J. Agric. Sci. Mansoura Univ., 25 (11): 6627 - 6642, 2000.

ESTIMATES OF HETEROSIS, COMBINING ABILITY AND TYPE OF GENE ACTION FOR YIELD AND ITS COMPONENTS IN SEVEN PARENT DIALLEL CROSSES OF SESAME (*Sesamum indicum*, L)

HobAllah, A. A.
Agronomy Department, Faculty of Agriculture, Cairo University, Giza.

ABSTRACT

A half diallel set of crosses involving seven parents were used to study heterosis and combining ability in the F_1 generation as well as the nature of gene action controlling seed yield and its contributing traits in both F_1 and F_2 generations.

Results indicated that the expression of heterosis varied with the crosses as also with characters investigated. The maximum significant positive heterobeltiosis was observed for branches/plant (52.9%) followed by seed yield/plant (38.0%), capsules/plant (33.6%), capsule length (19.0%), 1000-seed weight (18.6%) and plant height (12.1%).

Analysis of variance for combining ability indicated that general (GCA) and specific (SCA) combining ability variances were highly significant for all studied traits, suggesting the presence of both additive and non- additive (dominance) gene effects involved in the expression of these traits. General and specific combining ability effects were frequently significant among parents and crosses for the investigated traits. Superior parents were identified for particular characters. None of the parents appeared to be good general combiner for all traits together. The good combiner parents for seed yield/plant were also high combiner for two or more of yield contributing characters. Estimates of GCA effects showed that EUL92 (P4) and EXM90 (P5) were the best general combiner parents for earliness and low position of the first capsule. However, the local cultivar Giza 32 (P1) and Mutant 48 (P3) were the best general combiner parents for seed yield and two or more yield components especially number of capsules per plant. Moreover, the favorable cross combinations that indicated highly significant positive SCA effects for seed yield and some of its main components were derived from the P1 and P3 parents.

Estimates of the type of gene action confirmed the importance of both additive and non- additive (dominance) gene effects in the inheritance of the studied characters in both F_1 and F_2 generations. However, the dominance components were larger in magnitude than additive ones for most investigated traits in the F_1 and vise versa in the F_2 generation. The mean degree of dominance as estimated by the ratio $(H_1/D)^{0.5}$ revealed the existence of overdominance for all traits in the F_1 except capsule length, and partial dominance in the F_2 generation except seed yield/plant. The negative and positive genes were unequally distributed in the parents for all traits in both generations. Heritability in narrow sense (Hn) was found to be low for all characters except capsule length in the F_1 generation. The presence of overdominance and low heritability estimates recorded for most traits in the F_1, suggested the possibility using of cross breeding. High values of heritability were recorded for all the investigated traits in the F_2 generation, indicating that the genetic variance associated with those traits was mostly due to additive effect of genes.

INTRODUCTION

Although sesame (*Sesamum indicum*, L) is largely self-pollinated crop, high level of heterosis have been reported for certain hybrid combinations from studies done in various countries (Ashri, 1998). The magnitude of heterosis varied in different crosses, but generally it was high in the hybrids from diverse origin (Tu, 1993). Heterosis of varying degree for seed yield and other contributing traits in sesame has been reported (Atta, 1990; Yadav and Mishra, 1991; Padmavathi *et al*, 1993; El-Shazly *et al*, 1993b; Mishra *et al*, 1994; Quijada and Layrisse, 1995; Mishra and Yadav, 1996; Murty, 1997 and Ganesh *et al*, 1999).

Production of hybrids in sesame is possible by crossing suitable inbred parents, with high specific combining ability. Once such inbreeds are found, hybrid seed can be produced by three ways: 1) Hand emasculation and pollination, 2) Male sterility mechanisms and hand pollination, and 3) Male sterility and honey bees or other insect pollinators.

Hand emasculation and pollination are useful for researchers but not for commercial production due to time-consuming and high cost of hybrid seeds. However, Manivannan *et al* (1993) reported that production of sesame hybrid seeds by hand emasculation and pollination at commercial scale is possible and an easy method in this concern was described in their study. On the other hand, various research workers reported that the farmers hybrid seeds must be produced on a large scale with lower cost which necessitates the use of male sterility (Brar, 1982; Rangaswamy and Rathiram, 1982; Li, 1997; Ashri, 1998 and Ganesh *et al*, 1999). So far, only genetic male sterility (GMS) has been found in sesame. A naturally occurring ms allele was found in Venezuela about 30 years ago. This is the one, which is being used in China now (Tu, 1993 and Li, 1997).

The commercial use of heterosis is, probably, the most important area of research and development for sesame in the near future, because it will lead to greater productivity and consequently to an increase in the total crop area and more efficient use of fertilizers (Quijada and Layrisse, 1995). It is also likely to result in better seed quality since hybrid seed would have to be purchased yearly, whereas seeds for the pure-line cultivars are usually multiplied and maintained by farmers themselves.

The combining ability and genetic component analysis provide fair understanding about the nature of gene action of quantitative characters and help in identifying parents and their derived crosses to be used for genetic improvement. Among the biometrical methods which have been developed, diallel cross analysis provides information on combining ability that helps the breeder in choosing the parents with high general combining ability (GCA) and hybrids with high specific combining ability (SCA) effects. Moreover, diallel analysis would present estimates for the genetic variance and the relative importance of additive and non-additive types of gene action which assist the breeder in selecting the most efficient breeding techniques leading to rapid genetic improvement.

In sesame, although studies in this aspect have been carried out (El-Shazly *et al*, 1993a; Reddy and Haripriya, 1993; Padmavathi *et al*, 1994;; Macharo *et al*, 1995 and Yingzhong, 1999) more information about combining ability and type of gene action are needed. Hence, the present study was undertaken with the objective of determining the magnitude of heterosis, general and specific combining ability effects and nature of gene action for seed yield and its contributing traits in 21 hybrids derived from a diallel cross of 7 parental genotypes of sesame.

MATERIALS AND METHODS

Field layout and recorded data

Seven parental genotypes of sesame were selfed for two successive seasons before making diallel crosses. The seven parents were chosen on the basis of the presence of wide differences between them in respect to certain economic traits. These genotypes were: Giza 32 (local cultivar); Mut. 8, Mut. 48, EUL92 and TM90 (advanced mutant lines resulting from the mutation breeding program conducted at Agron. Dept., Fac. of Agric., Cairo Univ., Giza, Egypt); EXM90 [F7 hybrid population line derived from crossing between Margo201 (introduced line from USA) and Mut. 48] and EXL139 (exotic line from FAO world collection).

Field experiments were carried out at the Agric. Exp. and Res. Station, Fac. of Agric., Cairo Univ., Giza, Egypt during 1997, 1998 and 1999. In 1997 the parental genotypes were crossed in all possible combinations excluding reciprocals, to obtain a total of 21 F_1 hybrids using a half diallel mating system.

In 1998 selfed seeds from parents and their F_1's were planted in a randomized complete blocks design (RCBD) with three replications. Each block contained 21 F1's and 7 parents, i.e. a total of 28 entries per block. Each (F1) was planted in a 2-rows/plot and the parents in 4-rows/plot. Each row was 4 m long and 60 cm wide. Seeds were sown in hills 20 cm apart. Thinning was done 30 days after sowing to secure 2 plants/hill. At maturity, data on 10 randomly guarded plants from each plot were recorded for plant height, stem height to the first capsule, no. of fruiting branches/plant, no. of capsules/plant, 1000- seed weight and seed yield/plant. Number of days from sowing to maturity was recorded on whole plot basis.

In 1999 the parents and their F_2 populations were evaluated in RCBD with four replications. Both parents and F_2's were planted in a 3 rows/plot. Row length and spacing between and within rows were applied as in F_1 generation. At maturity, 10 random competitive plants per each entry were sampled to study the same characters mentioned before. Recommended agronomic practices were applied at the proper time in both generations.

Statistical and genetic component analysis

The collected data were tested for significance on the basis of the analysis of variance according to Snedecor and Cochran (1980). Heterosis and heterobeltiosis were estimated for all investigated traits as percentage of F_1 over mid- parents and better parent , respectively. Combining ability analysis was performed according to Griffing (1956) method 2 model 2. General and specific combining ability effects were also estimated.

To study the inheritance of mentioned traits, genetic parameters were computed according to diallel cross analysis proposed by Hayman (1954 a & b) in both F_1 and F_2 generations. These parameters and their ratios were as follows:

D : The component of variation due to additive effect.

H_1: The component of variation due to dominance effect.

H_2: The component of variation due to dominance effect, correlated for gene distribution to positive and negative genes in the parents, when they are equal then $H_1 = H_2$.

F : An indicator relative frequencies of dominant vs. recessive genes in the parents.

h^2: Dominance effect as algebraic sum over all loci in heterozygous phase in all crosses.

E : Environmental or non-heritable component of variation.

$(H_1/D)^{0.5}$: Mean degree of dominance.

$H_2/4H_1$: Proportion of positive and negative gene effects in the parents.

KD/KR : Proportion of dominant and recessive genes in the parents where;

$$K_D/K_R = (4DH_1)^{0.5} + F / (4DH_1)^{0.5} – F.$$

Narrow sense heritability (Hn) was estimated according to formulas proposed by Mather and Jinks (1971) in the F_1 and by Verhalen and Murray (1969) in the F_2 generation. The validity of diallel analysis assumption made by Hayman (1954) was tested by t^2 following the formula suggested by Singh and Chaudhary (1977).

RESULTS AND DISCUSSION

Heterotic effects

The heterotic effects expressed as the percentage deviation of F_1 mean performance from the mid- parents (heterosis) and better parent (heterobeltiosis) are presented in Table 1. The direction and magnitude of heterotic effects differed owing to crosses and characters investigated.

Concerning days to maturity, 8 crosses showed desirable significant negative heterosis and 4 out of them recorded highly significant negative heterobeltiosis indicating the possibility of obtaining earlier maturing combinations than those of the parents. The values of significant negative heterosis ranged from –2.2 to –13.4%, while the range of heterobeltiosis varied from -5.3% (P1xP3) to –9.9% (P1xP6). Significant negative heterosis for maturity was reported by Sasikumar and Sardana, 1990; Yadav and Mishra, 1991; El-Shazly *et al*, 1993b and Mishra and Yadav, 1996.

Estimates of heterosis for plant height showed significant positive values in 7 crosses ranging from 6.5 to 22.2%. However, significant positive heterobeltiosis was observed in 5 crosses and varied between 6.4% (P1xP3) to 12.1% (P2xP4). The remaining crosses possessed negative heterosis for this trait. These results are in harmony with those obtained by Shivprakash (1986), Singh *et al* (1986) and Yadav and Mishra (1991) who reported positive and/or negative heterosis for plant height.

Regarding the stem height to first capsule, as an important character to sesame breeder, the data in Table 1 indicated that most of cross combinations gave undesirable positive heterosis, and non of crosses showed negative heterosis for this trait. Mahdy and Bakheit (1988) found similar result. However, Ibrahim *et al* (1983a) and El-Shazly *et al* (1993b) reported favorable negative heterosis in other crosses.

Table (1): Heterosis (upper values) and heterobeltiosis (lower values) in a half diallel crosses of sesame in F_1 generation

Crosses	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Capsule length (cm)	Branch-es / plant	Capsul-es / plant	1000-seed weight (gm)	Seed yield/ plant (gm)
1. P1 x P2	-9.1** -5.4**	22.2** 3.1	27.8** 48.7**	2.1 -0.1	31.6 18.3	26.2* 23.2*	-16.6** -24.3**	9.9 2.2
2. P1 x P3	-8.2** -5.3**	21.5** 6.4*	26.3** 45.7**	3.3 -5.3	-12.6 -25.8	2.4 -7.6	-1.8 -11.9	16.1 2.9
3. P1 x P4	-1.4 10.3**	13.0** -4.5	54.9** 157.4**	0.0 -5.3	203.7** 52.9*	25.9* 22.3*	15.5* 0.7	41.9** 38.0**
4. P1 x P5	-10.1** 0.0	4.8 -10.2**	13.6** 59.7**	6.1** -7.6**	68.4* -15.3	20.7 9.3	25.8** 9.7	41.4** 28.3*
5. P1 x P6	-13.4** -9.9**	-21.5** -26.8**	-1.4 2.3	-5.9* -16.1**	-44.1 -54.2*	-41.1** -44.9**	-5.3 -11.9	-23.7 -24.7
6. P1 x P7	-6.0** -3.5**	4.8 -6.4*	10.5** 26.5**	11.9** 1.7	3.5 -6.6	43.9** 33.6*	10.8 -5.2	38.8** 31.0*
7. P2 x P3	-1.8 -0.9	-9.0** -13.0**	-3.8 -3.2	-4.0 -4.6	-48.8 -52.0*	-25.4* -31.2*	-7.3 -8.6	-25.9 -29.7
8. P2 x P4	-6.7** 0.0	12.4** 12.1**	42.2** 95.7**	-0.6 -3.4	109.0** 5.1	7.6 7.1	14.5* 9.7	1.2 -8.2
9. P2 x P5	-6.2** 0.0	6.5* 4.5	18.2** 40.0**	-5.3* -22.8**	21.2 -39.0	13.0 0.1	3.8 -0.8	14.9 -2.3
10.P2 x P6	0.9 0.9	-6.4 -16.0**	9.2 21.9**	-0.3 -3.9	1.4 -8.9	-28.7* -31.8*	7.5 4.7	-23.2 -27.6
11.P2 x P7	2.2* 3.6**	16.3** 9.0**	24.1** 25.8**	21.0** 19.0**	15.8 15.2	2.1 -7.3	11.8 5.0	-7.4 -18.1
12.P3 x P4	9.5** 18.6**	15.0** 10.2**	55.8** 116.2**	-2.6 -5.9	23.9 -37.8	1.2 -6.3	13.8 10.5	-4.1 -17.0
13.P3 x P5	4.3** 12.2**	14.0** 11.0**	25.9** 50.3**	-6.9* -24.7**	134.5** 17.8	47.4** 21.7*	6.8 3.4	45.9** 18.9
14.P3 x P6	0.9 1.8	8.9** 1.8	13.6** 26.0**	11.6** 8.7**	37.7 31.6	2.1 -1.8	0.0 -3.9	12.6 1.0
15.P3 x P7	1.3 1.8	-16.4** -18.2**	6.9 7.7	-4.0 -5.0	26.5 18.7	9.0 -8.0	-9.9 -14.2	-0.4 -16.0
16.P4 x P5	10.8** 11.3**	0.0 -1.6	-2.0 11.9*	1.2 -15.6**	0.0 0.0	-5.9 -16.7	2.1 2.1	-4.8 -11.4
17.P4 x P6	9.6* 17.5**	-13.6** -22.3**	-10.3 41.8**	3.0 -3.4	50.8 -24.3	-28.4* -31.2*	18.5** 10.8	-0.6 -4.6
18.P4 x P7	8.1* 17.5**	-14.4** -19.6**	27.5** 78.6**	6.8* 2.2	146.9** 23.5	-25.5 -32.7*	2.8 0.6	2.0 -1.1
19.P5 x P6	0.5 7.1**	-17.5** -24.7**	11.5* 49.7**	-3.1 -23.3**	-59.7 -79.8**	-37.6** -46.8**	12.7 5.0	-10.6 -19.8
20.P5 x P7	-0.9 7.1**	-12.5** -16.5**	22.4** 47.1**	5.1* -15.6**	86.7** -6.6	-15.4 -17.6	16.7* 14.6	15.5 10.8
21.P6 x P7	-2.2* -0.9	-19.8** -23.5**	9.1 20.0**	12.5** 10.5**	-28.8 -36.0	-40.2** -47.8**	29.5** 18.6*	-29.0* -33.9*

P1=Giza 32, P2= Mut.8, P3=Mut.48, P4=EUL 92, P5=EXM90, P6=EXL 139, P7=TM 90
*** and ** indicate significant at 5 % and 1 % levels of probability, respectively.**

Significant positive heterosis was recorded for capsule length in 6 crosses, and 3 out of them exhibited significant positive heterobeltiosis with values ranging from 8.7% (P3xP6) to 19.0% (P2xP7). El-Shazly *et al* (1993b) and Padmavathi *et al* (1993) reported significant positive heterosis for various cross combinations.

The maximum values of heterosis/heterobeltiosis were observed in number of fruiting branches. Significant positive heterosis was found in 6 crosses with values varied from 86.7% (P5xP7) to 203.7% (P1xP4), while only the cross (P1xP4) showed significant positive heterobeltiosis of 52.9%. On the other hand, significant negative heterobeltiosis of –54.2, -52.0 and –79.8% was recorded for crosses (P1xP6), (P2xP3) and P5xP6), respectively. The combinations showing significant positive values open the possibility of increasing the branches in hybrids. Sodani and Bhatnagar (1990) Mishra *et al* (1994) and Mishra and Yadav (1996) have reported positive heterosis for branches, but Ibrahim *et al* (1983a) and Jadon and Mehrotra (1988) found negative heterosis for this trait.

The most important yield component, number of capsules per plant, exhibited significant positive heterosis and heterobeltiosis in 4 crosses namely: (P1xP2), (P1xP4), (P1xP7) and (P3xP5) with values ranging from 25.9% to 47.4% for heterosis and from 21.7% to 33.6% for heterobeltiosis. Atta (1990), Sodani and Bhatnagar (1990), Mishra and Yadav (1996) and Ganesh *et al* (1999) have reported significant heterosis/heterobeltiosis in capsules/plant.

For seed index (1000- seed weight), results obtained indicated that 6 crosses viz. (P1xP4), (P1xP5), (P2xP4), (P4xP6), (P5xP7) and (P6xP7) gave significant heterosis of 15.5, 25.8, 14.5, 18.5, 16.7 and 29.5%, respectively. However, significant heterobeltiosis of 18.6% was recorded for only one cross (P6xP7). The remaining crosses showed insignificant values with exception of (P1xP2) which gave negative heterosis. These results are in agreement with that obtained by Singh *et al* (1986), Ding *et al* (1987) and Mishra and Yadav (1996).

Regarding seed yield per plant, 3 crosses namely: (P1xP4), (P1xP5) and (P1xP7), having the local cultivar Giza 32 as a female parent, recorded significant positive heterobeltiosis of 38.0, 28.3 and 31.0%, respectively. Whereas (P3xP5) showed significant positive heterosis of 45.9%. The remaining crosses showed insignificant heterosis in both directions with the exception of cross (P6xP7) which exhibited negative heterosis. Many investigators, i.e. Yadav and Mishra (1991), Padmavathi *et al* (1993) Mishra *et al* (1994), Mishra and Yadav (1996) and Ganesh *et al* (1999) reported significant heterosis/heterobeltiosis for seed yield in other crosses.

From the above results it is clear that the expression of heterosis varied with crosses and characters. The maximum significant positive heterobeltiosis was observed for number of fruiting branches/plant (52.9%) followed by seed yield/plant (38.0%), capsules/plant (33.6%), capsule length (19.0%), 1000- seed weight (18.6%) and plant height (12.1%)

Combining ability

Analysis of variance for combining ability was employed for all investigated characters in the F_1 generation (Table 2). The mean square (variance) of general (GCA) and specific (SCA) combining ability were highly significant for all studied traits, suggesting the presence of both additive and non- additive (dominance) gene effects involved in the expression of these traits. Several investigations revealed the importance of both additive and dominance gene effects in the genetic control of seed yield and its contributing characters in sesame (Ibrahim *et al*, 1983b; El-Shazly *et al*, 1993 a; Padmavathi *et al*, 1994; Mcharo *et al*, 1995 and Yingzhong, 1999).

However, non- additive gene action was found to be important for days to maturity, plant height, branches/plant, capsules/plant, 1000- seed weight and seed yield/plant as indicated by additive/dominance ratio being less than one. On the contrary, the ratio was more than one for stem height to first capsule and capsule length, indicating that additive component was more important in controlling these characters.

General combining ability effects

Estimates of general combining ability (GCA) effects of individual parents for each trait in the F_1 generation are illustrated in Table 3. GCA effects were found to be either significant or highly significant in some cases. Highly positive values would be of interest for all studied traits except days to maturity and stem height to first capsule where the reverse situation is desirable, i.e. high negative values would be useful from the breeder's point of view. In this respect, P2 (Mut. 8) appeared to be good general combiner for earliness, whereas P4 (EUL92) and P5 (EXM90) were good combiners for both earliness and stem height to first capsule.

Estimates of GCA effects for seed yield and its components indicated that the P1 (local cultivar Giza 32) and P3 (Mut. 48) were the best general combiner parents for seed yield/plant due to their highly significant positive values of GCA effects. Such parents were also exhibited significant or highly significant positive GCA effects for two or more yield components especially number of capsules/plant. Other parents *viz.* P5 (EXM90) showed to be good combiner for capsule length. P6 (EXL139) was good combiner for seed weight, while P7 (TM90) proved to be good combiner for number of branches. However, the three later parents (P5, P6 and P7) were poor general combiner for seed yield itself. These findings are in harmony with those reported by EL-Shazly *et al*, 1993a; Mcharo *et al*, 1995; Mishra and Yadav, 1997 and Yingzhong, 1999.

Thus, it is worth noting that the parental genotypes, which showed high GCA effects in seed yield, might be also good combiner in two or more of the traits contributing to yield. Therefore, it is suggested to use these genotypes in a multiple crossing program for isolating high yielding varieties. On the other hand, the genotypes containing high GCA effects for particular yield components such as capsule length, seed weight and no. of branches may not be good combiners for seed yield, but it may be utilized for improving such traits by using its best combiner parent.

Table (2): Estimates of variance (mean square) for general (GCA) and specific (SCA) combining ability from a half diallel crosses of sesame in F1 generation

Source of		Days to	Plant	Height	Caps-	Branch	Capsules/	1000-	Seed

variation	Df	Matu-rity	height	to first capsule	ule length	-es/ plant	plant	seed weight	yield/ plant
G.C.A	6	82.05**	2932.3**	889.40**	0.996**	1.416**	1561.4**	0.384**	49.05**
S.C.A	21	30.25**	648.93**	159.06**	0.041**	0.491**	796.3**	0.158**	22.35**
Error	54	0.71	22.35	10.59	0.004	0.173	184.2	0.039	6.39
Variance components									
Additive		11.51	507.42	162.30	0.21	0.21	170.0	0.05	5.93
Dominance		29.54	626.58	148.48	0.04	0.32	612.1	0.12	15.97
Add./Dom.		0.39	0.81	1.09	5.25	0.66	0.28	0.42	0.37

Table (3): Estimates of general combining ability effects for each parent in F1 generation

Parents	Days to Maturity	Plant Height	Height to first capsule	Capsule length	Branches/ plant	Capsules/ plant	1000-seed weight	Seed yield/ plant
P1 (Giza 32)	0.090	39.252**	16.354**	0.145**	0.017	10.913**	0.375**	2.294**
P2 (Mut. 8)	-0.873**	-3.966**	1.336	-0.166**	0.159	2.247	-0.115	-0.076
P3 (Mut. 48)	3.275**	3.523*	2.158*	-0.245**	0.390**	21.484**	-0.204**	3.875**
P4 (EUL92)	-1.947**	-10.351**	-12.883**	-0.087**	-0.394**	1.035	-0.048	-0.769
P5 (EXM90)	-5.132**	-11.274**	-11.731**	0.689**	-0.687**	-7.916	-0.049	-0.584
P6(EXL139)	1.164**	-7.166**	3.817**	-0.262**	0.202	-15.624**	0.187**	-2.726**
P7 (TM 90)	3.423**	-10.018**	0.947	-0.073**	0.313*	-12.139**	-0.145*	-2.013**
SE (gi)	0.260	1.459	1.004	0.020	0.129	4.189	0.061	0.780
SE (gi – gj)	0.398	2.229	1.534	0.031	0.196	6.398	0.093	1.191

*** and ** indicate significant at 5 % and 1 % levels of probability, respectively.**

Specific combining ability effects

In order to detect the potentiality of crossing between specific parents to produce promising hybrids, specific combining ability (SCA) effects were calculated for the investigated characters in F_1 generation (Table 4). Significant positive or negative SCA effects were noted for each character.

Highly significant negative SCA value as a desirable effects towards earliness were observed for eight cross combinations *viz.* (P1 x P2), (P1 x P3), (P1 x P5), (P1 x P6), (P1 x P7), (P2 x P4), (P2 x P5) and (P6 x P7), while (P5 x P7) exhibited significant negative values. In other crosses, EL-Shazly *et al* (1993a) and Mishra *et al* (1994) reported also significant negative SCA effects for this trait.

Table (4): Estimates of specific combining ability effects from a half diallel crosses of sesame in F1 generation

Crosses	Days to maturity	Plant height (cm)	Height to first capsule (cm)	Capsule Length (cm)	Branches /plant	Capsules /plant	1000-seed weight (gm)	Seed Yield/ plant (gm)

1. P1 x P2	-2.491**	29.918**	11.233**	0.003	0.445	23.843*	-0.680**	1.096
2. P1 x P3	-4.639**	31.463**	9.544**	0.105*	-0.452	-13.761	-0.044	0.745
3. P1 x P4	0.583	16.037**	24.119**	-0.052	1.065**	25.587*	0.366	6.622**
4. P1 x P5	-5.231**	1.626	-0.433	0.235**	0.291	8.306	0.764*	4.005*
5. P1 x P6	-9.528**	-46.748**	-8.781**	-0.271**	-0.798*	-42.887**	-0.429**	-6.621**
6. P1 x P7	-1.787**	10.704**	-2.911	0.183**	-0.208	43.761**	0.203	6.100**
7. P2 x P3	-0.676	-34.885**	-14.937**	-0.097	-1.179**	-42.728**	-0.161	-7.484**
8. P2 x P4	-8.454**	10.922**	11.737**	-0.045	0.589	13.487	0.342*	1.126
9. P2 x P5	-4.269**	4.178	3.385	-0.187**	0.015	11.672	-0.036	2.675
10.P2 x P6	3.435**	-5.063	3.037	-0.057	0.176	-14.754	0.141	-2.584
11.P2 x P7	4.176**	32.589**	8.841**	0.454**	0.082	5.928	0.267	-0.496
12.P3 x P4	5.065**	18.300**	19.981**	-0.046	-0.308	-1.783	0.351*	-2.625
13.P3 x P5	3.583**	20.756**	8.296**	-0.205**	1.234**	51.968**	0.106	8.817**
14.P3 x P6	0.287	28.715**	6.615**	0.352	0.945**	22.009*	-0.103	5.165*
15.P3 x P7	0.028	-31.933**	-4.915**	-0.251**	0.251	8.624	-0.424**	-1.081
16.P4 x P5	6.806**	-1.004	-12.463**	0.081	-0.631*	-8.583	-0.317*	-4.099*
17.P4 x P6	6.509**	-13.144**	-14.678**	0.051	0.347	-12.809	0.303*	1.642
18.P4 x P7	4.250**	-21.059**	4.459	0.039	0.786*	-26.161*	-0.268	-0.237
19.P5 x P6	0.694	-17.922**	6.337*	-0.112*	-0.728*	-26.924**	0.082	-2.475
20.P5 x P7	-1.565*	-13.604**	7.707**	0.066	0.495	-18.309	0.187	0.779
21.P6 x P7	-2.861**	-16.244**	4.359	0.166**	-0.644*	-24.135*	0.695**	-4.680*
SE (S_{ij})	0.644	3.611	2.485	0.050	0.318	10.366	0.150	1.930
SE (S_{ij}-S_{ik})	1.124	6.303	4.338	0.088	0.555	18.097	0.262	3.370
SE (S_{ij} -S_{ki})	1.052	5.896	4.058	0.082	0.519	16.928	0.245	3.152

P1= Giza 32, P2= Mut.8, P3= Mut.48, P4= EUL92, P5= EXM90, P6= EXL139, P7= TM 90

Concerning seed yield per plant, five crosses namely; (P1 x P4), (P1 x P5), (P1 x P7), (P3 x P5) and (P3 x P6) recorded highly significant positive SCA effects. These crosses possessed also highly significant or significant SCA effects for two or more characters contributing to seed yield, i.e. capsule length, branches/plant, capsules/plant and 1000- seed weight. Also, non of these favorable crosses gave significant negative SCA effects for any of the yield components. Therefore, such cross combinations being promising for varietal improvement purpose as it showed high SCA effects and involved one of the parents as good general combiner (Tables 3 & 4). The trend of SCA effects for seed yield and its components were more or less in agreement with that reported in the literature (EL-Shazly *et al* (1993a), Mishra *et al* (1994) and Mishra and Yadav (1997).

In general, it is of interest to mention that the local cultivar Giza 32 (P1) and Mut. 48 (P3) showed highly significant positive GCA effects for seed yield and two or more of its components (Table 3). Moreover the favorable cross combinations, that performed highly significant positive SCA effects of seed yield and some of its main components (Table 4), were derived from these two parents. Therefore, such parents and their derived crosses could be utilized for both hybrid sesame production and/or varietal improvement purpose in terms of the probability of isolating desirable segregates for yield and some of its components.

The performance of the crosses was compared on the basis of mean yield, desirable heterotic response, and SCA effects of hybrids and GCA effects of the parents. The best four crosses selected on the basis of these parameters are presented in Table 5. The first three crosses involving the local cultivar Giza 32, i.e. (P1xP4), (P1xP5) and (P1xP7) showed high means of seed yield/plant with values ranging from 32.2 to 34.6 g. These crosses exhibited also positive significant heterobeltiosis coupled with significant or highly significant SCA effects. The fourth cross (P3xP5) showed the highest mean yield (38.6 g) and positive significant heterosis along with highly significant SCA effects.

Table (5): Best four crosses selected for seed yield on the basis of heterotic response and SCA effects along with GCA effects of the parents involved

Crosses	Yield/ plant (gm)	Heterosis %	Hetero-beltiosis %	SCA effects	GCA effects		Desirable+ heterosis for other traits
					1st parent	2nd parent	
P1 x P4	34.60	41.9**	38.0**	6.622**	2.294**	-0.769	b, d, e, f
P1 x P5	32.17	41.4**	28.3*	4.005*	2.294**	-0.584	a, d, f
P1 x P7	32.83	38.8**	31.0*	6.100**	2.294**	-2.013**	a, c, e
P3 x P5	38.56	45.9**	18.9	8.817**	3.875**	-0.584	b, d, e

+ a = Days to maturity, b = Plant height, c = Capsule length
d = Branches/plant, e = Capsules/plant, f = 1000- seed weight

Results demonstrated also that the best four crosses which recorded significant positive heterosis/heterobeltiosis for seed yield and high SCA effects were also involving at least one parent as a good general combiner for this trait. Moreover, heterosis for seed yield in these crosses was accompanied by heterosis for two or more of yield components. Out of the best 4 crosses, 2 combinations (P1xP5 and P1xP7) recorded also significant negative heterosis for maturity indicating the possibility of obtaining high yield coupled with earlier maturing combinations than those of the parents.

Normally SCA effects do not contribute much to the improvement of self-pollinated crops like sesame. However, when SCA effects are observed in the crosses having at least one good general combiner parent, the possibility of their exploitation in practical breeding increases (Goyal and Kumar, 1988). In the present study, it may be concluded that on the basis of heterosis, combining ability and *per se* performance, the aforementioned 4 crosses are the most promising to be used in a breeding program aiming to improve seed yield and its components.

Type of gene action and heritability

The analysis of variance revealed significant differences between entries for all studied characters in both F_1 and F_2 generations. The genetic components of variance and their standard error estimated from the diallel analysis together with the ratios of the genetic parameters, heritability and "t^2" values are given in Table 6 . The values of t^2 were found to be not significant for all studied traits in both generations, indicating that the additive-dominance model was adequate to explain the present variation.

The results of Table 6 showed that the estimates of additive genetic component (D) were significant for days to maturity, plant height, stem height to first capsule, capsule length, branches/plant, 1000- seed weight in both F_1 and F_2 generations and for capsules/plant in the F_2 only, suggesting the importance of (D) component in the inheritance of such characters.

The presence of dominance effect was substantiated by the significant values of H_1 for all studied characters in both generations.

However, the values of H_1 were higher in magnitude as compared to the (D) component for all traits except capsule length in the F_1 and vice versa for all studied characters in the F_2 generation. These results suggested that since the non- additive gene action was predominant in the F_1, therefore, heterosis breeding in sesame could be used. Yadav and Mishra (1991), Mishra *et al* (1994), Mishra and Yadav (1996) and Ganesh *et al* (1999) also reported similar conclusion. However, the additive gene effect was the main component of the total genetic variance for most traits in the F_2 generation, suggesting the possibility of improving such traits by means of selection of superior segregates in early generations.

Estimates of dominant component (H_2) were smaller than (H1) for all studied characters in both generations, indicating that the frequencies of positive and negative genes at the loci governing these characters were not equal in proportion in the parents.

The distribution of dominant versus recessive genes (F) was positive and significant for days to maturity and capsule length in the F_1 and for branches/plant in both F_1 and F_2 generations, indicating an excess of dominant genes in the parents of these traits.

The overall dominance effects of heterozygous loci (h^2) were positive and significant for stem height to first capsule, branches/plant and 1000- seed weight in the F_1 and for plant height and seed yield/plant in the F_2 generation. This enhancing that dominant gene effects was mainly attributed to heterozygosity and dominance seems to be acting in positive direction (unidirectional) for such traits. The remaining characters showed insignificant values of h^2, indicating that dominance effect for the character was ambi-directional; i.e. both dominance and recessive genes were involved at various loci.

The environmental component of variance (E) was significant only for plant height in the F_2 and for branches/plant and capsules/plant in both F_1 and F_2 generations, reflecting the large effect of environmental factors on these traits.

The mean degree of dominance over all loci, as estimated by the ratio $(H_1/D)^{0.5}$ was found to be more than unity for all traits in the F_1 generation, revealing the role of overdominance gene effects in the inheritance of the traits. However, the ratio was less than unity for all traits in the F_2 generation (with two exceptions), suggesting the presence of partial dominance in controlling such traits.

The ratio of $H_2/4H_1$, which measure the average frequency of negative *vs.* positive genes in the parents, was less than its maximum theoretical value (0.25) in both generations, confirming that genes having positive and negative effects were not equally distributed in the parents.

Table (6): Estimates of genetic and environmental variance components and their derived ratios of F1's and F2's from diallel crosses of sesame for seed yield and its attributes

Parame-ters	Days to maturity	Plant height (cm)	Height to first capsule	Capsule Length (cm)	Branch-es/ plant	Capsules / plant	1000-seed weight	Seed yield/ plant

				(cm)				(gm)	(gm)
D	F1	71.82**	896.06**	409.30**	0.495**	0.901**	204.30	0.151*	10.63
		±10.35	±93.36	±87.08	±0.016	±0.074	±208.16	±0.062	6.86
	F2	103.02**	805.48**	1180.77**	0.228**	2.443**	524.06**	0.211	4.62
		±2.72	±81.85	±96.74	±0.035	±0.098	±73.94	±0.024	3.09
H1	F1	149.89**	2946.55**	567.81**	0.164**	1.594**	3178.84**	0.546**	85.50**
		±24.93	±465.52	±209.65	±0.038	±0.178	±501.14	±0.148	16.52
	F2	29.53**	578.65**	667.15**	0.177*	0.820**	422.46**	0.219**	29.22
		±6.56	±197.05	±232.89	±0.084	±0.236	±178.0	±0.057	7.44
H2	F1	93.97**	2209.12**	509.04**	0.137**	1.471**	2422.28**	0.489**	65.46**
		±21.97	±410.19	±184.73	±0.034	±0.157	±441.58	±0.131	14.55
	F2	27.40**	535.51**	605.18**	0.147	0.625**	281.50	0.190**	22.09**
		±5.78	±173.62	±205.21	±0.074	±0.208	±156.85	±0.051	6.56
F	F1	89.23**	60.46	67.93	0.090*	0.514**	34.06	0.035	3.79
		±24.84	±463.52	±208.91	±0.038	±0.178	±499.37	±0.148	16.46
	F2	3.03	265.48	450.99	0.009	0.988**	105.55	0.104	7.39
		±6.54	±196.35	±232.07	±0.083	±0.236	±177.38	±0.057	7.42
H^2	F1	3.61	-11.01	525.43**	0.016	0.254*	-55.94	0.174*	1.31
		±14.75	±275.5	±124.07	±0.023	±0.106	±296.58	±0.088	9.77
	F2	3.07	811.30**	108.57	0.041	-0.068	2.33	-0.003	30.45**
		±3.88	±116.61	±137.83	±0.049	±0.140	±105.35	±0.034	4.41
E	F1	0.69	25.30	10.24	0.004	0.168*	182.03*	0.039	6.22
		±3.66	±68.36	±30.79	±0.006	±0.026	±73.60	±0.022	2.43
	F2	0.93	74.68**	35.68	0.015	0.149**	72.32**	0.013	1.81
		±0.96	±28.94	±34.20	±0.012	±0.035	±26.14	±0.008	1.09
$(H1/D)^{0.5}$									
	F1	1.44	1.81	1.18	0.58	1.33	3.94	1.90	2.84
	F2	0.27	0.42	0.38	0.44	0.29	0.45	0.51	1.26
H2/4H1									
	F1	0.16	0.19	0.22	0.21	0.23	0.19	0.22	0.19
	F2	0.23	0.23	0.23	0.21	0.19	0.17	0.22	0.19
K_D/K_R									
	F1	2.51	1.04	1.15	1.38	1.55	1.04	1.13	1.13
	F2	1.06	1.48	1.68	1.05	2.07	1.25	1.63	1.93
Hn %+									
	F1	44.33	57.66	59.27	84.80	32.24	37.04	34.93	37.31
	F2	91.50	72.16	93.30	69.70	88.80	60.50	78.90	29.90
t^2									
	F1	0.70 ns	0.45 ns	1.23 ns	0.45 ns	0.37 ns	0.38 ns	0.52 ns	0.21 ns
	F2	1.61 ns	0.52 ns	0.69 ns	1.85 ns	0.83 ns	0.70 ns	0.39 ns	2.51 ns

***, ** indicate significant at 0.05 and 0.01 levels of probability, respectively**
ns= not significant, + Heritability in narrow sense

The ratio of dominant to recessive genes (K_D/K_R) in the parents was greater than one for all traits in both F1 and F2 generations, suggesting an excess of dominant genes in the parents for each trait.

Heritability in narrow sense (Hn) estimated from F_1 data was found to be low for the studied characters, except capsule length, with values ranging from 32.24 to 59.27%, indicating that the genetic variance associated with those characters was mostly due to dominance gene effects. However, heritability (Hn) on the basis of the F2 data recorded high estimates for all characters, except seed yield/plant, with values ranging between 60.5 and 93.3%, confirming that the additive gene effects was more prevalent. These results are in line with that obtained by Taha (1995) and Shrief (1997).

From the previous results it is evident that the estimates of genetic variance and its ratios indicated the importance of both additive and non-additive (dominance) gene effects in the inheritance of the investigated characters in both F_1 and F_2 generations. But the predominant role of non-additive component for most traits in the F_1 generation which were confirmed by the genetic parameters; H_1, $(H_1/D)^{0.5}$ and Hn and consistent with results from the combining ability analysis, suggested the possibility using of heterosis breeding in sesame. However, the predominance of additive genetic variance for most of the investigated characters in the F2 generation that confirmed by the significant and high magnitude of the parameters; D and Hn can be exploited by selection based on progeny performance. Thus, it is also apparent in the present materials that there are good chance of improvement seed yield and its components along with early maturity. In addition, the incorporation of desirable characters from sources other than the present ones can be fully exploited for further improvement.

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تقديرات قوة الهجين والقدرة علي الائتلاف وطبيعة فعل الجين للمحصول ومكوناته في الهجن التبادلية لسبعة آباء من السمسم

عادل عبد المنعم حب الله

قسم المحاصيل-كلية الزراعة-جامعة القاهرة-الجيزة

أجريت هذه الدراسة بمحطة التجارب والبحوث الزراعية بكلية الزراعة جامعة القاهرة خلال مواسم 1997و1998و1999 بهدف تقدير قوة الهجين والقدرة علي الائتلاف وطبيعة فعل الجين لصفات المحصول ومكوناته في السمسم وذلك لامكانية تحسين هذة الصفات

عن طريق التهجين. وقد استخدم لهذا الغرض سبعة آباء مختلفة في صفاتها المورفولوجية وهي Giza 32, Mut. 8, Mut. 48, EUL92, EXM90, EXL139, TM90. وقد تم إجراء كل التهجينات الممكنة فيما بينها بطريقة التهجين الدائري باستثناء الهجن العكسية حيث تم الحصول علي بذور من جميع الهجن التي تم إجرائها في نهاية موسم 1997. وفي الموسم التالي (1998) تم تقييم السبعة آباء والهجن المتحصل عليها (28 مصدر وراثي) في الجيل الأول في تجربة بنظام القطاعات الكاملة العشوائية في أربعة مكررات حيث قدرت قوة الهجين والقدرة علي الائتلاف العام للآباء والقدرة علي الائتلاف الخاص للهجن لصفات المحصول ومكوناته. وفي الموسم الثالث (1999) اجري تقييم الآباء والهجن في الجيل الثاني حيث تمت دراسة طبيعة فعل الجين وتقدير بعض المعالم الوراثية في كل من الجيل الأول والثاني.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلي؛-

1- أظهرت الدراسة وجود قوة هجين معنوية موجبة لمعظم الصفات موضع الدراسة حيث سجلت اعلي نسب لقوة الهجين (بناء علي متوسط الأب الأعلى) لصفة عدد الأفرع للنبات (52.9%) تبعها محصول البذور للنبات (38%) ثم عدد الكبسولات علي النبات (33.6%) ثم طول الكبسولة (19%) ثم وزن الألف بذرة (18.6%) ثم طول النبات (12.1%). كما أظهرت بعض الهجن قوة هجين معنوية سالبة في الاتجاه المرغوب لصفة التبكير في النضج تراوحت بين5.3%- إلى 9.9%-

2- أظهرت نتائج تحليل التباين للقدرة علي الائتلاف أن التباين الراجع للقدرة العامة والقدرة الخاصة علي الائتلاف كان عالي المعنوية لجميع الصفات موضع الدراسة دلالة علي أهمية كل من التباين المضيف وغير المضيف (السيادي) في التحكم في تلك الصفات. وبمقارنة النسبة بين التباين المضيف وغير المضيف اتضح أن الأخير هو الأكثر أهمية في وراثة صفات التبكير في النضج وطول النبات وعدد الأفرع علي النبات وعدد الكبسولات علي النبات ووزن الألف بذرة ومحصول النبات الفردي. وعلي العكس فقد كان التباين غير المضيف هو الأكثر أهمية بالنسبة لصفات ارتفاع أول كبسولة وطول الكبسولة.

3- أوضحت نتائج تأثيرات القدرة علي الائتلاف أن الآباء EUL92, EXM90 لها قدرة عالية علي الائتلاف العام لصفات التبكير في النضج وارتفاع أول كبسولة. ومن ناحية أخرى أظهرت الآباء Giza 32, Mut. 48 قدرة عالية علي الائتلاف العام بالنسبة لصفة محصول البذور بالإضافة إلى اثنين أو اكثر من مكونات المحصول وخصوصاً عدد القرون علي النبات. علاوة علي أن الهجن التي يشترك فيها أحد هذين الأبوين سجلت اعلي قدرة خاصة علي الائتلاف بالنسبة للمحصول واثنين أو اكثر من مكوناته حيث أظهرت تفوق واضح علي باقي الهجن مما يشير إلى إمكانية انتخاب سلالات متفوقة في الأجيال الانعزالية لهذه الهجن.

4- اتضح من دراسة طبيعة فعل الجين مايلي؛-

I- أهمية كل من التباين المضيف وغير المضيف في التحكم في وراثة الصفات موضع الدراسة في كل من الجيل الأول والثاني، إلا أن التباين غير المضيف كان الأكثر أهمية في وراثة معظم الصفات في الجيل الأول (وهذا ماأكدة تحليل القدرة علي الائتلاف) والعكس في الجيل الثاني حيث كان التباين المضيف هو الأهم مما يرجح أهمية الانتخاب لتحسين هذة الصفات في الأجيال الانعزالية.

II- أوضحت نتائج تقديرات المعالم الوراثية وجود سيادة فائقة لجميع الصفات موضع الدراسة في الجيل الأول (ماعدا صفة طول الكبسولة) بينما كانت السيادة جزئية لجميع الصفات في الجيل الثاني (ماعدا صفة المحصول للنبات) وان توزيع الأليلات الموجبة والسالبة في آباء الهجن توزيع غير متماثل لجميع الصفات المدروسة في الجيلين الأول والثاني.

V- أن انخفاض نسبة التوريث في المعني الخاص مع وجود السيادة الفائقة لمعظم الصفات المدروسة في الجيل الأول ترجح إمكانية استخدام قوة الهجين في تربية السمسم، وعلي العكس فان الارتفاع النسبي لقيم نسب التوريث المسجلة لمعظم الصفات في الجيل الثاني تعكس أهمية التأثير الجيني المضيف لتلك الصفات وبالتالي إمكانية ممارسة الانتخاب في الأجيال الانعزالية لتحسين هذة الصفات.