Genetic Analysis of Some Productivity Traits and Earliness in Upland Cotton (*Gossypium hirsutum* L.)

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Abstract
Genetic potential, combining ability, heterosis effects and heritability were studied in F1 genotypes of *Gossypium hirsutum* L., at Cotton Research Station in Deir Ezzor, Syria. Four parental genotypes (Aleppo 33/1 (P_1), Deir Ezzor 22 (P_2), Line 106 (P_3) and Line G73 (P_4)) and their six F1 half diallel progenies were grown in a randomized complete block design with three replications in 2011 season to study seed cotton yield (S.C.Y.kg/don.); lint percentage (L.P.%) and earliness percentage (E.P.%). Results showed significant ($p\leq0.01$) differences among the genotypes, parents and crosses for seed cotton yield and lint percentage. Significant ($p\leq0.05$) differences were observed for parent vs. crosses indication to average heterosis over all hybrids for the above two traits. For earliness, insignificant differences were showed among genotypes, crosses and parent vs. crosses, but significant ($p\leq0.05$) differences were showed among parents. Results indicated that best genotypes which performed highest mean and general combining ability were: lines 106 and G73 for seed cotton yield; Deir Ezzor 22 for lint percentage and Aleppo 33-1 for earliness percentage. Thus, it could be suggested that these parental varieties could be utilized in a breeding program for improving these traits to pass favorable genes for improving hybrid and subsequently producing improved genotypes through the selection in segregating generations. Best crosses based on mean performance and/or heterosis and/or specific combining ability were Aleppo 33-1*G73 followed by Aleppo 33-1*line 106 for seed cotton yield; Aleppo 33-1*G73 for lint percentage and Line 106*G73 for earliness percentage. Suggesting that these crosses could be used in breeding program to improve such traits. On the other hand, results showed high value of H^2_b % and low value of H^2_n%for seed cotton yield, ascertained that dominance effects had great role in the existence of the variability of this trait, which insure that the expected gain from recurrent back crossing for seed cotton yield would be high in the breeding program. However, estimates of H^2_b % and H^2_n% for both of lint percentage and earliness percentage were high. Theses convergence of narrow and broad heritability values revealed that both additive and non-additive gene actions played important roles in the inheritance of these two above traits, so breeding program should contain selection and hybridization for improving these traits.

Kay words: Cotton, Combining ability, Heterosis, Heritability.

Introduction:

Cotton is the king of fiber reside one of the momentous and important cash crops exercising profound influence on economics and social affairs of the world. The word “cotton” derived from the Arabic word “al qatan” (Gohil *et al.*, 2017) and popularly known as “White Gold”.

Upland cotton (*Gossypium hirsutum* L.) accounts for approximately 90% of the world cotton production (Lacape *et al.*, 2007; Yu *et al.*, 2011). Cotton breeders seriously face the problem of selecting suitable parents and promising crosses to breed high yielding and high quality cotton varieties. Combining ability and genetic variation are useful in determining the breeding value of some populations and the appropriate procedures to use in a breeding program (Ilyas *et al.*, 2007), however, the most commonly utilized experimental approach is the diallel design. Griffing’s biometrical analysis (Griffing, 1956) has been widely used to aid plant geneticists in selection of genotypes for hybridization. In a generalized theoretical form, Griffing’s combining ability is mostly used for analysis of diallel crosses.

Past studies revealed that in plants, the heterosis is known to be a multigenic complex trait and can be extrapolated as the sum total of many physiological and phenotypic traits (Baranwal *et al.*, 2012), and it enabled the plant and animal breeders to improve the performance for several economic traits (Khan, 2013). Rosas *et al*., (2010) discussed the role of variation in gene expression between parental species and its effect on phenotype, and concluded that F_1 hybrids might be expected to show increased performance with regard to basic physiological traits such as growth.

Sorour *et al.*, (2000) reported the presence of significant heterosis over mid-parents for earliness. Awad (2001), stated that heterosis relative to mid-parents was desirable and highly significant for earliness indicators, namely first fruiting node, while days to first flower was insignificant. In this respect, El-Helw (2002) stated that the average percentage of heterosis relative to better and mid-parents were -1.73 and -2.10 for days to first flower, while it was insignificant for first fruiting node. He showed the values of heterosis relative to mid-parents as 48.13%, 46.59%, 6.34%, 1.01% and -1.48% for seed cotton yield/plant, lint yield/plant, boll weight, seed index and lint percentage, respectively. Meanwhile, the corresponding values relative to better-parent were 11.03%, 10.85%, 5.69%, -2.94% and-2.64% for the same previous traits, respectively.

McPherson *et al.* (2002) reported that diallel crosses was including all possible crosses between a diverse group of nine varieties. The thirty-six F1's were tested during 2001 at five field locations near Leland (in India). Since the GxE interaction term in the combined ANOVA was significant, lint yield was analyzed separately for each location. At MS. the Upland X Upland crosses exhibited an average of 10.5% heterosis for yield. Interestingly, the cross of (X-6348 x PSC355) and (X-6348 x DP Pearl) resulted in the greatest heterosis as these crosses yielded 26.0% and 21.3% more than their respective best parents. At Waukena-CA, only four crosses yielded more than their best parent. At Stratford-CA, the Upland X Acala crosses on the average exhibited 6.6% heterosis with GTO/SG747, GTO/FM958, and GTO/FM966 having the highest heterosis at 13.5%, 13.3%, and 18.2%, respectively. Abd El-Bary (2003) from his studies on diallel analysis among six Egyptian cotton varieties (Giza-85, Giza-86, Giza-89, Giza-76, Giza-77; and Giza-87), mentioned that the results indicated the presence of highly significant genotypes mean squares for seed cotton yield, lint yield, number of branshs /plant, seed index, lint percentage, lint index and boll wieght. Positive heterosis observed over mid-parents (M.P) for all studied yield and its attribute traits except lint index (L.I). The value of positive (desirable) heterosis over mid-parents (M.P.) varied from 2.47% for seed index (S.I.) to 11.92% for seed cotton yield/plant

(S.C.Y./plant). In addition, the estimated values of heterosis relative to better-parent indicated the absence of heterotic effect in all studied yield and its component traits.

Iqpal *et al.*, (2011) reported that six cotton varieties were crossed in a complete diallel fashion to study the inheritance of seed cotton yield and its components, lint percentage and fiber length. Field evaluation of six parental genotypes and thirty F1 was made. Genotypes mean values differed significantly ($P \leq 0.05$) for all traits.

Khan *et al.*, (2015) detected that genetic potential and combining ability were studied in 6 × 6 F1 crosses of *Gossypium hirsutum* L. Six parental genotypes (CIM-446, CIM-496, CIM-499, CIM-506, CIM-554 and CIM-707) and their thirty F1 diallel progenies were grown. Significant ($p \leq 0.01$) differences were observed among the genotypes for bolls per sympodia, bolls per plant, boll weight, seed cotton yield per plant, lint % and lint index. F1 hybrids showed significant increase over parental means for all the traits.

Coban and Unay (2017) reported that gene action and useful heterosis were investigated for fiber quality and yield traits in interspecific cotton crosses. The twelve F1's and their parents were evaluated during 2011 and 2012 cotton growing season. Analysis of variance refered that mean squares of genotypes (G), parents (P) and crosses (C) for seed cotton yield and lint percentage were significant. On the other hand, mean squares of (P vs.C) was highly significant for lint percentage but insignificant for seed cotton yield. The useful heterosis were positively significant for fiber strength and fiber length. Candia x Giza 45 hybrid was promising hybrid for all observed characters.

Gohil *et al.*, (2017) reported that A line x tester analysis was undertaken to estimates the magnitude of heterosis in interspecific hybrids of cotton (*Gossypium hirsutum* L. x *Gossypium barbadense* L.) for yield and its components characters in 56 entries including (42 hybrids along with 13 parents and 1 standard check hybrid). Analysis of variance indicated the significant difference among the parents and hybrids for all thirteen characters studied which revealed existence of variability among the genotypes. Studies revealed that for seed cotton yield per plant out of 42 cross combinations, 10 hybrids had registered significant positive estimates of heterobeltiosis.

Djaboutou *et al.*, (2017) detected that analysis of variance showed highly significant differences among the14 cotton genotypes ($p<0.001$). On the other hand, the results showed high heritability for earliness traits.

Lingaraja *et al.*, (2017) used 60 hybrids which obtained from a line x tester analysis of crosses involving fifteen female parents and four male parents to evaluate the heterosis effects for economic and fibre quality traits. The results showed that range of economic heterosis varied from -11.06 to 3.37% for ginning outturn to -60.38 to 48.32 for seed cotton yield per plant. The overall study of heterosis revealed that the better performing hybrids, H1316 X H1236 for seed cotton yield, LH2232 x H1236 for ginning outturn.

For significant improvement in genetic potential of genotypes for yield and fiber quality traits, the cotton hybrid is a good approach (Khan *et al*., 2010b, 2011). However, for hybrid cotton, the various cotton lines are screened through combining ability to determine their GCA and SCA for new cross combinations. Many commercial cotton cultivars despite their high/low agronomic performance combine in a more good way/poorly when used as a parental cultivars in cross combinations.

Due to GCA and SCA, significant genetic variances were noticed for various yield related traits in *Gossypium hirsutum* L. (Baloch *et al*., 2000; Hassan *et al*., 2000; Islam *et al*., 2001; Azhar and Naeem, 2008 ; Khan *et al*., 2009 a, b; 2011). Non-additive type of gene action was observed for boll weight, boll number, lint % and seed cotton yield (Muthu *et al*., 2005; Ahuja and Dhayal, 2007 and Ilyas *et al*., 2007). However, additive genetic effects with enough genetic variability were noticed for most of the yield traits, and effective selection was suggested in early segregating generations in upland cotton (Chinchane *et al.*, 2002; Yuan *et al.*, 2002; Lukonge *et al*., 2008; Khan *et al.*, 2009b). Such contradictions might be due to varied genetic backgrounds of cotton genotypes used under different environmental conditions.

Ali *et al.*, (2016) reported that combining ability and heterosis for within-boll yield components and fiber quality traits were carried out using line ×tester mating system in upland cotton. Variance due to specific combining ability was greater than general combining ability for all the traits depicting the importance of non-additive genetic effects.

Karademir and Gencer (2010) found that in the populations, ginning percentage, was influenced by additive. On thae other hand, seed cotton yield was influenced by non-additive gene effects.

Khan *et al.*, (2010 b), find that high broad sense heritability and selection response were formulated for lint percentage % (0.96, 1.66 %) and seed cotton yield (0.98, 643.16 kg).

Iqpal *et al.*, (2011) reported that six cotton varieties were crossed in a complete diallel fashion to study the inheritance of seed cotton yield and its components, lint percentage and fiber length. Field evaluation of six parental genotypes and thirty F1 was made in a randomized block design with three replications. Estimates of narrow sense heritability (H^2n) were higher for all the traits that are due to additive gene action. The results of the present study indicated that the pedigree of progeny selection will be helpful to improve these traits.

Keeping in view the work of above scientists, the current study was carried out to analyze some genotypes with respect to involved genetic mechanism, genetic diversity, heritability, combining ability effects and heterotic potential of parental genotypes and their crosses for seed cotton yield (S.C.Y. kg/don.), lint percentage (L%) and earliness percentage (E%), and all that aimed to utilizing the accurate choice of parents and crosses to develop a genetic base for future breeding programs and provide a better insight into the genetic control of the traits considered.

Materials and Methods:

2.1. Genetic materials:

The genetic materials used in the present investigation included four genotypes, they were, Aleppo 33/1 (P_1), Deir-Ezzor-22 (P_2), line 106 (P_3) and line G73 (P_4), all of them are belong to (*Gossypium hirsutum* L.). This experiment was carried out at Almreiya Agricultural Experimental Station, Agricultural Research Center, Deir-Ezzor, GCSAR, Syria. over two seasons (2010 and 2011). Deir-Ezzor is located on the eastern part of Syria (latitude 35 º 19′ N and Longitude 40 º 8′ E), it is situated at elevation 212 meters above sea level. Planting dates were in the second week of April in each season.

The inbred seeds of all genotypes were obtained from Cotton Breeding Department, Cotton Research Admenistration, General Commission of Scientific Agricultural Research (GCSAR).

2.2. Mating design:

In 2010 season, the above four genotypes were grown and crosses were made according to the factorial mating design (method 2, model II) (Griffing, 1956). where, the F_1's crosses [p(p-1)/2] resulted in 6 F1 genotypes plus the four parental genotypes.

Crosses were made using hand emasculation and pollination techniques while the parental varieties were selfed. In the second season of 2011, the evaluation trial was carried out.

2.3. Experimental design:

The experimental design used in 2011 season, was a randomized complete blocks design with three replications. Each plot consisted of two rows 5.0 m long and 0.7 m. wide. Hills were 0.25m apart to insure 20 hills per row. Hills were thinned to keep a constant stand of one plant per hill at seedlings stage. Before planting, experimental plots were dressed with calcium super phosphate (15.5 % p_2o_5) at the rate of 9.8 Kg /donam during the preparation of experimental fields. Plants were fertilized with nitrogen in the form of urea (33.5 %) at rate of 38 Kg /donam given into three doses as recommended for cotton in Syria and were applied properly in the two seasons .

2.4. Studied traits:

Data were recorded for each individual plant and the means of each plot were used for analyzing the studied traits as follows:

- **Seed cotton yield (S.C.Y.) kg.don.**: it was measured as the weight of seed cotton per plot and converted to kg / don., equivalent.
- **Lint percentage (L.P.) %:** This trait was estimated as the ratio of cotton lint to 100 grams of seed cotton yield expressed as percentage, where

L.P.%= (weight of lint sample/ weight of seed cotton of the same sample)*100

- **Earliness percentage (E) %:** it was calculated according to the following equation:

Earliness%= (Seed cotton yield of the first pick/weight of the two picks)*100

2.5. Biometrical procedures:

- **Analysis of variance:**

The collected data were subjected to a normal analysis of variance of the randomized complete block design (RCBD) according to Cochran and Cox (1957), to test the significance of the genotype differences. The degrees of freedom and sum of squares due to genotypes were further partitioned into parents, crosses and parents vs. crosses. Differences between each item were tested for significant according to the regular F-test. The form of partitioning degrees of freedom is presented in Table (1).

Table 1. Analysis of variance and partitioning degrees of freedom.

Sources of variations	d.f	M.S
Replications	r-1	M_6
Genotypes	g-1	M_5
Parents (P)	p-1	M_4
Crosses (C)	(p(p-1)/2)-1	M_3
Parents vs.Crosses	1	M_2
Error	(r-1)(g-l)	M_1

Where:

r, g and p are number of replications, genotypes and parents, respectively.

M_1, M_2, M_3, M_4, M_5 an M_6 are the error, average heterosis, crosses, parents, genotypes and replications mean squares, respectively.

- **Estimation of heterosis**:

Values of F_1 heterosis relative to mid- parents (M.P.) and heterobeltiosis relative to better parent (B.P.) were calculated as follows:

$$H(F_1, M.P)\% = \frac{\overline{F_1} - \overline{M.P.}}{\overline{M.P.}} \text{x}100$$

$$H(F_1, B.P.)\% = \frac{\overline{F_1} - \overline{B.P.}}{\overline{B.P.}} \times 100$$

Where:

$\overline{F_1}$: Mean of the F_1 cross

$\overline{M.P}$: Mean of the two parents = $(P_1+P_2)/2$

$\overline{B.P}$: Mean of the better parent.

The significance of heterosis was determined using T test at 0.05 and 0.01 levels of significance, according to the following equation, which was calculated as suggested by Steel and Torrie (1980):

$T=(F_1\text{-}MP)/SE$

Where:

Standard deviation (SE) for mid-parent was calculated as:

$SE= (3EMS/2r)^{1/2}$

Standard deviation (SE)for better parent was calculated as:

$$SE= (2EMS/ r)^{1/2}$$

Where:

t = tabulated value at error degrees of freedom ($E._{d.f}$) at certain probability levels

E.M.S.= error mean square

r = number of replications

- **Types of heritability:**

The evaluation of genetic variability available is apreparatory to start a program of selection and particularly to choose the parents to be crossed (Hamli *et al.,* 2015). In the same way, the heritability of the characters determines the response to the selection and depends on the genetic material studied as well as experimental device (Atta *et al.,* 2008).

Depending upon the components of variance used as numerator in the calculation, heritability is of two types, viz, broad sense heritability and narrow sense heritability.

a. Broad sense heritability (H_b%): It is the ratio of genotypic variance to total or phenotypic variance. It is calculated from total genetic variance which consist of additive, dominance and epistatic variances.

b. Narrow sense heritability (H_n%): It is the ratio of additive or fixable genetic variance to the total or phenotypic variance. It plays an important role in the selection process in plant breeding.

3. Results and Discussion:

Cotton breeders usually seek for variations, which if not present they have to create it through hybridization programs. At the same time, the production of the promising hybrids depends on the choice of parental lines as well as their order in hybridization which yielded the useful heterosis when crossed together (Attiea, 2004).

3.1. Genotypes mean performance:

- **Seed Cotton Yield (S.C.Y.) kg/don.:**

The means of S.C.Y. for all genotypes used in this study are estimated and presented in Table (2). The means showed that there is no specific parent, which is superior, where the parent P_3 (line 106) had highest mean as (463.90 kg.don.) with insignificant differences above other parents, followed by P_4 (G73) with mean 457.20. While the variety Aleppo-33 (P_1) is the inferior parent where it exhibites worst value (287.25 kg/don.). In respect of crosses, they have the same manner, where there is no superior hybrid but the hybrid P_1*P_2 (Aleppo 33-1*Deir Ezzor) is the inferior which exhibtes worst value (343.62 kg/don.). The analysis of variance for this trait of the four parental genotypes, 6 F1's hybrids are computed and presented in Table (3). The results show that mean squares of genotypes and hybridsa ere highly significant expression of considerable variability may be attributed to the broadgenetic base of the genotypes used to develop the progeny (Ali *et al.*, 2016). Highly significant mean squares are observed among parents indicating the presence of variability among parents. These results are in accordance with those reported by Abd El-Bary (2003); Attiea (2004); Iqpal *et al.* (2011); Khan *et al.*m,(2015); Coban and Unay, (2017); Djaboutou *et al,*. (2017) and Gohil *et al.*, (2017). Significant mean squares are recorded among parent vs. crosses. indicating the importance of breeding for hybrid vigor. These results are in accordance with those reported byAbd El-Bary (2003); Guvercin (2011); Iqpal *et al.*, (2011); Khan *et al.*, (2015); Djaboutou *et al.* (2017) and Gohil *et al.*, (2017). On the other hand, Coban and Unay, (2017) reported insignificant mean square among parent vs. crosses for seed cotton yield.

- **Lint Percentage (L.P.) %:**

The means of 10 genotypes were determined and the results are presented in Table (2). The means show that the parent P_2 (Deir ezzor-22) is the best (40.22%), while P_1 (Aleppo-33) is the worst (37.05%). Regarding crosses, the hybrid P2*P3 was the best (39.87%), but the hybrid P1*P3 is the worst (38.23%). The analysis of variance for this trait of the four parental genotypes, 6 F1's hybrids are computed and presented in Table (3). The results show that highly significant mean squares are recorded among genotypes and among hybrids expression of considerable variability may be attributed to the broad genetic base of the genotypes used to develop the progeny (Ali *et al*., 2015). highly significant mean square are obsorved among parents which revealed the presence of variability among parents. On the other hand, highly significant mean square are showed among parent vs. crosses indicating the importance of breeding for hybrid vigor. These results are in accordance with those reported by Abd El-Bary (2003);Attiea (2004); Guvercin (2011); Khan *et al*. (2015); Ali *et al*. (2016); Coban and Unay (2017) and Lingaraja *et al*. (2017).

Table 2.The mean performance of parents and 6 F1 hybrids for the studied traits

Genotypes	S.C.Y. kg/don.	Lint Percentage %	Earliness %
P_1	287.25 b	37.05 d	93.59 a
P_2	419.03 a	40.22 a	89.16 b
P3	463.90 a	38.23 c	88.65 b
P4	457.20 a	38.40 c	89.07 b
P_1*P_2	343.62 b	39.30 b	89.93 ab
P_1*P_3	447.00 a	38.23 c	89.03 b
P_1*P_4	447.03 a	38.57 c	89.47 b
P_2*P_3	468.23 a	39.87 ab	87.93 b
P_2*P_4	470.07 a	39.57 ab	88.63 b
P_3*P_4	477.00 a	38.33 c	88.90 b
General mean	428.03	38.79	89.44
L.S.D. $_{0.05}$	73.68	0.84	3.87
C.V.%	10.04	1.25	2.52

Means with the same letters have no significant differences at 0.05 level of probability.

- **Earliness Percentage (E) %:**

The means of earliness for all genotypes used in this investigation are estimated and presented in Table (2). The means for earliness show that there is a specific parent as P_1 (Aleppo-33) which is superior (93.59%), but P_3 (line 106) was inferior (88.65%). In relative of crosses, the cross P_1*P_2 was insignificantly earlyer cross (89.93%), while P_2*P_3 is the worst (87.93%). The analysis of variance for earliness percentage of the four parental genotypes and six F1's hybrids are computed and presented in Table (3). The results indicate the presence of significant mean squares among parents indicating the presence of variability among parents, These results are in agreement with those obtained by Awad (1991), Abd El-Bary (2003), Attiea (2004); Guvercin (2011) and Botao *et al*., (2016). On the other hand, variances among genotypes, crosses and parent vs. crosses are insignificant.

Table 3. Analysis of variance for seed cotton yield, lint percentage and earliness percentage.

S.O.V.	d.f.	Mean Squares for Studied Traits		
		S.C.Y. kg/don.	**Lint Percentage%**	**Earliness%**
Replication	2	29947.09 **	0.78 n.s.	42.65 **
Genotypes (G)	9	11887.98 **	2.71 **	7.22 n.s.
Within parents (P)	3	20241.12 **	5.14 **	16.20 *
Within crosses (C)	5	7456.84 **	1.43 **	1.42 n.s.
P * C	1	8979.33 *	1.83 *	9.25 n.s.

(ns), *, **, denote not significant, significant differences at 0.05 and 0.01 levels of probability respectively.

3.2. Heterotic effects:

The significance of heterotic effects is determined for all comparisons by the differences against the suitable (T) values. Average heterosis is also computed through parents vs. crosses in the analysis of variance.

- **Seed Cotton yield (kg/don):**

Table (3) presents mean squares obtained for seed cotton yield. Results indicate that the mean square for parents vs. crosses, as indication to average heterosis over all hybrids, was significant, indicating that the heterotic effects over all crosses pronounced for this trait. Heterosis expressed as the percentage deviation of F_1 performance from either mid-parent or better parent (heterobeltiosis) are given in Table (4 and 5). Results in Table (4) showe that there were two crosses (P_1*P_3 and P_1*P_4) had desirable positive significant heterosis, namely (Aleppo 33-1*line 106 and Aleppo 33-1*G73). These results enable to recommend by using this cross in breeding program for producing much yield varieties. On the other hand, results in Ttable (5) showe that there is one undesirable significantly negative heterobeltiosis (P_1*P_2), namely (Aleppo 33-1*Deir Ezzor-22).These results are in harmony with those reported by Guvercin (2011) and Gohil *et al*., (2017).

- **Lint percentage (L%):**

Table (3) presents mean squares obtained for lint percentage. Results indicate that the mean square for parents vs. crosses, as indication to average heterosis over all hybrids, is significant, indicating that the heterotic effects over all crosses pronounced for this trait. The percent heterosis (relative to mid-parents) and heterobeltiosis (relative to better-parents) for lint percentage are determined from the data and the obtained results are presented in Table (4 and 5). Results in Table (4) showed that there is one cross (P_1*P_4) had desirable positive significant heterosis, namely (Aleppo 33-1*G73). These results enable to recommend by using this cross in breeding program for producing varieties with high lint percentage. On the other hand, results in Table (5) show that there is one undesirable negative heterobeltiosis (P_1*P_2), namely, (Aleppo 33-1*Deir Ezzor 22). These results are in harmony with those reported by Baranwal *et al*., (2012), Botao *et al*., (2016) and Gohil *et al*., (2017).

- **Earliness percentage (E%):**

The analysis of variance show that the mean squares for parents vs. crosses, as indication to average heterosis over all hybrids, is insignificant (Table 3). The percent heterosis (relative to mid-parents) and heterobeltiosis (relative to better-parents) for earliness percentage are determined from the data and the obtained results are presented in Tables (4, 5). Results in Table (4) showed that all F1 crosses had insignificant heterosis. On the other hand, Results in Table (5) show that three of crosses had negative significant heterobeltiosis, namely (P_1*P_2; P_1*P_3; P_1*P_4). These results are in harmony with those reported Guvercin (2011), Baranwal *et al*., (2012), Botao *et al*., (2016) and Gohil *et al*,. (2017).

Table 4. Heterosis manifestation for seed cotton yield, lint percentage and earliness percentage.

Crosses	**Studied Traits**		
	S.C.Y. kg/don.	**Lint Percentage %**	**Earliness %**
P_1 * P_2	-2.7 n.s.	1.73 n.s.	-1.58 n.s.
P_1 * P_3	19.02 *	1.58 n.s.	-2.29 n.s.
P_1 * P_4	20.09 *	2.24 *	-2.04 n.s.
P_2 * P_3	6.06 n.s.	1.64 n.s.	-1.10 n.s.
P_2 * P_4	7.29 n.s.	o.66 n.s.	-0.54 n.s.
P_3 * P_4	3.57 n.s.	0.43 n.s.	0.05 n. s.
SE	**30.40**	**0.35**	**1.60**

(ns), *, denote not significant, significant differences at 0.05 level of probability .

Table 5. Heterbeltiosis manifestation for seed cotton yield, lint percentage and earliness percentage.

Crosses	Studied Traits		
	S.C.Y. kg/don.	**Lint Percentage %**	**Earliness %**
P_1 * P_2	-17.99 *	-2.28 *	-3.90 *
P_1 * P_3	-3.64 n.s.	0.00 n.s.	-4.87 *
P_1 * P_4	-2.22 n.s.	0.44 n.s.	-4.40 *
P_2 * P_3	0.93 n.s.	-0.87 n.s.	-1.38 n.s.
P_2 * P_4	2.82 n.s.	-1.62 n.s.	-0.59 n.s.
P_3 * P_4	2.82 n.s.	-0.17 n.s.	-0.19 n.s.
SE	35.10	0.40	1.84

(ns), *, denote not significant, significant differences at 0.05 level of probability .

3.3. Combining ability estimates: Diallel analysis is a mating design whereby the selected parental lines are crossed in a certain order topredict combining ability of the parents and elucidate the nature of gene action involved in the inheritance of traits (Basal and Turgut, 2005; Azhar and Naeem, 2008; Khan *et al.*, 2009 a; Bibi *et al.*, 2011a, b).

- **Seed Cotton yield (kg/don)**:

According to genetic potential (Table 6), the parental genotypes (P_3 and P_4), namely, line 106 and G 73, respectively , show highly significant desirable general combining ability (29.98** and 28.05**), that refers these two genotypes have great amounts of genes with additive effect, which indicate that these lines, being good general combiner, can be used as donor parent for desirable genes regarding seed cotton yield. On the other hand, the parent (P_1), namely Aleppo 33-1 has highly significant undesirable performance (-54.67**), that refers this genotypes has non additive genes, like dominant or maybe epistasis controlling this trait and can be inherited to later progenies which reduces seed cotton yield. Regarding specific combining ability results showed in Table (7), where the cross P_1*P_4 has highly significant desirable effect (31.49**), indicating that cross can be used in breeding program to develop seed cotton yield. On the other hand. The cross P_1*P_2 had significantly negative performance (-40.51*). However, the cross P_3*P_4 exhibited negative specific combining ability value, resulted from two parents has positive general combining ability effects.

- **lint percentage (L%):**

Results in Table (6) show that the parental genotype (P_2), namely, Deir-Ezzor 22 has highly significant desirable general combining ability (0.88**), that refers this genotype has great amounts of genes with additive effect which indicated that this line, being good general combiner, can be used as donor parent for desirable genes regarding lint percentage. On the other hand, the parent (P_1), namely Aleppo 33-1-1 has highly significant undesirable performance (-0.61**), that refers this genotypes has non additive genes (dominant or maybe epistasis) controlling this trait and can be inherited to later progenies which reduces lint percentage The specific combining ability effects for all possible combinations were computed with respect to the studied trait, results are presented in Table (7). The results reveale that four crosses exhibited positive values, they are P_1*P_2, P_1*P_3, P_1*P_4 and P_2*P_3. However, the cross P_3*P_4 exhibits significantly negative effect (-0.38*).

- **Earliness Percentage (E%):**

Parental genotype P_1 (Aleppo 33-1) is found as best general combiner (Table 6) by having leading position for this trait (1.40**). While the remain three parental genotypes have insignificant negative effects. in F_1 generation. Three crosses had insignificant positive effects as (P_2*P_3, P_2*P_3,P_3*P_4) as shown in Table (7), but the other three crosses have insignificant negative effects. Although both the parents, P_2 and P_3 are negative general combiner , their combination produced valuable hybrid based on SCA effect, same the situation is observed with the crosses P_2*P_4 and P_3*P_4. These results predict that for producing valuable hybrids for specific character/s it is not necessary that anyone or both the parents should possess higher GCA value. Some contrasting situations may also arise which may beattributed to inter-genic interactions. Similar results were also shown by Patel *et al.*, (1997), Imran *et al.*, (2012) and Ali *et al.*, (2016).

3.4. Heritability types: The percentages of average variance due to additive effects (heritability in narrow sense) are computed by the values $H^2{}_n$%. , the percentages of average variance due to genetic effects (heritability in broad sense) were computed by the values $H^2{}_b$%. Results are presesnted in Table (7). Regarding seed cotton yield, estimate of broad sense heritability in the F_1 was high (80.31%) . On the other hand, estimate of narrow sense heritability is low (22.79%). These results are in agreement with those reported by Khan *et al.* (2010 b). The high value of $H^2{}_b$ % and low value of $H^2{}_n$% ascertained that dominance effects have great role in the existence of the variability of this trait, which insure that the expected gain from recurrent back crossing for seed cotton yield would be high in the breeding program.These results are in agreement with those obtained from El Adl *et al.* (2001); Zeina *et al*., (2001); Mcpherson *et al*., (2002); Abd El-Bary (2003); Ali *et al*., (2016) and Coban and Unay (2017). For lint percentage, estimates of $H^2{}_b$% and $H^2{}_n$% were 96.80% and 99.30%, respectivelly. In the same way, for earliness percentage, $H^2{}_b$ % and $H^2{}_n$% were 95.14% and 98.62%, respectivelly. Theses convergence of narrow and broad heritability values revealed that both additive and non-additive gene actions played important roles in the inheritance of lint percentage and earliness percentage, so breeding program should contains selection and hybridization for improving this trait. These results are accodance with those reported by El-Adl *et al.*, (2000); El-Helw (2002); Attiea (2004); Cole *et al.*, (2008); Khan *et al.*, (2010 a) and Iqpal *et al*., (2011).

Table 6. General combining ability effects of parents for seed cotton yield, lint percentage and earliness percentage.

Parents	Studied Traits		
	S.C.Y. kg/don.	**Lint Percentage%**	**Earliness%**
P_1	-54.67 **	-0.61 **	1.40 **
P_2	-3.37 n.s.	0.88 **	-0.39 n.s.
P_3	29.98 **	-0.16 n.s.	-0.67 n.s.
P_4	28.05 **	-0.10 n.s.	-0.34 n.s.
SE	8.77	0.14	0.46

(ns), *, **, denote not significant, significant differences at 0.05 and 0.01 levels of probability respectively.

Table 7. Specific combining ability effects of crosses and heritability percentages for seed cotton yield, lint percentage and earliness percentage.

Crosses	Studied Traits		
	S.C.Y. kg/don.	**Lint Percentage%**	**Earliness%**
$P_1 * P_2$	-40.51 *	0.06 n.s.	-0.06 n.s.
$P_1 * P_3$	29.53 n.s.	0.03 n.s.	-0.68 n.s.
$P_1 * P_4$	31.49 *	0.30 n.s.	-0.58 n.s.
$P_2 * P_3$	-0.54 n.s.	0.17 n.s.	0.01 n.s.
$P_2 * P_4$	3.22 n.s.	-0.19 n.s.	0.38 n.s.
$P_3 * P_4$	-23.19 n.s.	-0.38 *	0.93 n.s.
SE	15.69	0.18	0.68
H^2_b%	80.31	96.80	95.14
H^2n%	22.79	99.30	98.62

(ns),*,, denote not significant, significant differences at 0.05 and 0.01 levels of probability respectively.**

Conclusion:

1. Results indicated that the best genotypes which performed highest mean performance and general combining ability were: line 106 and G73 for seed cotton yield; Deir Ezzor 22 for lint percentage and Aleppo 33-1 for earliness percentage. Thus, it could be suggested that these parental varieties could be utilized in a breeding program for improving these traits to pass favorable genes for improving hybrid and subsequently producing improved genotypes through the selection in segregating generations.
2. The best cross which performed high mean performance, heterosis and specific combining ability for seed cotton yield was Aleppo 33-1* G73 followed by Aleppo 33-1*line 106, On the other hand, Aleppo 33-1 * G73 had significant heterosis for lint percentage. While Line 106 * G73 had high mean performance and positive values for each heterosis and specific combining ability for earliness percentage. Suggesting that these crosses can be used in breeding program to improve such traits.

3. Results showed high value of H^2_b % (80.31%) for seed cotton yield and low value of H^2_n%(22.79%); ascertained that dominance effects had great role in the existence of the variability of this trait, which insure that the expected gain from recurrent back crossing for seed cotton yield would be high in the breeding program. For lint percentage, estimates of H^2_b % and H^2_n% were 96.80% and 99.30%, respectively. In the same way, for earliness percentage, H^2_b % and H^2_n% were 95.14% and 98.62%, respectively. Theses convergence of narrow and broad heritability values revealed that both additive and non-additive gene actions played important roles in the inheritance of lint percentage and earliness percentage, so breeding program should contain selection and hybridization for improving this trait.

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التحليل الوراثي لبعض الصفات الإنتاجية والتبكير في القطن الابلند (*Gossypium hirsutum* L.)

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الملخص

تم دراسة الأداء الوراثي، والقدرة على التوافق، وقوة الهجين ونسبة التوريث لعشرة طرز وراثية من نبات القطن (*Gossypium hirsutum* L.) وهي عبارة عن ستة هجن ناتجة عن التهجين نصف الدائري لأربعة طرز أبوية: حلب 33-1 (P_1) ودير الزور 22 (P_2) والسلالة 106 (P_3) وG73 (P_4). تمت زراعة الهجن والآباء في محطة بحوث القطن، دير الزور، سورية، باستخدام تصميم القطاعات الكاملة العشوائية بثلاثة مكررات في الموسم الزراعي 2011 لدراسة كلاً من: إنتاجية القطن الزهر (كغ/دونم)، وتصافي الحليج (%) ونسبة التبكير. أظهرت النتائج وجود فروق عالية المعنوية بين الطرز الوراثية العشرة، بين الآباء وكذلك بين الهجن لكل من إنتاجية القطن الزهر وتصافي الحليج، كما لوحظ وجود فروق معنوية بين الآباء مقابل الهجن، مما يدل على وجود قوة هجين في الهجن الناتجة للصفتين السابقتين. بالنسبة لنسبة التبكير، لوحظ وجود فروق غير معنوية بين الطرز الوراثية، وبين الهجن وبين الآباء مقابل الهجن، بينما كانت الفروق معنوية بين الآباء. دلت النتائج أن أفضل الطرز الوراثية التي أعطت أعلى متوسط وأعلى قدرة عامة على التوافق كانت السلالة 106 وG73 لصفة إنتاجية القطن الزهر؛ ودير الزور 22 لصفة تصافي الحليج وحلب 33-1 لصفة نسبة التبكير. لذا يمكن استخدام هذه الطرز الوراثية في برامج التربية لتحسين هذه الصفات عن طريق نقل المورثات المتفوقة الى الأجيال اللاحقة بالانتخاب. أفضل الهجن هو حلب 33-1*G73 يليه الهجين حلب 33-1*سلالة 106 لصفة إنتاجية القطن الزهر، وحلب 33-1 *G73 لصفة تصافي الحليج والسلالة 106*G73 لصفة نسبة التبكير، مما يشير إلى إمكانية استخدام هذه الهجن في برامج التربية لتحسين الصفات السابقة الذكر. من جهة أخرى، أظهرت النتائج قيم عالية لنسبة التوريث بالمعنى العام وقيم منخفضة لنسبة التوريث بالمعنى الخاص لصفة إنتاجية القطن الزهر، مما يشير إلى أن للمورثات السائدة تأثير أكبر في توريث هذه الصفة، مما يؤكد أن تحسين هذه الصفة يكون عن طريق اتباع التهجين الرجعي المتكرر في برامج التربية. بينما كانت قيم كلاً من نسبة التوريث بالمعنى العام والمعنى الخاص عالية لصفتي تصافي الحليج ونسبة التبكير، هذا التقارب بين النسب يشير إلى أهمية كل من المورثات التراكمية واللاتراكمية في توريث الصفتين سابقتي الذكر، لذا يجب أن تتضمن برامج التربية انتخاب وتهجين من أجل تحسين تلك الصفتين.

الكلمات المفتاحية: قطن، القدرة على الائتلاف، قوة الهجين، نسبة التوريث.