COBINING ABILITY IN RELATION TO GENETIC DIVERSITY IN COTTON (*G. BARBADDENSE* L.)

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ABSTRACT

The experiments were carried out at Sakha Agriculture Research Station, Cotton Research Institute, Agriculture Research Center, Egypt. The aim of this investigation was to study heterosis and combining ability for the most important characters of cotton (seed cotton yield, lint yield, boll weight, seed index, lint percentage, lint index and hallo length). Ten cotton genotypes TNB, Karsheneski$_2$, G.45, G.89 x G.86, G.86, G.94, G. 93, CB.58, G.75 x Sea and Australian$_{12}$ were crossed in half diallel. These parents and their respective 45 F_1 crosses were evaluated in a randomized complete blocks design. The results obtained could be summarized as follows:-

Highly significant mean square values were obtained for genotypes, general combining ability and specific combining ability for all the studied characters. The best general combiner for all studied traits were parents G.94 and G.75 x sea. Also the best combination for most of studied characters were crosses G.45 x CB 58, TNB x Aus.$_{12}$, Kar.$_2$ x G.94, G45 x CB 58, G.94 x (G.75 x sea) and G.93 x (G.75 x sea).

The first three principle components were significant and accounted about 90.3% of the total variability of all characters. Which having maximum Eigen value. Lint index followed by lint percentage, boll weight and lint yield were a primary source of variation in the first ax. The second ax was principally affected by seed cotton yield and hallo length. The ten parents in this study were grouped in different clusters and there were accordance between parental diversity and significant general and specific combining ability.

Key words: Combining ability, principle components diversity, and cotton.

INTRODUCTION

The choice of selection breeding procedures for genetic improvement of cotton or any crop, is largely conditioned by the type and relative amounts of genetic variance components in the population. The exploitation of genetically diverse stock in cross combinations helps to identify promising hybrid and / or to develop superior inbred lines. The diallel cross analysis has been used by many investigators to assist in the investigation of nature of heterosis and partition in the genetic variance. Many investigators studies general and specific combining ability and type of gene action using diallel mating design **(Khan *et al*. (2011), Amein *et al*. (2013), Abou El-Yazied *et al*. (2014) and Abdel-Hafez *et al*. (2016)** and found significant general and specific combining ability for yield and its contributed characters which reflect the importance of additive and non-additive gene effects in the inheritance of such characters.

Estimation of genetic diversity is an important step for any breeding program, but not the last one. Another helpful issue to be evaluated is the relative importance of the characters. Though plant breeders, often measure several characters simultaneously in cotton development, then it is possible to estimate the genetic divergence using multivariate method exist.

Multivariate technique could resolve several phenotypic measurements into fewer, more interpretable and more easily visualized dimensions such an analysis which use principal components **(Hair** et al**. 1987)**, seemed to elucidate pattern of variation in agronomic attributes and to obtain the initial factor solution using Eigen values. These values measure the explained variance associated with each variable and refer to its contribution to the whole divergence. Principle component analysis (PCA) reflects the importance of the largest contributor to the total variation at each ax for differentiation **Sharma, 1998**. This analysis seemed to elucidate patterns of variation in agronomic attributes which are of economic importance and obtain entail factor solution using, Eigen values. These values could measure the explained variance associated with each vector, variable. The efficacy of the genetic divergence as a criterion for choosing parents for crossing programmers has been reported by several workers **(Sandhu** and **Boparai, 1997; Patial *et al*., 1999; El-Mansy, 2005; Gooda, 2007 and Abou El- Yazied *et al*., 2009)**. Moreover, principal component analysis and factor analysis have analogous efficacy to determine the most suitable combinations and grouping the varied genotypes into varied groups. **Seyam *et al*., 1984** used factor analysis in determining characters that could be selected for high yield. **Abd El- Sayyed *et al*., 2000 and El- Mansy *et al*., 2008** used principal component and cluster analysis to create genetic variability in Egyptian cotton.

Thus information about genetic variance of parents, GCA, and SCA will be helpful for the necessary testing of parents and crosses before their use in breeding cultivars suitable in future. These studies indicate the necessity to develop cotton cultivars with high stability for agronomic performance in planting growing system.

Therefore, the main objectives of the present study are to study the behavior of genotypes, general and specific combining ability and to select the suitable parents and combinations. Also, to determine genetic diversity among parental cotton genotypes as well as F_1

hybrids combinations by using multivariate analysis to select the most suitable combinations and parents.

MATERIALS AND METHODS

The present investigation was carried out at Sakha Agriculture Research Station, Cotton Research Institute, Agriculture Research Center, Egypt, during the two growing seasons of 2015 and 2016. Ten parents genotypes of wide divergent origin namely TNB (P_1), Karsheneski$_2$ (Kar.$_2$) (P_2), Giza 45 (G. 45) (P3), Giza 89 x Giza 86 (G. 89 x G. 86) (P_4), Giza 86 (G. 86) (P_5), Giza 94 (G. 94) (P_6), Giza 93 (G. 93) (P_7), CB.58 (P_8), Giza 75 x Sea (G. 75 X Sea) (P_9) and Australian$_{12}$ (Aus.$_{12}$) (P_{10}) were crossed in a half diallel mating design to produce 45 F_1 hybrids in 2015 season. The 45 F_1 hybrids and their parents were grown in 2016 season in a randomized complete blocks design with three replications was used. Plot size was one row, 5 m long and 0.7 m wide with 0.3 m. hill spacing. Hills were thinned to two plants per hill. The normal cultural practices for cotton production were performed at proper time. Data were recorded on ten individual guarded plants chosen at random from each plot in middle ridge for F_1 and their parents.

Collected data: The collected data were recorded for the following characters: Seed cotton yield (SCY) / plant (g), Lint yield (LY) / plant (g), Boll weight (BW) (g), Seed index (SI) (g), Lint percentage (LP) (%), Lint index (LI) (g), and Fiber length (hallo length) (HL) (mm).

Statistical procedure:

Data were subjected to method of statistical analysis. Firstly, analysis of variance was done as outlined by **Snedecor** and **Cochran (1982)**, general combining ability (GCA) and specific combining ability variance (SCA), effects of the hybrids were estimated according to **Griffing, s (1956)**. Also, heterosis over better parent was calculated as the percentage of increase better parent (BP) of each cross as follow: Heterosis relative to better parent (B.P) % = ((F_1 – BP)/ BP) x 100.

After this step, multivariate technique was conducted by using principal component analysis according to **Haire** et al**., (1987)** this analysis was calculated from a matrix based on correlation between the studied characters for all genotypes. The genotypes were also grouped as diagram on principal components axes. All this computations were performed using **SPSS** Computer procedures.

RESULTS AND DISCUSSION

The results in Table (1) exhibited that the mean squares of genotypes, parents and crosses were highly significant for all characters except for parent versus crosses that was insignificant for boll weight, lint index and hallo length. Also, the mean squares of general combining ability and specific combining ability were highly significant for all characters. The previous results indicated that the experimental materials possessed considerable amount of variability and the two types of combining ability were involved in the genetic expression of these characters. Higher proportion of variance for general combining ability than specific combining ability, suggested that the major roll of additive and non-additive gene effects in the genetic control of these characters with the predominance of additive ones.

These results support the findings of **Ahuja** and **Tuteja (2000)**, **Tuteia *et al*. (2003)**, **El- Lawendy *et al*. (2008)** and **Abdel-Hafez *et al*. (2016).**

Table 1. Mean squares of parents and F1 for all studied characters

S O V	df	SCY/P	LCY/P	BW/g	SI/g	LP (%)	LI/g	HL/cm
Replications	2	9.41	3.05	0.12	0.001	1.669	0.157	0.065
Genotypes	(54)	681.3**	123.91**	0.328**	1.76**	18.015**	3.131**	5.137**
Parents	9	721.04**	182.45**	0.5535**	2.4852**	33.779**	6.1743**	5.9824**
Crosses	44	683.25**	113.88**	0.2881**	1.5997**	14.979**	2.5771**	5.0678**
P. V. Cross	1	237.76**	38.11**	0.07316	2.2638**	9.719**	0.1069	0.5798
GCA	9	1025.62**	280.20**	0.9217**	4.364**	75.888**	12.6053**	4.6717**
SCA	45	612.43**	92.65**	0.2097**	1.2387**	6.4397**	1.2359**	5.2302**
error	108	31.37	4.91	0.091	0.264	0.448	0.129	0.638

** and * Significant at 0.05 and 0.01 levels of probability respectively.

Mean performance

Significant of differences among genotypes exhibited that there are difference between these materials. The mean performance for parents and all crosses are presented in Table (2). The results indicated that the highest parent was Giza 75 x Sea (P_9) for seed cotton yield/plant, lint yield / plant, boll weight, seed index, lint percentage and lint index with the mean values of (98.96 g., 41.33 g., 3.90 g., 12.03 g., 41.80% and 8.64 g. respectively).

Table 2: Mean performance of parents and F1 for all studied characters

Genotypes	No. of genotype	SCY/Plant	LCY/Plant	BW, g	SI, g	LP, %	LI, g	H L, mm
TNBXKar. 2	1	51.93	17.28	2.74	9.77	33.25	4.87	37.83
TNBXG .45	2	49.61	16.72	3.02	10.47	33.69	5.32	39.83
TNBX(G. 89XG. 86)	3	54.15	20.28	3.26	10.35	37.42	6.19	38.67
TNBXG. 86	4	62.66	24.07	3.45	10.33	38.39	6.45	39.67
TNBXG. 94	5	72.39	25.26	3.91	11.71	34.86	6.26	40.33
TNBxG. 93	6	70.81	24.66	3.49	10.31	34.81	5.51	40.00
TNBxCB 58	7	42.64	15.60	3.03	9.73	36.64	5.63	36.50
TNBxG. 75XSea	8	64.80	24.80	3.40	10.45	38.25	6.47	38.67
TNBXAus. 12	9	83.59	30.33	3.21	9.33	36.30	5.32	37.00
Kar. 2XG. 45	10	30.85	10.39	2.73	9.73	33.60	4.93	39.17
Kar. 2X(G. 89XG. 86)	11	79.10	27.70	3.11	9.82	35.02	5.29	38.67
Kar. 2XG. 86	12	70.82	26.01	2.83	10.06	36.72	5.84	38.50
Kar. 2XG. 94)	13	66.62	24.61	3.33	10.99	36.93	6.44	39.67
Kar. 2XG. 93	14	71.04	23.73	2.97	9.74	33.39	4.89	41.83
Kar. 2XCB 58	15	63.18	21.34	2.83	9.74	33.81	4.98	39.67
Kar. 2X(G. 75XSea)	16	43.30	16.50	3.31	10.29	38.09	6.33	39.17
Kar. 2XAus. 12	17	40.13	14.32	3.02	9.61	35.70	5.34	37.50
G. 45X(G. 89XG. 86)	18	63.34	25.32	2.78	10.24	40.00	6.83	36.33
G. 45XG. 86	19	68.30	27.21	3.58	10.50	39.82	6.94	39.33
G. 45XG. 94	20	45.71	16.67	2.95	9.68	36.47	5.56	39.50
G. 45XG. 93	21	48.16	18.54	3.27	10.26	38.48	6.42	36.33
G. 45XCB 58	22	95.37	37.34	3.41	10.79	39.14	6.95	38.67
G. 45X(G. 75XSea)	23	94.95	35.74	2.96	9.22	37.64	5.56	39.83
G. 45XAus12	24	57.34	21.39	3.11	9.72	37.31	5.79	38.50
(G. 89XG. 86)XG86	25	69.34	27.46	2.85	10.72	39.58	7.02	39.50
(G. 89XG. 86)X G. 94	26	57.97	23.14	2.86	10.46	39.91	6.94	37.83
(G. 89XG. 86)XG. 93	27	61.81	23.12	3.25	10.76	37.43	6.45	40.00
(G. 89XG. 86)XCB 58	28	61.17	22.69	3.29	9.45	37.11	5.58	39.00
(G. 89XG. 86)XG. 75XSea	29	64.69	25.28	3.66	10.92	39.09	7.01	39.33
(G. 89XG. 86)xAus12	30	61.09	23.23	3.23	10.76	38.03	6.61	36.83
G. 86X G. 94	31	54.98	22.64	3.45	11.07	41.22	7.76	37.17
G. 86XG. 93	32	82.60	31.05	3.00	9.74	37.62	5.88	40.83
G. 86XCB 58	33	60.73	23.98	3.48	10.93	39.47	7.13	39.67
G. 86X(G. 75XSea)	34	50.34	20.51	3.79	11.96	40.81	8.26	38.00
G. 86XAust12	35	51.68	20.70	3.40	12.75	40.08	8.53	39.83
G. 94XG. 93	36	69.28	24.64	2.68	10.50	35.59	5.80	40.67
G. 94XCB 58	37	87.32	32.70	3.53	10.46	37.42	6.24	39.33
G. 94X(G. 75XSea)	38	94.92	39.66	3.79	11.06	41.69	7.92	39.50
G. 94XAus. 12	39	52.12	19.82	3.12	11.02	38.00	6.75	38.67
G. 93XCB 58	40	58.50	22.64	2.85	10.43	38.67	6.57	35.83
G. 93X(G. 75XSea)	41	90.89	37.58	3.45	11.56	41.38	8.17	38.50
G. 93XAus. 12	42	71.19	25.33	2.92	11.06	35.59	6.11	39.00
CB 58X(G. 75XSea)	43	74.84	29.73	3.38	11.46	39.71	7.55	39.83
CB 58XAus. 12	44	52.94	20.55	3.49	10.69	38.84	6.78	40.17
(G. 75XSea)XAus. 12	45	59.98	22.23	3.11	10.17	37.09	5.99	38.50
TNB	46	55.34	20.09	3.05	9.68	36.31	5.52	36.00
Kar. 2	47	46.76	15.19	2.74	10.24	32.49	4.93	37.67
G. 45	48	45.41	14.88	2.92	10.35	32.73	5.04	40.00
(G89XG86)	49	65.23	24.87	3.48	10.52	38.15	6.50	39.50
G. 86	50	66.16	26.58	3.55	10.72	40.19	7.20	38.67
G. 94	51	63.52	26.31	3.92	12.70	41.41	8.98	39.33
G. 93	52	61.27	21.49	2.85	10.73	35.09	5.80	39.33
CB 58	53	47.32	16.56	2.97	10.16	34.99	5.47	39.83
G. 75XSea	54	98.98	41.38	3.90	12.03	41.80	8.64	40.00
Aus. 12	55	58.70	21.18	3.22	10.53	36.12	5.96	36.83
LSD .01		11.99	4.74	0.65	1.10	1.43	0.77	1.71

Also, the parent Giza 94 (P_6) recorded the highest values for boll weight, seed index and lint index with the mean values of 3.92, 12.7 and 8.98 g. respectively. While the parents Karsheneski$_2$ (P_2) and Giza 45 (P_3) gave low mean performance in most characters. For crosses the results cleared that, the crosses Giza 45 x CB 58, Giza 45 x (Giza 75 x Sea), Giza 94 x (Giza 75 x Sea) and Giza 93 x (Giza 75 x Sea) were the highest crosses for seed cotton yield / plant, lint yield / plant, boll weight and lint percentage. For seed index and lint index results cleared that the crosses Giza 86 x (Giza 75 x Sea) and Giza 86 x $Aus._{12}$ were the highest crosses for seed index and lint index. For hallo length character the crosses TNB x Giza 94, $Kar._2$ x Giza 93, Giza 86 x Giza 93, Giza 94 x Giza 93 and CB 58 x $Aus._{12}$ were the highest crosses. These results were almost similar to that of **Seyam *et al*., 1984** and **Abdel-Hafez et al. (2016).**

General combining ability (GCA)

Results of general combining ability effects of parental genotypes were obtained for studied characters (Table 3). The results exhibited that positive general combining ability effect was found for most studied characters, the comparison of GCA effect of parent exhibited the parental genotypes Giza 75 x Sea followed by Giza 94 were observed to be a good combiner for all studied characters in the same trend Giza 86 showed a good combiner for most yield contributed characters. On the other hand the parental Giza 93 showed a good combiner for seed cotton yield with
the best value for hallo length. However, the Russian genotype, $Kar._2$, followed by

Table 3: General combining ability effects of parental genotypes for all studied characters

Parents	SCY/Plant	LCY/Plant	BW, g	SI,g	LP, %	LI,g	H L,mm
TNB	-2.859	-1.951*	0.019	-0.322*	-1.303*	-0.564*	-0.564*
Kar. 2	-7.256*	-4.196*	-0.253*	-0.454*	-2.530*	-0.923*	0.006
G.45	-4.427*	-1.961*	-0.146*	-0.366*	-0.855*	-0.457*	0.019
(G89XG86)	0.461	0.447	-0.010	-0.096	0.667*	0.090	-0.175
G.86	0.516	1.183*	0.129*	0.317*	1.851*	0.698*	0.214
G. 94	2.563*	1.595*	0.175*	0.555*	1.086*	0.649*	0.339*
G.93	4.105*	0.973*	-0.148*	0.012	-0.727*	-0.204*	0.367*
CB 58	-0.520	-0.242	-0.012	-0.141	-0.088	-0.124*	0.089
G75XSea	11.592*	6.045*	0.274*	0.455*	2.123*	0.893*	0.339*
Aus. 12	-4.176	-1.862*	-0.027	0.041	-0.224*	-0.058	-0.633*

* Significant probability at 0.05

the Egyptian variety Giza 45 was observed to be a poor combiner for all yield Characters. Thus, the breeder may utilize the good general combiner such as the genotypes Giza 75 x Sea, Giza 94 and Giza 86 in specific breeding programs for improving most yield characters in our cotton. Theses results were in harmony with similar results reported by **Amein *et al*. (2013) and Abdel- Hafez *et al*. (2016).**

Specific combing ability (SCA)

Specific combing ability effects (SCA) are given in Table 4. Significant positive SCA effects were obtained for some crosses indicating the presence of a considerable non-allelic gene effect. On the other hand, the significant negative estimates of SCA revealed the presence of undesirable types of epistasis in these combinations. The positive specific combining ability effects were found for variable traits in (16 crosses) Giza 45 x CB 58 for seed cotton yield/plant, lint yield/plant, boll weight, seed index, lint percentage and lint index. Also, the crosses Kar.$_2$ x Giza 94, Giza 45 x Giza 86, Giza 94 x (Giza 75 x Sea) and Giza 93 x (Giza 75 x Sea) had positive specific combining ability effects for seed cotton yield / plant, lint yield / plant and lint percentage.

Table 4: Specific combining ability for all studied characters

Genotypes	SCY/Plant	LCY/Plant	BW, g	SI, g	LP, %	LI, g	H L, mm
TNBXKar. 2	-1.37	-0.440	-0.246	0.029	-0.360	0.008	-0.451
TNBXG .45	-6.52*	-3.240*	-0.073	0.641*	-1.595*	-0.012	1.535*
TNBX(G. 89XG. 86)	-6.86*	-2.090	0.032	0.255	0.613	0.315	0.563
TNBXG. 86	1.59	0.960	0.086	-0.182	0.399	-0.032	1.174*
TNBXG. 94	9.27*	1.750	0.500*	0.963*	-2.366*	-0.171	1.716*
TNBxG. 93	6.15*	1.760	0.403*	0.106	-0.599	-0.071	1.355*
TNBxCB 58	-17.40*	-6.080*	-0.194	-0.324	0.588	-0.028	-1.867*
TNBxG. 75XSea	-7.34*	-3.140*	-0.106	-0.203	-0.013	-0.204	0.049
TNBXAus. 12	27.21*	10.270*	0.005	-0.906*	0.387	-0.404*	-0.645
Kar. 2XG. 45	-20.88*	-7.330*	-0.085	0.030	-0.454	-0.043	0.299
Kar. 2X(G. 89XG. 86)	22.48*	7.580*	0.157	-0.146	-0.564	-0.223	-0.006
Kar. 2XG. 86	14.14*	5.150*	-0.259	-0.323	-0.041	-0.287	-0.562
Kar. 2XG. 94)	7.89*	3.330*	0.189	0.372	0.931*	0.361	0.480
Kar. 2XG. 93	10.78*	3.080*	0.152	-0.332	-0.792*	-0.335	2.619
Kar. 2XCB 58	7.54*	1.900	-0.125	-0.178	-1.012*	-0.319	0.730
Kar. 2X(G. 75XSea)	-24.45*	-9.190*	0.069	-0.225	1.058*	0.014	-0.020
Kar. 2XAus. 12	-11.85*	-3.500*	0.084	-0.490	1.014*	-0.028	-0.715
G. 45X(G. 89XG. 86)	3.89	2.960*	-0.284	0.185	2.742*	0.851*	-2.354*
G. 45XG. 86	8.80*	4.120*	0.377*	0.029	1.378*	0.347	0.258
G. 45XG. 94	-15.84*	-6.840*	-0.299	-1.030*	-1.203*	-0.985*	0.299
G. 45XG. 93	-14.93*	-4.340*	0.345*	0.100	2.623*	0.729*	-2.895*
G. 45XCB 58	36.90*	15.670*	0.348*	0.784*	2.643*	1.181*	-0.284
G. 45X(G. 75XSea)	24.37*	7.810*	-0.388*	-1.386	-1.073*	-1.222*	0.633
G. 45XAus12	2.52	1.340	0.067	-0.475	0.943*	-0.048	0.271
(G. 89XG. 86)XG86	4.94	1.960	-0.481*	-0.018	-0.381	-0.113	0.619
(G. 89XG. 86)X G. 94	-8.47*	-2.780*	-0.517*	-0.519	0.714*	-0.148	-1.173*
(G. 89XG. 86)XG. 93	-6.17*	-2.170	0.196	0.330	0.044	0.215	0.966*
(G. 89XG. 86)XCB 58	-2.19	-1.380	0.099	-0.830*	-0.909*	-0.736*	0.244
(G. 89XG. 86)XG. 75XSea	-10.78*	-5.050*	0.180	0.044	-1.140*	-0.322	0.327
(G. 89XG. 86)xAus12	1.39	0.770	0.048	0.302	0.143	0.226	-1.201*
G. 86X G. 94	-11.52*	-4.010*	-0.066	-0.319	0.837*	0.064	-2.229
G. 86XG. 93	14.56*	5.020*	-0.197	-1.103*	-0.947*	-0.966*	1.410*
G. 86XCB 58	-2.68	-0.830	0.144	0.237	0.267	0.210	0.521
G. 86X(G. 75XSea)	-25.19*	-10.560*	0.171	0.674*	-0.607	0.324	-1.395*
G. 86XAust12	-8.08*	-2.500*	0.079	1.875*	1.010*	1.541*	1.410*
G. 94XG. 93	0. 81	-1.800	-0.559*	-0.581*	-2.215	-0.997*	1.119*
G. 94XCB 58	21.86*	7.470*	0.151	-0.474	-1.018*	-0.635*	0.063
G. 94X(G. 75XSea)	17.35*	8.180*	0.125	-0.471	1.035*	0.033	-0.020
G. 94XAus. 12	-9.68*	-3.790*	-0.240	-0.093	-0.308	-0.187	0.119
G. 93XCB 58	-8.50*	-1.970	-0.203	0.039	2.045*	0.549*	-3.465*
G. 93X(G. 75XSea)	11.78*	6.720*	0.112	0.579*	2.542*	1.129	-1.048*
G. 93XAus. 12	7.85*	2.350*	-0.117	0.493	-0.905*	0.020	0.424
CB 58X(G. 75XSea)	0.36	0.090	-0.095	0.632*	0.232	0.432*	0.563
CB 58XAus. 12	-5.78	-1.220	0.313	0.270	1.712*	0.616*	1.869*
(G. 75XSea)XAus. 12	-10.85*	-5.800*	-0.349*	-0.843*	-2.252*	-1.190*	-0.048

* Significant probability at 0.05

Also, the cross TNB x Australian$_{12}$ showed positive specific combining ability effects for seed cotton yield / plant, lint yield / plant and hallo length. Concerning seed cotton yield / plant and hallo length the crosses TNB x Giza 94 and TNB x Giza 93 exhibited positive specific combining ability effects. Also, the crosses Giza 86 x Aus.$_{12}$ and CB 58 x Aus.$_{12}$ had positive specific combining ability effects for lint percentage and hallo length. The results reported by **Khan *et al*. (2011)**, **Amein *et al.* (2013**) and **Abdel-Hafez *et al*. (2016)** agreed with the present one.

It's important to note that the most of combinations having significant SCA effect were between genetically diverse parents as stated by **El- Mansy et al, (2014)**. Most combinations which had good specific combining ability were having one or two parents of either good x good or good x poor general combiner.

Better parent (BP.)

The amount of heterosis versus the better parent (BP.) is presented in Table (5). The results exhibited that the crosses Giza 45 x CB 58 was superior and positive heterosis for most characters, seed cotton yield, lint yield, lint percentage and lint index, with the mean heterosis values of 101.52%, 125.45 %, 11.86 % and 27.13 % respectively. On the other hand, the crosses TNB x Aus.$_{12}$, Kar.$_2$ x CB 58 and Giza 94 x CB 58 were the best and showed the highest positive heterosis values for seed cotton yield / plant and lint yield / plant of (42.39 %, 43.22 %), (33.49 % , 28.85 %) and (37.47, 24.31 %) respectively . In the same time, for seed index in the cross Giza 86 x Aus.$_{12}$ was the best cross with highest positive heterosis value of 18.97 %. Also, the crosses Kar.$_2$ x Giza 45, Giza 45 x Giza 94 and Giza 45 x Aus.$_{12}$ exhibited the best and highest positive heterosis values for lint percentage with a mean heterosis values of 3.41% , 4.85 %, 9.67 % and 3.27 % respectively . Also, high positive heterosis values for lint index of 18.47 %, 13.21 % and 13.81 % were obtained for the crosses Giza 86 x Aus.$_{12}$, Giza 93 x CB 58 and CB 58 X Aus.$_{12}$ respectively. The superior positive heterosis for hallo length of 6.35 %, 3.81%, 3.39 % and 10.04 % for Kar.$_2$ x Giza 93, Giza 86 x Giza 93, Giza 94 x Giza 93 and Giza 93 x CB 58 respectively were found. The results cleared that no one cross from all crosses was superior and showed high positive heterosis for all the studied characters. These results were harmony with **Sorour *et al.*, 2013** and **Abou El- Yazied *et al*., 2009.**

Table 5: Heterosis relative to better parent (BP.) for all studied characters

Genotypes	SCY/Plant	LCY/Plant	BW, g	SI, g	LP, %	LI, g	H L, mm
TNBXKar. 2	-6.171	-13.985	-10.273	-4.590	-8.422**	-11.775*	0.442
TNBXG .45	-10.359	-16.780	-1.093	1.192	-7.210**	-3.684	-0.417
TNBX(G. 89XG. 86)	-16.980	-18.430*	-6.418	-1.615	-1.905**	-4.720	-2.110
TNBXG. 86	-5.290	-9.467	-2.726	-3.608	-4.473**	-10.417**	2.586
TNBXG. 94	13.960	-3.960	-0.340	-7.793*	-15.826**	-30.252**	2.542
TNBxG. 93	15.568*	14.723	14.426	-3.854	-4.116**	-5.055	1.695
TNBxCB 58	-22.963**	-22.337*	-0.656	-4.201	0.915	2.053	-8.368**
TNBxG. 75XSea	-34.529**	-40.081**	-12.810*	-13.137**	-8.482**	-25.048**	-3.333*
TNBXAus. 12	42.391**	43.221**	-0.104	-11.424**	-0.013	-10.682*	0.453
Kar. 2XG. 45	-34.020**	-32.649**	-6.393	-5.992	3.412*	-2.184	-2.083
Kar. 2X(G. 89XG. 86)	21.273**	11.413	-10.632	-6.683	-8.205**	-18.522**	-2.110
Kar. 2XG. 86	7.041	-2.151	-20.113**	-6.159	-8.620**	-18.935**	-0.431
Kar. 2XG. 94)	4.881	-6.456	-15.208*	-13.487**	-10.828**	-28.322**	0.848
Kar. 2XG. 93	15.948*	10.358	3.972	-9.168*	-4.832**	-15.795**	6.356**
Kar. 2XCB 58	33.496**	28.855**	-4.933	-4.851	-3.370**	-8.842	-0.418
Kar. 2X(G. 75XSea)	-56.252**	-60.128**	-15.286*	-14.413**	-8.857**	-26.669**	-2.083
Kar. 2XAus. 12	-31.629**	-32.387**	-6.114	-8.734*	-1.163	-10.403*	-0.443
G. 45X(G. 89XG. 86)	-2.900	1.816	-20.211**	-2.692	4.850**	5.182	-9.167**
G. 45XG. 86	3.237	2.370	0.846	-2.053	-0.923	-3.657	-1.667
G. 45XG. 94	-28.037**	-36.628**	-24.894	-23.825**	-11.939**	-38.122**	-1.250
G. 45XG. 93	-21.400**	-13.746	11.872	-4.320	9.674**	10.569*	-9.167**
G. 45XCB 58	101.520**	125.453**	14.574	4.316	11.862**	27.134**	-3.333*
G. 45X(G. 75XSea)	-4.067	-13.630**	-24.253**	-23.337**	-9.950**	-35.585**	-0.417
G. 45XAus12	-2.328	0.999	-3.316	-7.753	3.276*	-2.908	-3.750*
(G. 89XG. 86)XG86	4.799	3.292	-19.549**	0.031	-1.512*	-2.454	0.000
(G. 89XG. 86)X G. 94	-11.128	-12.057	-27.018**	-17.685**	-3.632**	-22.717**	-4.219*
(G. 89XG. 86)XG. 93	-5.238	-7.037	-6.514	0.341	-1.887**	-0.718	1.266
(G. 89XG. 86)XCB 58	-6.222	-8.746	-5.364	-10.199*	-2.709	-14.110**	-2.092
(G. 89XG. 86)XG.75XSea	-34.647**	-38.893*	-6.234	-9.202**	-6.465**	-18.834**	-1.667
(G. 89XG. 86)xAus12	4.060	-6.602	-7.280	2.184	-0.306	1.693	-6.751**
G. 86X G. 94	-16.904*	-14.828*	-11.980	-12.857**	-0.477	-13.586	-5.508**
G. 86XG. 93	24.846**	16.821**	-15.414*	-9.168*	-6.389**	-18.380**	3.814*
G. 86XCB 58	-8.200	-9.781	-1.974	1.990	-1.777	-0.926	-0.418
G. 86X(G. 75XSea)	-49.145**	-50.433**	-2.903	-0.527	-2.357	-4.323	-5.000**
G. 86XAust12	-11.968	-22.151**	-4.229	18.973**	-0.267	18.472**	3.017
G. 94XG. 93	9.066	-6.330	-31.606**	-17.318**	-14.071	-35.449**	3.390**
G. 94XCB 58	37.471**	24.317**	-10.025	-17.685**	-9.637	-30.512**	-1.255
G. 94X(G. 75XSea)	-4.101	-4.157	-3.398	-12.962**	-0.260	-11.767**	-1.250
G. 94XAus. 12	-11.216	-24.672**	-20.391**	-13.251**	-8.252	-24.796**	-1.695
G. 93XCB 58	-4.521	5.303	-4.036	-2.797	10.215	13.211**	-10.042**
G. 93X(G. 75XSea)	-8.167	-9.188*	-11.529	-3.853	-0.993	-5.442	-3.750*
G. 93XAus. 12	16.193**	17.848*	-9.119	3.138	-1.485	2.461	-0.847
CB 58X(G. 75XSea)	-24.383**	-28.143**	-13.322*	-4.685	-4.989	-12.582*	-0.417
CB 58XAus. 12	-9.810	-2.974	8.497	1.456	7.530	13.814**	0.837
(G. 75XSea)XAus. 12	-39.404**	-46.276**	-3.213	-15.438**	-11.258	-30.606**	-3.750*

** and * significant at 0.05 and 0.01 levels of probability respectively.

Principal component

Principal component analysis (PCA) reflects the important of the largest contributor to the total variation at each ax for differentiation **Sharma, (1998)**. Principal component analysis seemed to elucidate patterns of variation in agronomic attributes which are of economic importance and obtain entail factor solution using Eigen values. These values could measure the explained variance associated with each variable **Hair *et al.*, (1987)**. The first three principal components (PCS) whose Eigen values were greater than one were significant and accounted 90.3 % of total variation of all characters (Table 6). The first PC explained about 54.2 % of the all total variation with the highest Eigen value of 3.7935, the second explain 21.5 % with Eigen value of 1.5066, the third explained 14.6 % of the total variation with Eigen value of 1.0227.

According to **(Chahal and Gosal, 2002)** characters with largest absolute values closer to unity within the first principal component influence the clustering more than those with lower absolute values closer to zero.

Thus, it is possible to include the corresponding amount of variance in a two dimensional plot of the components. Each genotype is plotted at it is principal component score on each axes **(Brown, 1991)**. Each character was an important source of variation in at least one PC axes, because each of PC axes was given equal weight in the multivariate analysis. Thus each of character was contributed to the information which used to group genotypes; however some characters may have greater importance in determine plant phenotypes than others. Lint index followed by lint percentage, boll weight, lint yield as well as seed index were a primary source of variation with the largest coefficient in the first PC axes respectively. Thus, the first PC ax was correlated with yield and weighted characters with positive loadings. While the second PC ax was principally affected by seed cotton yield with hallo length. The other rest axes deals with hallo length which showed negative loading. In this connection **Abdel- Salam *et al*, (2010)** and **El- Mansy *et al*, (2014).**

The present study confirmed that cotton genotypes showed wide amount of variation for studied characters and it also suggests ample opportunities for genetic improvement of cotton genotypes. Each component score is a linear combination of the characters, similar to an index, such that the maximal amount of variance is shown in the first and second PC, etc. The two dimensional distance between genotypes might reflect a summary of differences based on all characters measured to the extent that the first two PC axes are effective in capturing the combined variance of most characters (Fig. 1). Therefore, the first two PC axes were used to plotting the studied parental genotypes and F_1 hybrids. In this connection **Hair *et al*., (1987), Sharma, (1998), You *et al*., (1998), Abd El- Sayyed *et al*., (2000)** and **El-Lawendy *et al*., (2008).**

On the basis of the relative contribution of the studied yield and fiber characters, the 10 parental genotypes and 45 F_1 crosses combinations were grouped into varied genotypes (Figure 1). The parental genotypes were separated into varied groups. The parental genotype Giza 75 x Sea formed unique group, however the other two varieties Giza 86 and Giza 94 clustered in one group and nearly related with Giza 75 x Sea group. Such genotypes characterized as a good combiner for most yield characters. On the other side Giza 93 located in group with some F_1 combinations. This parent was a good combiner for hallo length character.

Table 6: Principal components (PC) analysis of characters associated with nine cotton genotypes showing Eigen values and proportion variation associated with the five PC axes and Eigen vector of characters

Variable	PC1	PC2	PC3	PC4	PC5
Eigen value	3.7935	1.5066	1.0227	0.3839	0.2886
Proportion	0.542	0.215	0.146	0.055	0.041
Cumulative	54.2	75.7	90.3	95.8	99.9
Eigen vector					
SCY/Plant	0.638	0.723	0.229	0.013	0.133
LCY/Plant	0.771	0.574	0.267	0.04	0.042
BW, g	0.799	-0.146	-0.208	-0.546	0.009
SI, g	0.756	-0.393	-0.356	0.196	0.33
LP, %	0.848	-0.288	0.275	0.096	-0.336
LI, g	0.911	-0.375	0.002	0.161	-0.054
H L, mm	0.188	0.506	-0.809	0.104	-0.21

Five Parental genotypes TNB, Kar.$_2$,Giza 45, Aus.$_{12}$ and CB 58 were grouped in the same group and characterized as poorer parent for GCA for yield and fiber characters these parents were isolated by the second PC axes . On the basis of SCA most combination having significant SCA effect was between genetically diverse parents. On the other side most F_1 combinations which formed wide distance groups were between parents in different clusters.

It is evident to no that crossing of distantly related parents may give best hybrids which surpassed their parents in most characters and should produce higher variances for most characters in segregating generations rather than crossing between closed related parents which agree with **Suinaga *et al*., (2005) and El- Mansy *et al*, (2014).**

From a plant breeding principal component analysis is useful in identifying and the most influential characters affecting genetic variation of plant population. The loading of morphological and agronomic characters of an individual genotype indicate the magnitude of genetic variation.

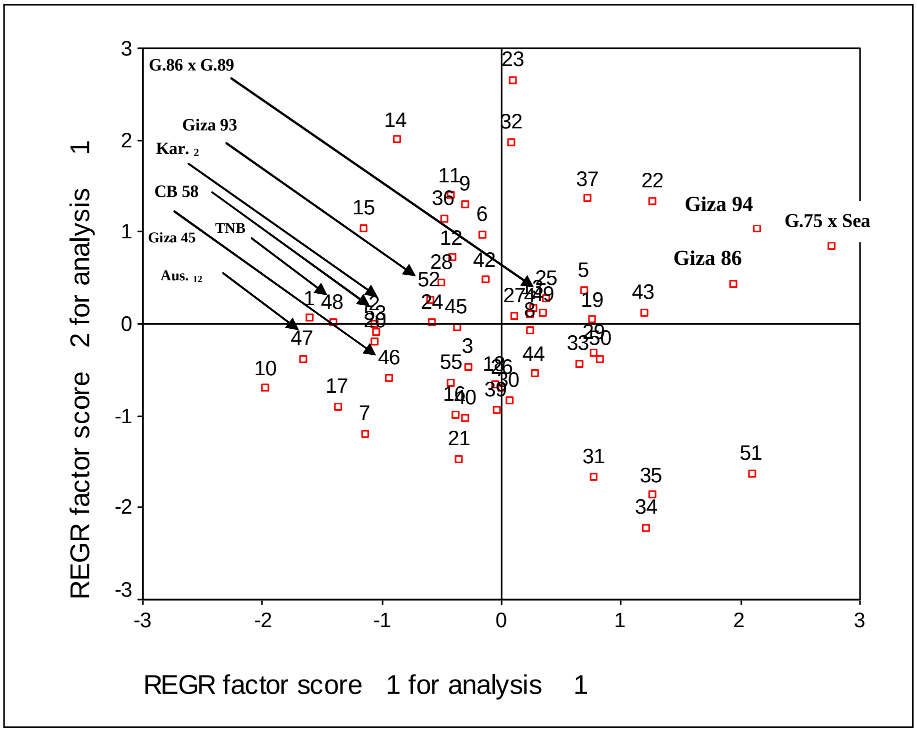

Figure 1: Representation of 55 cotton genotypes of the first two PC axes of principal component analysis

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الملخص العربى

القدره على التألف وعلاقتها بالتباعد الوراثى فى أقطان الباربادينس

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اجريت هذه الدراسة في محطة البحوث الزراعية بسخا , معهد بحوث القطن وذلك لتقييم الأباء والهجن الناتجه عنها للحصول على تراكيب وراثيه جديده متميزه فى صفات المحصول والتيله في بعض هجن القطن (الباربادينس) الناتجة من التهجين نصف الدائري (half-diallel) بين عشرة اباء وتقدير بعض المقاييس الوراثيه مثل القدره العامه والخاصه على التألف واستخدام تكنيك التحليل المتعدد Multivariate analysis باستعمال المكونات الأساسيه Principal components analysis لدراسة الأهميه النسبيه للصفات المختلفه ومدى مساهمتها فى التباين الوراثى وفصل التراكيب الوراثيه المتشابهه فى مجاميع مختلفه. اجرى التهجين للاباء موسم 2015 وتقييم الأباء العشره والخمسه واربعون هجين الناتجه عنها موسم فى2016 لتقدير صفات محصول القطن الزهر/نبات ،محصول الشعر/نبات، وزن اللوزه (جرام)، معامل البذره (جرام)، معدل الحليج (%)، معامل الشعر(جرام)، طول الهاله (ملليمتر).

أظهرت النتائج مايلى:

وجود اختلافات عالية المعنويه للتراكيب الوراثيه والقدره العامه والخاصه للتألف لكل

الصفات تحت الدراسه.
بالنسبه لتقدير القدره العامه على التألف كان الأبوين Giza 94, Giza 75 x Sea الأفضل وذات قدره عامه على التألف لكل الصفات تحت الدراسه.
أظهرت تقديرات القدره الخاصه على التألف أن الهجن
Giza 45 x CB 58, TNB x Aus. $_{12}$, Kar. $_{2}$ x Giza 94, Giza 94 x (Giza 75 x Sea), Giza 93 x (G.75 x sea).
كانت الأعلى والأفضل للقدره الخاصه على التألف لمعظم الصفات تحت الدراسه.
أظهرت النتائج بالنسبه لتقدير قوة الهجين مقارنة بأفضل الأباء أن الهجن
Giza 45 x CB 58, TNB x Aus. 12, Kar. 2 x CB 58, Giza 94 x Giza 93, Kar.2 x Giza 45, Giza 45 x Giza.93, Giza 45 x Aus.12, Kar. 2 x Giza 93, Giza 93 x CB 58.
تفوقت وأعطت قوة هجين موجبه لمعظم الصفات تحت الدراسه مقارنة بباقي الهجن.
- أظهر تحليل المكونات الأولية أن الثلاث مكونات الأولي كانت معنوية وتحصر حوالي 90.3% من التباين الكلي مع أقصي قيمه من التباين المرتبط Eigen value .
- كانت صفات معامل الشعر يليها معدل الحليج ووزن اللوزة ومحصول الشعر الأكثر أهمية في التباين علي المحور الأول بينما تأثر المحور الثاني بصفات محصول القطن الزهر وطول الهالة .
- قورنت الأباء العشرة في مجاميع مختلفة علي أساس المساهمة النسبية للصفات المدروسة . كما وجد توافق بين كل من التباعد الوراثي للأباء مع القدرة العامة والخاصة علي التألف.
اوضحت النتائج ان تحليل المكونات الأساسية فصل بعض التراكيب الوراثية فى مجموعات متباعده مما يفيد مربى القطن باستخدام تلك المعلومات لإختيار أفضل الأباء والهجن لتحسين الصفات المختلفة في الأجيال الإنعزالية .