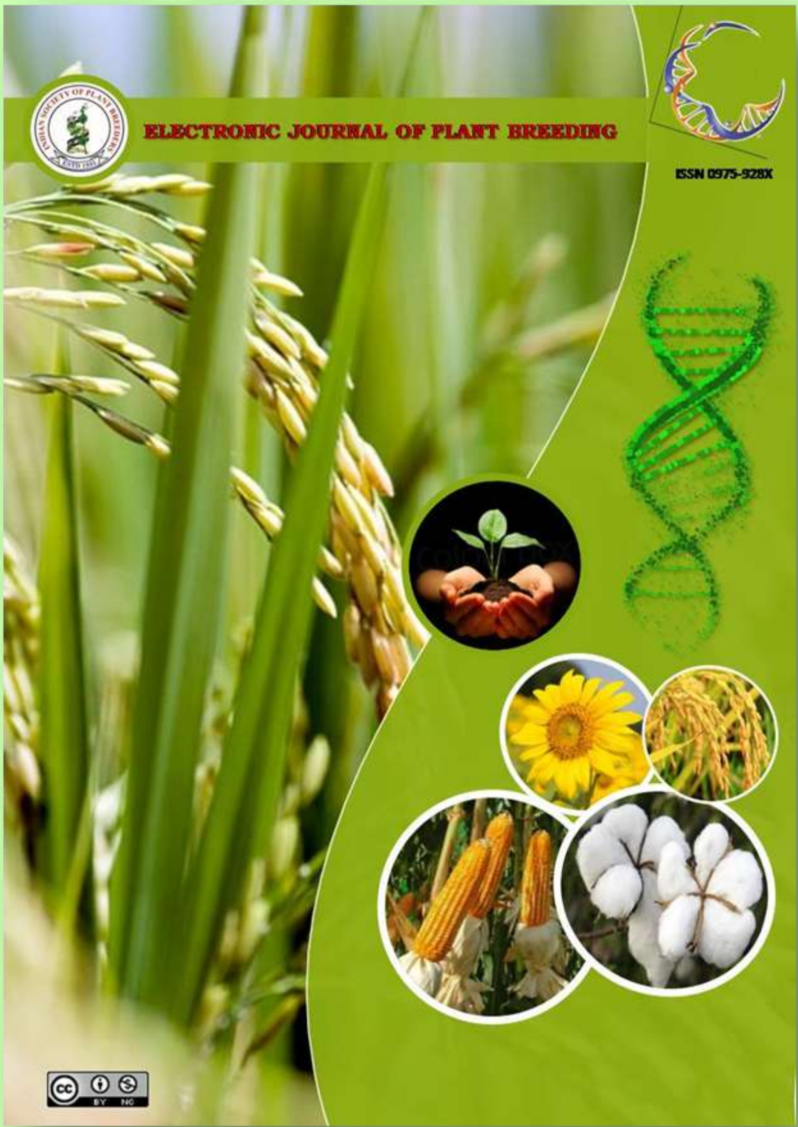
Estimation of heterosis and combining ability in interspecific cotton hybrids

Abasianyanga Isong, Amala Balu, Chioma Isong and Eunice Bamishaiye



ISSN: 0975-928X

Volume: 10

Number:2

EJPB (2019) 10(2):827-837

DOI:10.5958/0975-928X.2019.00110.8

Electronic Journal of Plant Breeding, 10 (2): 827-837(Jun 2019) DOI: 10.5958/0975-928X.2019.00110.8
ISSN 0975-928X

Research Article

Estimation of heterosis and combining ability in interspecific cotton hybrids

Abasianyanga Isong[1], Amala Balu[1], Chioma Isong[2] and Eunice Bamishaiye[3]
[1]Tamil Nadu Agricultural University, Coimbatore – 641003, India
[2]Federal University of Technology, Minna, Nigeria
[3]Nigerian Stored Products Research Institute, Nigeria
E-Mail: isongplus@yahoo.com

(Received:01 Nov 2018; Revised:20 May 2019; Accepted:20 May 2019)

Abstract
Investigation was to assess heterosis, general and specific combining ability for seed cotton yield, yield contributing traits and fibre quality parameters in interspecific F_1 hybrids of cotton. 45 hybrids along with their parents and a standard commercial variety using randomized complete block design were evaluated for per se performance, heterosis and combining ability potential. Significant variation existed among the genotypes, crosses, parents and their interactions. Hybrid TCH1819 x TCB37 was outstanding in yield followed by COD-5-1-2 x DB3 and KC2 x TCB37. TCH1705-101 x CCB36 performed best in number of seeds per boll, fibre fineness and plant height, while TCH1819 x TCB209 out performed in uniformity ratio and elongation per cent. The highest standard and better heterosis of 90.6% and 193.69% respectively were recorded in TCH1819 x TCB37 for seed cotton yield. The combining ability analysis showed an equal importance of additive and non-additive genetic components in yield contributing traits and fibre quality parameters. The lines TCH1819, COD-5-1-2, VS-9-S11-1 and MCU7 and testers DB3 and TCB37 were distinguished as best combiners. Surabhi x TCB209, TSH0250 x CCB36, VS-9-S11-1 x DB3 and TCH1705-101 x DB3 were identified as best specific combiners and may be recommended for further breeding program

Keywords
Cotton, heterosis, combining ability, interspecific hybrids.

Introduction

Cotton (*Gossypium* spp) is an important fibre crop all over the world. It is the leading natural fibre source and vital component of the global economy. Cultivated cotton has both diploid (*G. arboreum* and *G. herbaceum*) and tetraploid (*G. hirsutum* L. and *G. barbadense* L.) genomes. The *G. barbadense* produces the much-required extra-long fibres for the production of superior textiles whereas *G. hirsutum* is well known for its adaptability and high yield. Commercially, India is pioneer in hybrid cotton cultivation and production. According to Dongre and Parkhi 2005, hybrid cotton occupies about 45 per cent of the total area and contributes about 55 per cent to the total production. It is therefore a common practice in India and China to use the phenomenon of heterosis in the improvement of cotton yield (Wu *et al*., 2004). Yield is regarded as the most important agronomic trait and it is included in virtually all cotton selection programs. Fibre quality traits have also been emphasized upon in the last few decades. This is predicated on the basis of the rapid change in the demand for high value quality cotton for spinning, weaving and dying units in the textile industry. The adequate choice of parents is vital to the two objectives of increased yield per unit area and good fibre quality to meet the industry demand.

Amidst several methods deployed to improve yield and quality in the cultivated cotton, development of hybrids (Interspecific and intraspecific) as commercial varieties to meet the current demand for cotton is reported by Ashokkumar (2013) as very important. Khan *et al*. (2010), Ganapathy and Nadarajan (2008) and Pheirim *et al.* (2017) corroborated that heterosis has significantly remained one of the most achieved landmarks in cotton breeding programs. Dhamayanthi (2011) has also reported significant heterosis in both inter-specific and intra-specific hybridization in both diploid and tetraploid cotton. Soregaon *et al*. (2007) buttressed that interspecific hybrids of cotton are better in performance compared to non-hybrid for fibre yield, ginning efficiency, fibre length, fibre fineness and fibre uniformity.

To predict heterosis, breeders are often interested in the selection of potential lines among the available parents and bypassing the field evaluation of a large number of crosses (Pheirim *et al.* 2017). Several methods have been deployed including combining ability to this end. Combining ability is the capacity of a genotype to produce superior progeny. Along with heterosis it can be useful in determining the effectiveness of genotypes to be

Electronic Journal of Plant Breeding, 10 (2): 827-837(Jun 2019) DOI: 10.5958/0975-928X.2019.00110.8
ISSN 0975-928X

included in further breeding programs (Griffing 1956). Combining ability test in cotton like line × tester analysis used to identify superior parental lines was recommended by Virmani *et al*. (1994). Rajendrakumar *et al.* (2015) however maintained that high general combining ability (*gca*) effects will most likely results in the development of heterotic hybrids in any crop. He also promoted the existence of moderate to strong correlation between combining ability effects and *per se* performances as well as mid-parent heterosis, but in varying degrees. However, for hybrid selection to be of superior performance, Rajendrakumar *et al.* (2015) opined for an earlier generation selection in cotton. Therefore, to guide an informed selection in the improvement of this population for higher yield, this present investigation aimed at predicting levels of heterosis, identify good parental combiners and estimate the mean performance of yield, yield contributing parameters and quality traits of interspecific F_1 hybrids of cultivated cotton

Materials and Methods

The research field of the Department of Cotton, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore was the location of this investigation. This was conducted during the 2016 and 2017 cropping seasons. During winter season of 2016, Nine number of *G. hirsutum* genotypes (MCU7, TCH1819, COD-5-1-2, African-1-2, VS-9-S11-1, TCH1705-101, KC2, TSH0250 and Surabhi) as females and Five number of *G. barbadense* genotypes (TCB26, TCB37, TCB209, CCB36, DB3) as males were crossed in a Line x Tester fashion using a conventional hand emasculation and pollination method developed by Doak (1934). This produced 45 interspecific hybrids that were evaluated along with the 14 parents and a check hybrid DCH32 in the summer of 2017. The genotypes were planted in a Randomized Block Design (RBD) with three replications. Two rows each for parents and hybrids were planted at a spacing of 90 cm between rows and 60cm between plants. Basic agronomic procedures like irrigation, soil conditioning, fertilizer application, weed and pest control were applied. Observations were recorded from five randomly selected plants in each entry and in each replication for the traits *viz*., seed cotton yield (SCYPP) (g), plant height (PH) (cm), number of bolls per plant (NBPP), number of sympodia branches per plant (NSPP), number of monopodia branches per plant (NMPP), boll weight (BW) (g), number of seeds per boll (NSPB), ginning percentage(GP), lint index (LI) and seed index (SI). Samples of seed cotton obtained were pooled, ginned and the lint obtain was evaluated for fibre quality characters *viz*; 2.5% span length (2.5%SL) (mm), fibre fineness (FF), bundle strength (BS), elongation percentage (EP) and uniformity ratio (UR) using High Volume Instrument 900 classic. Days to flowering (DF), days to 50 per cent flowering (DFF) and days to first bursting (DFB) were also observed for each entry per replication

AGRISTAT statistical analyses software was employed to statistically analyze the mean data obtained from F_1 hybrids, parents and the standard check for various properties. Results for analysis of variance (ANOVA), heterosis of hybrids, combining ability of parents and hybrids were collated in tables for discussion. Heterosis was estimated over mid parent (Relative), better parent (Heterobeltiosis) and the standard hybrid (Standard heterosis) values. They were expressed as percentage deviation from the mean as follows;
Relative heterosis = (F_1 – MP/MP) x 100; Heterobeltiosis = (F_1 – BP/BP) x 100; Standard Heterosis = (F_1 – SP/SP) x 100

Where;
F_1 = Mean of the F_1 hybrid
MP = Mean of mid parent
BP = Mean of better parent
SP = Mean of standard hybrid (DCH32)
Test of significance was according to the formulae suggested by Turner (1953). Also, the general and specific combining ability effects of the parents and hybrids respectively were evaluated by Line × Tester analysis method as described by Kempthorne (1957)

Results and Discussion

Analysis of variance (ANOVA) for the Line x Tester design involving 45 F_1 hybrids derived by crossing 9 Lines (*G. hirsutum*) and 5 Testers (*G. barbadense*) was statistically carried out and the results are presented in Table 1. Mean performance, Coefficient of Variation, Range and *per se* performance for various characters of interspecific F_1 hybrids are as indicated in Tables 2 and 3 respectively. Relative heterosis (d_i), heterobeltiosis (d_{ii}), standard heterosis (d_{iii}), general combining ability (*gca*), specific combining ability (*sca*) for both yield contributing parameters and quality traits are in Tables 4, 5 and 6 respectively.
The ANOVA table showed significant differences for genotype, crosses and interactions for all the characters studied except the quality parameters and duration traits. However, fibre fineness also had significant differences in genotype, crosses, parents and interactions. Separation of parents into lines, testers and their interactions also confirmed the presence of significant variability in almost all the studied parameters. Similar range of significant variability has been reported by Ashokkumar *et al* (2013) for all the traits for parents and their hybrids in a cross between the adapted lines and accession populations. Table 2 indicated that seed cotton yield per plant had the highest coefficient of variability (19.1) with a mean value ranging from

115.6 – 232.7 followed by fibre fineness with a coefficient of variability of 17.17 and a mean value range of 2.6 – 6.7. The duration parameters (days to first boll bursting, days to 50 per cent flowering and days to flowering recorded the least coefficient of variability of 2.62, 3.74 and 4.22 respectively. The results however indicated that environment impacted more on the seed cotton yield per plant than the duration parameters and fibre quality traits.

Per se performance as presented in Table 3, showed that the cross combination TCH1819 x TCB37 had the highest yield per plant of 232.7g followed by COD-5-1-2 x DB3 (227.74g) and KC2 x TCB37 (189.82g). The crosses KC2 x CCB36 (115.59g) and Surabhi x CCB36 (117.94g) recorded the least values for seed cotton yield per plant. The range for seed cotton yield in F_1 hybrid population is consistent with the reports of Muhammad *et al.* (2014), Nidagundi *et al*. (2012) and Thiyagu *et al.* (2010). The highest values scored for plant height, number of bolls per plant, number of sympodial branches per plant, number of monopodial branches per plant, boll weight, number of seeds per boll, ginning percent, lint index and seed index by the yield contributing parameters were in the cross-combinations VS-9-S11-1 x DB3 (145.5g), MCU7 x CCB209 (57.3), MCU7 x CCB209/ VS9-S11 x DB3 (22.00), TSH0250 x DB3 (3.1), VS-9-S11-1 x TCB26 (4.1), TCH1705-101 x CCB36 (26.00), Surabhi x CCB36 (39.74), MCU7 x DB3 (5.11) and African 1-2 x TCB209 (12.4) respectively. Among the cotton quality parameters, TSH0250 x TCB26 (38.2), TCH1819 x TCB209 (52.2), Surabhi x TCB26 (30.9), TCH1819 x TCB209 (8.6) and TCH1705-101 x TCB26 (6.4) recorded the highest values for 2.5% span length, uniformity ratio, bundle strength, elongation per cent and fibre fineness respectively. The hybrid TCH1705-101 x CCB36 had the shortest plant height (78.0cm) the fibre fineness of 2.6, and highest number of seeds per boll. Also, African 1-2 x TCB209 was the earliest to flower (44) and scored the highest seed index (12.4). In terms of *per se* performance, TCH1819 x TCB209 was distinguished as the best quality hybrid for uniformity ratio and elongation percent.

Heterosis of 50% over commercial varieties and 20% over check hybrids is considered desirable for development of hybrids. Shakeel *et al*. (2014), Rajamani *et al*. (2009) and Pathak and Parkash Kumar (2011) independently reported on intraspecific hybrids giving varying levels of both hetrobeltiosis and standard heterosis. In the present study, majority of the F_1 hybrids expressed significant standard heterosis for number of bolls per plant and seed cotton yield per plant. The highest significant standard heterosis was observed for VS-9-S11-1 x DB3 (22.78%), MCU7 x TCB209 (70.03%), TSH0250 x DB3 (55.0%), VS-9-S11-1 x TCB26 (68.38%), TCH1705-101 x TCB36 (39.41), TCH1819 x TCB37 (90.6%), MCU7 x DB3 (25.58%), MCU7 x DB3 (63.0%) and African1-2 x TCB209 (68.16%) for plant height, number of bolls per plant, number of sympodial branches per plant, number of monopodial branches per plant, boll weight, number of seeds per boll, seed cotton yield per plant, ginning per cent, lint index and seed index respectively. Majority of the hybrids did not record significant standard heterosis for fibre quality traits, however, TCH1819 x CCB209 (38.71%) and TCH1705-101 x TCB26 (68.42%) expressed the highest significant values for elongation per cent and fibre fineness respectively. The high expression of heterosis by majority of the hybrids for number of bolls per plant and seed cotton yield per plant is consistent with the reports of Kaushik and Sastry (2011). For commercial exploitation of hybrids based on the *per se* performance and heterosis breeding, TCH1819 x TCB37, MCU7 x TCB209, TSH0250 x DB3, VS-9-S11-1 x TCB26, MCU7 x DB3 and African1-2 x TCB209 can therefore be selected and advanced for further breeding program. For quality parameter especially fibre fineness, TCH1705-101 x TCB if selected would be of significant benefit. The selected hybrids expressed more than 50% heterobeltiosis and standard heterosis, and the inheritance of the traits as reported in earlier works by Ali *et al.* (2010) and Soomro *et al.* (2009) were due to additive and non-additive gene effects. The additive and non-additive genetic effect estimated from crossbreeding can be used to improve breeding programs (Thanh *et al.*, 2010).

Knowledge of combining ability allow producers to use additive effects to match their practical production situation and gain further increases in productivity through non-additive gene action (Su *et al*., 2013) .The results obtained in this experiment shows that to improve on seed cotton yield per plant, selection of TCH1819, COD-5-1-2, VS-9-S11-1 and MCU7 among the lines and DB3 and TCB37 for Testers would be effective. The selected parents had high and positive significant general combining ability values. To improve on fibre quality traits, selection of TCH1819 for elongation per cent and fibre fineness, TCH1705-101 and TCB26 for fibre fineness will prove effective. The four best specific combiners that can be selected as described by Kwaye *et al. (*2008) for seed cotton yield were TCH1819 x TCB37, COD-5-1-2 x DB3, KC2 x TCB37 and TCH05-101 x TCH26. Four promising hybrids Surabhi x TCB209, TSH0250 x CCB36, VS-9-S11-1 x DB3 and TSH0250 x TCB26 can as well be selected for recombination breeding in view of their *per se* performance, heterotic values and non-significant specific combining ability. The range of the results for heterosis study was consistent with the reports of Rajamani *et al.* (2009) in intraspecific hybrids and Isong *et al.* (2017) in interspecific hybrids.

In conclusion, the results indicated that much more combinations exceeded the standard commercial check for yield and yield contributing traits than for fibre quality traits. However, broad genetic base should be developed and more combinations may be applied to regularly evaluate and select to achieve high yielding cotton per hectare as well as high fibre quality traits for textile industry.

Acknowledgement

The authors express their profound gratitude to the West African Agricultural Development Program (WAAPP) and National Cereals Research Institute (NCRI), Nigeria for sponsoring this study. We also acknowledge Tamil Nadu Agricultural University, Coimbatore for providing Professional guidance, field and Laboratory for the experiment.

References

Ali M. A., Bhatti M. F., Abbas A. and Khan I. A. 2010. Assessment of inheritance pattern of some multigenic characters in cotton (*Gossypium hirsutum* L.). J. Agric. Res. **48**(1)**:** 224

Ashokkumar K., Kumar K. S. and Ravikesavan R. 2013. Heterosis studies for fibre quality of upland cotton in line x tester design. Afr. J. Agric. Res., **8**(48): 6359-6365

Dhamayanthi K. P. M. 2011. Study of Interspecific Hybrids (*Gossypium hirsutum* x *G. barbadense*) for Heterosis and Combining Ability. World Cotton Research Conference-**5**, 51-53.

Doak C. C. 1934. A new technique in hybridizing suggested changes in existing methods of emasculation and bagging cotton flowers. J. Hered., **25:** 201–204

Dongre A and Parkhi V. 2005. Identification of Cotton Hybrid through the Combination of PCR Based RAPD, ISSR and Microsatellite Markers. J. Plant Biochemistry & Biotechnology **14**: 53-55

Griffing B. 1956. Griffing, Concept of general and specific combining ability in relation to diallel crossing system. Aust. J. Bio. Sci. **9**:463-493.

Isong A., Balu A., Ravikesavan R. 2017. Study on Heterosis and Combining ability in Interspecific Hybrids of Cotton (*G. hirsutum*x*G. barbadense*). Int. J. Pure App. Biosci. **5** (3): 922-933

Kaushik S. K. and Sastry E. V. D. 2011. Heterosis and inbreeding depression in *Gossypiumhirsutum* L. *Sab.* J. Breed. **43**: 107-21

Kempthorne O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, Inc. New York.

Khan N, Basal H and Hassan G. 2010. Cottonseed oil and yield assessment via economic heterosis and heritability in intraspecific cotton populations. Afr. J. Biotechnol. **9**(44):7418–7428

Kwaye G. R., Shimelis H, William P. M. 2008. Combining ability analysis and association of yield and yield components among selected cowpea lines. Euphytica**162**:205-210.

Muhammad M. Y., Mari T. S., Laghari S, Soomro Z. A, Abro S. 2014. Estimation of heterosis and heterobeltiosis in F1 hybrids of upland cotton. J. of Bio., Agric. and Healthcare, **4**(11): 68-71

Ganapathy S, Nadarajan N. 2008. Heterosis studies for oil content, seed cotton yield and other economic traits in cotton *(G. hirsutum*L.). Madras Agric. J**. 95**(7-12):306-310.

Nidagundi J. M., Patil S. S., Salimath P. M., Kajjidoni S. T., Patil B. C. and Hegde MG. 2012. Genetic analysis of seed cotton yield and its components in *Gossypiumhirsutum* L. *Karnataka J.* Agric. Sci., **25**(2**)**: 260-216.

Pathak R. S. and Parkash K. 2011. A study of heterosis in upland cotton (*Gossypiumhirsutum* L). Theoretical and Applied Genetics. **47**: 45-49.

Pheirim R. R., Niyaria P., Singh K. 2017. Heterosis prediction through molecular markers. J. for researchers **1**(1): 45-50

Rajamani S, Rao C. H. M. and Naik R. K. 2009. Heterosis for yield and fibre properties in upland cotton (*Gossypiumhirsutum* L.). J. Cotton Res. Dev. **23**(1): 43–45.

Rajendrakumar P., Hariprasanna K., Seetharama N. 2015. Prediction of Heterosis in Crop Plants – Status and Prospects. Am. J. of Exp. Agri**. 9**(3): 1-16

Shakeel A, Mehmood H, Sheraz M. M., Saeed A, Saleem M. F and Nabi G. 2014. Evaluation of New F_1 Hybrids using Hybrid vigour analysis in Upland cotton for seed cotton yield and fibre quality traits, J. Agric. Res., **52**(4): 472.

Soomro Z. A., Kumbhar M. B., Larik A. S. 2009. Heterosis and inbreeding depression for quality traits in diverse cotton genotypes. *J. Agric. Res*. **47**(4):349-58

Soregaon C. D., Veereshgowda R. P., Katageri I. S. and Khadi B. M. 2007. Introgression of fibre traits of *Gossypium barbadense* L. into

Gossypiumhirsutum L. Indian J. Genet**., 67**(1): 56–61

Su S, Xu P and Yuan X. 2013. Estimates of combining ability and heterosis for growth traits in a full diallel cross of three strains of common carp, *Cyprinuscarpio* L. African journal of Biotechnology. **12**(22): 3514-3521

Thanh N. M., Nguyen NH, Ponzoni RW, Vu NT, Barnes A. C, Mather PB. 2010. Estimates of strain additive and non-additive genetic effects for growth traits in a diallel cross of three strains of giant freshwater prawn (Macrobrachiumrosenbergii) in Vietnam. Aquaculture **299**:30-36.

Thiyagu K, Nadarajan N, Rajarathinam S, Sudhakar D, Rajendran K. 2010. Association and path analysis for seed cotton yield improvement in inter-specific crosses of cotton (*Gossypium spp*. Electron. J. Plant Breed. **1**(4): 1001-1005.

Turner J. H. 1953. A study of heterosis in upland cotton, Combining ability and inbreeding effects. Agron. J., **45**: 487–490.

Virmani S. S. 1994. Heterosis and hybrid rice breeding-Monographs on Theoretical and Applied Genetics 22, Springer-Verlag, Berlin, Heidelberg.

Wu Y. T., Yin J. M., Guo W. Z., Zhu X. F. and Zhang Z.2004. Heterosis performance of yield and fibre quality in F_1 and F_2 hybrids in upland cotton. Plant Breed, **123**:285-289.

Table 1. Mean squares for different yield and quality parameters

Sources of variation	d.f	PH	NBPP	NSPP	NMPP	BW	NSPB	SCYPP	GP	LI	SI	2.5%SL	UR	BS	E%	FF
Replication	1	1224.4	1.01	4.76	0.003	0.18	6.091	37.34	15.52	0.01	8.67	0.24	2.449	20.68	1.48	0.71
GENO	58	526.43**	200.51**	8.79**	0.45**	0.38*	15.04**	2414.02**	27.91**	0.74**	5.26**	22.87	12.768	11.79	1.28	1.02**
Crosses	44	395.14*	97.52**	5.42	0.22**	0.37*	13.96*	1457.44**	26.71**	0.65**	4.50**	7.67	7.518	8.44	0.97	0.70**
Lines	8	282.62	245.66**	8.12	0.36**	0.68*	8.14	1681.37**	37.40*	1.28**	9.37**	7.08	10.371	16.28	2.28	0.76*
Testers	4	1529.1*	58.46**	9.27	0.14	0.62	26.12	2224.75**	17.39	1.16*	9.58*	3.45	21.416	12.10	0.76	0.83*
LXT	35	281.51	65.37**	4.26	0.19**	0.25	13.91*	1305.54**	25.21**	0.43*	2.65**	8.34	5.068	6.02	0.67	0.67**
Parents	13	199.3	43.82**	3.69	0.31**	0.41	18.98*	652.06**	33.05**	0.48*	1.18	24.67	25.121	8.18	2.10	0.95**
Cross vs Parent	1	10555.5	6768.9*	223.5	12.65	0.57	11.04	67409.3*	14.36	8.26	91.30	668.47	83.187	206.1	4.28	15.99
Error	58	168.3	2.44	3.34	0.06	0.18	5.46	23.52	8.09	0.17	0.69	37.45	73.718	11.07	0.75	0.16

** significant at 1% , * significant at 5%

Table 2. Mean performance, coefficient of variation and range for various characters of interspecific F_1hybrids

Traits	Mean	SE (D)	Range	CV
DF	48.71	8.619	44.0 - 53.5	4.22
DFF	56.59	8.135	54.5 - 67.5	3.74
DFB	90.43	18.152	85.5 – 98.0	2.62
PH	118.17	12.912	78.0 - 145.5	11.89
NBPP	42.90	1.838	32.1 – 57.3	16.28
NSPP	18.76	1.642	14.4 – 22.0	8.77
NMPP	2.22	0.259	1.3 – 3.1	14.89
BW	3.15	0.445	2.3 – 4.1	13.59
NSPB	20.60	2.481	13.3 – 26.0	12.83
SCYPP	141.48	5.402	115.6 – 232.7	19.10
GP	29.38	3.064	23.1 – 39.7	12.44
LI	3.69	0.452	2.3 – 5.1	15.43
SI	9.04	0.861	5.6 – 12.4	16.59
2.5%SL	35.82	6.380	30.7 – 38.2	4.84
UR	46.80	8.644	43.0 – 52.2	4.45
BS	26.08	3.154	20.1 – 30.9	7.67
E%	6.13	0.902	4.9 – 8.6	11.37
FF	3.45	0.414	2.6 – 6.4	17.17

Table 3. ***Per se*** **performance of 45 F_1cotton hybrids for yield and quality parameters**

Crosses	DF	DFF	DFB	PH	NBPP	NSPP	NMPP	BW	NSPB	SCYPP	GP	LI	SI	2.5%SL	UR	BS	E%	FF
MCU7 X TCB26	48	55	90.5	117	50.6	18.3	2.2	2.67	19.35	135.42	29.41	3.33	7.88	35.9	46.5	25.6	6.1	3.4
MCU7 X TCB37	47	56	88.5	119.5	51.2	19.7	2	3.08	24.05	125.74	27.75	3.03	7.73	34.8	46.6	26.5	5.7	3.0
MCU7 X TCB209	50	56	92	136.5	57.3	22	2.4	3.59	19.75	172.79	27.27	4.14	11.08	36.3	47.0	25.7	6.4	3.6
MCU7 X CCB36	48	56.5	89	115	41.9	18.3	2.4	2.32	19.25	123.90	29.54	2.81	6.72	34.5	49.3	24.9	6.1	2.8
MCU7 X DB3	48.5	56.5	90.5	142	56.4	21.2	2.3	3.08	24.4	175.78	39.2	5.11	9.6	36.1	49.9	26.6	5.9	3.3
TCH1819 X TCB26	48.5	56	89	128.3	55.1	20.7	2.1	3.39	20.2	130.55	29.63	4.21	10.09	34.8	44.7	22	6.3	3.6
TCH1819 X TCB37	49	56	90	130.5	52.4	19.9	2.1	3.81	25.5	232.71	31.23	4.04	8.8	35.5	45.7	28.5	6.9	4.7
TCH1819 X TCB209	49	55.5	89	122.6	38.5	18.8	2	3.28	20.85	126.74	33.21	4.35	8.76	30.9	52.2	24.7	8.6	4.0
TCH1819 X CCB36	48	55	90.5	108.5	50.1	19	2.2	3.03	21.85	158.67	32.6	3.79	7.86	35.7	47.7	27.1	5.8	3.3
TCH1819 X DB3	48.5	54.5	88	141.5	53.4	20.8	2.1	3.64	23.45	162.09	29.15	3.79	9.24	36.1	50.7	27.6	7.8	3.1
COD-5-1-2 X TCB26	47	56	91.5	122.5	49.3	20	2.2	3.65	20.75	141.00	28.34	4.2	10.67	37.3	47.0	24.4	7.3	3.7
COD-5-1-2 X TCB37	47	56.5	89.5	106.5	36.6	18.1	1.3	3.57	21.05	134.61	26.66	3.95	10.95	37.8	43.9	25.2	5.8	2.9
COD-5-1-2 X TCB209	47.5	54.5	88.5	122.6	49	20	2	3.38	19.75	154.53	29.52	4.19	10.02	37.3	47.8	26.8	5.8	3.9
COD-5-1-2 X CCB36	49.5	57	90	108.5	33.4	17.8	2.2	2.65	21.35	119.08	30.31	3.05	6.88	32.7	47.8	23.7	6.7	3.3
COD-5-1-2 X DB3	49.5	57	90	144	42.4	21.2	1.4	3.34	18.55	227.74	27.74	4.18	10.9	29.8	51.3	27	6.4	3.2
African1-2 X TCB26	48.5	56	90	95.6	41.4	17.3	2.6	3.38	21.2	126.43	28.53	4.05	10.09	36.4	46.0	22	6.4	3.3
African1-2 X TCB37	47.5	55.5	85.5	112.5	45.8	18.1	1.7	3.9	24.9	123.61	28.85	3.89	9.53	36.2	47.5	27.1	6.2	3.5
African1-2 X TCB209	44	56.5	90.5	112.1	42.9	17.6	2.1	3.73	18.75	127.17	23.07	4.14	12.36	36.4	46.4	27.7	6	3.3
African1-2 X CCB36	48.5	55.5	89	121.5	40.5	19.1	1.9	2.93	18.85	122.62	24.69	3.3	8.91	38.1	46.5	26.7	5.8	3.1
African1-2 X DB3	47	55	89	136.1	35.9	19.9	2.3	3.09	18.4	140.32	30.01	4.44	10.36	36.7	49.0	25.8	6.1	3.5
VS-9-S11-1 X TCB26	48.5	55	89	115.8	49.5	19.4	2.3	4.1	24.5	171.02	25.89	3.9	9.86	37.1	46.9	25	5.3	3.2
VS-9-S11-1 X TCB37	48.5	55	89	104	40.1	18	2.1	3.61	20.6	150.79	29.79	4.47	11.06	35.8	47.9	28.3	6.4	3.1
VS-9-S11-1 X TCB209	47	56	89	111.5	41.3	18.3	2.2	2.64	19.6	125.12	30.33	3.12	7.23	36.3	47.6	27.2	6.4	3.2
VS-9-S11-1 X CCB36	47	57	90.5	108.5	39.4	18.9	2.5	3.06	17.9	125.99	24.11	3.88	10.75	36.8	48.2	26.3	6.4	3.0
VS-9-S11-1 X DB3	48	56	93	145.5	56.3	22	2.4	3.57	18.25	166.71	29.47	4.7	11.27	37.7	46.5	24.6	5.8	3.5
TCH1705-101 X TCB26	46.5	56.5	90.5	124	39.6	19.9	2	3.31	20.4	173.11	27.63	3.38	8.88	36.8	45.5	20.1	5.6	6.4
TCH1705-101 X TCB37	47	55.5	90.5	129	42.4	19.1	2.7	3.11	23.2	118.44	29.81	3.52	8.31	34.6	49.0	22.3	7.1	3.7
TCH1705-101 X TCB209	47	57	91.5	120.2	32.1	18.5	1.9	2.39	15.56	132.00	26.48	2.7	7.46	35.6	48.1	25.5	6.6	3.0
TCH1705-101 X CCB36	50.5	56.5	91.5	78	36.3	14.4	2	2.72	26	127.59	29.78	2.33	5.56	32.0	46.4	25.3	6	2.6
TCH1705-101 X DB3	47.5	54.5	90.5	139	45.6	21.7	2.7	3.1	19.65	156.39	28.91	3.25	7.92	36.9	47.5	25.1	6.9	4.1
KC2 X TCB26	48	55	91	118	40.5	17.6	1.9	3.27	21.3	126.91	27.31	3.43	9.05	34.0	44.1	26.5	6.1	3.7
KC2 X TCB37	47	56	90.5	96.5	37.8	16.2	2.3	3.13	19.05	189.84	27.61	3.89	10.23	34.5	46.9	26.1	6.5	3.6
KC2 X TCB209	46.5	56.5	87	109	32.9	18.1	2.5	2.97	18.5	127.57	29.27	4.6	11.16	37.5	47.2	27.2	6.2	3.5
KC2 X CCB36	46	56	90	114	50.5	18.5	2.5	3.49	23.3	115.59	28.3	3.61	9.15	37.3	43.0	25.1	5.2	4.1
KC2 X DB3	52	56.5	89	116.5	38.9	17.2	2.6	3.37	20.05	136.5	27.76	3.78	9.15	37.1	50.4	28.9	6.1	3.5
TSH0250 X TCB26	50	58.5	97	100.5	38.65	17.55	2.45	3.09	18.75	133.81	23.26	2.99	8.85	38.2	43.8	26.8	4.9	3.2
TSH0250 X TCB37	48.5	58	90	110.5	41.8	18.8	2.4	2.71	21.85	120.56	31.08	3.27	7.26	30.7	47.2	27.7	5.2	3.1
TSH0250 X TCB209	51	67.5	92.5	125	43.5	20.8	2.5	2.96	18.8	155.51	27.07	3.68	8.95	36.5	46.5	26.2	5.4	3.5
TSH0250 X CCB36	51.5	56.5	88.5	113	36.5	17.2	1.9	3.05	22.85	121.45	39.15	3.28	7	36.6	43.9	26	5.5	3.5
TSH0250 X DB3	50.5	56.5	90.5	118	36	15.8	3.1	2.28	13.25	119.03	26.77	3.29	9.06	36.3	47.2	25	6.3	3.1
Surabhi X TCB26	52.5	56.5	88.5	100.25	33.7	17.3	2.25	3.08	24.1	122.43	36.14	3.33	7	35.55	46.3	30.9	5.9	3.4
Surabhi X TCB37	53	59	93.5	130.5	42.1	18.9	2.35	2.63	16.4	127.76	27.93	3.43	8.8	36.3	44.3	29	5.9	3.4
Surabhi X TCB209	53.5	58	98	127.5	38.2	18	2.1	2.94	21.25	125.55	32.92	3.28	8.16	37.2	44.7	26.2	5.7	3.3
Surabhi X CCB36	51.5	60	91	108.5	35.1	16.8	2.7	2.45	21	117.94	39.74	3.67	7.25	37.3	43.8	26.5	5.2	2.8
Surabhi X DB3	52.5	60.5	97	111	37.8	17.6	2.2	3.06	18.85	119.45	29.03	3.43	9.11	38.1	44.5	30.1	5.3	3.2
DCH -32	**47**	**56.5**	**90**	**118.5**	**33.7**	**18.7**	**2**	**2.435**	**18.65**	**121.06**	**31.215**	**3.135**	**7.35**	**35.3**	**46.2**	**26.2**	**6.2**	**3.8**

Electronic Journal of Plant Breeding, 10 (2): 827-837(Jun 2019) DOI: 10.5958/0975-928X.2019.00110.8
ISSN 0975-928X

Table 4. Relative heterosis, heterobeltiosis and standard heterosis of promising inter specific F_1hybrids for different traits

	PH			Number of bolls/plant			Number of sympodia/plant			NMPP			BW			NSPB		
	di	Dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
MCU7 x TCB26	28.5*	23.81	-1.27	81.69**	54.27**	50.15**	25.77*	14.38	-2.14	39.68**	12.82	10	-1.39	-5.32	9.65	0.78	-6.3	3.75
MCU7 x TCB37	29.54*	26.46	0.84	96.55**	75.34**	51.93**	22.74*	22.36	5.35	17.65	-9.09	0	16.7	14.95	26.28	19.8	16.46	28.95*
MCU7 x TCB209	26.68*	12.81	15.19	161.05**	150.22**	70.03**	35.38**	33.33**	17.65	65.52**	41.18**	20	43.89**	38.34*	47.43*	1.41	-4.36	5.9
MCU7 x CCB36	15.29	9.52	-2.95	85.81**	82.97**	24.33**	13.66	12.96	-2.14	84.62**	71.43**	20	-5.21	-10.6	-4.72	13.24	-6.78	3.22
MCU7 x DB3	47.53**	44.9**	19.83	121.18**	100.71**	67.36**	32.5**	32.5**	13.37	48.39**	21.05	15	10	2.5	26.49	25.13*	18.16	30.83*
TCH1819 x TCB26	41.22**	36.34**	8.27	86.15**	67.99**	63.5**	61.72**	58.02**	10.7	42.37**	7.69	5	2.42	-10.79	39.22*	-3.92	-16.87	8.31
TCH1819 x TCB37	41.77**	38.68**	10.13	88.49**	79.45**	55.49**	39.16**	23.6*	6.42	31.25*	-4.55	5	17.84	0.39	56.67**	16.44	4.94	36.73**
TCH1819 x TCB209	13.99	1.32	3.46	62.45**	45.83**	14.24*	29.66**	13.94	0.53	48.15**	17.65	0	5.89	-13.68	34.7	-2.11	-14.2	11.8
TCH1819 x CCB36	8.99**	3.33	-8.44	106.17**	89.77**	48.66**	32.4**	17.28	1.6	83.33**	57.14**	10	-0.66	-20.26	24.44	16.07	-10.08	17.16
TCH1819 x DB3	47.32**	44.39**	19.41	95.96**	90.04**	58.46**	45.96**	30*	11.23	44.83**	10.53	5	7.13	-4.08	49.69**	9.96	-3.5	25.74
COD-5-1-2 x TCB26	30.6*	22.5	3.38	85.69**	50.3**	46.29**	32.89**	17.65	6.95	60**	12.82	10	20.8	13.37	49.69**	11.38	6.36	11.26
COD-5-1-2 x TCB37	12.11	6.5	-10.13	47.88**	25.34**	8.61	9.37	6.47	-3.21	-13.33	-40.91**	-35**	21.22	11.04	46.61*	7.92	7.89	12.87
COD-5-1-2 x TCB209	10.95	1.32	3.46	137.29**	133.33**	45.4**	19.4*	17.65	6.95	60**	17.65	0	20.5	5.13	38.81*	4.47	1.23	5.9
COD-5-1-2 x CCB36	5.85	3.33	-8.44	57.18**	50.45**	-0.89	7.23	4.71	-4.81	100**	57.14**	10	-4.08	-17.73	8.62	29.95*	9.43	14.48
COD-5-1-2 x DB3	45.45**	44**	21.52	75.21**	50.89**	25.82**	28.48**	24.71*	13.37	3.7	-26.32*	-30*	7.56	4.04	37.37*	-2.01	-4.92	-0.54
African1-2 x TCB26	8.14	7.17	-19.32	39.39**	26.22**	22.85**	23.13*	15.33	-7.49	76.27**	33.33**	30*	4.65	-7.02	38.6*	-4.61	-20.6*	13.67
African1-2 x TCB37	25.56*	25	-5.06	64.16**	56.85**	35.91**	16.4	12.42	-3.21	6.25	-22.73*	-15	23.87*	7.58	60.37**	7.79	-6.74	33.51*
African1-2 x TCB209	6.66	-7.36	-5.4	80.25**	61.28**	27.3**	11.75	6.67	-5.88	55.56**	23.53	5	23.65	2.62	52.98**	-16.67	-29.78**	0.54
African1-2 x CCB36	25.13*	15.71	2.53	65.98**	52.26**	20.18**	22.44*	17.9	2.14	58.33**	35.71*	-5	-1.01	-19.15	20.53	-5.87	-29.4**	1.07
African1-2 x DB3	45.41**	38.88**	14.85	31.26**	27.76**	6.53	28.39**	24.37*	6.42	58.62**	21.05	15	-6.71	-14.74	27.1	-18.31*	-31.09**	-1.34
VS-9-S11-1 x TCB26	31.74*	31.29*	-2.28	90.38**	50.91**	46.88**	38.57**	30.2*	3.74	37.31**	17.95	15	27.23*	13.1	68.38**	24.52*	13.43	31.37*
VS-9-S11-1 x TCB37	16.72	15.56	-12.24	65.7**	37.33**	18.99**	16.13	11.8	-3.74	16.67	-4.55	5	14.44	-0.55	48.05*	0.24	-4.63	10.46
VS-9-S11-1 x TCB209	6.6	-7.85	-5.91	105.47**	96.67**	22.55**	16.56	10.91	-2.14	41.94**	29.41*	10	-12.29	-27.17*	8.42	-1.75	-9.26	5.09
VS-9-S11-1 x CCB36	12.32	3.33	-8.44	90.34**	77.48**	16.91**	21.54*	16.67	1.07	78.57**	78.57**	25	3.46	-15.45	25.87	2.43	-17.13	-4.02
VS-9-S11-1 x DB3	56.28**	48.47**	22.78*	138.05**	100.36**	67.06**	42.39**	37.5**	17.65	45.45**	26.32*	20	7.69	-1.52	46.61*	-8.64	-15.51	-2.14
TCH1705-101 x TCB26	45.37**	41.55**	4.64	35.85**	20.73**	17.51**	40.64**	30.92*	6.42	15.94	2.56	0	15.71	13.92	36.14	11.29	7.88	9.38
TCH1705-101 x TCB37	49.13**	43.33**	8.86	55.03**	45.21**	25.82**	22.04*	18.63	2.14	45.95**	22.73*	35**	11.19	6.7	27.52	20.8	18.97	24.4
TCH1705-101 x TCB209	17.84	-0.66	1.43	38.06**	25.88**	-4.75	16.72	12.12	-1.07	18.75	11.76	-5	-9.71	-17.7	-1.64	-16.37	-17.72	-16.57
TCH1705-101 x CCB36	-17.02	-25.71	-34.18**	52.2**	42.35**	7.72	-8.28	-11.11	-22.99*	37.93**	33.33*	0	4.41	-6.53	11.7	61.19**	37.49**	39.41**
TCH1705-101 x DB3	53.59**	41.84**	17.3	70.15**	62.28**	35.31**	39.1**	35.62**	16.04	58.82**	42.11**	35**	4.82	3.16	27.31	5.48	3.91	5.36
KC2 x TCB26	33.64**	32.58*	-0.42	36.13**	23.48**	20.18**	23.94*	15.03	-5.88	10.14	-2.56	-5	11.99	8.28	34.29	13.89	8.37	14.21
KC2 x TCB37	7.82	7.22	-18.57	35.24**	29.45**	12.17*	3.18	0.62	-13.37	24.32*	4.55	15	9.75	3.48	28.34	-2.69	-3.08	2.14
KC2 x TCB209	3.81	-9.92	-8.02	37.95**	23.22**	-2.37	13.84	9.7	-3.21	56.25**	47.06**	25	9.7	-1.66	21.97	-2.52	-5.88	-0.8
KC2 x CCB36	17.53	8.57	-3.8	106.54**	89.14**	49.85**	17.46	14.2	-1.07	72.41**	66.67**	25	31.2*	15.56	43.33*	41.19**	18.54	24.93
KC2 x DB3	24.6*	18.88	-1.69	41.97**	38.43**	15.43**	9.9	7.5	-8.02	52.94**	36.84**	30*	11.7	11.42	38.19*	5.51	2.01	7.51
TSH0250 x TCB26	9.48	4.69	-15.19	52.17**	17.84**	14.69**	19.39	7.67	-6.15	46.27**	25.64*	22.5	10.38	9.4	26.69	0.91	-3.4	0.54
TSH0250 x TCB37	18.82	15.1	-6.75	77.12**	43.15**	24.04**	16.05	15.34	0.53	33.33**	9.09	20	-0.64	-2.35	11.09	12.31	12.05	17.16
TSH0250 x TCB209	15.21	3.31	5.49	123.08**	107.14**	29.08**	26.83**	26.06*	11.23	61.29**	47.06**	25	14.42	6.68	21.36	-0.29	-3.14	0.8
TSH0250 x CCB36	12.44	7.62	-4.64	81.59**	64.41**	8.31	5.85	5.52	-8.02	35.71*	35.71*	-5	20.51	10.29	25.46	39.5**	17.72	22.52
TSH0250 x DB3	21.65	20.41	-0.42	56.18**	28.11**	6.82	-2.17	-3.07	-15.51	87.88**	63.16**	55**	-21.04	-24.13	-6.37	-29.82**	-31.74**	-28.95*
Surabhi x TCB26	2.77	-6.74	-15.4	3.22	2.74	0	13.82	0	-7.49	34.33**	15.38	12.5	5.66	2.33	26.49	26.34*	18.14	29.22*
Surabhi x TCB37	32.15**	21.4	10.13	36.47**	29.54**	24.93**	13.17	9.25	1.07	30.56*	6.82	17.5	-7.48	-12.62	8.01	-17.79	-19.61	-12.06
Surabhi x TCB209	11.6	5.37	7.59	42.8**	17.54**	13.35*	6.51	4.05	-3.74	35.48*	23.53	5	8.6	-2.49	20.53	9.82	4.17	13.94
Surabhi x CCB36	2.12	0.93	-8.44	28.34**	8	4.15	0.3	-2.89	-10.16	92.86**	92.86**	35**	-7.53	-18.44	0.82	24.44*	2.94	12.6
Surabhi x DB3	8.03	3.26	-6.33	24.75**	16.31**	12.17*	5.71	1.73	-5.88	33.33*	15.79	10	1.75	1.66	25.67	-2.71	-7.6	1.07
SE+	**11.23**	**12.97**	**12.91**	**1.35**	**1.56**	**1.838**	**1.58**	**1.826**	**1.64**	**0.21**	**0.24**	**0.259**	**0.36**	**0.418**	**0.445**	**2.02**	**2.33**	**2.48**
CD@5%	**25.68**			**3.09**			**3.616**			**0.48**			**0.828**			**4.62**		
CD@1%	**34.11**			**4.105**			**4.80**			**0.638**			**1.10**			**6.14**		

** significant at 1% , * significant at 1%

Table 4 Contd.

	SCYPP			GP			LI			SI			E%			FF		
	di	Dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii	di	dii	diii
MCU7 x TCB26	74.3**	69.35**	11.86*	16.29	11.34	-5.77	30.53*	24.67	6.38	22.72*	15.96	7.28	7.02	-6.15	-1.61	-16.05	-19.05*	-10.53
MCU7 x TCB37	68.42**	57.26**	3.87	-9.69	-20.79*	-11.1	1.76	-7.62	-3.35	20.39	13.75	5.24	-8.8	-25*	-8.06	-18.92*	-28.57**	-21.05
MCU7 x TCB209	118.09**	116.1**	42.73**	-0.14	-3.3	-12.62	45.52**	37.31**	32.06*	71.2**	60.65**	50.82**	5.79	-11.11	3.23	-10	-14.29	-5.26
MCU7 x CCB36	76.74**	54.95**	2.35	2.43	-5.49	-5.38	2.18	-0.53	-10.37	9.71	8.39	-8.57	6.09	-7.58	-1.61	-41.05**	-47.17**	-26.32*
MCU7 x DB3	111.75**	104.24**	45.2**	41.21**	34.71**	25.58*	64.44**	44.35**	63**	30.99**	11.57	30.54*	8.26	-1.67	-4.84	-17.5*	-21.43*	-13.16
TCH1819 x TCB26	69.56**	66.17**	7.84	-7.22	-25.36*	-5.09	22.8*	-4.85	34.45*	47.3**	46.23**	37.28**	0.8	-3.08	1.61	-20**	-29.41*	-5.26
TCH1819 x TCB37	211.97**	193.69**	90.6**	-16.4*	-21.3*	0.06	4.8	-8.8	28.87	28.54**	27.61*	19.8	1.47	-9.21	11.29	13.25	-7.84	23.68*
TCH1819 x TCB209	61.38**	61.31**	4.69	-2.17	-16.33*	6.39	16.86	-1.81	38.76**	26.96**	26.96*	19.18	30.3**	19.44	38.71*	-10.11	-21.57*	5.26
TCH1819 x CCB36	128.61**	101.95**	31.06**	-8.11	-17.88*	4.42	4.48	-14.45	20.89	19.92	13.84	6.87	-7.94	-12.12	-6.45	-36.54**	-37.74**	-13.16
TCH1819 x DB3	96.91**	88.33**	33.89**	-15.25*	-26.56**	-6.62	-5.02	-14.56	20.73	19.16*	7.38	25.65*	30*	30*	25.81	-30.34**	-39.22**	-18.42
COD-5-1-2 x TCB26	82.92**	79.07**	16.48**	6.35	-2.68	-9.23	46.13**	26.66*	34.13*	43.72**	32.53**	45.24**	16.8	12.31	17.74	-20.43**	-31.48**	-2.63
COD-5-1-2 x TCB37	81.77**	70.94**	11.19*	-16.88*	-23.9**	-14.59	19.85	19.13	26.16	47.43**	35.94**	48.98**	-14.71	-23.68*	-6.45	-32.56**	-46.3**	-23.68*
COD-5-1-2 x TCB209	96.55**	96.24**	27.65**	2.98	1.37	-5.45	32.28**	26.2*	33.65*	34**	24.39*	36.33*	-12.12	-19.44	-6.45	-15.22	-27.78**	2.63
COD-5-1-2 x CCB36	71.34**	51.22**	-1.64	0.42	-3.01	-2.9	-0.73	-8.13	-2.71	-3.54	-14.65	-6.46	6.35	1.52	8.06	-38.32**	-38.89**	-13.16
COD-5-1-2 x DB3	176.36**	164.61**	88.12**	-4.68	-4.71	-11.12	21.87*	18.08	33.33*	30.95**	26.8**	48.37**	6.67	6.67	3.23	-30.43**	-40.74**	-15.79
African1-2 x TCB26	24.24**	-1.31	4.44	4.61	-6.09	-8.59	42.3**	24.46	29.03*	41.61**	35.44**	37.28**	11.3	-1.54	3.23	-19.51*	-23.26*	-13.16
African1-2 x TCB37	25.19**	-3.51	2.11	-11.82	-17.67*	-7.59	18.99	18.45	23.92	33.75**	27.92*	29.66*	-1.59	-18.42	0	-6.67	-18.6*	-7.89
African1-2 x TCB209	23.1**	-0.74	5.04	-21.23*	-24.06*	-26.08*	32.16**	27.38*	32.06*	72.26**	65.91**	68.16**	-1.64	-16.67	-3.23	-18.52*	-23.26*	-13.16
African1-2 x CCB36	30.2**	-4.29	1.29	-19.9*	-21.01*	-20.92*	8.48	1.38	5.1	30.62**	19.66	21.29	0	-12.12	-6.45	-35.42**	-41.51**	-18.42
African1-2 x DB3	31.04**	9.53*	15.91**	0.92	-1.22	-3.84	30.93**	25.56*	41.79**	29.16**	20.52*	41.02**	10.91	1.67	-1.61	-13.58	-18.6*	-7.89
VS-9-S11-1 x TCB26	82.01**	52.02**	41.27**	-1.89	-9.49	-17.06	51.16**	43.12**	24.4	47.36**	44.93**	34.08**	-7.02	-18.46	-14.52	-20.99**	-23.81*	-15.79
VS-9-S11-1 x TCB37	65.84**	34.04**	24.56**	-6.38	-14.97	-4.57	48.88**	36.28**	42.58**	65.38**	62.65**	50.48**	2.4	-15.79	3.23	-16.22	-26.19**	-18.42
VS-9-S11-1 x TCB209	31.02**	11.22*	3.35	6.78	6.03	-2.84	8.71	3.48	-0.48	7.38	4.86	-1.56	5.79	-11.11	3.23	-20*	-23.81*	-15.79
VS-9-S11-1 x CCB36	45.87**	12**	4.08	-19.46*	-22.86*	-22.78*	39.82**	37.35*	23.76	68.3**	63.5**	46.26**	11.3	-3.03	3.23	-36.84**	-43.4**	-21.05
VS-9-S11-1 x DB3	67.91**	48.19**	37.71**	2.14	1.27	-5.59	50.04**	32.77**	49.92**	48.53**	31.05**	53.33**	6.42	-3.33	-6.45	-12.5	-16.67	-7.89
TCH1705-101 x TCB26	107.45**	89.26**	42.99**	8.01	2.37	-11.48	26.54*	16.12	7.97	20.75*	12.34	20.75	-4.27	-13.85	-9.68	58.02**	52.38**	68.42**
TCH1705-101 x TCB37	47.28**	29.49**	-2.17	-3.88	-14.91	-4.5	13.64	7.32	12.28	13.06	5.19	13.06	10.94	-6.58	14.52	0	-11.9	-2.63
TCH1705-101 x TCB209	55.32**	44.31**	9.03*	-4.05	-6.12	-15.17	-9.11	-10.61	-14.04	0.81	-5.57	1.5	6.45	-8.33	6.45	-25**	-28.57**	-21.05
TCH1705-101 x CCB36	68.21**	39.5**	5.4	2.25	-4.72	-4.61	-18.64	-19.9	-25.52	-21.21*	-29.68*	-24.42*	1.69	-9.09	-3.23	-45.26**	-50.94**	-31.58**
TCH1705-101 x DB3	76.18**	70.98**	29.18**	3.1	-0.64	-7.37	0.7	-8.19	3.67	-4	-7.91	7.76	23.21	15	11.29	2.5	-2.38	7.89
KC2 x TCB26	78.08**	68.26**	4.83	-2.22	-13.81	-12.53	29.56*	19.93	9.41	39.77**	33.09**	23.13	8.93	-6.15	-1.61	-18.68*	-28.85**	-2.63
KC2 x TCB37	178.21**	173.7**	56.81**	-17.23*	-21.19*	-11.55	26.71*	18.6	24.08	57.92**	50.37**	39.12**	5.69	-14.47	4.84	-14.29	-30.77**	-5.26
KC2 x TCB209	75.23**	62.52**	5.38	-2.26	-7.62	-6.25	56.43**	52.4**	46.57**	71.03**	61.74**	51.84**	4.2	-13.89	0	-22.22**	-32.69**	-7.89
KC2 x CCB36	81.52**	72.24**	-4.52	-10.07	-10.68	-9.35	27.18*	26.4	15.31	48.18**	47.58**	24.49*	-7.96	-21.21	-16.13	-21.9**	-22.64*	7.89
KC2 x DB3	78.22**	58.6**	12.75**	-8.65	-12.37	-11.07	18.12	6.78	20.57	24.14*	6.45	24.56*	14.02	1.67	-1.61	-22.22**	-32.69**	-7.89
TSH0250 x TCB26	57.33**	41.33**	10.53*	-21.04*	-33.06**	-25.48*	10.43	0.34	-4.63	34.96**	30.15*	20.41	-13.27	-24.62	-20.97	-13.51	-17.95	-15.79
TSH0250 x TCB37	46.98**	27.33**	-0.42	-10.91	-11.27	-0.42	4.31	-0.46	4.15	10.64	6.69	-1.29	-16.13	-31.58**	-16.13	-7.46	-11.43	-18.42
TSH0250 x TCB209	79.59**	64.24**	28.45**	-13.98	-22.08**	-13.26	22.94	22.22	17.54	35.45**	29.71*	21.77	-10	-25*	-12.9	-4.11	-7.89	-7.89
TSH0250 x CCB36	56.79**	28.27**	0.32	18.66*	12.69	25.44*	13.01	10.07	4.63	11.87	10.85	-4.76	-3.51	-16.67	-11.29	-20.45**	-33.96**	-7.89
TSH0250 x DB3	31.71**	25.72**	-1.68	-16.12*	-22.94**	-14.22	1.07	-6.92	5.1	21.49*	5.35	23.27	16.67	5	1.61	-15.07	-18.42*	-18.42
Surabhi x TCB26	45.03**	31.06**	1.14	40.02**	31.63**	15.79	28.25*	20.91	6.06	1.82	0.72	-4.76	10.28	-9.23	-4.84	-17.07*	-20.93*	-10.53
Surabhi x TCB37	56.97**	36.75**	5.53	-10.63	-20.29*	-10.54	13.76	4.57	9.41	28**	26.62*	19.73	0	-22.37	-4.84	-9.33	-20.93*	-10.53
Surabhi x TCB209	46.05**	34.39**	3.7	18.3*	16.73	5.48	13.62	8.62	4.47	17.76	17.34	10.95	0	-20.83	-8.06	-18.52*	-23.26*	-13.16
Surabhi x CCB36	53.5**	26.25**	-2.58	35.36**	27.15**	27.29**	31.66*	29.91*	17.07	10.27	4.32	-1.36	-3.7	-21.21	-16.13	-41.67**	-47.17**	-26.32*
Surabhi x DB3	33.1**	27.86**	-1.33	2.67	-0.22	-6.98	8.9	-3.25	9.25	17.11	5.87	23.88*	3.92	-11.67	-14.52	-20.99**	-25.58**	-15.79
SE+	**4.19**	**4.84**	**5.40**	**2.46**	**2.84**	**3.06**	**0.35**	**0.41**	**0.45**	**0.71**	**0.82**	**0.86**	**0.74**	**0.86**	**0.90**	**0.34**	**0.39**	**0.41**
CD@5%	**9.60**			**5.63**			**0.81**			**1.64**			**1.71**			**0.78**		
CD@1%	**12.75**			**7.48**			**1.07**			**2.18**			**2.27**			**1.036**		

** significant at 1% , * significant at 1%

Electronic Journal of Plant Breeding, 10 (2): 827-837(Jun 2019) DOI: 10.5958/0975-928X.2019.00110.8
ISSN 0975-928X

Table 5. General combining ability ofparents in cotton

Parents	PH	NBPP	NSPP	NMPP	BW	NSPB	SCYPP	GP	LI	SI	2.5%SL	UR	BS	E%	FF
Lines															
MCU7	7.83	8.58**	1.14*	0.04	-0.2	0.76	5.25**	1.25	-0.01	-0.44	-0.3	1.06	-0.22	-0.09	-0.23
TCH1819	8.11	7**	1.08*	-0.12	0.29	1.77*	20.28**	1.78*	0.34*	-0.09	-1.22	0.4	-0.1	0.95**	0.29*
COD-5-1-2	2.65	-0.76	0.66	-0.4**	0.17	-0.31	13.91**	-0.87	0.22	0.84**	-0.84	0.76	-0.66	0.27	-0.05
African1-2	-2.61	-1.6**	-0.36	-0.1	0.26	-0.18	-13.45**	-2.35**	0.27	1.21**	0.94	0.28	-0.22	-0.03	-0.11
VS-9-S11-1	-1.11	2.42**	0.56	0.08	0.25	-0.43	6.45**	-1.47	0.32*	0.99**	0.92	0.62	0.2	-0.07	-0.25
TCH1705-101	-0.13	-3.7**	-0.04	0.04	-0.22	0.36	0.02	-0.86	-0.66**	-1.42**	-0.64	0.5	-2.42*	0.31	0.51**
KC2	-7.37	-2.78**	-1.24*	0.14	0.1	-0.16	-2.2	-1.34	0.17	0.71*	0.26	-0.48	0.68	-0.11	0.23
TSH0250	-4.77	-3.61**	-0.73	0.25**	-0.33*	-1.5	-11.41**	0.09	-0.39**	-0.82**	-0.16	-1.08	0.26	-0.67*	-0.17
Surabhi	-2.62	-5.52**	-1.04	0.1	-0.31*	-0.28	-18.85**	3.77**	-0.27	-0.98**	1.07	-2.08	2.46*	-0.53	-0.23
SE	**4.16**	**0.54**	**0.52**	**0.08**	**0.14**	**0.80**	**1.74**	**0.86**	**0.14**	**0.278**	**2.05**	**2.79**	**1.00**	**0.29**	**0.13**
Testers															
TCB26	-4.62	1.36**	-0.09	0	0.18	0.57	-1.4	-0.92	-0.05	0.11	0.4	-1.15	-1.27	-0.14	0.32**
TCB37	-2.67	0.45	-0.23	-0.12	0.14	1.24*	5.42**	-0.42	0.03	0.14	-0.69	-0.24	0.67	0.06	0
TCB209	2.61	-1.16**	0.36	-0.03	-0.05	-1.4*	-2.93*	-0.59	0.11	0.42*	0.18	0.15	0.28	0.21	0.03
CCB36	-9.78**	-2.49**	-0.99*	0.03	-0.29**	0.77	-15.61**	1.53*	-0.39**	-1.26**	-0.16	-0.51	-0.34	-0.28	-0.28**
DB3	14.45**	1.84**	0.95*	0.12	0.02	-1.18	14.52**	0.4	0.3**	0.58**	0.27	1.76	0.67	0.16	-0.06
SE	**3.105**	**0.406**	**0.39**	**0.06**	**0.107**	**0.59**	**1.30**	**0.64**	**0.105**	**0.20**	**1.52**	**2.08**	**0.74**	**0.21**	**0.09**

** significant at 1% , * significant at 1%

Electronic Journal of Plant Breeding, 10 (2): 827-837(Jun 2019) DOI: 10.5958/0975-928X.2019.00110.8
ISSN 0975-928X

Table 6. Specific combining ability of F_1hybrids for yield and quality parameters

Hybrids	PH	NBPP	NSPP	NMPP	BW	NSPB	SCYPP	GP	LI	SI	2.5%SL	UR	BS	E%	FF
MCU7 x TCB26	-4.38	-2.24	-1.51	-0.06	-0.46	-2.58	-9.91*	-0.3	-0.3	-0.83	-0.02	-0.21	1.01	0.2	-0.14
MCU7 x TCB37	-3.83	-0.73	0.03	-0.14	-0.01	1.45	-26.4**	-2.47	-0.68*	-1.01	-0.03	-1.02	-0.03	-0.4	-0.22
MCU7 x TCB209	7.89	6.98**	1.74	0.17	0.69*	-0.21	28.99**	-2.77	0.35	2.06**	0.6	-1.01	-0.44	0.15	0.35
MCU7 x CCB36	-1.22	-7.09**	-0.61	0.11	-0.34	-2.88	-7.22	-2.63	-0.48	-0.63	-0.86	1.95	-0.62	0.34	-0.14
MCU7 x DB3	1.55	3.08*	0.35	-0.08	0.11	4.22*	14.53**	8.16**	1.12**	0.41	0.31	0.28	0.07	-0.3	0.14
TCH1819 x TCB26	6.64	3.84**	0.95	0	-0.22	-2.74	-29.8**	-0.61	0.22	1.03	-0.2	-1.35	-2.71	-0.64	-0.46
TCH1819 x TCB37	6.89	2.05	0.29	0.12	0.25	1.89	63.57**	0.49	-0.02	-0.29	1.59	-1.26	1.85	-0.24	0.96**
TCH1819 x TCB209	-6.29	-10.24**	-1.4	-0.07	-0.1	-0.12	-32.09**	2.64	0.21	-0.61	-3.88	-0.15	-1.56	1.31	0.23
TCH1819 x CCB36	-8	2.69*	0.15	0.07	-0.11	-1.29	12.52**	-0.09	0.14	0.16	1.26	1.01	1.46	-1	-0.16
TCH1819 x DB3	0.77	1.66	0.01	-0.12	0.19	2.26	-14.19**	-2.41	-0.55	-0.29	1.23	1.74	0.95	0.56	-0.58
COD-5-1-2 x TCB26	6.3	5.8**	0.67	0.38*	0.15	-0.11	-12.98**	0.75	0.33	0.68	1.92	0.59	0.25	1.04	-0.02
COD-5-1-2 x TCB37	-11.65	-5.99**	-1.09	-0.4*	0.12	-0.48	-26.2**	-1.44	0.01	0.92	3.51	-3.42	-0.89	-0.66	-0.5
COD-5-1-2 x TCB209	-0.83	8.02**	0.22	0.21	0.11	0.86	2.07	1.59	0.17	-0.29	2.14	0.09	1.1	-0.81	0.47
COD-5-1-2 x CCB36	-2.54	-6.25**	-0.63	0.35	-0.38	0.29	-20.71**	0.27	-0.48	-1.75**	-2.12	0.75	-1.38	0.58	0.18
COD-5-1-2 x DB3	8.73	-1.58	0.83	-0.54**	0	-0.56	57.82**	-1.17	-0.04	0.44	-5.45	1.98	0.91	-0.16	-0.14
African1-2 x TCB26	-15.34	-1.26	-1.01	0.48*	-0.21	0.21	-0.19	2.43	0.13	-0.27	-0.76	0.07	-2.59	0.44	-0.36
African1-2 x TCB37	-0.39	4.05**	-0.07	-0.3	0.36	3.24	-9.84*	2.23	-0.1	-0.87	0.13	0.66	0.57	0.04	0.16
African1-2 x TCB209	-6.07	2.76*	-1.16	0.01	0.37	-0.27	2.06	-3.37	0.07	1.69**	-0.54	-0.83	1.56	-0.31	-0.07
African1-2 x CCB36	15.72	1.69	1.69	-0.25	-0.18	-2.34	10.2*	-3.87	-0.28	-0.08	1.5	-0.07	1.18	-0.02	0.04
African1-2 x DB3	6.09	-7.24**	0.55	0.06	-0.34	-0.84	-2.23	2.58	0.18	-0.47	-0.33	0.16	-0.73	-0.16	0.22
VS-9-S11-1 x TCB26	3.36	2.82*	0.17	0	0.52	3.76*	24.49**	-1.1	-0.07	-0.29	-0.04	0.63	-0.01	-0.62	-0.32
VS-9-S11-1 x TCB37	-10.39	-5.67**	-1.09	-0.08	0.07	-0.81	-2.55	2.29	0.43	0.88	-0.25	0.72	1.35	0.28	-0.1
VS-9-S11-1 x TCB209	-8.17	-2.86*	-1.38	-0.07	-0.71*	0.83	-19.88**	3	-1**	-3.22**	-0.62	0.03	0.64	0.13	-0.03
VS-9-S11-1 x CCB36	1.22	-3.43**	0.57	0.17	-0.04	-3.04	-6.32	-5.34**	0.26	1.97**	0.22	1.29	0.36	0.62	0.08
VS-9-S11-1 x DB3	13.99	9.14**	1.73	-0.02	0.15	-0.74	4.26	1.15	0.38	0.66	0.69	-2.68	-2.35	-0.42	0.36
TCH1705-101 x TCB26	10.58	-0.96	1.27	-0.26	0.21	-1.13	33**	0.03	0.39	1.14	1.22	-0.65	-2.29	-0.7	2.12**
TCH1705-101 x TCB37	13.63	2.75*	0.61	0.56**	0.04	1	-28.49**	1.7	0.46	0.54	0.11	1.94	-2.03	0.6	-0.26
TCH1705-101 x TCB209	-0.45	-5.94**	-0.58	-0.33	-0.48	-4.00*	-6.58	-1.45	-0.45	-0.59	0.24	0.65	1.56	-0.05	-0.99**
TCH1705-101 x CCB36	-30.26**	-0.41	-3.33**	-0.29	0.08	4.27*	1.7	-0.27	-0.31	-0.81	-3.02	-0.39	1.98	-0.16	-1.08**
TCH1705-101 x DB3	6.51	4.56**	2.03	0.32	0.15	-0.14	0.36	-0.01	-0.09	-0.28	1.45	-1.56	0.77	0.3	0.2
KC2 x TCB26	11.82	-0.98	0.17	-0.46**	-0.15	0.29	-10.97**	0.18	-0.39	-0.81	-2.48	-1.07	1.01	0.22	-0.3
KC2 x TCB37	-11.63	-2.77*	-1.09	0.06	-0.25	-2.63	45.14**	-0.02	0	0.33	-0.89	0.82	-1.33	0.42	-0.08
KC2 x TCB209	-4.41	-6.06**	0.22	0.17	-0.22	-0.54	-8.78*	1.81	0.63	0.99	1.24	0.73	0.16	-0.03	-0.21
KC2 x CCB36	12.98	12.87**	1.97	0.11	0.54	2.09	-8.08*	-1.28	0.14	0.66	1.38	-2.81	-1.32	-0.54	0.7*
KC2 x DB3	-8.75	-3.06*	-1.27	0.12	0.1	0.79	-17.31**	-0.69	-0.39	-1.17	0.75	2.32	1.47	-0.08	-0.12
TSH0250 x TCB26	-8.28	-2	-0.39	-0.02	0.09	-0.92	5.14	-5.29**	-0.27	0.52	2.14	-0.77	1.73	-0.42	-0.4
TSH0250 x TCB37	-0.23	2.06	1	0.05	-0.25	1.51	-14.93**	2.03	-0.07	-1.11	-4.27	1.72	0.69	-0.32	-0.18
TSH0250 x TCB209	8.99	5.37**	2.41*	0.06	0.19	1.10	28.36**	-1.81	0.28	0.3	0.66	0.63	-0.42	-0.27	0.19
TSH0250 x CCB36	9.38	-0.3	0.16	-0.6**	0.53	2.98	6.99	8.16**	0.37	0.03	1.1	-1.31	0	0.32	0.5
TSH0250 x DB3	-9.85	-5.13**	-3.18**	0.51**	-0.56	-4.67*	-25.56**	-3.1	-0.31	0.26	0.37	-0.28	-2.01	0.68	-0.12
Surabhi x TCB26	-10.68	-5.04**	-0.33	-0.07	0.07	3.21	1.21	3.92*	-0.05	-1.17	-1.74	2.73	3.63	0.44	-0.14
Surabhi x TCB37	17.62	4.27**	1.41	0.15	-0.34	-5.16*	-0.29	-4.81*	-0.02	0.59	0.1	-0.18	-0.21	0.24	0.18
Surabhi x TCB209	9.34	1.98	-0.08	-0.19	0.15	2.33	5.85	0.36	-0.26	-0.33	0.13	-0.17	-2.62	-0.11	0.05
Surabhi x CCB36	2.73	0.21	0.07	0.35	-0.09	-0.09	10.92**	5.06*	0.64*	0.44	0.57	-0.41	-1.7	-0.12	-0.14
Surabhi x DB3	-19*	-1.42	-1.07	-0.24	0.2	-0.29	-17.7**	-4.52*	-0.3	0.46	0.94	-1.98	0.89	-0.46	0.04
SE (D)	**9.31**	**1.21**	**1.17**	**0.18**	**0.32**	**1.79**	**3.90**	**1.92**	**0.31**	**0.62**	**4.58**	**6.24**	**2.243**	**0.65**	**0.29**

** significant at 1% , * significant at 1%