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Evaluation of *Gossypium Hirsutum* L. Genotypes for Combining Ability Studies of Yield and Quality Traits

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ABSTRACT: Current study was carried out to study plant material for good quality and high yielding cotton varieties. For this purpose combining ability effects were calculated for different plant traits related to yield and quality in upland cotton. The present study revealed the potential of different varieties for breeding programme. All six parents i.e. FH-945, MNH-93, MNH-129, CIM-496, CIM-446 and NIAB-78 displayed their prospective general and specific combining abilities for various characters except boll weight and fiber strength. CIM-496 proved the best general combiner for number of boll per plant, seed cotton yield, lint percentage, fiber length and fiber fineness while MNH-129 followed closely. The hybrid CIM-496 × NIAB-78 displayed diligent specific combining ability for number of bolls per plant, CIM-496 × NIAB-78 for seed cotton yield, MNH-129 × CIM-446 for lint percentage and CIM-496 × CIM-446 for fiber length. Some of the hybrids involved one parent with good and one with poor general combining ability e.g., CIM-446 × NIAB-78 for number of bolls per plant, CIM-446 × NIAB-78 for seed cotton yield, MNH-93 × NIAB-78 for lint percentage and MNH-93 × CIM-446 for fiber length. Parameters with dominance gene effects revealed that the genes having non-additive influence were present in the genetic makeup of the characters, and this pattern of inheritance seems to be complex, suggesting that further genetic advance may be possible by making hybrids. While parameters having additively controlled genetic action will have scarce complexion in their inheritance, suggesting that further genetic advance may be possible by making single plant selection from F_2 generation.

Keywords: *Gossypiun hirsutum*, general combining ability, specific combining ability, gene action, yield, quality

Gossypium Hirsutum L Genotiplerinin Verim ve Kalite Karakterlerinin Combine Yeteneği Çalışmalarının Değerlendirilmesi

ÖZET: Bu çalışma, iyi kaliteli ve yüksek verimli pamuk çeşitlerinin değerlendirmesi amacıyla yürütülmüştür. Bu amaçla, pamuk çeşitlerindeki verim ve kalite ile ilgili farklı bitki karakterleri için kombinasyon yeteneği etkileri hesaplanmıştır. Mevcut çalışma ıslah programları için farklı çeşitlerin potansiyelini ortaya koymuştur. FH-945, MNH-93, MNH-129, CIM-496, CIM-446 ve NIAB-78 gibi 6 ebeveyn koza ağırlığı ve lif mukavemeti hariç bitkilerin genel ve özel kombine yetenekleri için farklı karakterler göstermiştir. CIM-496 bitki başına koza sayısı, pamuk çiğidi verimi, tiftik oranı, lif uzunluğu ve lif inceliği yönünden en iyi genel kombinasyonu vermiş, bunu MNH-129 hattı takip etmiştir. CIM-496xNIAB-78 hibridi bitki başına koza sayısı yönünden, CIM-496xNIAB-78 hibridi pamuk çiğidi verimi, MNH-129xCIM-446 hibridi en iyi tiftik oranı, CIM-496xCIM-446 hibridi ise en iyi lif uzunluğu spesifik kombine yeteneğini vermiştir. Bazı hibritlerde ebeveynlerden birisi iyi genel kombine yeteneği gösterirken bazılarında zayıf combine yeteneği göstermiştir. Örneğin, CIM-446xNIAB-78 bitki başına koza sayısı, CIM-446xNIAB-78 pamuk çiğidi verimi, MNH-93xNIAB-78 tiftik oranı ve MNH-93xCIM-446 lif uzunluğu yönünden böyle bir özellik göstermiştir. Dominant gen etkisiyle elde edilen parametreler karakterlerin genetik manipülasyonunda genlerde eklemeli olmayan etkinin mevcut olduğunu ortaya koymuş ve bu durum kalıtsallığın kompleks olabileceğini, hibrit oluşturmada daha ileri genetik değerlendirmelerin gerektiğini göstermiştir. Genetik tezahürü eklemeli kontrol eden parametreler kalıtsallıkta az tesirli olacağından f2'den sonra tek bitki seleksiyonu yapmak suretiyle daha ileri genetik değerlendirmenin mümkün olabileceğini göstermektedir.

Anahtar kelimeler: *Gossypium hirsutum*, genel kombine yeteneği, özel kombine yeteneği, gen tezahürü, verim, kalite

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INTRODUCTION

Cotton is a major fiber crop and contributes a large share in the economy of Pakistan. Cotton is the main source of foreign exchange earnings. There is need to enhance cotton yield and quality to become a key producer in the global cotton market. All cotton breeders aim to develop cotton cultivars with good fiber quality and yield. Yield of cotton can be improved by improving characteristics that make genotype of cotton plant, such as; developmental characters (optimum plant height, number of sympodial and monopodial branches, number of nodes or internodal length and earliness), economic characters (number of bolls per plant, boll size or weight, yield of seed cotton) and quality traits (lint percentage or ginning out turn, lint index, seed index, staple length, fiber strength and fiber fineness). Plant breeder should combine these desirable components of yield and quality. Informations about combining ability, gene action and heterosis are important in breeding programs superior cotton cultivars.

Combining ability method is important in the breeding programme as it provide information's about the heritability of crossing parents involved in the production of hybrid cotton seeds. It provides a specific guide line to the plant breeder about the establishment of a unique breeding experiment for the evolution of spectacular cotton varieties. Owing to the immense importance in the economy of Pakistan, scientists have been continuously exploring the local as well as exotic cotton germplasm. Additive and non-additive type of gene action for fiber length and fiber strength and finess respectively was reported by May and Green (1994), Haq and Azhar (2004), while non-additive and additive genetic effects were reported for staple length and fiber length respectively were reported by Ajmal et al., (2000), Khan et al. (2001) and Ahmad et al. (2003). Rahman et al., (2007) reported dominance type of gene action in the phenotypic expression of fiber fineness. Ali *et al* (2008) reported additive type of gene action for staple length, fiber fineness and fiber elongation while over-dominance type of gene action for fiber strength and fiber uniformity. Laxman et al. (2003), Neelima et al. (2004), Tuteja et al. (2004) and Nirania et al. (2004) conducted genetic studies for determining the genetic control of yield and yield related traits. These scientists devised additive as well as non-additive type of gene action for the control of yield component traits.

Therefore six cotton (*Gossypiun hirsutum* L.) varieties were evaluated to determine the genetic potential of elite parental combinations having remarkable combining abilities of yield and quality traits. Apart from determining the genetic potential of parents combining ability estimate also depict the type of gene action underlying the yield as well as the fiber quality traits of cotton. On the basis of genetic information controlling the potential traits forthcoming breeding strategies will be outlined.

MATERIALS AND METHOD

The material consisted of six cotton varieties (*Gossypium hirsutum* L.), namely FH-945, MNH-93, MNH-129, CIM-496, CIM-446 and NIAB-78. These six cotton varieties were sown in experimental farm of department of Plant Breeding and Genetics, University of Agriculture Faisalabad and crosses were made in all possible combinations except reciprocals. All plants were emasculated in the evening and pollinated during next morning. As a result 15 F_1 hybrids were produced. In the next growing season these 15 F_1 hybrids along with their six parents were grown in the field. The Randomized Complete Block design by means of three replications was used to conduct the experiment.

Drilling machine was used for sowing of cotton in sandy loam soil with pH 7.8. Row to row (75 cm) and plant to plant (30cm) distance was maintained for proper aeration and sunlight penetration. Recommended dosages of Nitrogen and Phosphorus i.e., 125-75 kg ha^{-1} were applied in the form of Urea and DAP. Dual Gold 960 EC @ 2.5 lit per hectare was applied before sowing to control weeds. Cultural practices, such as thinning and hoeing were manually followed in the field. Insects' population was kept below threshold level through the application of insecticides such as Systoate 400ml/acr and Azodrin 500 ml acre^{-1}. After plants matured the data was recorded from all genotypes on number of bolls per plant, seed cotton yield, boll size or weight, ginning out turn or lint percentage, fiber length, fiber strength and fiber fineness. In order to evaluate general and specific combining ability studies of yield and quality traits analysis of variance was carried out as suggested by Steel and Torrie (1997).

RESULTS

The analysis of variance of bolls per plant, boll weight, seed cotton yield, ginning out turn, fiber length, fiber strength and fiber fineness was carried out and data are presented in Table 1. Mean squares obtained from analysis of variance of number of bolls per plant, seed cotton yield, ginning out turn fiber length were found to have significant genotypic differences. So they

Table 1. Means, general and specific combining ability effects of various earliness traits of cotton

Parents	NBP	SCY	GOT	FL	FF
GCA					
FH-945	0.36	5.03	-0.26	0.47	-0.21
MNH-93	0.3	3.78	-0.25	-0.25	0.096
MNH-129	1.6	5.11	-0.055	-0.78	-0.04
CIM-496	0.013	0.6	0.47	0.053	0.19
CIM-446	-1.89	-5.06	0.27	-0.38	0.084
NIAB-78	-0.4	-9.46	-0.17	0.88	-0.12
S.E. (sij-sik)	0.88	2.83	0.28	0.46	0.083
Crosses	**SCA**	**SCA**	**SCA**	**SCA**	**SCA**
FH-945 × MNH-93	1.11	-1.85	0.13	-1.14	0.087
FH-945 × MNH-129	0.39	1.58	-0.14	0.12	-0.04
FH-945 × CIM-496	-0.25	1.87	0.43	-0.21	0.23
FH-945 × CIM-446	4.73	11.87	0.034	0.46	-0.033
FH-945 × NIAB-78	-2.75	-8.52	0.33	0.85	-0.097
MNH-93 × MNH-129	3.54	1.82	0.26	0.41	0.017
MNH-93 × CIM-496	-1.94	-2.42	0.23	0.043	0.25
MNH-93 × CIM-446	6.54	15.36	-0.45	0.78	-0.17
MNH-93 × NIAB-78	-5.44	-10.55	0.53	0.25	0.19
MNH-129 × CIM-496	7.33	12.47	0.098	0.23	-0.21
MNH-129 × CIM-446	3.9	9.84	0.73	-1.018	0.096
MNH-129 × NIAB-78	-9.33	-11.07	-1.17	0.53	-0.04
CIM-496 × CIM-446	-3.58	-11.28	-0.16	1.077	0.19
CIM-496 × NIAB-78	7.59	32.74	0.57	0.38	0.084
CIM-446 × NIAB-78	2.91	15.44	0.11	-0.12	-0.12
S.E.(sij-sik)	2.33	7.5	0.75	1.22	0.083

Table2. Combining ability analysis of various traits of 21 genotypes of *Gossypium hirsutum* L.

		NBP	SCY	GOT	FL	FF
	MS	10.49*	290.13**	0.75*	2.90*	0.18 *
GCA	σ^2	-2.49	9.26	0.06	0.3	0.02
	V_A GE	-4.98	18.53	0.12	0.60	0.039
	MS	30.41**	216.00**	0.27 ^{NS}	0.51 ^{NS}	0.022 ^{NS}
SCA	σ^2	27.28	183.79	0.057	-0.33	-0.006
	V_D GE	27.28	183.79	0.057	-0.33	-0.0055
	σ^2GCA/σ^2SCA	-0.09	0.05	1.05	-.90	-3.33

were further analyzed for analysis of combining ability. While mean squares of boll weight and fiber strength were non-significant and were unable to be subjected to the combining ability analysis.

Number of bolls per plant: Analysis of variance of number of bolls per plant showed that 15 crosses and 6 parents revealed highly significant (76.29, P < 0.01) differences for the character. These results suggested that data for the character may be analyzed genetically following combining ability technique, and results of analysis are presented in Table 2. The mean squares revealed that effects of general combining ability and specific combining ability were significant (P < 0.05) and highly significant (P < 0.01), respectively (Table 2). The magnitude of variance resulting from general combining ability was lower (-2.49) than that of specific combining ability (27.28), this showed that variation was affected by dominant gene effects (V_D= 27.28, Table 3).

The assessment of the parent for their general combining ability for number of bolls per plant was made and is given in Table 1. As effects of general combining ability on controlling the inheritance of number of bolls per plant were highly significant, therefore comparison of estimates showed that two parents, CIM-446 and NIAB-78 attained negative values (-1.89 and -0.40), respectively and were declared as poor general combiners for the character. Remaining parents attained positive values i.e. FH-945 (0.36), MNH-93 (0.30), MNH-129 (1.60) and CIM-496 (0.013) and clearly showed better general combining ability for number of bolls per plant.

The potential of parents was compared in their combinations, and the comparisons are given in Table 1. The ranking order showed that out of 15 crosses, nine combinations attained positive values, namely, CIM-496 × NIAB-78 (7.59), MNH-129 × CIM-496 (7.33), MNH-93 × CIM-446 (6.54), FH-945 × CIM-446 (4.73), MNH-129 × CIM-446 (3.90), MNH-93 × MNH-129 (3.54), CIM-446 × NIAB-78 (2.91), FH-945 × MNH-93 (1.11) and FH-945 × MNH-129 (0.39) for number of bolls per plant. The remaining crosses in Table 1 attained negative values and showed poor specific combining ability effects for number of bolls per plant.

Boll weight: The data on average boll weight for all 15 crosses and 6 parents subjected to analysis of variance showed that the mean squares were not significant (0.06). This suggested absence of differences among them for the character. Therefore, the data was not analyzed further using Griffing approach (1956).

Seed cotton yield: Analysis of variance of seed cotton yield showed that the degree of seed cotton yield in 15 crosses and 6 parents differed significantly (703.6, P < 0.01) from each other for the character. Therefore, the data were further analyzed in order to determine the genetic mechanism controlling seed cotton yield. The results of combining ability analysis are presented in Table 2, which revealed that differences for general combining ability and specific combining ability were significant (P < 0.01, Table 2). The variance resulting from general combining ability was lower (9.26) than that due to specific combining ability (183.79); which, indicated that variation was affected by dominance gene effects (V_D = 183.79, Table 2) in the inheritance of seed cotton yield.

The parents were compared individually for their general combining ability for seed cotton yield (Table 1). As the effects of general combining ability on controlling seed cotton yield were significant (Table 2), therefore, only two parents, CIM-446 and NIAB-78 attained negative values (-5.06 and -9.46), respectively and were identified as poor general combiners for the character. Remaining four parents attained positive values for FH-945 (5.03), MNH-93 (3.78), MNH-129 (5.11) and CIM-496 (0.60) and clearly showed better general combining ability for seed cotton yield.

The performance of parents was compared in their specific combinations, and the comparisons are given in Table 2. The comparison ranking order showed that out of 15 crosses, nine combinations attained positive values, namely, CIM-496 × NIAB-78 (32.74), CIM-446 × NIAB-78 (15.44), MNH-93 × CIM-446 (15.36), MNH-129 × CIM-496 (12.47), FH-945 × CIM-446 (11.87), MNH-129 × CIM-446 (9.84), FH-945 × CIM-496 (1.87), MNH-93 × MNH-129 (1.82) and FH-945 × MNH-129 (1.58) for seed cotton yield. The remaining crosses CIM-496 × CIM-446 (-11.28), MNH-129 × NIAB-78 (-11.07), MNH-93 × NIAB-78 (-10.55), FH-945 × NIAB-78 (-8.52), MNH-93 × CIM-446 (-2.42) and FH-945 × MNH-93 (-1.85) attained negative values and showed poor specific combining ability effects for seed cotton yield.

Lint percentage (G.O.T): Genotypic difference among 15 crosses and 6 parents were significant (1.17, P < 0.05) for lint percentage when the data were subjected to variance analysis. The results of analysis for combining ability are presented in Table 1. Significant differences were observed for GCA and non significant differences for SCA (P < 0.05, Table 2). The variance due to general combining ability was higher (0.060) compared to specific combining ability (-0.057), which showed that additive variance (V_A = 0.12, Table 3) due to general combining ability controlled the inheritance of lint percentage.

The contribution of individual parent to lint percentage was accomplished by comparing their GCA as in Table 1. Effects of general combining ability on controlling lint percentage were shown to be significant (Table 2), but further analysis revealed that four parents, FH-945, MNH-93 MNH-129 and NIAB-78 attained negative values (-0.26, -0.25, -0.050 and -0.17), respectively and proved poor general combiner for the character.

Remaining parents attained positive values i.e. CIM-496 (0.47) and CIM-446 (0.27) and had the best general combining ability for lint percentage.

The values of specific combining ability of different parental combinations are given (Table 1). The ranking order showed that out of 15 crosses, eleven combinations attained positive values, namely, MNH-129 × CIM-446 (0.73), MNH-93 × NIAB-78 (0.59), CIM-496 × NIAB-78 (0.57), FH-945 × CIM-496 (0.43), FH-945 × NIAB-78 (0.33), MNH-93 × MNH-129 (0.26), MNH-93 × CIM-496 (0.23), CIM-446 × NIAB-78 (0.11), FH-945 × MNH-93 (0.13), MNH-129 × CIM-496 (0.098) and FH-945 × CIM-446 (0.034) for lint percentage and these are better specific combiner for this character. The remaining crosses in Table 1 attained negative values and showed poor specific combining ability effects for lint percentage.

Fiber length: Statistical analysis of data revealed that fiber length differed significantly among 21 genotypes for the character (P < 0.01). Due to significant genotypic differences the data were further analyzed following combining ability technique and results of analysis are presented in Table 3. The mean squares for general combining ability and specific combining ability were significant (P < 0.05), respectively (Table 3). The magnitude of variance resulting from general combining ability was higher (0.30) than that due to specific combining ability (-0.33), this showed that variation was affected by additive gene effects (V_A = 0.60, Table 3).

The parents were compared individually for their general combining ability for fiber length (Table 1). Although mean square of GCA on controlling fiber length was statistically significant (P < 0.01, Table 2), yet further analysis revealed that three parents, MNH-93, MNH-129 and CIM-446 attained negative values of -0.25, -0.78 and -0.38 respectively and declared the poor general combiners for the character. Three parents attained positive values i.e. FH-945 (0.47), CIM-496 (0.053) and NIAB-78 (0.88) and these were identified as best general combiners for fiber length.

The parents in their specific combinations were studied, and the comparisons are given in Table 1. The ranking order showed that out of 15 crosses, ten combinations attained positive values, namely, CIM-496 × CIM-446 (1.07), FH-945 × NIAB-78 (0.85), MNH-93 × CIM-446 (0.78), MNH-129 × NIAM-78 (0.53), FH-945 × CIM-446 (0.46), MNH-93 × MNH-129 (0.41), CIM-496 × NIAB-78 (0.38), MNH-93 × NIAB-78 (0.25), MNH-129 × CIM-496 (0.23), FH-945 × MNH-129 (0.12) and MNH-93 × CIM-496 (0.043) for fiber length and displayed good specific combiner. The remaining crosses attained negative values and showed poor specific combining ability effects for fiber length.

Fiber strength: Mean square values for fiber strength were found to be non significant (P < 0.05) for 21 genotypes, suggesting the genetic similarity among them (Table 1) restricting Griffing approach (1956) analysis.

Fiber fineness: All genotypes showed significant (0.18) differences among them for fiber fineness. Therefore, the data was further analyzed following Griffing approach (1956) and the results of analysis are present in (Table 2). These results showed that mean squares for general combining ability and specific combining ability were significant and non significant (P < 0.01), respectively (Table 2). The resulting variance of general combining ability was higher (0.019) compared to specific combining ability (-0.0055), thus displaying that additive gene effects (V_A = 0.039, Table 3) were more important for the character.

General combining ability of the six parents for fiber fineness was determined and is given in Table 1. The results of combining ability showed that three parents, FH-945, MNH-129 and NIAB-78 attained negative values of -0.21, -0.041 and -0.12 , respectively and were declared as poor general combiner for the character. Remaining three parents attained positive values i.e. MNH-93 (0.096), CIM-496 (0.19) and CIM-446 (0.084) and declared as positive general combiner for fiber fineness.

The potential of parents was compared in their specific combinations, and the comparisons are given in (Table 1). The comparison showed that out of 15 crosses, eight combinations attained positive values, namely, MNH-93 × CIM-496 (0.25), FH-945 × CIM-496 (0.23), MNH-93 × NIAB-78 (0.19), MNH-129 × CIM-446 (0.15), MNH-93 × MNH-129 (0.017), CIM-446 × NIAB-78 (0.016) and CIM-496 × NIAB (-0.00019) for fiber fineness and these were good crosses for the character. Remaining crosses mentioned in Table 2 attained negative values and showed poor specific combining ability effects for fiber fineness.

DISCUSSION

Fiber quality and yield improvement is an important objective in most cotton breeding programs, although the factors that determine these traits are not completely understood. Biometrical analysis of the data revealed that number of bolls per plant, seed cotton yield, lint percentage, fiber length and fiber fineness were genetically manifested. The genetic variability in each character was further partitioned into various components i.e. due to general and specific combining ability as out lined by Griffing approach (1956).

Mean squares of general combining ability (GCA) were significant for all five traits; number of bolls per plant, seed cotton yield, ginning out turn, fiber length and fiber fineness, showing or expressing the role of Additive gene action (Table 1). Mean squares of specific combining ability were significant for number of bolls per plant and seed cotton yield indicating non-additive or dominance effects. The results for seed cotton yield are inconsistent with the findings of Bhardwaj and Kapoor (1998), who found that seed cotton yield was controlled by additive and non-additive genetic effects but contradicted for lint percentage which was controlled by additive genetic variance only. Specific combining ability effects for GOT, fiber length and fiber fineness were non-significant.

The study of general combining ability is useful in parental lines in terms of their projected hybrid combinations. The comparison of performance of six parents for their general combining ability shows that parent FH-945 proved the best general combiner for seed cotton yield and fiber length. While MNH-93 was the best general combiner for number of bolls per plant, seed cotton yield and fiber strength. MNH-129 was also the best general combiner for number of bolls per plant and seed cotton yield.

Genotype CIM-496 proved to be the best general combiner for number of bolls per plant, seed cotton yield, lint percentage, fiber length and fiber fineness. Parent CIM-446 was the best general combiner for lint percentage and fiber strength. Genotype NIAB-78 was proved to be best general combiner for fiber length.

The relative contribution of general and specific combining ability provides some understanding on the genetic control of the characters. It is reported that parents having good GCA for a particular trait are expected to yield good hybrids (Khan et al., 1991), and this behavior of the parents was found similar to present studies.

For number of bolls per plant four parents attained positive values i.e. FH-945 (0.36), MNH-93 (0.30), MNH-129 (1.60) and CIM-496 (0.013) and showed the best general combining ability for number of bolls per plant. CIM-496 × NIAB-78, MNH-129 × CIM-496, MNH-93 × CIM-446 and FH-945 × CIM-446 proved good hybrids for number of boll per plant. For boll weight, there was no significance difference among the genotype; therefore data were not analyzed further using Griffing approach (1956).

Four parents i.e. FH-945 (5.03), MNH-93 (3.78), MNH-129 (5.11) and CIM-496 (0.60) attained positive values and had the best general combining ability for seed cotton yield. CIM-496 × NIAB-78, CIM-446 × NIAB-78, MNH-93 × CIM-446, MNH-129 × CIM-496, FH-945 × CIM-446, MNH-129 × CIM-446 and FH-945 × CIM-496 were good hybrids for seed cotton yield, as they involved parents having awesome general combining ability for the character, therefore additive gene action is suggested for the said trait. Similar results were obtained by Kiani et al., (2007) who reported that both additive and non-additive components of genetic variances were important in the inheritance of yield. Parents i.e. CIM-496 and CIM-446 attained positive values (0.47), (0.27) respectively and clearly showed best general combining ability for lint percentage. MNH-129 × CIM-446, MNH-93 × NIAB-78, CIM-496 × NIAB-78, FH-945 × CIM-496, FH-945 × NIAB-78, MNH-93 × MNH-129 and MNH-93 × CIM-496 were good hybrids for lint percentage, as they involve parents that have good general combining ability for the character.

Varieties FH-945, CIM-496 and NIAB-78 attained positive numerical values i.e. (0.47), (0.053) and (0.88) showing best general combining ability for fiber length. Whereas CIM-496 × CIM-446, FH-945 × NIAB-78, MNH-93 × CIM-446, MNH-129 × NIAB-78 and FH-945 × CIM-446 proved good hybrids for fiber length. Three parents attained positive values i.e. MNH-93 (0.096), CIM-496 (0.19) and CIM-446 (0.084) showed better general combiner for fiber fineness. MNH-93 × CIM-496, FH-945 × CIM-496, MNH-93 × NIAB-78, MNH-129 × CIM-446, MNH-93 × MNH-129 and CIM-446 × NIAB-78 were good hybrids for fiber fineness. For fiber strength there was no significance difference among the genotype; therefore data were not analyzed further using Griffing approach (1956).

It is not always necessary that all the hybrids should be produced from parents having high GCA; sometimes the parents with poor GCA may produce potential hybrids. The present results are supported by Azhar and Rana (1993) and Islam et al., (1998).

Additive and non-additive genes effects are discussed below for all character. For number of bolls per plant non additive genetic effects were important, similar results were found by Murtaza et al., (1995), Hassan et al., (1999) and Neelima et al., (2004), while additive effects were shown for the character by the findings of Khan et al., (1992) and Ahmad et al., (1997). For fiber length additive type of gene action was present and this confirms the findings of Khan et al., (1994) and Liu and Han (1998) while deviate from the findings of Cheatham et al., (2003) according to which Australian and wild cotton varieties have the genes to improve fiber quality and fineness and length primarily exhibit dominance genes effects, whereas fiber percentage and fiber strength are controlled by additive gene effects; yield and fiber quality and proposed that these traits could be improved by using these varieties in the U.S.A breeding studies.

CONCLUSION

In the present investigation, results may provide a guide line to breeder while handling breeding material. Parents CIM-496, FH-945, MNH-129 and NIAB-78 proved better general combiners for most of the investigated parameters and hybrids such as CIM-446 × NIAB-78, FH-945 × MNH-93, CIM-496 × CIM-446, CIM-496 × NIAB-78, MNH-129 × CIM-446 and FH-945 × CIM-446, were found to be best specific combiners and are recommended to be utilized in future studies. It has been reported that the characters controlled by non additive gene action may have low heritability (Falconer and Mackay, 1996), suggesting that the segregating population are not amenable to selection pressure in early generations like F_2, as selection must be delayed till the genes are established in the breeding population. By contrast, variation in characters controlled by additive gene action might have high heritability (Falconer and Mackay, 1996), as these characters were controlled by the additive gene action so plants having good characters would be easily identified in F_2 population.

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