.I	L.W	SI	NNFSB	NNFEB	TNN	TBP	BW	IND	FL	FS	FU	FF
CRS-2007	100.7	16.7	42.6	40.5	96.4	55.9	47.5	44.1	4.7	19.85	6.3	10.5	12.8	38.3	18	2.2	2.6	26.6	19.9	82.9	5.3
KZ-189	98.3	14.8	58.3	37.4	99	61.6	39.7	32.2	3.3	18	6.7	8	8.2	32	23.1	2.4	3.1	24.4	28	84.4	5.4
C-26	99.5	14	28.5	33.1	98.6	65.5	39.7	47.7	4.8	12.3	6.3	9.7	9.5	30.3	25.9	2.6	3.3	20.6	34.7	82.1	6.2
Kehkshan	115.5	16.3	22.6	39.2	92.3	53.1	62.8	46.7	6	11.4	6.3	7.3	8.3	25.3	12.7	1.9	3.4	26.3	22.5	83.1	5.6
FH-313	99.4	17.2	53.3	42.3	98.6	56.3	44.5	40.8	4.6	21.7	6.7	8.8	9.8	33.2	19.4	2.5	3.6	24.9	25.7	84	4.15
CRS-2007×KZ-189	113.6	16.7	55.5	36.6	95.1	58.5	53.9	44.4	4.8	22.5	6.3	10.5	10.3	32.8	23.2	2.3	3.3	24.7	20.9	82.9	5.4
CRS-2007×C-26	94	16.3	55.7	37.3	94.3	57	50.5	44.9	4.8	23.6	6.5	9.5	12.3	33.3	26.8	2.2	3.3	24.7	22.7	82.4	5.1
CRS-2007×Kehkshan	96.9	17	49.6	41.45	91.5	50	45.2	53.3	7.8	23.3	7	11.5	11.8	33.5	22.7	2.5	3	24.3	23.4	81.7	5.2
CRS-2007×FH-313	87.4	17.2	44.3	43.4	100.6	57.2	54.5	45.9	5.9	18.8	6.7	8.7	8.7	32.5	23.05	2.3	3.6	25.5	25.7	83.9	4.6
KZ-189×C-26	98	18.8	62.3	37.8	96	58.2	60.6	42.9	4.5	22.9	6.8	8.5	8.27	28.7	25.6	2.6	3.3	23.2	26.7	83.6	5.6
KZ-189×Kehkshan	84.7	14.8	67.6	36.4	93	56.6	65.2	44.9	4.8	25.4	6.3	9.8	9.8	27	27.1	2.4	3.3	24.7	19.9	83.3	5.8
KZ-189×FH-313	101.9	18.2	44.5	36.5	93.5	57.1	78	51.5	5.7	19.4	6.2	11	11.3	30	17.1	2.4	3.6	25.2	24.3	82	5.4
C-26×Kehkshan	98.6	13	54.6	32.5	94.1	61.4	57.8	43.4	4.4	19.3	6.5	9.7	10	27.3	20.9	2.5	3.6	23.8	23.5	82.8	6.4
C-26×FH-313	98.259	14.5	67.3	34.1	93.6	59.5	46.3	43.1	5.6	28.9	7.3	9.8	10.8	26.7	24.9	2.9	3.6	23	22.1	80.8	6.3
Kehkshan×FH-313	97.9	15.7	49.4	34.5	92.2	57.6	78.6	50.9	4.9	21.8	6.8	8.8	10	27.3	20.3	2.7	2.7	24.8	26.1	84.5	5.3
KZ-189×CRS-2007	83.1	15.2	77.4	40.3	99.8	59.5	58.2	36.9	3.4	26.7	6.5	9.2	8.7	34.2	32.6	2.3	2.9	25.7	27.6	83.3	4.7
C-26×CRS-2007	105	15	41.3	32.8	93.9	61.1	77.6	46.4	4.6	17.4	6.3	6.9	8.2	26.8	17.1	2.2	3.6	24.8	23.4	81.2	5.3
C-26× KZ-189	94.5	13.8	79.9	32.4	98.1	65.7	27.5	43.4	4.8	27.6	6.7	7.5	8.8	32.2	24.3	3	3.6	24.8	28.3	83.8	4.9
Kehkshan×CRS2007	98.4	17	29.3	36.8	96	59.2	72.5	54.1	6.8	18.8	6.7	6.8	7.2	25	17.9	2.6	3.9	22.5	22.1	83.3	5.6
Kehkshan×KZ-189	99.9	15	51.7	36.1	92.5	56.4	71.7	44.2	3.3	18.2	6	7.7	7.5	26.8	19.3	1.5	3.6	23	22	83.1	5.9
Kehkshan×C-26	85.7	14.5	58	35	91.2	56.2	76	51.9	6.7	27.8	6.7	8.8	9.2	26.8	23.1	2.3	3.3	25.6	21.3	82.2	5.3
FH-313×CRS-2007	82.7	16.3	49.4	35.9	92.2	56.2	73.7	42.2	5	20.7	6.8	10	10.5	25.8	24.2	2.4	3.9	26.2	22.5	80.6	5.2
FH-313×KZ-189	101.2	16	42.4	34.4	93	58.6	74.6	44.7	5.4	20.6	6.7	8.3	9.3	27.3	20.7	2.2	2.5	24.9	22.6	81.9	5.8
FH-313×C-26	93.2	18.3	59.6	28.6	88.1	59.5	68.4	40.6	4.7	24	6.8	8.7	9.3	30.5	24.4	2.3	2.8	24.3	24.5	81.9	6.1
FH-313×Kehkshan	99.8	17.3	30.2	41.4	95.6	54.3	87.6	45.3	5.7	16.8	6.3	8.5	9.3	28.3	20.5	1.8	3.2	22.4	21.7	82.2	5.4

Table 4: Mean Performance, General and Specific Combining Effects of All the Earliness, Yield and Fiber Regarding Parameters of Upland Cotton

Parents	PH	B	SCY	BMP	DFBO	DFF	EI	GOT	LI	L.W	SI	NNFSB	NNFEB	TNN	TBP	BW	IND	FL	FS	FU	FF
CRS-2007	1.05	0.51	1.74	1.89*	0.85	1.04	2.51	0.59	0.15	0.04	0.02	0.43	0.73*	2.38**	0.56	0.03	0.003	0.75**	1.28*	0.22	0.28**
KZ-189	0.49	0.17	8.35 **	0.15	1.15	1.29	3.72	3.32**	0.73**	0.83	0.09	0.13	0.57	0.61	1.82*	0.01	0.06	0.05	0.75	0.55**	0.01
C-26	0.23	0.75*	2.14	2.99**	0.12	2.87**	6.21*	0.12	0.08	0.5	0.06	0.1	0.02	0.39	0.09	0.16**	0.07	0.90**	2.12**	0.42*	0.300**
Kehkshan	1.99	0.29	7.26 *	0.59	1.71**	2.30**	8.00**	3.08**	0.54*	1.69*	0.07	0.36	0.45	2.40**	2.07*	0.16**	0.05	0.07	1.58*	0.22	0.18
FH-313	1.19	0.70*	1.48	0.66	0.17	0.83	4.43	0.46	0.12	0.33	0.13*	0.17	0.3	-0.2	0.4	0.04	0.05	0.16	0.001	0.13	0.20*
CRS-2007×KZ-189	1.62	0.41	9.3	0.04	0.7	0.67	1.66	1.65	0.43	2.63	0.04	0.56	0.27	0.82	3.73*	0.03	0.01	0.05	0.67	0.04	0.15
CRS-2007×C-26	3.49	0.08	2.43	0.52	1.4	0.87	12.13*	0.16	0.43	1.15	0.19	1.06*	0.07	1.59	0.5	0.27*	0.09	0.47	1.87	0.31	0.28
CRS-2007×Kehkshan	0.58	0.79	1.93	0.02	0.18	0.15	7.25	4.97*	1.46**	1.59	0.36**	0.09	0.38	0.41	0.02	0.36**	0.19	1.71**	1.52	0.22	0.07
CRS-2007×FH-313	10.01**	0.45	0.46	0.46	0.94	0.49	1.55	0.02	0.1	1.73	0.07	0.24	1.05	2.69	1.67	0.01	0.49**	0.46	1.31	-0.1	0.06
KZ-189×C-26	0.89	1.27*	5.58	1.562	1.26	-0.3	6.62	1.3	0.55	2.84	0.21	0.75	0.56	0.5	1.24	0.29*	0.17	0.39	0.55	0.87*	0.47*
KZ-189×Kehkshan	7.48*	0.61	8.004	0.86	1.45	0.58	3.54	0.25	0.89*	1.56	0.24*	0.26	0.08	0.98	1.66	0.21	0.15	0.56	2.28	0.29	0.25
KZ-189×FH-313	4.93	0.57	13.95*	1.76	2.46	-0.7	14.93*	6.80**	1.06*	2.26	0.19	0.65	1	1.43	4.31*	0.08	0.13	0.38	1.36	1.17**	0.38
C-26×Kehkshan	6.90*	1.2	10.89	0.45	0.31	0.14	4.51	0.62	0.01	3.61*	0.02	0.72	0.45	0.19	2.18	0.002	0.009	1.21*	2.19	0.008	0.06
C-26×FH-313	0.15	0.49	12.26*	2.99*	3.63 **	0.63	1.55	2.87	0.004	4.51*	0.32**	0.2	0.2	0.51	3.16	0.05	0.09	0.05	2.90*	0.82*	0.64**
Kehkshan×FH-313	0.75	0.1	3.59	0.02	0.97	0.99	10.06	0.41	0.44	0.45	0.04	0.13	0.22	0.75	1.08	0.005	0.34*	0.95	1.37	0.54	0.07
KZ-189×CRS-2007	15.25**	0.75	10.95	1.85	2.35	0.5	2.13	3.69	0.67	2.1	0.08	0.67	0.83	0.67	4.70*	0.01	0.159	-0.5	3.35*	0.23	0.35
C-26×CRS-2007	-5.5	0.67	7.2	2.25	0.2	2.05	13.56	0.74	0.09	3.1	0.08	1.25*	2.08**	3.25	4.85*	0.001	0.17	0.08	038	0.6	0.08
C-26× KZ-189	0.45	2.50*	-4.3	2.7	1.05	3.70*	16.50*	0.22	0.28	2.33	0.08	0.5	0.33	1.75	0.65	0.24	0.11	-0.8	0.78	-0.1	0.3
Kehkshan×CRS2007	0.75	0	10	2.33	2.28	4.60**	13.63	0.37	0.49	2.25	0.17	2.36**	2.33**	4.25*	2.4	0.08	0.29	0.88	0.63	0.83	-0.2
Kehkshan×KZ-189	-7.6	0.08	7.98	0.15	0.25	0.1	3.24	0.41	0.72	3.6	0.17	1.08	1.17	0.08	3.9	0.44**	0.13	0.83	1.05	0.08	-0.1
Kehkshan×C-26	6.45	0.75	-1.7	1.18	1.43	2.6	9.13	4.24	1.16*	4.28*	0.08	0.42	0.42	0.25	1.1	0.09	0.13	-0.9	1.1	0.3	0.55*
FH-313×CRS-2007	2.35	0.42	2.55	3.73*	4.23**	0.5	9.61	1.76	0.42	0.95	0.08	0.67	0.92	3.33*	0.58	0.05	0.12	0.28	1.6	1.70**	-0.3
FH-313×KZ-189	0.37	1.08	1.05	1.02	0.28	0.75	1.75	3.38	0.15	0.6	0.25	1.33*	1	1.33	1.8	0.08	0.60**	0.15	0.85	0.05	-0.2
FH-313×C-26	2.52	1.92*	3.85	2.75	2.75	0	11.13	1.24	0.45	2.45	0.25	0.58	0.75	1.92	0.25	0.29*	0.38*	0.63	1.18	0.53	0.08
FH-313×Kehkshan	0.95	0.83	8	3.35	-1.7	1.65	4.48	2.84	0.47	2.5	0.25	0.17	0.33	-0.5	0.1	0.46**	0.22	1.2	2.2	1.18	0.05

4 | DISCUSSION

Cotton is regarded as beneficial crop in Pakistan and many other countries of the world because it provides livelihood to the farmer and help in the economic stability of a country. However this crop is facing many challenges dues to climatic ambiguity, soil degradation and many biotic and abiotic constituents therefore it is urgent need for the breeders to improve the present germplasm of cotton by using adequate breeding program. Valuable genetic exploitation in cotton genotypes can achieved by utilizing diallel mating analysis which help to generate the high yielding cultivars with improved agronomic characteristics (Tadele, 2017).

The ANOVA results of this research investigation manifested that all experimental genotypes showed valuable genetic differences among each other for all the measured traits expect for number of monopodial branches per plant and number of seeds per plant which exhibited the preponderance of environmental effects hence prohibited for further combining ability analysis similar with the findings of (Palve et al. 2021),(QUEIROZ et al. 2017). Combining ability analysis provided detail information about the genetic inheritance of different measured characteristics. Variance results advocated that additive sort of gene exhibited flexible effects whereas non additive sort of gene action have non flexible effects which are also shown from the findings of (Ekinci & Basbag, 2018; Reddy et al. 2017). Higher magnitude of GCA variance for different experimental parameters deducted that selection on the basis of performance of each distinctive parent could be more effective because all those characters were governed by additive sort of genetic effects these conclusions coinciding with the previous results. Whereas higher magnitude of SCA variance than the GCA for almost 16 measured parameters suggested that performance of hybrids could be estimated by considering the performance of parental lines in their specific cross combination as mentioned in the outcomes of (İmtiaz et al. 2016), (Kaleem et al. 2016). The GCA and SCA ratio provide insight information regarding the involvement of additive and dominance sort of gene action in the inheritance pattern of experimental traits. The GCA and SCA ratio was less than unity which showed the predominance of dominance sort of genetic mode for different parameters such as plant height, seed cotton yield, days to first ball open, days to first flowering ,earliness index , GOT% , lint index, lint weight, seed index, node number of first sympodial branch, total ball picked, ball weight, internodal distance, fiber length, fiber strength, fiber uniformity and fiber fineness ,these finding are analogous to the results of (Bourgou et al. 2022),(Giri et al. 2020b),(Vasconcelos et al. 2018),(Monicashree et al. 2017),(Khokhar et al. 2018),(Bilwal et al. 2018)which conveyed that these characters could be better exploited in hybrid breeding. However parameters like number of sympodial branches per plant, ball maturation period, node number of first effective ball and total number of nodes showed the preponderance of additive kind of genetics which manifested that mass selection could be exploited to further improve these characters for high yield and fiber quality. The outcomes of these parameters showed similarity with the results of (Zhang et al. 2017),(Soomro et al. 2021),(Akiscan & Gencer, 2014), (Thiyagu et al. 2019).

Combining ability analysis is regarded as constructive tool for differentiating prominent parents and their hybrids for generating high yielding cultivars. Most commonly one or both parent was observed as prominent general combiners to acquire a hybrid with good SCA effects. Parent CRS-2007 was observed good prominent general combiner for plant height, node number of first effective boll, internodal distance because the negative but significant estimates of GCA effects for these parameters will positively influence over all cotton yield , these outcomes were contrasting with the findings of .(Manonmani et al. 2020),(Udaya et al. 2020) . However parent FH-313 was found with significant positive GCA effects which conferred that this parent could be used as good general combiner for number of sympodial branches. However parent Kehkshan was found prominent general combiner for days to first ball open, days to first flowering, GOT% and lint index, which suggested that these two parents could be efficiently exploited in breeding program for the improvement of these traits and generating high yielding cultivars however the findings of the above parameters were coinciding with the outcomes of (Soomro et al. 2021), (Reddy et al. 2017), (Balci et al. 2023) and (Patil et al. 2017). However among specific cross combination effects C-26 x FH-313 was observed prominent specific combiner for boll weight, seed cotton yield, boll maturation period, days to first boll open , lint weight, fiber fineness and seed index which manifested that this combination could be better exploited in hybridization program , such contrasting findings were given by (Bourgou et al. 2022), (Some et al. 2019), (Mokadem et al. 2019) and (Ekinci & Basbag, 2015).

Parent Kehkshan was found with valuable estimate of mean performance value for days to first boll open, days to first flower, earliness index, lint index, ginning out turn total number of nodes, node number of first sympodial branch and fiber length. Parent KZ showed good mean performance estimates for seed cotton yield, boll maturation period, days to first flowering, seed index, fiber uniformity and fiber strength however among crosses Kehkshan×CRS-2007 and its reciprocal cross manifested good mean performance for various earliness traits. Hence these parental genotypes and crosses could be in cooperated in future breeding program to attain more yield and fiber quality objectives however the findings of mean performance were found similar with the outcomes of (Queiroz et al. 2021), (Swetha et al. 2018), (Vekariya et al. 2017) and (Prakash et al. 2018).

Conclusion

Genetic variability is major factor which plays a pivotal role in the improvement of different cultivars. The mechanism of genetic variability could be exploited to enhance and further improve the yield related components. Different research studies were directed to exploit the genetic variation of different genotypes for yield and fiber quality parameters in upland cotton Gossypium hirsutum L. In cotton both yield attributes (seed index, plant height, number of sympodial branches and number of bolls) and fiber related traits (fiber length, uniformity, strength and fineness) were given supreme importance. Analysis of variance revealed significant dissimilarities were present among all the genotypes for all the measured characters excluding number of seeds per boll and number of monopodial branches per plant. Five parental genotypes under diallel analysis were utilized for the estimation of combining ability. Griffing's numerical technique was applied to evaluate the general and specific combining ability and gene action in different parameters. Mean performance of the parents and their crosses were also recorded. Results indicated that all the yield and fiber quality related parameters significantly varied from each other except for number of monopodial branches per plant and number of seeds per boll. The mean square value for GCA was significant in almost all the characters excluding plant height, internodal distance, lint weight, seed index, node number of first sympodial branch and total number of bolls picked, whereas SCA mean square was found significant in plant height, earliness index, lint weight, seed cotton yield and all fiber quality traits. Genetic variance for SCA was higher in magnitude than the GCA for almost all the traits whereas GCA variance was higher for total number of nodes, node number of first effective boll, boll maturation period and number of sympodial branches. The parent CRS-2007 was found with positive and higher GCA effects for fiber length, total number of nodes, node number of first effective boll and boll maturation period. The parent KZ-189 was reported as prominent general combiner for seed cotton yield, Kehkshan for GOT% parent C-26 for boll maturation period, fiber strength and uniformity. However cross combination C-26×FH-313 was found good specifically for boll weight and seed cotton yield, boll maturation period, days to first boll open, lint weight. Fiber fineness and seed index; CRS-2007×Kehkshan for boll weight, seed index, lint index and GOT% whereas KZ-189×Kehkshan for fiber length.

Specific cross combination Kehkshan×CRS-2007 and its reciprocal cross exhibited good mean performance for different earliness characters such as plant height, days to first flower, seed index, node number of first sympodial branch, node number of first effective boll, total number of nodes and GOT% whereas C-26×KZ-189 displayed preferable mean value for seed cotton yield, boll maturation period and boll weight however KZ189×CRS-2007 also showed suitable mean performance for yield and fiber quality traits (fiber length, strength and fineness). Hence all these cross combinations could be implied in future breeding projects to attain more yield and fiber quality objectives.

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