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ESTIMATES OF COMBINING ABILITY AND HETEROSIS THROUGH LINE × TESTER IN EGYPTIAN COTTON

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ABSTRACT

General Combining ability of parents, specific combining ability of hybrids and heterosis over better parent were studied in a cross involving ten cotton genotypes (6 lines × 4 testers) for yield and quality traits. The six lines were Egyptian cotton genotypes Giza 70, Menofi, Giza 86, Giza 89, Ashmoni and Dandara, While the four testers were involved two foreign cotton genotypes (BBB and Suvin) and two Egyptian cotton genotypes (Giza 92 and Giza 88). Ten parents and 24 F_1 hybrids were laid out in completely randomized block design with three replications at Sakha Agriculture Research Station in 2011 season. Analysis of variance revealed highly significant differences among genotypes, parents and crosses indicating the presence of considerable amount of genetic variability. Parents VS crosses was also significant, except for most fiber characters, indicating the presence of heterotic response for these characters. The magnitude of SCA variance was greater than GCA variance for all characters indicating the importance of SCA. The maximum contribution to the total variance was made by line × tester interaction for most characters. While the contribution of testers were higher than lines.

The results reported that the best general combiner; for earliness were Dandara and Giza 86, for yield were Suvin amd Giza 92 and for fiber quality was Giza 70. On the basis of specific combining ability SCA effect for yield and its components characters in relation to significant positive heterosis over better parent, the crosses Giza 86 × Suvin, Dandra × Suvin and Giza 86 × BBB exhibited highest magnitude of positive significant SCA with desirable heterosis for yield characters. Therefore, these hybrids may be preferred to improve several yield characters simultaneously by selection or may be used for hybrid cotton crop development.

Kaywords. *Gossypium barbadense*, combining ability, Heterosis.

INTRODUCTION

Breeders reply on genetic variation between parents to create unique gene combination necessary for new superior cultivars. This, breeders tend to select genetically – diverse parents having different genes for cotton breeding programs for higher yield and best fiber quality.

High seed cotton yield is the ultimate objective of any breeding program. Seed cotton yield is the end product of number of yield components such as boll number, boll weight etc. Industrial demand of cotton with superior fiber quality traits is also source of guide line for cotton breeders.

Seed cotton yield and its components as well as fiber quality characters are quantitative characters, which are controlled by several genes, thus showing a range of values in segregating generation. Such characters are highly affected by environmental conditions, thus genotypes ×

environment interaction is an important and essential component of plant breeding programs dedicated to cultivar development. (Yuan *et al* (2005)).

Combining ability analysis an important tool for the selection of desirable parents together with the information of grading nature and magnitude of gene effects controlling the quantitative characters. The success of the hybridization program depends on the ability of the parents entering into hybridization to yield desirable recombinant Khorgade *et al* (2000), Christopher *et al* (2003) and Ahuja and Dhayal (2007).

Previous studies showed that variation in seed cotton yield and its components as well as fiber quality characters were influenced by additive and non-additive gene action Cheatham *et al* (2003) reported that fineness and length exhibited primarily dominance gene effects, fiber percentage and fiber strength by additive gene effects, fiber yield and fiber elongation are controlled equal by additive and non-additive effects. Rauf *et al* (2005) showed that SCA was greater in magnitude and more important for seed cotton yield, number of bolls and plant height, while additive gene action predominated for boll weight and fiber strength.

The high magnitude of variance due to SCA effects give us indication of non-additive type of gene action which makes interesting to estimate useful heterosis manifested by various cross combinations in particular characters. Heterosis and hetero beltiosis in cotton have been reported by various workers (Tuteja *et al* 2003, Rauf *et al* 2005 and Jatoi *et al* (2010)).

The purposes of this study were (i) to estimate general and specific combining abilities for yield, its components and fiber quality characters (ii) to identify appropriate parents and crosses for the investigated characters (iii) to determine heterosis for 24 F_1 combinations developed by 6 × 4 line × tester mating system and the pattern of gene action and heritability for some earliness, yield and its contributed characters as well as fiber quality characters.

MATERIALS AND METHODS

Ten cotton genotypes were selected as parents based on agronomic and technological performance which eight cotton genotypes as Egyptian genotypes, varied in yield capacity and fiber quality characters, and two foreign genotypes. Giza 70, Menofi, Giza 86, Giza 89, Ashmoni and Dandara were used as lines; BBB, Suvin, Giza 92 and Giza 88 were used as testers and crossed in a line × tester mating design in 2010 growing season at Sakha Agric. Res. Stat. to generate a total of 24 hybrids. Ten cotton parents and 24 F_1 hybrids were grown in the randomized complete block design with three replicates at the same experimental area in 2011 growing season. Each plot contained one row of 4.0 m length and 0.70 m width. Hills were spaced at 40 cm apart. At seedling stage, hills were thinned to keep constant stand of one plant / hill. The recommended cultural practices were applied. At the end of season, randomly sample of five plants were harvested from each plot to determine the studied yield and fiber characters.

Traits measurement and statistical analysis:

Data were recorded on days to first flower (D.F.F),position of first fruiting node (P.F.F.N.), seed cotton yield / plant (SCY/P), lint yield / plant (LY/P) in gm, boll weight (B.W) in gram, number of bolls / plant (N.B/P), lint percentage (L%), seed index (Si). A high volume instrument (HVI) was used to measure, micronaire (Mic), fiber length (UHM), fiber strength (Str) and fiber uniformity (UI). The analysis of variance was carried out to study the difference among the genotypes. The general combining ability (GCA) affects of the parents and the specific combining ability (SCA) effects of the hybrids were estimated by the using of line × tester analysis method described by Kempthorne (1957) and adopted by Singh and Choudhry (1979).

Heterosis in F_1 hybrids were computed in relation to better parent value. Heritability estimates in narrow and broad senses was computed by using the formula suggested by Allard 1960 as follow

$$h_b^2 = \frac{6^2 G}{6^2 Ph} \times 100, \qquad h_n^2 = \frac{6^2 A}{6^2 Ph} \times 100$$

RESULTS AND DISCUSSION

The results of the analysis of variance for line × tester population are presented in (Table 1). Mean squares of genotypes found to be highly significant for all characters investigated indicating the presence of considerable amount of genetic variability. Significant differences were detected among parents and hybrids for all studied characters except for uniformity ratio among parents. The variation due to parents Vs crosses was also significant most characters except for days to first flower, seed index, fiber length and fiber strength indicating the presence of heterotic response for these traits.

The combining ability further revealed that variances due to lines, testers and line × testers were non-significant for most studied characters except due line × testers which showed significant for most studied characters.

The magnitude of SCA variances was greater than GCA for all studied characters (Table 1), indicating that additive × additive and non-additive types of interactions were significantly higher among hybrids, thus which could be exploited by heterosis breeding. Similar results were obtained by Ahuja and Tuteja (2001), Verma *et al* (2004) and Kumar *et al* (2009).

The proportional contributions of lines, testers and their interactions to the total variance for different characters (Table 2) revealed that the maximum contribution to the total variance for most characters was made by line × tester interaction. While the contribution of testers were higher than lines for most characters. This indicates the unequal magnitude of the role of either lines or testers in the expression of specific combining ability and heterosis. Similar results were obtained by Gooda (2007) and El-Mansy and EL-Lawendy (2008).

T1

Table 2. Proportion contributions of lines , testers and their interaction for the studied characters.

Traits	Line	Tester	Line X Tester
Days to first flower	28.56	34.35	37.09
Position of first fruiting node	12.42	2.95	84.63
Boll weight in gram	24.08	20.85	55.06
Number of bolls / plant	10.43	23.03	66.54
Seed cotton yield / plant	7.01	28.3	64.7
Lint yield / plant	5.4	33.23	61.37
Lint percentage	16.38	44.2	39.42
Seed index	41.15	20.33	38.52
Micronaire	7.29	32.8	59.92
Fiber length	22.63	18.38	59
Fiber uniformity	24.82	64.58	10.6
Fiber strength	13.83	26.87	59.3

The ultimate choice of parents in a breeding program in generally based on the per-se performance of parents and their F_1's, however GCA and SCA effects are more informative than per-se performance values, since it also reveals the type of gene effects. The estimated of general combining ability effects of lines and testers (Table 3) revealed significant differences among the parents. Among the line parents, Dandara was a good general combiner for earliness characters followed by tester parent Giza 92. With respect to yield and yield components characters, the Egyptian parents Giza 86 and Dandara as well as Indian genotype Suvin were good general combiner for most yield and its' contributing characters which showed significant positive GCA effects. The other parents were found to be a poor combiner for most yield characters.

Concerning to fiber quality characters (Table 3). The Egyptian varieties Giza 92, G 88 and Giza 70 were the best combiners for most fiber quality characters, with superior of Giza 92. High GCA effects are mostly due to additive gene effects or additive × additive interaction effects.

The correlation among GCA effects for the studied character were summarized in (Table 4). The genes effected GCA for days to first flower were correlated with each of those for lint percentage and micronaire reading. Uniformity ratio was negatively significant association with position of first fruiting node, lint yield and lint percentage, and positively associated with both fiber length and strength. Selection for high lint percentage significantly decreased for fiber length and uniformity ratio. These correlations among characters should provide cotton breeder with insights on possible impacts of selection for one characters on others. Mendez-Natera *et al* (2012) detected significant correlation among GCA effects for yield and fiber characters.

T3-4

T4On the basis of specific combining ability effects (Table 5) revealed that, the cross combination Giza 89 × BBB and Giza 88 × Menofi exhibited significant desirable SCA values for earliness characters. As both parents of this crosses were low combiners, this indicated the accumulation of favorable genes in them probably resulted in high SCA effects.

The cross combinations Dandra × Suvin and Giza 70 × BBB showed maximum significant SCA effects for number of bolls / plant, seed cotton yield and lint yield. The combinations G 86 × Suvin and Ashmoni × G 88 gave desirable SCA effect for most yield characters. On the other side Giza 70 × Giza 88 showed high significant and negative specific combining ability effects for all yield characters followed by crosses Giza 70 × Suvin and G 89 × BBB indicating unfavorable combinations.

The cross combination Giza 70 × Giza 88 and Menofi × Giza 92 exhibited significant positive SCA effects for most fiber quality characters. While the cross Menofi × Giza 88 showed the maximum significant negative desirable value SCA effect value for micronaire reading.

The significant estimated and positive general and specific combining ability effects indicated that the epistasis and / or dominance effect in F_1 hybrids in cotton could be important to certain extent (Tang *et al* 1993) and Basbage *et al* (2007).

Heterosis estimates over better parent are presented in (Table 6). It is indicated that four F_1 combinations showed significant desirable heterosis over better parent for days to first flower. The cross combination Ashmoni × G92 showed the best value for earliness character. The cross combinations G. 86 × BBB, G. 86 × Suvin and Dandra × Suvin showed the best useful heterosis for most yield characters. The parents involves in these combinations were distantly related with different geographic origin.

There is no any cross combination showed desirable heterosis for all fiber characters. This was true since parents VS crosses mean squares were non-significant for fiber characters.

From the present study it can be concluded that the performance of parents dose not seem to be an index of GCA effects in the material therefore, the which high GCA effects for economic characters can be used for concentration breeding program and crosses with high SCA effects, for exploitation of hybrid vigor. In a situation where both additive and non-additive variance were important recurrent selection approach would be appropriate for rapid improvement of yield. This can be achieved by adapting inter population mating in F_2 among selected crosses or following selection.

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تقدير القدرة علي التآلف وقوة الهجين من خلال تحليل السلالة X الكشاف في القطن المصري

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أجريت هذه الدراسة لتقدير كل من القدرة العامة على الإئتلاف للآباء و القدرة الخاصة على الإئتلاف للهجن و كذلك تقدير قوة الهجين لأفضل الآباء للـ24 تركيب وراثى الناتجين من الجيل الأول و الذى نتج من (6×4) بطريقةالسلالة × الكشاف عن طريق نظم التزاوج لدراسة 12 صفة و قد تمت زراعة هذه التجربة فى محطة البحوث الزراعية بسخا فى عام 2011م.

* أظهر تحليل التباين إختلافات معنوية عالية بين التراكيب الوراثية و التى أظهرت تغير فى الإختلافات الوراثية ، و سلوك الآباء داخل الهجن كان معنوى لجميع الصفات عدا معظم صفات التيلة و هذا يدل على تحكم السيادة فى تلك الصفات ، و التى توضح وجود قوة الهجين لهذه الصفات.
* و أظهرت الدراسة أن تباين القدرة الخاصة على الإئتلاف كان أفضل من تباين القدرة العامة على الإئتلاف لكل الصفات مما يدل على أهميتها.
* وجد أن أعلى مساهمة نسبية من التباين الكلى كان يرجع إلى تفاعل السلالة × الكشاف لمعظم الصفات مما يدل على أهمية السيادة لتلك الصفات، بينما كانت المساهمة النسبية للكشافات (Testers)أعلى من السلالات (Lines) فى تلك الصفات.
* أوضحت النتائج أن التركيب الوراثى دندرة و الصنف جيزة86 كانا الأفضل لتحسين صفة التبكير بينما كان التركيب الوراثى سوفين و الصنف جيزة92 الأفضل لتحسين صفة المحصول أما بالنسبة لصفات التيلة فقد كان الصنف جيزة 70 هو الأفضل.
* وجد أن هناك علاقة موجبة ما بين تأثير القدرة الخاصة على الإئتلاف و قوة الهجين على أساس الأب الأفضل و على هذا فإنه يمكن إستخدام هذه الهجن (جيزة 86 × سيوفين ، دندرة × سوفين و جيزة 86 × BBB) فى برامج التربية لتحسين معظم صفات المحصول بإستخدام الإنتخاب فى الأجيال الإنعزالية او بإستخدام القطن الهجين.

قام بتحكيم البحث

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Table 1. Analysis of variance and mean squares of the studied characters.

Source of Variation	df	Days to first flower	Position of first fruiting node	Boll weight in gram	Number of bolls / plant	Seed cotton yield / plant	Lint yield / plant	Lint percentage	Seed index	Micronaire	Fiber length	Fiber uniformity	Fiber strength
Rep.	2	24.34**	1.45*	0.17	14.95	17.53	3.3	0.26	1.33	0.03	2.42**	43.13**	9.79
Genotypes	33	19.80**	1.62**	0.07	180.35	2268.94	372.05	6.42	0.45	0.13**	5.10**	1.67**	12.87**
Parents	9	17.19**	1.61**	0.05	17.41	270.54	36.44	6.53	0.5	0.22**	8.87**	0.86	10.58**
Parent versus crosses	1	7.73	8.84**	0.4	1987.38	26992.28	4416.83	21.36	0.07	0.24**	0.67	12.07**	5.31
Crosses	23	21.34**	1.30**	0.06	165.54	1975.99	327.52	5.73	0.44	0.09**	3.82**	1.54**	14.09**
Testers	3	56.20*	0.29	0.1	292.26	4286.92	838.42	19.41	0.69	0.21	5.38	7.62**	29.03
Lines	5	28.04	0.74	0.07	79.44	636.81	81.36	4.32	0.83	0.03	3.98	1.76**	8.97
Line X tester	15	12.14**	1.69**	0.05	168.9	1960.2	308.19	3.46	0.26	0.08**	3.46**	0.25	12.82**
Error (B)	66	2.61	0.46	0.03	15.76	187.82	28.39	0.85	0.24	0.02	0.33	0.59	3.56
GCA		0.258	0.013	0.004	0.002	1.092	0.572	0.057	0.001	0.004	0.009	0.03	0.038
SCA		3.176	0.41	0.006	51.047	590.793	93.267	0.87	0.006	0.02	1.043	0.114	3.086
GCA/SCA		0.081	0.032	0.667	0	0.002	0.006	0.066	0.107	0.2	0.009	0.263	0.012

***, ** significant and highly significant at .05 and .01 probability levels, respectively.**

Table 3. General combining ability effects of the parental genotypes (lines and testers) for the studied characters.

Parents	Days to first flower	Position of first fruiting node	Boll weight in gram	Number of bolls / plant	Seed cotton yield / plant	Lint yield / plant	Lint percentage	Seed index	Micronaire	Fiber length	Fiber uniformity	Fiber strength
Lines :												
G.70	-1.46**	0.32	0	-0.56	-0.97	-0.88	-0.43	-0.30*	0.04	0.86**	-0.24	1.42*
Menofi	-0.18	-0.16	-0.02	1.64	4.69	1.59	-0.1	0.18	-0.06	-0.47**	-0.03	-0.95
G.86	0.23	0.28	0.12*	-0.72	1.25	1.39	0.63*	0.37*	0.02	-0.70**	-0.60**	-0.64
G.89	2.15**	-0.22	-0.05	2.29*	6.13	2.56	0.26	-0.25	0.04	0.45**	0.49*	0.38
Ashmoni	1.15*	0.01	0.04	-4.55**	-13.97**	-4.71**	0.55*	0.12	0.03	-0.13	0.18	-0.46
Dandara	-1.88**	-0.23	-0.10*	1.9	2.87	0.05	-0.91**	-0.12	-0.06	-0.01	0.2	0.24
LSD 0.05	0.93	0.39	0.1	2.29	7.9	3.07	0.53	0.28	0.08	0.33	0.44	1.09
LSD 0.01	1.24	0.52	0.13	3.04	10.49	4.08	0.71	0.38	0.1	0.44	0.59	1.44
Testers :												
BBB	1.54**	0.15	-0.04	1.01	2.11	1.45	0.46*	-0.25*	0.05	-0.17	-0.49**	-1.38**
Suvin	0.69	-0.04	0.09*	4.78**	18.82**	8.52**	1.21**	0.14	0.09**	-0.61**	-0.63**	-0.49
G.92	-2.54**	-0.15	0.03	-0.89	-2.18	-2.27	-1.13**	0.17	-0.16**	0.70**	0.55**	0.26
G.88	0.31	0.03	-0.08*	-4.90**	-18.74**	-7.70**	-0.54*	-0.06	0.01	0.08	0.57**	1.62**
LSD 0.05	0.76	0.32	0.08	1.98	6.45	2.51	0.43	0.23	0.06	0.27	0.36	0.89
LSD 0.01	1.01	0.42	0.11	2.63	8.57	3.33	0.58	0.31	0.08	0.36	0.48	1.18

***, ** significant and highly significant at .05 and .01 probability levels, respectively.**

Table 4. Correlation coefficients between GCA effects among the ten influential cotton genotypes.

characters	Days to first flower	Position of first fruiting node	Boll weight in gram	Number of bolls / plant	Seed cotton yield / plant	Lint yield / plant	Lint percentage	Seed index	Micronaire	Fiber length	Fiber uniformity	Fiber strength
Days to first flower												
Position of first fruiting node	0.08											
Boll weight in gram	0.07	0.44										
Number of bolls / plant	0.05	-0.32	0.08									
Seed cotton yield / plant	0.06	-0.19	0.30	0.98*								
Lint yield / plant	0.21	-0.10	0.39	0.94*	0.98*							
Lint percentage	0.77*	0.30	0.58*	0.29	0.40	0.57						
Seed index	-0.13	-0.02	0.70*	-0.09	0.05	0.09	0.23					
Micronaire	0.73*	0.49	0.23	0.15	0.21	0.35	0.80*	-0.26				
Fiber length	-0.40	-0.06	-0.38	-0.23	-0.29	-0.40	-0.66*	-0.60*	-0.33			
Fiber uniformity	-0.20	-0.60*	-0.58	-0.44	-0.55	-0.65*	-0.68*	-0.20	-0.57	0.59*		
Fiber strength	-0.36	0.06	-0.36	-0.39	-0.44	-0.51	-0.56	-0.40	-0.09	0.68*	0.55	

***, ** significant and highly significant at .05 and .01 probability levels, respectively.**

Table 5. Estimates of specific combining ability effects for the studied characters.

Crosses	Days to first flower	Position of first fruiting node	Boll weight in gram	Number of bolls / plant	Seed cotton yield / plant	Lint yield / plant	Lint percentage	Seed index	Micronaire	Fiber length	Fiber uniformity	Fiber strength
G.70 X BBB	-1.09	-0.57	0.02	7.28**	23.55**	8.84**	0.15	0.07	0.19*	-1.28**	0.08	-1.19
Menofi X BBB	1.52	-0.2	0.08	6.99**	25.44**	11.69**	1.43**	0.18	0.19*	-0.22	0.22	0.04
G.86 X BBB	1.77	0.42	0.11	3.47	16.47*	7.97*	1.41**	0.21	-0.08	-1.12**	-0.54	1.25
G.89 X BBB	-2.48**	0.08	-0.03	-10.90**	-36.81**	-15.07**	-0.94	-0.13	-0.21**	1.14**	-0.02	-1.18
Ashmoni X BBB	0.74	0.07	-0.07	-2.75	-11.56	-6.69*	-2.03**	0.1	-0.03	1.17**	0.34	0.64
Dandara X BBB	-0.45	0.21	-0.1	-4.09	-17.09*	-6.74*	-0.03	-0.42	-0.06	0.32	-0.08	0.44
G.70 X Suvin	0.09	-0.27	-0.05	-7.27**	-26.59**	-10.77**	-0.43	-0.01	-0.14	0.85*	-0.09	-1.66
Menofi X Suvin	1.59	0.07	0.14	-11.49**	-33.20**	-11.63**	0.94	-0.5	-0.04	1.31**	0.46	1.8
G.86 X Suvin	0.29	0.22	-0.12	6.99**	19.81*	6.82*	-0.66	0.26	0.03	0.97**	-0.06	0.17
G.89 X Suvin	-1.29	-0.67	0.03	0.72	3.73	1.71	-0.01	-0.19	0.17*	-0.73*	-0.04	1.13
Ashmoni X Suvin	-0.19	0.59	0.04	0.2	2.28	1.26	0.23	0.25	0.16*	-1.63**	-0.2	-1.42
Dandara X Suvin	-0.49	0.06	-0.04	10.85**	33.97**	12.62**	-0.06	0.2	-0.18*	-0.77*	-0.07	-0.02
G.70 X G.92	1.54	0.62	0.19	2.69	16.34*	7.19*	0.87	0.04	-0.06	-0.32	-0.01	-2.28*
Menofi X G.92	-0.52	1.44**	-0.02	3.67	11.79	2.59	-1.22*	0.14	0.05	0.51	-0.31	1.23
G.86 X G.92	-1.82	-0.56	0	-6.48**	-23.21**	-9.53**	-0.76	-0.07	0.02	0.17	0.28	-0.22
G.89 X G.92	-0.74	-0.61	-0.02	8.64**	27.31**	10.51**	0.4	-0.02	-0.05	-0.04	0.15	-0.86
Ashmoni X G.92	-0.85	-0.74	-0.06	-0.88	-4.8	-0.92	0.72	0	-0.19*	-0.18	-0.23	1.54
Dandara X G.92	2.40*	-0.15	-0.09	-7.64**	-27.43**	-9.84**	0	-0.08	0.23**	-0.14	0.11	0.59
G.70 X G.88	-0.54	0.22	-0.16	-2.69	-13.3	-5.26	-0.59	-0.09	0.02	0.74*	0.01	5.13**
Menofi X G.88	-2.59**	-1.30**	-0.20*	0.82	-4.03	-2.64	-1.15*	0.19	-0.21**	-1.59**	-0.37	-3.07**
G.86 X G.88	-0.23	-0.08	0.01	-3.98	-13.07	-5.26	0.02	-0.4	0.03	-0.01	0.32	-1.2
G.89 X G.88	4.51**	1.20**	0.02	1.53	5.77	2.85	0.55	0.34	0.09	-0.37	-0.08	0.91
Ashmoni X G.88	0.3	0.08	0.08	3.44	14.08	6.34*	1.09*	-0.34	0.07	0.64	0.09	-0.76
Dandara X G.88	-1.45	-0.12	0.23*	0.88	10.55	3.96	0.08	0.31	0.01	0.6	0.03	-1.01
LSD 0.05	1.86	0.78	0.2	4.58	15.8	6.14	1.06	0.57	0.15	0.66	0.89	2.17
LSD 0.01	2.47	1.04	0.27	6.08	20.99	8.16	1.41	0.75	0.2	0.88	1.18	2.89

***, ** significant and highly significant at .05 and .01 probability levels, respectively.**

Table 6. Heterosis relative to the better parent for the studied traits.

Hybrid	days to first flower	Position of first fruiting node	boll weight in gram	number of bolls / plant	seed cotton yield / plant	lint yield / plant	lint percentage	seed index	Micronaire	fiber length	fiber uniformity	fiber strength
G.70 X BBB	-2.8	12.82	4.55	62.42**	75.46**	73.23**	-1.37	-6.93	14.09**	-6.76**	-2.26*	-4.8
Menofi X BBB	3.74*	38.31**	5.4	75.66**	84.69**	90.16**	2.84	-1.71	11.49**	-4.56**	-0.66	-1.72
G.86 X BBB	6.71**	27.35**	10.01*	52.96**	69.54**	77.70**	4.54*	0.31	7.03**	-7.79**	-3.67**	-4.1
G.89 X BBB	3.66*	19.64*	1.37	4.94	8.3	7.96	-2.4	-8.26*	4.05	1.98	-1.1	-5.87
Ashmoni X BBB	1.6	17.94*	-4.89	14.22	8.67	1.45	-6.61**	-3.36	8.25**	0.4	-0.85	0.83
Dandara X BBB	-0.3	16.24	-4.24	33.94**	27.37*	26.51	-3.11	-9.69**	5.41*	-1.69	-0.77	1.98
G.70 X Suvin	2	13.56	2.44	6.37	9.18	17.46	5.37*	-0.26	7.63**	-2.05	-2.62**	-3.87
Menofi X Suvin	5.85**	39.90**	7.77	-0.14	8.23	21.97	8.55**	-0.36	7.70**	0.04	-1.04	4.94
G.86 X Suvin	4.62*	20.34*	3.76	52.03**	57.32**	73.26**	1.06	6.89	11.58**	-1.22	-3.30**	-4.5
G.89 X Suvin	5.08**	4.46	3.42	41.47**	46.22**	62.19**	8.73**	-2.5	15.40**	-2.32	-1.29	1.22
Ashmoni X Suvin	5.24**	22.03*	2.02	17.64	24.90*	40.52**	1.05	1.46	14.71**	-6.65**	-1.64*	-1.43
Dandara X Suvin	0.62	10.17	-0.45	73.03**	72.95**	85.79**	7.52**	2.28	4.37	-3.79**	-1.37	3.46
G.70 X G.92	-4.72**	19.35*	9.07*	27.88*	40.50**	44.20**	2.5	-1.06	5.40*	-1.67	-1.17	-4.02
Menofi X G.92	-4.48*	63.84**	1.84	38.87**	41.68**	37.90**	-3.74	4.2	5.68*	-1.07	-1.05	-1.53
G.86 X G.92	-3.81*	1.62	6.6	-4.24	0.83	1.66	-5.28**	4.04	6.92**	-2.70*	-1.55*	-4.01
G.89 X G.92	0.46	3.57	1.05	58.21**	59.71**	64.07**	3.13	-1.09	5.54*	-0.03	0.06	-3.19
Ashmoni X G.92	-5.26**	-4.84	-2.57	1.86	4.23	7.39	-3.66	-0.52	1.66	-2.07	-0.71	0.21
Dandara X G.92	-1.96	0	-2.83	0.82	-1.93	-3.23	-1.23	-0.47	9.98**	-1.61	-0.3	-0.35
G.70 X G.88	-2.68	12.5	1.19	3.27	5.61	5.93	0.1	-7.41*	8.94**	-0.45	-1.14	13.10**
Menofi X G.88	-3.44	14.9	-4.73	40.61**	34.80*	32.48*	-1.94	-0.76	0.67	-10.39**	-0.63	-9.55**
G.86 X G.88	2.29	11.29	5.79	9.56	15.59	13.41	-1.71	-4.28	8.22**	-6.64**	-1.49*	-4.9
G.89 X G.88	11.59**	35.71**	2.99	29.09*	34.31*	42.09**	5.43*	-3.23	10.10**	-4.44**	0.04	1.82
Ashmoni X G.88	1.94	-1.45	-1.55	16.13	14.11	12.69	-1.2	-5.93	9.29**	-3.24*	0.08	-3.55
Dandara X G.88	-3.32	1.59	4.87	30.29*	35.47**	41.02**	2.24	-2.3	5.65*	-3.02*	0.11	-2.6
LSD .05	2.63	1.11	0.29	6.47	22.34	8.69	1.5	0.8	0.21	0.93	1.25	3.07
LSD .01	3.5	1.47	0.38	8.6	29.68	11.54	2	1.07	0.28	1.24	1.67	4.08

***, ** significant and highly significant at .05 and .01 probability levels, respectively.**