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NATURE OF COMBINING ABILITIES AND GENETIC INTERPRETATION FOR SOME QUANTITATIVE TRAITS IN EGYPTIAN COTTON

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ABSTRACT

This investigation was conducted with the objective of approaching an efficient parental choice of cotton cultivars in the breeding program for developing superior cultivars for high yielding and good fiber quality. Five Egyptian cotton genotypes were crossed in a diallel pattern, *i.e.* in all possible combinations, excluding reciprocals in season 2009. In the summer 2010, field evaluation experiment of 15 entries (5 parents and 10 F_1's) was undertaken. The data revealed that there were noticeable differences between the parental genotypes for their positive significant general combining ability (GCA) effects for most studied traits. In generall, the magnitude of GCA mean squares was mostly greater than SCA mean squares expressed as GCA/SCA ratio, indicated that the magnitude of additive and additive x additive genetic effects were considerable in the inheritance of all characters rather than non-additive effects, except for boll number, where the effects were mainly non-additive.

The parental genotype Giza 83 (P_4) superseded all other parents for GCA effect and showed the highest GCA effects for lint yield and was also in the 2[nd] rank for seed cotton yield. Giza 81 (P_3) had maximum GCA effects for seed cotton yield followed by Giza 85 (P_2) for boll number.

Furthermore, Giza 75 (P_1) was in the 1[st] rank by having maximum GCA effects for fiber strength and showed desirable negative GCA effects for fiber fineness, revealing that these parental genotypes could be considered as good combiners in breeding program for developing high yielding genotypes. Out of 10 hybrids, five hybrid combinations, *i.e.* $P_1 \times P_2$, $P_1 \times P_3$, $P_1 \times P_4$, $P_1 \times P_5$ and $P_4 \times P_5$ showed desirable specific combining ability and heterotic effects for most of the studied traits.

***Key words:** combining ability, cotton, heterosis, G. barbadense, mean performance.*

1. INTRODUCTION

Cotton the "white gold" is an important fiber crop and plays vital roles as a cash crop in many countries such as Egypt. Development of a new variety with high yield and fiber quality is the primary objective of all cotton breeders. The need to further amplify efforts for continued genetic improvement of cotton for yield and quality traits in Egypt is even greater today than before in view of a low production per unit area and low fiber quality as compared to other advanced cotton growing countries of the world to meet the challenges of the 21[st] century.

Breeders of self pollinated crops are primarily interested in combining desirable genes from different genotypes into a single genotype to create variability for a characteristic they wish to improve (Dabholkar, 1992). F_1s may exhibit superior performance due to dominance and/or non-allelic interaction. In advanced generations, however, linkage breaks and new combinations are formed. This leads to dissipation of superiority because the degree of dominance observed in the F_1s declines and appearance of new re-combinations, which showed superiority due to non- allelic interaction.

However, Tang *et al.* (1993) in cotton reported superior F_2s over parents, as they might have a broader range of adaptation than conventional cultivars due to high heterosis. In order to improve productivity, one of the most important steps in a breeding program is the detection of suitable parents. In the current study combining ability analysis (general and specific) was used as a tool to differentiate between good and poor combiners, followed by selection of appropriate crosses. One of the techniques, widely used for this purpose in different crops, including cotton, is diallel analysis (Hayman, 1954 a,b and Dabholkar, 1992). Diallel analysis leads to identification of parents and the appropriate breeding program (Murtaza *et al.*, 2005).

In cotton, heterosis has a potential of increasing yield from 10-20% and improving fiber quality. identification of genetic diversity and GCA effects of parents before crossing reduces the number of crosses to be made and the progenies to be screened and leads to a reduction in cost and time (Kumar, 1999).

Studies of Shakeel *et al.*(2001) and Ahuja and Dhayal (2007) revealed that seed cotton yield, number of bolls and boll weight were influenced by genes acting non-additively. On the contrary, studies of Ashokkmar *et al.* (2010) indicated that additive and non- additive gene effects were important for controlling seed cotton yield and number of bolls.

However, Luramge *et al.* (2007) revealed additive gene effects for fiber strength and micronaire value and non-additive gene action for fiber length. Non-additive gene action for fiber quality traits (fiber length, fiber strength and micronaire reading) have been reported by Hassan *et al.* (2000) and Preeth and Raveendran (2008).

effects for yield contributing parameters and fiber quality of diallel crosses among five different cotton genotypes and to determine appropriate parents and crosses for improving the investigated traits.

2. MATERIALS AND METHODS

2.1. Genetic materials and experimental procedures

Five long staple genotypes belonging to Egyptian cotton *(Gossypium barbadense)* germplasm were crossed in a diallel mating design, without reciprocals in season 2009. In the summer 2010, 15 entries (5 parents and 10 F_1's) were planted in 25 March, for field evaluation in the Experimental Station, Fac. Agric., Fayoum Univ. The experimental design was randomized complete blocks with three replications. Plot area was one row; 4 x 0.60 m. Restricted randomization was applied where single rows of F_1 of specific cross combinations were surrounded by its two respective parents. The used parents are presented in (Table 1).

Table (1): Pedigree, origin, year of release and main fiber quality traits of cotton varieties used *

Genotype	Origin	Year of release	Fiber quality traits		
			2.5% FL (mm)	FF (μg/inch)	FS (g/tex)
Giza 75 (P_1)	Giza 67x Giza 69	1975	34.00	4.50	33.00
Giza 85 (P_2)	Giza 67 x C.B.58	1993	30.00	4.10	29.90
Giza 81(P_3)	Giza 67x (A 5844)	1983	31.40	4.20	34.70
Giza 83 (P_4)	Giza 72x Giza 67	1992	30.40	4.20	27.50
Giza 90 (P_5)	Giza 83 and Dandara	2000	30.80	4.20	31.20

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Recently, a great attention of several investigators has been directed to carefuly study combining abilities and heterotic effects in cotton (Abo El-Zahab and Amein, 2000 a and b, Mosalem *et al.*, 2003, Sorour *et al.* (2000), Abd El-Hamid and Esmail (2001).

As for Fayoum region, it is known that the obsolete varieties; Giza 75, Giza 85, Giza 81 and Giza 83 were cultivated since 1975 and replaced by Giza 90 in the current time. However, most of the obsolete varieties proved to be good combiners as judged by their ability to transmit high yield to their progenies and were employed in crosses to develop new promising cotton varieties.

The purposes of this research were to estimate the amount of heterosis and the GCA and SCA

2.2. Characters measured

Ten individual random guarded plants from each plot were monitored and tagged to collect data. The studied traits were; seed cotton yield per plant (SCY, g), lint yield per plant (LY, g), boll number per plant (BN), boll weight (BW, g), ginning outturn (GOT, %), fiber length (FL, mm), fiber strength (FS, g/tex) and fiber fineness (FF, μg/inch).

After the harvest, seed cotton samples were ginned on a mini-laboratory roller-gin for measuring lint percentage and fiber quality. Fiber samples were analyzed for fiber quality properties by High Volume Instrument (HVI).

2.3. Statistical manipulation of the data

General (GCA) and specific (SCA) combining abilities were computed according to Griffing's method 2 (parents and one set of F_1's are included but not reciprocals, *i.e.*{P(P+1)/2} combinations, model 1 (fixed effects). Forms of analysis given by Griffing (1956) and Singh and Chaudhary (1979) were applied. Magnitude of heterosis in terms of percentage of increase (+) or decrease (-) of F_1 over mid parents (MP) for each character was calculated (Falconer, 1981).

3. RESULTS AND DISCUSSION

3.1. Analysis of variance

The analysis of variance exerted significant differences among entries for each trait (Table 2) among parents (P), F_1 crosses (C), genotypes (G) and P vs C for cotton yield, its components and fiber quality traits. The significant variation among parents indicated that the data are reliable for further analysis by diallel mating procedure as suggested by Griffing (1956). The mean squares of general and specific combining ability for most studied yield and fiber quality traits were significant and highly significant in F_1 generation.

The magnitude of the GCA/ SCA ratios indicated that additive gene effects were more important in controlling all traits, except boll number, where the effects were non-additive (Table 2). These results agreed with those obtained by Ashokkmar *et al.* (2010), Khan *et al.* (2011) and Lu and Myers (2011).

3.2. Combining abilities

Estimates of general and specific combining ability effects for the five cotton varieties and their hybrids in yield, its component and fiber quality traits are shown in Table (3). The results showed high positive GCA and SCA effects in the studied traits. These findings indicated that the parental genotype Giza 83 (P_4) superseded all other parents for GCA and showed the highest GCA effects for lint yield and was also in the 2nd rank in GCA effects for seed cotton yield.

The genotype Giza 81 (P_3) had maximum GCA effects for seed cotton yield followed by Giza 85 (P_2) for boll number. While, Giza 75 (P_1) was in the 1st rank by having maximum GCA effects for fiber strength and showed desirable negative GCA for fiber fineness.

Moreover, Giza 85 (P_2) and Giza 90 (P_5) showed desirable GCA effects in some cases, revealing that these varieties could be considered as good combiners in breeding programs for developing high yielding and fiber quality genotypes. While, the other parental genotypes showed negative GCA effects and could be considered as poor combiners for most studied traits.

Significant or highly significant positive SCA effects were obtained for seed cotton yield per plant by the crosses; P_1 x P_2, P_1 x P_4, P_2 x P_3, P_3 x P_5 and P_4 x P_5. Furthermore, desirable SCA effects for lint yield were exerted by four crosses; P_2 x P_4, P_2 x P_5, P_3 x P_4 and P_4 x P_5.

The cross combination P_1 x P_4 was the best in SCA effects for SCY, while for LY the cross P_2x P_5 was the best. Concerning fiber length trait, estimates of SCA effects were significant or highly significant for the three hybrids; P_1 x P_2, P_1 x P_3 and P_1 x P_4. While, for fiber strength, the pronounced SCA effects were detected by the two crosses P_1 x P_3 and P_3 x P_4.

In the meantime, desirable negative SCA effects for fiber fineness were exerted by three crosses; P_1 x P_2, P_1 x P_4 and P_1 x P_5. Out of 10 hybrids, five hybrid combinations; i.e. P_1 x P_2, P_1 x P_3, P_1 x P_4, P_1 x P_5 and P_4 x P_5 showed desirable specific combining ability effects for most studied yield and fiber quality traits .

These findings confirm the data obtained in Table (4) which showed the magnitude of heterosis effects. This indicates the presence of allelic interaction.

It is worthy to mention that high x low, low x high and in some cases high x high GCA parents performed well in F_1 of high SCA effects and reveal also the best mean performance. Similar results were noted by Shakeel *et al.* (2001), Ahuja and Dhayal (2007), Luramage *et al.* (2007) Preeth and Raveendran (2008) and Ashokkmar *et al.* (2010).

3.3. Heterosis

The cross P_4 x P_5 showed highly significant positive and negative heterosis for SCY, LY, BN, GOT and FF traits with estimated values of 13.14, 38.28, 20.84, 21.12, and 8.23 %, respectively. However, the three crosses; P_1x P_3 , P_1x P_5 and P_2 xP_4 also showed highly significant positive heterotic effects for boll weight ,fiber length and fiber strength (Table 4). These findings confirm the data obtained in Table (3) which showed the magnitude of SCA effects. This indicates the presence of allelic interaction. Similar results were noted by Pavasia *et al.* (1999) ,Sorour *et al.* (2000), Abdel–Hamid and Esmail (2001) and Rauf *et al.* (2005).

3.4. Mean performance of genotypes

Mean performances of the five parental varieties and their hybrid combinations for yield, its components and fiber quality traits are presented in (Table 5). The variety Giza 75 (P_1) showed the highest seed and lint yields, ginning outturn and fiber fineness traits. Also, the variety

Table (2) : Analysis of variance showing mean squares for yield, its components and fiber quality traits in Egyptian cotton.

S.O.V.	SCY	LY	BN	BW	GOT	FL	FS	FF
Genotypes (G)	8.30**	6.50**	4.90**	0.21*	0.04**	9.25**	11.21**	1.11**
Parents (P)	9.67**	2.80*	3.95*	0.10	0.01	7.31**	9.35**	0.90*
Crosses (C)	7.40**	8.00**	8.14**	0.17	0.06**	6.60**	8.47**	0.87*
P vs C	30.23**	23.57**	11.12**	0.07	0.11	5.42**	6.50*	0.79
GCA	20.41**	8.50**	5.16**	0.14	0.06*	3.51**	4.36**	0.91*
SCA	6.31**	6.41**	5.84**	0.09	0.05*	1.91*	3.71**	0.85*
Pooled error	0.39	0.30	0.36	0.05	0.02	0.25	0.28	0.17
GCA/SCA	3.23	1.32	0.88	1.55	1.20	1.83	1.17	2.60

* ,** Significance at % and 1 % levels .

Table (3): General and specific combining ability effects for yield, its components and fiber quality traits of five parents and their ten F_1' s in Egyptian cotton.

Genotypes	SCY	LY	BN	BW	GOT	FL	FS	FF
P1	0.450**	-0.390**	0.370*	-0.400**	0119**	0.009	0.317**	-0.341
P2	0.730**	-0.223	0.920**	0.265**	0.112**	0.123**	-0.005	-0.116
P3	0.950**	-0.517**	-0.410**	-0.175**	-0.012	0.116**	-0.038	0.318
P4	0.832**	1.130**	0.731**	-0.161*	0.120**	0.110**	-0.131**	0.410
P5	-0.390**	0.240*	0.260	-0.101	0.111**	0.112**	0.001	0.219
P1 x P2	0.881**	-0.253	0.620	0.051	0.115**	0.113**	-0.291*	-0.710
P1 x P3	0.170	0.516	0.980**	0.192	0.016	0.118**	0.821**	0.360
P1 x P4	2.210**	0.245	0.491	0.032	-0.012	0.032*	-0.032	-0.420
P1 x P5	3.340**	-0.712*	-0.301	0.170	-0.045**	0.009	0.401**	-0.900
P2 x P3	0.501*	-0.612*	-0.562	-0.071	-0.031	0.016	0.003	0.811
P2 x P4	0.340	1.231**	-1.312**	0.316**	-0.037*	0.014	0.200	0.690
P2 x P5	-0.811*	1.980**	-1.130**	0.220	0.085**	0.008	0.195	2.110**
P3 x P4	-0.471	1.856**	0.617	-0.212	0.761**	0.101	0.690**	1.601**
P3 x P5	1.610**	0.231	0.556	0.101	-0.031	0.014	0.390*	0.400
P4 x P5	1.230**	1.120**	1.890**	-0.318**	0.019	0.108	0.315*	0.053

G_i and S_{ij} denote general and specific combining ability effects.

Table (4): Percentage of heterosis over the mid-parent (MP%) for yield, its components and fiber quality traits in Egyptian cotton.

Genotypes	SCY	LY	BN	BW	GOT	FL	FS	FF
P1 x P2	6.38**	16.40**	3.78**	0.80**	8.10**	3.65**	-0.37	11.68**
P1 x P3	-1.34*	4.29**	7.84**	21.51**	5.26**	5.92**	6.24**	-0.96**
P1 x P4	6.36**	4.67**	9.14**	9.73**	-1.35	-1.83**	10.96**	-6.26**
P1 x P5	11.98**	-1.55**	2.79**	13.43**	-13.5**	2.79**	9.02**	-14.63**
P2 x P3	4.34**	0.74	9.80**	-5.51**	-2.77	2.02**	2.50**	2.56**
P2 x P4	3.52**	6.80**	-3.44**	9.05**	1.40	2.18**	5.13**	1.75**
P2 x P5	0.17	26.11**	4.06**	0.81**	20.00**	-4.20**	-6.97**	-8.10**
P3 x P4	6.45**	25.52**	10.11**	-9.48**	16.21**	3.44**	-7.21**	7.14**
P3 x P5	11.04**	17.18**	3.96	-6.77**	4.10**	3.28**	-3.00**	6.02**
P4 x P5	13.14**	38.28**	20.84**	-6.60**	21.12**	-3.15**	2.45**	-8.23**

* and ** indicate significance at 0.05 and 0.01 probability levels, respectively.

Table (5): Mean performances of parental genotypes and their crosses for yield, its component and fiber quality traits in Egyptian cotton.

Genotypes	SCY	LY	BN	BW	GOT	FL	FS	FF
P1	34.20	13.23	13.66	2.31	0.39	32.17	27.23	4.00
P2	35.60	12.37	13.33	2.66	0.35	31.25	31.00	3.70
P3	31.69	11.90	14.00	2.43	0.38	30.89	33.00	4.10
P4	33.69	12.00	15.67	2.21	0.36	31.00	34.06	4.30
P5	31.89	11.15	14.22	2.30	0.35	33.01	33.50	4.20
P1 x P2	37.13	14.90	14.00	2.50	0.40	32.87	29.00	4.30
P1 x P3	32.50	13.10	15.00	2.88	0.40	32.00	32.00	4.01
P1 x P4	36.10	13.20	16.00	2.48	0.37	31.00	34.60	3.89
P1 x P5	37.00	12.00	14.33	2.61	0.32	33.50	33.10	3.50
P2 x P3	35.10	12.22	15.00	2.40	0.35	31.70	32.80	4.00
P2 x P4	35.86	13.00	14.00	2.65	0.36	31.80	34.20	4.07
P2 x P5	33.80	14.10	14.33	2.50	0.42	30.78	30.00	3.63
P3 x P4	34.80	15.00	16.33	2.10	0.43	32.02	31.11	4.50
P3 x P5	35.30	13.50	14.67	2.20	0.38	33.00	32.25	4.40
P4 x P5	37.10	16.00	18.00	2.10	0.43	31.00	34.61	3.90
LSD 5%	1.10	0.89	1.50	0.20	0.03	0.87	1.24	0.36
LSD 1%	1.40	1.13	1.86	0.36	0.04	1.02	1.70	0.51

Giza 90 (P_5) showed the highest means of fiber length and strength traits, while the genotypes Giza 83 (P_4) and Giza 85 (P_2) were the highest performing for boll number and boll weight, respectively.

The high means of the tested genotypes were transmitted to most of their hybrids. While, the lowest means were shown by Giza 81 (P_3) for SCY, Giza 90 (P_5) for LY and GOT, Giza 85 (P_2) for BN, (P_4) for BW, FL and FF and Giza 75 (P_1) for FS.

Four hybrids; P_1 x P_2 , P_1 x P_4, P_1 x P_5 and P_4 x P_5 showed the values of 37.13, 36.10, 37.00 and 37.10 (g) for only SCY/P trait, respectively.

The performance of the F_1 hybrids showed higher values for LY than their parents for three crosses; P_1 x P_2, P_3 x P_4 and P_4 x P_5 where the values were 14.90, 15.00 and 16.00 (g). The performance of the F_1 hybrids showed higher values than their respective parents for the crosses; P_1 x P_4 , P_2 x P_3 , P_3 x P_4 and P_4 x P_5 for BN where the highest values were expressed by the cross P_4 x P_5 (18.00).

The mean values for the tested crosses ranged from 2.1 to 2.88 (g) for boll weight, 32 to 43 % for ginning outturn, 30.78 to 33.50 (mm) for fiber length, 29.00 to 34.61 (g/tex) for fiber strength and 3.5 to 4.5 (µg/inch) for fiber fineness. These results are in general agreement with those obtained by Abo El-Zahab and Amein (2000 a and b) and El-Adl *et al.* (2001) working on Egyptian cotton varieties.

It may be concluded that the four parents, *i.e.* P_4 (Giza 83), P_3 (Giza 81), P_2 (Giza 85) and P_1 (Giza 75), besides five hybrids, *i.e.* P_1 x P_2, P_1 x P_3, P_1 x P_4, P_1 x P_5 and P_4 x P_5 (as a source of high yielding genes to enrich the gene pool) may be incorporated in multiple crosses system followed by pedigree selection for obtaining high yielding and good fiber quality lines.

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طبيعة القدرات الإئتلافية والتفسير الوراثى لبعض الصفات الكمية فى القطن المصرى

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ملخص

يهدف هذا البحث إلى دراسة المعالم الوراثية ممثلة فى القدرات الإئتلافية العامة والخاصة بالإضافة إلى قوة الهجين لمجموعة الهجن التبادلية بين خمسة من أصناف القطن المصرى القديمة والمنزرعة حاليا بمحافظة الفيوم بهدف الحصول على بعض المعلومات الوراثية التى تساعد عند اختيار الأباء التى تدخل فى برامج التهجين وذلك لإنتاج أصناف متفوقة فى صفات المحصول ومكوناته و جودة الألياف .

تم الحصول على المواد الوراثية المستخدمة فى هذا البحث من خلال التهجين الدائرى لجميع الهجن الممكنة (عدا الهجن العكسية) بين الآباء المختارة وهى جيزة ٧٥، جيزة ٨٥، جيزة ٨١، جيزة ٨٣ و جيزة ٩٠ وذلك خلال صيف ٢٠٠٩، وفى عام ٢٠١٠ تم إجراء التقييم لخمسة عشرة تركيب وراثى ممثلة فى خمسة آباء وعشرة هجن فى الجيل الأول وذلك بمحطة التجارب الزراعية بكلية الزراعة– جامعة الفيوم، ويمكن إيجاز أهم النتائج المتحصل عليها فيما يلى:

كانت القيم المحسوبة لتباين القدرة العامة على الإئتلاف عالية المعنوية لمعظم الصفات موضع الدراسة وكانت أكبر من مثيلتها المحسوبة للقدرة الخاصة على الإئتلاف لمعظم الصفات .

دلت قيم تباين القدرة العامة الإئتلافية منسوبة لتباين القدرة الخاصة على أن الفعل الجينى الإضافى هو السائد عدا صفة وزن اللوزة حيث كان الفعل غير الإضافى هو السائد.

أظهر الصنف جيزة ٨٣ تفوقاً واضحاً على الأصناف الأخرى فى صفة محصول الشعر بالنسبة لتأثيرات القدرة العامة الإئتلافية، كذلك أحتل نفس الصنف المرتبة الثانية لصفة محصول القطن الزهر.

كان الصنف جيزة ٨١ ذو تأثيرات قدرة عامة على الإئتلاف عالية لصفة محصول القطن الزهر يليه الصنف جيزة ٨٥ لصفة وزن اللوزة، فى حين سجل الصنف جيزة ٧٥ الترتيب الأول لتأثيرات القدرة العامة للإئتلاف لصفتى الألياف (متانة ونعومة)، والتى تعكس تأثير الفعل الجينى المضيف و أن هذه الأصناف معطية من صفاتها لأنسالها والتى يمكن إستخدامها فى برامج تربية القطن.

أشارت النتائج إلى أن عدد من الهجن ذات تأثيرات مرغوبة للقدرة الخاصة على الإئتلاف، وهى جيزة٧٥ X جيزة٨١، جيزة٧٥ X جيزة٨٣، جيزة٧٥ X جيزة٨٣، جيزة٧٥ X جيزة٩٠و جيزة٨٣ X جيزة٩٠، كذلك أظهرت بعض الهجن السابقة تميزاً فى قوة الهجين لبعض الصفات.

وأخيراً تُوصى النتائج المتحصل عليها من هذه الدراسة فى مُجملها إعطاء أولوية لهذه الهجن لإستخدامها المباشر لإنتخاب تراكيب وراثية ذات قدرة محصولية عالية وجودة ألياف متميزة، بالإضافة إلى أن الآباء جيزة ٨٣، جيزة٨١، جيزة ٨٥ وجيزة ٧٥ تعتبر مصدر جيد لجينات المحصول العالى لإثراء مستودع الجينات ، والتى يمكن أن تدخل فى نظام تهجينات متعددة يليها الإنتخاب المنسب من أجل الحصول على سلالات عالية المحصول وصفات ألياف ذات جودة عالية.