Alex. J. Agric. Res. 50 (2) 107-120, 2005

HETEROSIS AND GENETIC BEHAVIOR OF SOME QUANTITATIVE TRAITS OF SQUASH AT DIFFERENT ENVIRONMENTAL CONDITIONS

Abd El-Hadi, A.H.; A.M. El-Adl; M.S. Hamada and M.A. Abdein

Received on: 8/3/2005 ***Accepted on: 3/5/2005***

ABSTRACT

This investigation was conducted to study the manifestation of heterosis and evaluate the genetic behavior of some quantitative traits of squash. Four parental varieties (Eskandrani, Zucchino mezza lung bianco, White Bush Scallop and Zucchino nano verde di Milano) were used and 12 $F_{1,1r}$ hybrids were obtained through diallel crosses mating design.

Tests of significance of the mean squares of the 16 genotypes (four parental varieties and 12 $F_{1,1r}$ hybrids) showed highly significant variations for all studied yield and yield component traits for the combined data. The results cleared that the mean values showed that no specific parent was superior for all studied traits.

The results also indicated that the amounts of heterosis versus mid-parents showed highly significant values for all studied traits. The estimates of heterosis versus the better parent showed highly significance for most studied traits. The results revealed the importance of general and specific combining abilities. However, GCA values were larger than their corresponding estimates of SCA for studied yield and yield component traits at both $F_{1,1r}$ hybrids. Reciprocal effects (r) were significant for most studied traits for the combined data.

Estimation of genetic parameters showed that additive genetic variance was very important for most studied traits. The importance of additive and non-additive genetic variance added to cytoplasmic genetic factors that played the major role in the inheritance of these traits. The estimates of heritability in broad sense were larger in magnitudes than their corresponding values in narrow sense.

Most pairs of studied traits showed highly significant positive genotypic and phenotypic correlation coefficients among (No.F./P. with F.Y./P.kg), (F.L.cm with F.Sh.I.) and (F.D.cm with W.F.g.). Therefore, plant breeders could design programs, which make use of these advantages to select superior lines from the advanced segregating generations of the high yielding F_1 hybrids.

INTRODUCTION

The manifestation of heterosis as well as the nature of gene action were studied in squash by many authors among them El-Adl *et al.* (1988), Kash and El-Diasty (1989) and Damarany *et al.* (2001). They estimated heterosis for yield and some economical traits in squash and melon. They cleared that the amounts of heterosis were observed over the mid-parents values or over its best parent for all yield and yield component traits. In this respect, El-Mighawry *et al.*(2001a) evaluated five muskmelon cultivars and their ten F_1 hybrids. They cleared that heterotic expression over mid and better parents were positive and significant for number of fruits/plant trait. Similarly, El-Shimi *et al.* (2003) observed heterosis values over mid-parents. While the heterosis values against the B.P. were insignificant for number of internodes in the cross $P_1 \times P_4$ and total fruit yield/fed. for $P_2 \times P_3$ and $P_2 \times P_4$ crosses.

Concerning general and specific combining abilities, Farid (1990) investigated the magnitudes of genetic parameters in cucumber. He indicated the importance of both dominance and additive genetic variances for all studied traits. On the other hand, El-Sharkawy (2000) stated the presence of additive and some partial dominance effects for fruit length and fruit shape traits. In pumpkins, Abd El-Rahman *et al.* (2001) found significant differences among the ten studied populations. In this respect, Ana and Staub (2002) revealed that GCA was significant for all studied traits, while SCA was significant for only fruit number. Moreover, Kamooh (2002) studied GCA and SCA for some traits in squash. He showed that the GCA and SCA, contributed highly significant differences and seemed to be responsible for the differences noticed among the single crosses. In sweet melon, Shamloul (2002) cleared that δ^2m was negative in yield per plant, diameter of fruit and shape index, while δ^2f was positive for all studied yield traits. He also indicated that the magnitudes of δ^2mf values were higher than those of δ^2m for all studied yield traits, except for length of fruits trait. In squash, Abd El-Hadi and El-Gendy (2004) studied four squash varieties and their 12 $F_{1,1r}$ hybrids. They cleared that the analysis of variance of diallel crosses indicated that the mean squares of GCA, SCA, GCA × L and SCA × L showed highly significance for most studied traits at each location and over both locations. Recently, Abd El-Hadi *et al.* (2004) showed that GCA were larger than their corresponding estimates of SCA for all studied traits at both $F_{1,1r}$ hybrids and $F_{2,2r}$ generations.

Abd El-Hadi *et al.* (2001) reported that total yield per plant and length of fruit in sweet melon were positively correlated with weight of fruit traits. On the other hand, El-Mighawry *et al.* (2001b) in watermelon obtained negative correlations among number of branches, number of leaves, number of days to male flowering and number of seeds. Dara *et al.* (2002) in yield per plant trait was significantly and positively correlated with number of fruits per plant, fruit set (%), and fruit retention (%) both at genotypic and phenotypic levels. In squash, Abd El-Maksoud *et al.* (2003) reported that most pairs of traits exhibited

Dept. of Genetics, Faculty of Agric. Mansoura University, Egypt.

negative genotypic and phenotypic correlation coefficients, while the following pairs of traits showed positive and significant correlation:- sex ratio with days to the first female flower, early yield as weight and number of fruits in the 7 picking per plant with total yield as total number and weight of fruits per plant.

The present investigation was planned to evaluate the genetic behavior of some important economical traits for four parental varieties, six F_1 hybrids and six F_{1r} hybrids.

MATERIAL AND METHODS

Four different squash varieties belong to *Cucurbita pepo*, L. were used in this study. These varieties were: Eskandrani (P_1), Zucchino mezza lung bianco (P_2), White Bush Scallop (P_3) and Zucchino nano verde di Milano (P_4). The seeds of these parental varieties were obtained from different countries i.e.: P_1 from Egypt, P_2 from Germany, P_3 from United States of America (U.S.A.) and P_4 from Italy. All these varieties represent a wide range of variability for most studied traits.

The four parental varieties were self-pollinated for three generations to obtain inbred lines of squash. In the summer growing season of 2002, all hybrids among the four parental varieties were made according to a complete diallel crosses mating design to produce six F_1 hybrids and six F_1 reciprocal hybrids. In the same growing season, the parental varieties were also self-pollinated to obtain enough seeds from each variety. In the two summer growing seasons of 2003 and 2004, all the 16 genotypes obtained from the last season were evaluated in a field trial experiment at El-Barmoun Station, Vegetables Research Station, Mansoura.

The experimental design used was a randomized complete blocks design with three replications. Each block consisted of 16 plots. The plot or the experimental unit was one ridge 5.0 m. long and 1.0 m. wide. The distance between hills 0.5 m. apart. Therefore, each ridge contained 10 hills.

Data were recorded on several plants within each plot for the following traits: first picking date (1^{st}P.D.), number of fruits per plant (No.F./P.), fruit yield per plant (F.Y./P.kg), fruit length (F.L.cm), fruit diameter (F.D.cm), fruit shape index (F.Sh.I.) and weight of fruit (W.F.g).

The significance of differences among genetic means for all studied traits were detected according to F-test. The analysis of variances and the expectations of mean squares were made according to Steel and Torrie (1960).

The amounts of heterosis were determined as the deviation of the mid-parents and the better parent as follows :

1. Heterosis from the mid-parents:-

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

2. Heterosis from the better parent:-

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

The analysis of variance of diallel crosses were made to obtain the estimates of general combining ability (G.C.A.), specific combining ability (S.C.A.) and reciprocal effect (r). The procedures of these Analysis were described by Griffing (1956) method I.

The estimates of GCA variance ($\delta^2 g$) and SCA variance ($\delta^2 s$) could be expressed in terms of genetic variances according to Matzingar and Kempthorne (1956) and Cockerham (1963) with the assumption that there was no epistasis.

RESULTS AND DISCUSSION

1. Analysis of variances:-

The analysis of variances for all genotypes for yield and yield comp . These traits were: first picking date (1^{st}P.D.), number of fruits per plant (No.F./P.), fruit yield per plant (F.Y./P.kg), fruit length (F.L.cm), fruit diameter (F.D.cm), fruit shape index (F.Sh.I.) and weight of fruit (W.F.g). The results of analysis of variances and the mean squares for yield and yield component traits for all genotypes are presented in Table (1).

The results cleared that the mean squares of genotypes showed highly significant values for all studied yield traits in the combined data. These results indicated the presence of large variations among the yield and yield component traits. These results were expected where the genotypes in this investigation included variable genetic materials of parental varieties, F_1 hybrids and F_{1r} hybrids. Thus, the partition of the genetic variation to its components could be made through the analysis of complete diallel crosses.

2. Mean performances of genotypes:-

Mean performances of four parental varieties, F_1 hybrids and F_1 reciprocal hybrids for yield and yield component traits were obtained and the results are presented in Table (2). The results showed that there was no single parent exceeded the other parents for all studied yield traits. It was also regarded from the results in the combined data that the parental variety Zucchino mezza lung bianco (P_2) was the earlier parent and has the lowest mean for 1^{st}P.D. In the same time, Eskandrani (P_1) and Zucchino nano verde di Milano (P_4) were the highest parents for No.F./P. and Eskandrani (P_1) was the highest parent for F.Y./P.kg and F.L.cm. While, the parental variety White Bush Scallop (P_3) was the highest parent for 1^{st}P.D. (undesirable), F.D.cm and W.F.g, but it was the lowest parent for No.F./P., F.Y./P.kg, F.L.cm and F.Sh.I. traits.

The parental variety P_4 was the lowest variety for F.D.cm and W.F.g traits. It was also noticed from the same table that the differences between the means of the lowest parent and the highest parent were always significant. This finding indicated the presence of genetic differences between the four parents. In general, these results suggested that there was a wide range of variation among parental varieties for all studied traits.

The results indicated that the highest F_1 hybrid was $P_2 \times P_3$ with the mean 2.96. While, the highest F_1 reciprocal hybrid was $P_4 \times P_2$ with the mean 2.78 for F.Y./P.kg in combined data. On the other hand, F_1 hybrid $P_1 \times P_4$ was the lowest with the mean 2.47 for combined data. While, $P_3 \times P_1$ F_{1r} hybrid was the lowest with the mean 2.29 for combined data for the same trait. The results cleared that the means of F_1 hybrids for the combined data ranged from 44.9 to 50.3; 19.5 to 21.7; 2.47 to 2.96; 8.3 to 15.2; 2.93 to 5.78; 1.44 to 4.56 and 119.1 to 140.9 for 1stP.D., No.F./P., F.Y./P.kg, F.L.cm, F.D.cm, F.Sh.I. and W.F.g, respectively. On the other hand, the mean values in F_{1r} hybrids ranged from 43.0 to 52.4; 17.3 to 22.0; 2.29 to 2.78; 8.0 to 15.8; 3.00 to 5.55; 1.44 to 4.92 and 123.9 to 136.6 for the same obvious traits, respectively.

Concerning the performances of F_1 hybrids and F_{1r} hybrids for yield and yield component traits, the results indicated that the magnitudes of the means of F_1 hybrids and F_{1r} hybrids were close to each other for most studied traits. At the same time, the results showed presence of significant differences among hybrids for many studied traits. It was also cleared that some F_1 hybrids and F_{1r} hybrids exceeded the better parent for yield and yield component traits. As we would expect, there were a higher heterotic values over the mid-parents.

3. Heterosis:-

3.1. Heterosis from the mid-parents:-

Mid-parents (M.P.) ranges, heterosis versus the mid-parents were estimated and the results are presented in Table (3). The results cleared that the average means of F_1 hybrids significantly exceeded the mid-parents for all studied traits. Therefore, all studied traits exhibited heterotic effect.

The results indicated that the obtained values of heterosis from the mid-parents for F_1 hybrids from the combined data ranged from -13.1 to -3.6 for 1stP.D.; 21.3 to 70.3 for No.F./P.; 33.4 to 102.6 for F.Y./P.kg; 2.8 to 23.5 for F.L.cm; 3.6 to 33.5 for F.D.cm; -43.2 to 1.3 for F.Sh.I and 3.7 to 18.2 for W.F.g. At the same time, the calculated values of heterosis over the mid-parents for F_{1r} hybrids ranged from -12.7 to -3.4; 21.5 to 52.0; 41.3 to 81.2; 1.3 to 34.4; 7.7 to 29.5; -43.1 to 8.9 and 7.9 to 19.3 for 1stP.D., No.F./P., F.Y./P.kg, F.L.cm, F.D.cm, F.Sh.I and W.F.g, respectively.

3.2. Heterosis from the better parent:-

Better parent (B.P.) ranges and heterosis against the better parent were estimated for yield and yield component traits and the results are presented in Table (4). The results cleared that the calculated values of heterosis over the better parent for F_1 hybrids from the combined data ranged from -7.9 to 1.2 for 1stP.D.; 18.3 to 34.5 for No.F./P.; 29.2 to 66.2 for F.Y./P.kg; -35.9 to 17.4 for F.L.cm; -3.3 to 20.1 for F.D.cm; -68.6 to -0.4 for F.Sh.I and 2.8 to 15.2 for W.F.g. Similarly, the values of heterosis measured from F_{1r} hybrids ranged from -11.7 to 4.1; 4.9 to 33.0; 19.7 to 55.2; -38.6 to 21.2; -10.8 to 17.6; -68.6 to 6.9 and 4.1 to 15.3 for the same obvious traits, respectively. These results are in agreement with the results obtained by Abd El-Hadi *et al.* (2001), Damarany *et al.* (2001), Shamloul (2002) and Abd El-Maksoud *et al.* (2003).

4. Analysis of combining ability variances:-

The analysis of variance for combining ability of four varieties and their 12 F_1 hybrids for yield and yield components, in two years and their combined data are presented in Table (5). The results revealed that the mean squares of hybrids showed highly significance differences for all studied traits. The results also cleared that the mean squares of general combining ability (GCA) and specific combining ability (SCA) exhibited significance values for all studied traits in combined data. This findings indicated that the additive and non-additive gene actions were involved in the inheritance of all studied traits. While, the mean squares due to general combining ability were highly significant for 1stP.D., F.L.cm, F.D.cm and F.Sh.I. for combined data. At the same time, the mean squares due to reciprocal effect were highly significant for F.L.cm, F.D.cm and F.Sh.I. traits for combined data. The values of GCA mean squares were higher than those of SCA mean squares for all studied yield traits. These results cleared that additive genetic variances were important in the inheritance of these traits. Meanwhile, the combining ability interaction with years (GCA × Y), (SCA × Y) and (Rec. × Y) were insignificant for traits and could be negligible with the except of (GCA × Y), (SCA × Y) and (Rec. × Y) for F.Y./P.kg. While, the interaction between crosses by years exhibited highly significant values for F.D.cm trait.

5. Genetic parameters and heritability:-

The relative magnitudes of genetic parameters were estimated for yield and yield component traits and the obtained results are shown in Table (6). The results showed that both additive (δ^2A) and non-additive genetic variances including dominance (δ^2D) were positive for all studied traits except for F.Y./P.kg. The observed data indicated that these variances play a role in genetic expression of yield and yield component traits. In addition, although the magnitudes of additive genetic variance was higher than the dominance for all studied traits. It could be suggested that additive genetic variance predominated in the inheritance of these traits. The results also illustrated that the importance of reciprocal variances which were smaller than additive genetic variances. Thus the cytoplasmic genetic factors also contributed in the genetic expression of yield and yield component traits.

In general, the heritability in broad sense (h^2_b%) was higher than the corresponding values of heritability in narrow sense (h^2_n%) for all studied traits except No.F./P and F.Y./P.kg. traits. These values ranged from 41.11% to 83.18% for No.F./P and 1stP.D. for the combined data in broad sense, respectively. In the same time, the highest values of h^2_n% was 82.07% for the combined data for F.L.cm trait. These results are in agreement with the results obtained by Abd El-Hadi *et al.* (2001), Dara *et al.* (2002) and Abd El-Maksoud *et al.* (2003).

6. General combining ability effects (g_i) for the parental varieties:-

Positive or negative GCA effects (g_i) estimate could indicate that a given inbred is better or more poorer than the average of the group involved with it in the complete diallel crosses mating design. General combining ability (GCA) effects of four parents for all studied traits are shown in Table (7). The results revealed that the GCA effects were positive and highly significant for desirable parent P_2 for No.F./P., F.Y./P.kg, F.L.cm and F.Sh.I traits. In this respect, the results also cleared that the GCA effects were negative (desirable) and highly significant for the parent P_2 for 1stP.D. trait toward earliness. While, the GCA effects were found to be highly significant and positive (undesirable) for the parent P_3 for the same trait.

These findings indicated that the two parents P_2 and P_3 seemed to be the best combiners for F.Y./P.kg trait. In the same time, the two parents P_2 and P_4 were the best combiners for F.L.cm and F.Sh.I. traits. The parent P_3 was the best combiner for F.D.cm and W.F.g. traits.

7. Specific combining ability effects (s_{ij}):-

Estimated values of specific combining ability effects (s_{ij}) of 12 F_1 hybrids for yield and yield component traits at both years and their combined data are presented in Table (8). The results illustrated that the F_1 hybrids $P_1 \times P_4$ and $P_2 \times P_3$ showed insignificant negative (desirable) of SCA effects for 1stP.D. trait from combined data. While, the F_1 reciprocal hybrid $P_3 \times P_2$ showed highly significant negative (desirable) of SCA effects for combined data for the same trait. At the same time, the same F_1 reciprocal hybrid gave the highest negative value -1.69 for the combined data for this trait.

For No.F./P. trait the F_1 hybrids $P_1 \times P_2$ and $P_3 \times P_4$ gave the highest values for combined data. At the same time, the F_1 reciprocal hybrid $P_3 \times P_1$ gave the highest value 1.79 for the combined data for the same trait. For F.Y./P.kg the F_1 hybrid $P_1 \times P_4$ gave the same highest value 0.029 for the combined data. At the same time, the F_1 reciprocal hybrid $P_3 \times P_1$ gave the highest value 0.237 for the combined data for the same trait. For F.L.cm the F_1 hybrid $P_1 \times P_2$ gave the highest value 0.229 for combined data. While, the F_{1r} hybrid $P_4 \times P_1$ gave the highest value 2.73 for the combined data for the same trait.

For F.D.cm the F_1 hybrid $P_2 \times P_4$ gave the highest value 0.104 for combined data. While, the F_{1r} hybrid $P_3 \times P_2$ gave the highest value 1.24 for the combined data for the same trait. For F.Sh.I. the F_1 hybrid $P_1 \times P_3$ gave the same highest value 0.069 for the combined data. At the same time, the F_{1r} hybrid $P_4 \times P_1$ gave the highest value 1.46 for the combined data for the same trait. For W.F.g the F_1 hybrid $P_2 \times P_3$ gave the highest value 1.36 for combined data. At the same time, the F_{1r} hybrid $P_3 \times P_2$ gave the highest value 3.75 for the combined data for the same trait.

8. Genotypic and phenotypic correlation coefficients:-

The information about the degree of association among different traits of squash is great importance. The coefficient of genotypic correlation provides a measure of the genotypic association among pairs of traits to identify the traits to be improved through the selection programs.

The covariance Analysis between pairs of all studied traits were made from the combined data over both years. Subsequently, genotypic (r_g) and phenotypic (r_{ph}) correlation coefficients were determined and the results are presented in Table (9). The results showed that the magnitudes of phenotypic correlation were close to the corresponding genotypic correlation in most of cases. Meanwhile, No.F./P. trait showed highly significant positive genotypic and phenotypic correlations with F.Y./P.kg trait. The coefficients were 0.94 and 0.93 for genotypic and phenotypic correlations, respectively. Similarly, F.L.cm trait showed highly significant positive genotypic and phenotypic correlations with F.Sh.I. trait. The coefficients were 0.94 for genotypic correlation and 0.88 for phenotypic correlation. In the same time, F.D.cm trait cleared highly significant positive genotypic and phenotypic correlations with W.F.g trait with coefficients correlation values 0.75 and 0.67 genotypic correlation and phenotypic correlation, respectively.

In general, most pairs of studied traits exhibited negative genotypic and phenotypic correlation coefficients, while the following pairs of traits showed significant positive genotypic and phenotypic correlations: (No.F./P. with F.L.cm), (F.Y./P.kg with W.F.g). Similar results were obtained by many authors among them Abd El-Hadi *et al.* (2001), El-Mighawry *et al.* (2001b), Dara *et al.* (2002), Shamloul (2002) and Abd El- Maksoud *et al.* (2003).

Table 1: Analysis of variances and mean squares for yield and yield component traits for each year and their combined data.

S.V.	d.f	1st P.D.			No.F./P.			F.Y./P.kg			F.L.cm		
		Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
Years	1	-	-	0.09	-	-	0.01	-	-	0.001	-	-	0.2
Rep.	2	1.52	0.19	0.86	0.1	0.1	0.1	0.002	0.001	0.001	0.04	0.03	0.04
Gen.	15	43.9**	47.4**	90.4**	31.9**	31.6**	62.9**	0.71**	0.68**	1.39**	35.8**	39.1**	74.7**
G ×Y	15	-	-	0.91	-	-	0.58	-	-	0.004	-	-	0.14
Error	30	1.36	1.10	1.23	1.12	1.27	1.20	0.02	0.03	0.02	0.10	0.12	0.11

Table 1: Cont.

S.V.	d.f.	F.D.cm			F.Sh.I			W.F.g		
		Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
Years	1	-	-	0.04	-	-	0.12	-	-	4.17
Rep.	2	0.003	0.002	0.002	0.33	0.01	0.17	0.9	7.0	3.95
Gen.	15	5.02**	5.1**	10.1**	7.4**	8.1**	15.4**	244.9**	258.2**	500.8**
G ×Y	15	-	-	0.02*	-	-	0.09	-	-	2.39
Error	30	0.01	0.01	0.01	0. 18	0.02	0.10	8.32	7.64	7.98

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

Table 2: The mean performances of four parental varieties, F_1 and F_{1r} hybrids for yield and yield component traits for each year and their combined data.

Genotypes	1st F.D.			No.F./P.			F.Y./P.kg			F.L.cm		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
P_1	54.1	53.7	53.9	16.6^H	16.4^H	16.5^H	1.93^H	1.90^H	1.91^H	13.1^H	12.9^H	13.0^H
P_2	48.4^L	49.0^L	48.7^L	15.7	15.5	15.6	1.79	1.76	1.78	12.9	12.8	12.9
P_3	59.1^H	58.4^H	58.7^H	8.6^L	9.4^L	9.0^L	1.10^L	1.19^L	1.14^L	2.8^L	2.7^L	2.8^L
P_4	49.1	50.3	49.7	16.6^H	16.4^H	16.5^H	1.80	1.77	1.79	12.3	12.2	12.3
$P_1 \times P_2$	45.5^L	44.3^L	44.9^L	21.1	22.2^H	21.7^H	2.53	2.64	2.58	13.2	13.4	13.3
$P_1 \times P_3$	49.9	49.6	49.8	20.6	21.2	20.9	2.73	2.79	2.76	8.1^L	8.6	8.3^L
$P_1 \times P_4$	46.3	45.6	46.0	20.8	20.5	20.6	2.48^L	2.45^L	2.47^L	13.7	13.9	13.8
$P_2 \times P_3$	46.9	46.5	46.7	21.4^H	20.6	21.0	3.00^H	2.92^H	2.96^H	9.6	9.7	9.7
$P_2 \times P_4$	47.2	47.7	47.4	19.6^L	19.5^L	19.5^L	2.58	2.54	2.56	15.0^H	15.3^H	15.2^H
$P_3 \times P_4$	50.2^H	50.4^H	50.3^H	19.6^L	19.5^L	19.5^L	2.61	2.65	2.63	8.5	8.4^L	8.5
$P_2 \times P_1$	45.6	45.7	45.7	20.6	21.5	21.1	2.56	2.66	2.61	15.4^H	16.1^H	15.8^H
$P_3 \times P_1$	52.2^H	52.5^H	52.4^H	17.5^L	17.1^L	17.3^L	2.32^L	2.25^L	2.29^L	8.1^L	7.9^L	8.0^L
$P_4 \times P_1$	49.3	50.8	50.1	20.6	19.6	20.1	2.75	2.62	2.68	14.3	14.6	14.5
$P_3 \times P_2$	47.8	46.7	47.3	18.5	18.2	18.4	2.43	2.41	2.42	8.5	8.2	8.4
$P_4 \times P_2$	43.4^L	42.6^L	43.0^L	21.6^H	22.3^H	22.0^H	2.77^H	2.79^H	2.78^H	14.6	14.9	14.8
$P_4 \times P_3$	51.5	51.9	51.7	19.5	19.3	19.4	2.68	2.62	2.65	10.2	10.0	10.1
L.S.D. $_{0.05}$	1.94	1.75	1.81	1.76	1.88	1.79	0.24	0.29	0.23	0.53	0.58	0.54
L.S.D. $_{0.01}$	2.62	2.35	2.41	2.38	2.53	2.38	0.32	0.39	0.31	0.71	0.78	0.72

Table 2: Cont.

Genotypes	F.D.cm			F.Sh.I			W.F.g		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
P_1	2.83	2.85	2.84	4.62^H	4.53	4.58	116.2	115.6	115.9
P_2	2.81	2.79	2.80	4.60	4.59^H	4.60^H	113.9	113.6	113.8
P_3	5.70^H	5.75^H	5.73^H	0.49^L	0.47^L	0.48^L	127.1^H	126.6^H	126.8^H
P_4	2.78^L	2.76^L	2.77^L	4.44	4.43	4.43	108.2^L	107.8^L	108.0^L
$P_1 \times P_2$	2.87^L	2.98^L	2.93^L	4.61	4.49	4.55	119.9	118.4^L	119.1^L
$P_1 \times P_3$	5.76	5.84	5.80	1.40^L	1.47^L	1.44^L	132.4	131.5	132.0
$P_1 \times P_4$	2.97	3.08	3.03	4.60^H	4.53	4.56^H	119.5^L	119.9	119.7
$P_2 \times P_3$	5.69^H	5.87^H	5.78^H	1.69	1.66	1.67	140.1^H	141.8^H	140.9^H
$P_2 \times P_4$	3.38	3.35	3.36	4.43	4.59^H	4.51	131.8	130.3	131.1
$P_3 \times P_4$	5.65	5.44	5.54	1.51	1.54	1.53	133.6	135.7	134.6
$P_2 \times P_1$	3.31	3.37	3.34	4.65	4.79	4.72	124.5^L	123.4^L	123.9^L
$P_3 \times P_1$	5.57^H	5.53^H	5.55^H	1.46^L	1.42^L	1.44^L	132.8	131.2	132.0
$P_4 \times P_1$	3.30	3.32	3.31	4.33	4.41	4.37	133.4	133.9	133.6
$P_3 \times P_2$	5.08	5.14	5.11	1.68	1.59	1.63	131.6	132.4	132.0
$P_4 \times P_2$	2.98^L	3.03^L	3.00^L	4.92^H	4.92^H	4.92^H	127.9	125.3	126.6
$P_4 \times P_3$	5.03	5.27	5.15	2.03	1.90	1.97	137.3^H	135.9^H	136.6^H
L.S.D.$_{0.05}$	0.17	0.17	0.17	0.71	0.24	0.52	4.80	4.60	4.61
L.S.D.$_{0.01}$	0.22	0.22	0.22	0.95	0.32	0.69	6.48	6.21	6.14

H= The highest value L= The lowest value

Table 3: Heterosis relative to mid-parents ($H_{M.P.}$%) for yield and yield component traits for each year and their combined data over the two years.

Hybrids	1^{st}P.D.			No.F./P.			F.Y./P.kg			F.L.cm		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$P_1 \times P_2$	-11.3**	-13.8**^{L}	-12.6**	30.5**	39.1**	34.8**	35.9**	43.8**	39.8**	1.5**^{L}	4.0**^{L}	2.8**^{L}
$P_1 \times P_3$	-11.8**	-11.5**	-11.7**	63.3**	64.1**	63.7**	80.3**	80.4**	80.4**	1.7**	9.8**	5.7**
$P_1 \times P_4$	-10.3**	-12.3**	-11.3**	25.2**	24.5**	24.9**	33.2**^{L}	33.5**^{L}	33.4**^{L}	7.6**	10.7**	9.2**
$P_2 \times P_3$	-12.8**^{L}	-13.4**	-13.1**^{L}	75.6**^{H}	65.0**^{H}	70.3**^{H}	108**^{H}	97.8**^{H}	103**^{H}	22.0**^{H}	25.1**^{H}	23.5**^{H}
$P_2 \times P_4$	-3.2**^{H}	-4.0**^{H}	-3.6**^{H}	20.9**^{L}	21.8**^{L}	21.3**^{L}	43.4**	43.7**	43.5**	18.5**	22.3**	20.4**
$P_3 \times P_4$	-7.2**	-7.3**	-7.2**	54.9**	51.0**	52.9**	80.3**	78.9**	79.6**	12.8**	11.8**	12.3**
$P_2 \times P_1$	-11.0**	-11.0**	-11.0**	27.2**	34.7**	30.9**	37.7**^{L}	45.0**	41.3**^{L}	18.5**	25.0**	21.7**
$P_3 \times P_1$	-7.7**	-6.3**	-7.0**	38.7**	32.6**	35.6**	53.7**	45.5**	49.6**	2.1**^{L}	0.4^{L}	1.3**^{L}
$P_4 \times P_1$	-4.4**^{H}	-2.4**^{H}	-3.4**^{H}	24.0**^{L}	19.1**^{L}	21.5**^{L}	47.2**	42.6**^{L}	45.0**	12.6**	16.3**	14.4**
$P_3 \times P_2$	-11.1**^{L}	-12.9**	-12.0**	51.8**	46.0**	48.9**	68.5**	63.2**	65.8**	8.5**	4.9**	6.7**
$P_4 \times P_2$	-11.0**	-14.3**^{L}	-12.7**^{L}	33.7**	39.3**	36.5**	54.0**	57.9**	55.9**	15.8**	18.9**	17.4**
$P_4 \times P_3$	-4.7**	-4.5**	-4.6**	54.6**^{H}	49.4**^{H}	52.0**^{H}	85.1**^{H}	77.4**^{H}	81.2**^{H}	34.8**^{H}	34.1**^{H}	34.4**^{H}
$L.S.D._{0.05}$	1.68	1.51	1.57	1.53	1.63	1.55	0.20	0.25	0.20	0.46	0.50	0.47
$L.S.D._{0.01}$	2.27	2.04	2.09	2.06	2.19	2.06	0.28	0.34	0.27	0.61	0.67	0.62

Table 3: Cont.

Hybrids	F.D.cm			F.Sh.I			W.F.g		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$P_1 \times P_2$	1.6**^{L}	5.7**^{L}	3.6**^{L}	-0.01	-1.6**	-0.8**	4.2*^{L}	3.3^{L}	3.7^{L}
$P_1 \times P_3$	35.1**^{H}	35.8**	35.5**^{H}	-45.2**^{L}	-41.2**^{L}	-43.2**^{L}	8.9**	8.6**	8.7**
$P_1 \times P_4$	6.0**	9.7**	7.8**	1.6**^{H}	1.0**	1.3**^{H}	6.5**	7.3**	6.9**
$P_2 \times P_3$	33.7**	37.4**^{H}	35.5**^{H}	-33.7**	-34.5**	-34.1**	16.3**	18.1**^{H}	17.2**
$P_2 \times P_4$	20.7**	20.5**	20.6**	-1.8**	1.6**^{H}	-0.1	18.7**^{H}	17.7**	18.2**^{H}
$P_3 \times P_4$	33.3**	27.7**	30.5**	-38.7**	-37.2**	-38.0**	13.5**	15.8**	14.7**
$P_2 \times P_1$	17.4**	19.2**	18.3**	0.9**	4.9**	2.9**	8.2**^{L}	7.6**^{L}	7.9**^{L}
$P_3 \times P_1$	30.6**^{H}	28.5**^{H}	29.5**^{H}	-43.0**^{L}	-43.2**^{L}	-43.1**^{L}	9.2**	8.3**	8.8**
$P_4 \times P_1$	17.6**	18.2**	17.9**	-4.3**	-1.6**	-2.9**	18.8**^{H}	19.8**^{H}	19.3**^{H}
$P_3 \times P_2$	19.3**	20.4**	19.8**	-33.9**	-37.4**	-35.6**	9.3**	10.3**	9.8**
$P_4 \times P_2$	6.4**^{L}	9.1**^{L}	7.7**^{L}	8.9**^{H}	9.0**^{H}	8.9**^{H}	15.1**	13.2**	14.2**
$P_4 \times P_3$	18.6**	23.8**	21.2**	-17.7**	-22.3**	-20.0**	16.7**	16.0**	16.3**
$L.S.D._{0.05}$	0.14	0.14	0.14	0.61	0.20	0.45	4.16	3.99	3.99
$L.S.D._{0.01}$	0.19	0.19	0.19	0.83	0.28	0.59	5.61	5.37	5.31

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.
H= The highest value L= The lowest value

Table 4: Heterosis relative to better parent ($H_{B.P.}$%) for yield and yield component traits for each year and their combined data over the two years.

Hybrids	1st P.D.			No.F./P.			F.Y./P.kg			F.L.cm		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$P_1 \times P_2$	-6.1**	-9.7**^{L}	-7.9**^{L}	27.1**	35.6**^{H}	31.3**	31.0**	38.7**	35.2**	0.76**	3.9**	2.3**
$P_1 \times P_3$	-7.7**^{L}	-7.6**	-7.7**	24.1**	29.3**	26.7**	41.3**	46.7**	44.4**	-38.4**^{L}	-33.3**^{L}	-35.9**^{L}
$P_1 \times P_4$	-5.7**	-9.3**	-7.5**	25.3**	24.8**	25.1**	28.7**^{L}	29.0**^{L}	29.2**^{L}	4.3**	8.0**	6.2**
$P_2 \times P_3$	-3.2**	-5.2**	-4.2**	36.3**^{H}	32.7**	34.5**^{H}	67.5**^{H}	65.9**^{H}	66.2**^{H}	-25.6**	-24.0**	-25.1**
$P_2 \times P_4$	-2.5*	-2.7**	-2.6**	17.9**^{L}	18.7**^{L}	18.3**^{L}	43.2**	43.4**	42.9**	16.0**^{H}	19.8**^{H}	17.4**^{H}
$P_3 \times P_4$	2.2*^{H}	0.20^{H}	1.2^{H}	17.9**^{L}	18.9**	18.4**	45.1**	49.5**	46.9**	-30.6**	-31.4**	-31.3**
$P_2 \times P_1$	-5.7**	-6.7**	-6.2**	23.9**	31.3**	27.6**	32.7**	39.8**	36.6**	17.6**^{H}	24.8**^{H}	21.2**^{H}
$P_3 \times P_1$	-3.5**	-2.2*	-2.8**	5.4**^{L}	4.5**^{L}	4.9**^{L}	20.4**^{L}	18.3**^{L}	19.7**^{L}	-38.2**^{L}	-39.0**^{L}	-38.6**^{L}
$P_4 \times P_1$	0.48	0.93	0.70	24.1**	19.3**	21.7**	42.3**	37.8**	40.4**	9.2**	13.4**	11.3**
$P_3 \times P_2$	-1.2	-4.6**	-2.9**	17.8**	17.4**	17.6**	36.0**	36.9**	36.1**	-33.9**	-36.2**	-35.3**
$P_4 \times P_2$	-10.3**^{L}	-13.1**^{L}	-11.7**^{L}	30.3**^{H}	35.8**^{H}	33.0**^{H}	53.7**^{H}	57.7**^{H}	55.2**^{H}	13.4**	16.4**	14.5**
$P_4 \times P_3$	5.0**^{H}	3.2**^{H}	4.1**^{H}	17.7**	17.7**	17.7**	49.0**	48.2**	48.2**	-17.1**	-17.8**	-17.8**
L.S.D. $_{0.05}$	1.94	1.75	1.81	1.76	1.88	1.79	0.24	0.29	0.23	0.53	0.58	0.54
L.S.D. $_{0.01}$	2.62	2.35	2.41	2.38	2.53	2.38	0.32	0.39	0.31	0.71	0.78	0.72

Table 4: Cont.

Hybrids	F.D.cm			F.Sh.I.			W.F.g		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$P_1 \times P_2$	1.3**	4.7**	3.0**	-0.30^{H}	-2.2**	-1.1**	3.2	2.4^{L}	2.8^{L}
$P_1 \times P_3$	1.1**	1.6**	1.3**	-69.7**^{L}	-67.5**^{L}	-68.6**^{L}	4.2	3.9	4.1
$P_1 \times P_4$	5.1**	8.1**	6.6**	-0.47	-0.10^{H}	-0.40^{H}	2.9^{L}	3.7	3.3
$P_2 \times P_3$	-0.18*	2.1**	0.87**	-63.3**	-63.9**	-63.6**	10.2**	12.0**	11.1**
$P_2 \times P_4$	20.2**^{H}	20.0**^{H}	20.1**^{H}	-3.6**	-0.11	-2.0**	15.7**^{H}	14.7**^{H}	15.2**^{H}
$P_3 \times P_4$	-0.90^{L}	-5.4**^{L}	-3.3**^{L}	-66.0**	-65.2**	-65.6**	5.1*	7.2**	6.2**
$P_2 \times P_1$	17.1**^{H}	18.1**^{H}	17.6**^{H}	0.63	4.3**	2.6**	7.1**	6.7**	6.9**
$P_3 \times P_1$	-2.3**	-3.8**	-3.1**	-68.5**^{L}	-68.6**^{L}	-68.6**^{L}	4.5	3.6^{L}	4.1^{L}
$P_4 \times P_1$	16.6**	16.5**	16.5**	-6.2**	-2.7**	-4.6**	14.8**^{H}	15.8**^{H}	15.3**^{H}
$P_3 \times P_2$	-10.9**	-10.6**^{L}	-10.8**^{L}	-63.5**	-65.4**	-64.5**	3.6^{L}	4.6*	4.1^{L}
$P_4 \times P_2$	5.9**	8.6**	7.3**	6.9**^{H}	7.2**^{H}	6.9**^{H}	12.3**	10.3**	11.2**
$P_4 \times P_3$	-11.8**^{L}	-8.3**	-10.1**	-54.3**	-57.0**	-55.6**	8.0**	7.3**	7.7**
L.S.D.$_{0.05}$	0.17	0.17	0.17	0.71	0.24	0.52	4.80	4.60	4.61
L.S.D.$_{0.01}$	0.22	0.22	0.22	0.95	0.32	0.69	6.48	6.21	6.14

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.
H= The highest value L= The lowest value

Table 5: Analysis of combining abilities and mean squares of F_1 hybrids for yield and yield component traits.

S.V.	d.f.	1st F.D.			No.F./P.			F.Y./P.kg			F.L.cm		
		Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
Cross	11	21.5**	29.9**	50.5**	4.48**	7.34**	11.1**	0.09**	0.09**	0.20**	7.70**	8.80**	16.5**
G.C.A.	3	21.0**	26.4**	46.9**	1.96	3.20	4.85*	0.07	0.06	0.11*	23.4**	26.5**	49.8**
S.C.A.	2	0.51	0.61	1.12	0.27	0.92	0.56	0.006	0.003	0.003	0.17	0.15	0.31
R.E.	6	2.47*	4.87**	7.03**	1.67	2.59*	4.20**	0.022	0.037	0.058*	4.68**	5.67**	10.3**
C × Y	11	--	--	0.85	--	--	0.69	--	--	0.007	--	--	0.04
G.C.A. × Y	3	--	--	0.44	--	--	0.31	--	--	0.003	--	--	0.08
S.C.A. × Y	2	--	--	0.003	--	--	0.63	--	--	0.006	--	--	0.01
R.E. × Y	6	--	--	0.30	--	--	0.07	--	--	0.002	--	--	0.05
Pooled Error	22/44	0.62	0.50	0.56	0.51	0.58	0.54	0.01	0.01	0.01	0.05	0.05	0.05
G.C.A./ S.C.A.	--	41.2	43.3	41.9	7.26	3.48	8.66	11.67	20.0	36.67	137.6	176.7	160.6
G.C.A.× Y/S.C.A.× Y	--	--	--	146.7	--	--	0.49	--	--	0.50	--	--	8.0

Table 5: Cont.

S.V.	d.f.	F.D.cm			F.Sh.I			W.F.g		
		Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
Cross	11	4.64**	4.59**	9.21**	6.62**	7.55**	14.06**	121**	144**	262**
G.C.A.	3	3.83**	3.74**	7.57**	5.25**	6.47**	11.66**	102**	123**	224**
S.C.A.	2	0.05	0.03	0.07*	0.05	0.02	0.05	7.81	13.36*	17.84
R.E.	6	0.90**	0.93**	1.83**	1.41**	1.38**	2.75**	20.36*	22.2*	42.0**
C × Y	11	--	--	0.02**	--	--	0.113	--	--	3.22
G.C.A. × Y	3	--	--	0.001	--	--	0.05	--	--	0.56
S.C.A. × Y	2	--	--	0.003	--	--	0.02	--	--	3.34
R.E. × Y	6	--	--	0.01	--	--	0.04	--	--	0.57
Pooled Error	22/44	0.003	0.003	0.003	0.08	0.009	0.05	3.78	3.47	3.63
G.C.A./ S.C.A.	--	76.6	124.7	108.1	105.0	323.5	233.2	13.06	9.20	12.57
G.C.A. × Y/S.C.A. × Y	--	--	--	0.3	--	--	2.5	--	--	0.17

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

Table 6: The relative magnitudes of different genetic parameters and heritability for vegetative and earliness traits for each year and the combined data over the two years.

Genetic parameters and heritability	V.L.cm			No.L./P.			L.A.cm^2			F.W./P.g		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$\delta^2 A$	10.24	12.88	11.34	0.84	1.14	1.16	0.04	0.02	0.03	11.62	13.16	12.36
$\delta^2 D$	0.052	0.054	0.28	0.12	0.17	0.02	-0.001	-0.004	-0.001	0.06	0.05	0.07
$\delta^2 r$	0.92	2.18	1.68	0.58	1.0	1.03	0.007	0.013	0.014	2.32	2.81	2.56
$\delta^2 A \times Y$	--	--	0.11	--	--	0.08	--	--	0.001	--	--	0.018
$\delta^2 D \times Y$	--	--	-0.28	--	--	0.04	--	--	-0.002	--	--	-0.02
$\delta^2 r \times Y$	--	--	-0.13	--	--	-0.24	--	--	-0.004	--	--	0.002
$\delta^2 E$	0.62	0.50	0.56	0.51	0.58	0.54	0.009	0.012	0.01	0.05	0.06	0.05
h^2_b%	86.98	82.84	83.18	46.83	45.33	41.11	71.43	44.44	54.55	83.13	82.15	82.54
h^2_n%	86.54	82.49	81.17	40.98	39.45	40.42	71.43	44.44	54.55	82.70	81.84	82.07

Table 6: Cont.

Genetic parameters and heritability	D.W./P.g			No.1stF.F.N.			D.1stF.F.			D.1stM.F.		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$\delta^2 A$	1.90	1.86	1.88	4.48	3.22	2.90	47.1	54.74	52.32	1.90	1.86	1.88
$\delta^2 D$	0.022	0.013	0.018	0.016	0.005	0.007	2.02	4.94	3.63	0.022	0.013	0.018
$\delta^2 r$	0.45	0.46	0.45	0.68	0.66	0.67	8.29	9.36	10.35	0.45	0.46	0.45
$\delta^2 A \times Y$	--	--	0.0005	--	--	0.008	--	--	0.69	--	--	0.0005
$\delta^2 D \times Y$	--	--	-0.0001	--	--	-0.013	--	--	-0.15	--	--	-0.0001
$\delta^2 r \times Y$	--	--	0.0037	--	--	-0.004	--	--	-1.53	--	--	0.0037
$\delta^2 E$	0.0034	0.0032	0.0033	0.083	0.009	0.046	3.78	3.47	3.63	0.0034	0.0032	0.0033
h^2_b%	80.91	80.17	80.58	85.49	82.82	80.06	80.27	82.31	79.23	80.91	80.17	80.58
h^2_n%	79.99	79.62	79.81	85.19	82.69	79.87	76.97	75.49	74.09	79.99	79.62	79.81

Note: Negative values were considered equal to zero during the calculation of heritability in broad and narrow senses.

Table 7: General combining ability effects (g_i) of the four parents for yield and yield component traits from each year and from combined data.

Parents	1stP.D.			No.F./P.			F.Y./P.kg			F.L.cm		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
P1	-0.142	-0.667**	-0.404	-0.404	-0.012	-0.196	-0.166**	-0.118**	-0.142**	-0.658**	-0.617**	-0.637**
P2	-2.517**	-2.416**	-2.466**	1.046**	1.229**	1.138**	0.114**	0.124**	0.119**	3.125**	3.392**	3.258**
P3	3.042**	3.633**	3.337**	-0.371	-0.862**	-0.617**	0.093**	0.045	0.069*	-2.70**	-2.825**	-2.763**
P4	-0.383	-0.550*	-0.467	-0.271	-0.379	-0.325	-0.041	-0.051	-0.046	0.233**	0.05	0.142*
L.S.D. $_{0.05}$	0.499	0.448	0.462	0.45	0.48	0.45	0.063	0.063	0.060	0.141	0.141	0.138
L.S.D. $_{0.01}$	0.677	0.600	0.618	0.61	0.65	0.60	0.086	0.086	0.082	0.192	0.192	0.184

Table 7: Cont.

Parents	F.D.cm			F.Sh.I			W.F.g		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
P1	-0.058**	-0.041*	-0.049**	-0.059	-0.09**	-0.015	-5.375**	-5.708**	-5.542**
P2	-1.067**	-1.048**	-1.058**	1.370**	1.549**	1.459**	-1.208	-1.625**	-1.417*
P3	1.302**	1.290**	1.296**	-1.433	-1.561**	-1.497**	6.792**	7.542**	7.167**
P4	-0.177**	-0.201**	-0.189**	0.004	0.101**	0.053	-0.208	-0.208	-0.208
L.S.D. $_{0.05}$	0.034	0.034	0.033	0.18	0.06	0.28	1.23	1.18	1.18
L.S.D. $_{0.01}$	0.047	0.047	0.045	0.24	0.08	0.38	1.67	1.60	1.57

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 8: Specific combining ability effects of the 12 hybrids for yield and yield component traits from the two years and their combined data.

Hybrids	1st F.D.			No.F./P.			F.Y./P.kg			F.L.cm		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$P_1 \times P_2$	0.212	0.210	0.211	0.071	0.520	0.294	0.020	0.036	0.028	0.230**	0.228**	0.229**
$P_1 \times P_3$	0.190	0.245	0.217	-0.284	-0.101	-0.193	-0.017	-0.022	-0.020	-0.158**	-0.081**	-0.119**
$P_1 \times P_4$	-0.414	-0.450	-0.432	-0.201	-0.426	-0.314	0.047	0.012	0.029	-0.080**	-0.152**	-0.116**
$P_2 \times P_3$	-0.410	-0.440	-0.425	0.211	-0.419	-0.104	0.044	-0.011	0.018	-0.075**	-0.141**	-0.108**
$P_2 \times P_4$	0.194	0.233	0.214	-0.289	-0.103	-0.196	-0.022	-0.023	-0.022	-0.168**	-0.084**	-0.126**
$P_3 \times P_4$	0.219	0.217	0.218	0.078	0.522	0.299	0.023	0.031	0.027	0.233**	0.220**	0.226**
$P_2 \times P_1$	-0.083	-0.717	-0.399	0.267	0.350	0.308	-0.015	-0.013	-0.014	-1.10**	-1.35**	-1.23**
$P_3 \times P_1$	-1.15*	-1.45**	-1.30*	1.55**	2.03**	1.79**	0.201**	0.272**	0.237**	-0.02	0.367*	0.175
$P_4 \times P_1$	-0.75	-0.55	-0.65	1.15*	1.13*	1.14*	0.025	0.022	0.023	2.57**	2.88**	2.73**
$P_3 \times P_2$	-1.23*	-2.15**	-1.69**	0.40	0.50	0.45	0.125	0.15*	0.137	-2.35**	-2.45**	-2.40**
$P_4 \times P_2$	1.88**	2.55**	2.22**	-1.03	-1.40*	-1.22*	-0.097	-0.127	-0.112	0.167	0.217	0.192
$P_4 \times P_3$	-0.67	-0.75	-0.71	0.017	0.101	0.059	-0.035	0.012	-0.012	-0.834**	-0.833**	-0.833**
L.S.D.$(s_{ij})_{0.05}$	0.78	0.63	0.65	0.63	0.68	0.64	0.09	0.09	0.09	0.02	0.02	0.02
L.S.D.$(s_{ij})_{0.01}$	0.96	0.86	0.87	0.86	0.92	0.86	0.12	0.12	0.12	0.03	0.03	0.03
L.S.D.$(r_{ij})_{0.05}$	1.15	1.03	1.06	1.04	1.11	1.10	0.14	0.14	0.14	0.33	0.33	0.33
L.S.D.$(r_{ij})_{0.01}$	1.56	1.40	1.43	1.42	1.51	1.40	0.19	0.19	0.19	0.44	0.44	0.44

Table 8: Cont.

Hybrids	F.D.cm			F.Sh.I			W.F.g		
	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.	Y_1	Y_2	Comb.
$P_1 \times P_2$	-0.081**	-0.091**	-0.086**	0.018	0.071	0.045	-1.618	-1.588	-1.616
$P_1 \times P_3$	0.120**	0.082**	0.101**	0.119	0.019	0.069	0.881	-0.412	0.236
$P_1 \times P_4$	0.031	0.003	0.017	-0.122	-0.061	-0.092	0.716	1.97*	1.34
$P_2 \times P_3$	-0.039	0.002	-0.019	-0.117	-0.075	-0.096	0.722	1.99*	1.36
$P_2 \times P_4$	0.123**	0.086**	0.104**	0.109	-0.009	0.050	0.889	-0.420	0.238
$P_3 \times P_4$	-0.084**	-0.082**	-0.083**	0.008	0.074	0.041	-1.61	-1.58	-1.60
$P_2 \times P_1$	-0.223**	-0.192**	-0.208**	-0.022	-0.149**	-0.085	-2.33	-2.50	-2.42
$P_3 \times P_1$	0.097*	0.157**	0.127**	0.474*	0.023	0.248	-0.17	0.17	0.00
$P_4 \times P_1$	-1.05**	-1.03**	-1.04**	1.46**	1.47**	1.46**	-6.00**	-6.17**	-6.08**
$P_3 \times P_2$	1.20**	1.28**	1.24**	-1.33**	-1.38**	-1.35**	3.50*	4.00**	3.75**
$P_4 \times P_2$	0.20**	0.159**	0.179**	-0.242	-0.167*	-0.205	2.00	2.50	2.25
$P_4 \times P_3$	0.31**	0.084*	0.197**	-0.26	-0.183*	-0.222	-1.83	-0.17	-1.00
L.S.D.$(s_{ij})_{0.05}$	0.05	0.05	0.05	0.25	0.09	0.19	1.74	1.67	1.66
L.S.D.$(s_{ij})_{0.01}$	0.07	0.07	0.07	0.34	0.16	0.26	2.36	2.26	2.22
L.S.D.$(r_{ij})_{0.05}$	0.08	0.08	0.08	0.41	0.14	0.32	2.85	2.73	2.72
L.S.D.$(r_{ij})_{0.01}$	0.11	0.11	0.11	0.56	0.19	0.43	3.86	3.70	3.64

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 9: Genotypic (above diagonal) and phenotypic (below diagonal) correlation for all pairs of yield and yield component traits.

Traits	1st P.D.	No.F./P.	F.Y./P.kg	F.L.cm	F.D.cm	F.Sh.I.	W.F.g
1st P.D.		-0.83**	-0.69**	-0.69**	0.43	-0.56*	0.04
No.F./P.	-0.65**		0.94**	0.61*	-0.18	0.38	0.28
F.Y./P.kg	-0.55*	0.93**		0.39	0.11	0.10	0.58*
F.L.cm	-0.60*	0.53*	0.35		-0.85**	0.94**	-0.35
F.D.cm	0.39	-0.16	0.10	-0.83**		-0.97**	0.75**
F.Sh.I.	-0.50*	0.31	0.07	0.88**	-0.93**		-0.63**
W.F.g	0.03	0.21	0.53*	-0.31	0.67**	-0.56*	

REFERENCES

Abd El-Hadi, A.H.; M.M. Zaghloul and A.H. Gabr (2004). Nature of gene action, heterosis and inbreeding depression of yield and yield component traits in squash (*Cucurbita pepo,* L.). Zagazig J. Agric, Res., 31(6): 2707-2725.

Abd El-Hadi, A.H. and Soher E.A. El-Gendy (2004). Effect of genotypes by locations interaction on economical traits of squash. J. Agric. Sci., Mansoura Univ., 29(10): 5667-5687.

Abd El-Hadi, A.H.; Z.A. Kosba; Z.M. El-Diasty; El-S.H. Askar and G.M. Shamloul (2001). Evaluation of F_1 hybrids among new selected inbred lines of sweet melon (*Cucumis melo var. aegyptiacus,* L.).J. Agric. Sci., Mansoura Univ., 26(5): 2831-2845.

Abd El-Maksoud, M.M.; A.M. El-Adl; M.S. Hamada and M.S. Sadek (2003). Inheritance of some economical traits in squash (*Cucurbita pepo,* L.). J. Agric. Sci. Mansoura Univ., 28(6): 4463-4474.

Abd El-Rahman, M.M.; M.E. Abou El-Nasr and A.A. Kamooh (2001). Diallel analysis for variability in pumpkin (*Cucurbita moschata,* Poir) J. Agric. Sci. Mansoura Univ., 26 (4): 2205-2213.

Ana, I. Lopez-Sese and J. Staub (2002). Combining ability analysis of yield components in cucumber. J. Amer. Soc. Hort. Sci. 127(6): 931-937.

Cockerham, C.C. (1963). Estimation of genetic variances. Statistical Genetics and Plant Breeding. NAS-NRC, 982, pp.53-68.

Damarany, A.M.; M.H. Abou El-Nasr and M.M.A. Abdalla (2001).Estimation of heterosis, for yield and some economical characters in melon (*Cucumis melo,* L.) under sandy soil in Upper Egypt. The fifth Arabian Hort. Conf., Ismailia, Egypt, March 24-28, (11): 213-226.

Dara, D.K.; T.K. Behera; G.C. Acharya; P. Mohapatra and B. Mishra (2002). Genetic variability and character association in pointed gourd (*Trichosanthes dioica* Ro×b.). Indian J. Hort., 60(2) 163-166.

El-Adl, A.M; Z.A. Kosba; T.M. El-Gazar and M.M. El-Maksoud (1988). Manifestation of heterosis and types of genetic effects associated with it for some quantitative traits in squash (*Cucurbita pepo,* L.) I. Magnitudes of heterosis and inbreeding depression. J. Agric. Sci. Mansoura Univ., 13(3): 1287-1295.

El-Mighawry, A.; A.A. Kamooh; M. Abd El-Salam and S.S. Gaman (2001b). Inheritance of some economical characters in watermelon. J. Agric. Sci. Mansoura Univ., 26 (7): 4159-4170.

El-Mighawry, A.; M.M. Abd El-Salam and R.A. El-Shabrawy (2001a). The heritability coefficient and response to selection for heterosis in muskmelon, (*Cucumis melo,*L.). J. Agric. Sci. Mansoura Univ., 26(9): 5517-5526.

El-Sharkawy, Gehan A.M. (2000). An analytical study for the genetic behavior of some important characters of summer squash (*Cucurbita pepo,*L.) using a diallel cross system among seven inbred lines of "Eskandrani" cultivar. M.Sc. Thesis, Fac. of Agric., Alex. Univ.

El-Shimi, A.S.; S.A. Mohamedein and A.H.M. El-Fouly (2003). Inheritance of some economic traits in melon (*Cucumis melo*, L.). J. Agric. Sci. Mansoura Univ., 28 (6): 4907-4918.

Farid, S.D.M. (1990). Efficiency of diallel crosses and factorial mating design in estimating genetic parameters of quantitative traits in cucumber, Ph.D. Thesis, Fac. of Agric., Mansoura Univ.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crosses system. Aust. J. Biol. Sci., 9: 463-493.

Kamooh, A.A. (2002). Studies on general and specific combining abilities of some characters in squash (*Cucurbita pepo*, L.). J. Agric. Sci. Mansoura Univ., 27(7): 9861-4888.

Kash, Kawther S. and Z.M. El-Diasty (1989). The importance of additive and non-additive genetic variances estimated from diallel and factorial mating designs in squash (*Cucurbita pepo*, L.) I. Heterosis and types of gene action associated with it. J. Agric. Sci. Mansoura Univ., 14(1): 222-232.

Matzinger, D.F. and O. Kempthorne (1956). The modified diallel Table with partial inbreeding and interactions with environment. Genetics, 41: 822-833.

Shamloul, G.M. (2002). Evaluation of selected inbred lines of sweet melon (Ismailawy) and hybrids among them. Ph.D. Thesis, Fac. of Agric., Mansoura Univ.

Steel, G.D. and H. Torrie (1960). Principles and procedures of statistics. Mc. raw. Hill Book Company, INC, New York, pp. 43.

الملخص العربى

قوة الهجين والسلوك الوراثي لبعض الصفات الكمية في قرع الكوسة في ظروف بيئية مختلفة

أشرف حسين عبد الهادي، علي ماهر العدل، محمد سعد حماده و محمد عبد الحميد عابدين

قسم الوراثة ـ كلية الزراعة ـ جامعة المنصورة ـ مصر.

تهدف هذه الدراسة إلى تقدير قيم كل من قوة الهجين بطريقتي متوسط الآباء و أحسن الآباء، ومكونات التباين الوراثي، وطبيعة فعل الجين ومعامل الارتباط الوراثي والمظهري لبعض صفات المحصول ومكوناته في قرع الكوسة وذلك لتوفير قدر من المعلومات حول السلوك الوراثي للصفات الكمية في قرع الكوسة.

تم استخدام أربع أصناف كآباء وهي: Eskandrani(الأب الأول)، bianco(Zucchino mezza lung الأب الثـاني)، White Bush Scallop(الأب الثالث)، Milano(Zucchino nano verde di الأب الرابع).

تم زراعة الآباء الأربعة في الموسم الصيفي ٢٠٠٢ وأجريت كل التهجينات الممكنة (الهجن والهجن العكسية) كما أجـرى عمليـة إخصاب ذاتي للأصناف المستخدمة كآباء. تم تقييم جميع التراكيب الوراثية الناتجة من السنة السابقة من الدراسة في تجربة حقلية في موسـمي الصيف ٢٠٠٣ و ٢٠٠٤ في تجربة قطاعات كاملة العشوائية من ثلاث مكررات بغرض تقييم جميع التراكيب الوراثية المتحصل عليها والمتمثلة في الآباء وجميع الهجن(٦ هجن) والهجن العكسية(٦ هجن) الناتجة منها وقد تم إجراء هذه التجربة في المزرعة البحثية بالبرامون محطة بحوث البساتين بالمنصورة.

وبعد إجراء التحليلات الإحصائية المناسبة يمكن تلخيص النتائج فيما يلي:-

أشارت اختبارات المعنوية لجميع التراكيب الوراثية (١٦ تركيب وراثي) في البيانات المجمعة لكلا السنتين والتي اشتملت على أربعـة آبـاء والجيل الأول الهجين (٦هجن) و الهجين العكسي (٦هجن) إلى وجود اختلافات عالية المعنوية بين التراكيب الوراثية محل الدراسـة لجميـع الصفات وهذه النتائج من المتوقع الحصول عليها، حيث أن هذه التراكيب الوراثية المستخدمة في هذه الدراسة تختلف وتتباين من حيث صفات الآباء المختارة للبدء في هذا العمل. أظهرت النتائج وجود اختلافات كبيرة بين هجن الجيل الأول والأول العكسي مع عدم تميز هجـين معـين بذاته لكل الصفات المدروسة، ولكن معظم التراكيب الوراثية للجيل الأول الهجين تميزت عن الآباء الداخلة في تكوينها، ولذا فإن الهجن قد فاقت الآباء في معظم الصفات محل الدراسة. كما أظهرت النتائج عدم تميز أي أب من الآباء لكل صفات المحصول ومكوناته محل الدراسة .

أظهرت النتائج وجود قيم معنوية لقوة الهجين قياسا من متوسط الآباء لجميع الصفات محل الدراسة. أوضحت القيم المحسوبة لقوة الهجين مقارنة بأفضل الآباء وجود قيم عالية المعنوية لمعظم الصفات محل الدراسة. أظهرت النتائج تعاظم قيم كل من القدرة العامة على التآلف

والقدرة الخاصة على التآلف. وأوضحت النتائج أهمية القدرة العامة على التآلف لجميع الصفات التي تمت دراستها للجيل الأول الهجين، بينما كانت قيمة تأثير التهجين العكسي معنوية لمعظم الصفات المدروسة. كما تؤكد النتائج أن الفعل الجيني المضيف وغير المضيف لعبا الدور الأكبر في توريث هذه الصفات وكانت قيمة التباين الوراثي الراجع للإضافة أعلي من قيمة التباين الوراثي غير الإضافي لمعظم الصفات المدروسة والذي يشمل على تباين السيادة والأخير يحتوى ضمنيا على جزء من التباين الوراثي والذي يعزى إلى التفوق كما أنه لا يمكن تجاهل تأثير التهجين العكسي (العوامل السيتوبلازمية)، وكذلك تم تقدير معامل التوريث في مداه الواسع والضيق لجميع الصفات محل الدراسة وقيم معامل التوريث في مداه الواسع كانت أعلي منه في مداه الضيق لجميع الصفات محل الدراسة.

كما أظهرت النتائج وجود ارتباط معنوي بين معظم أزواج الصفات التي درست فقد كانت صفة عدد الثمار على النبات ترتبط ارتباطا معنويا موجبا مع صفة المحصول الكلى للنبات بالكيلوجرام وارتبطت صفة طول الثمرة مع صفة دليل الشكل الثمري وكذلك ارتبطت صفة قطر الثمرة مع وزن الثمرة بالجرام، وبالتالي فالانتخاب إلى اى من هذه الصفات يؤدى إلى تحسينها.

ومن النتائج السابقة يمكن لمربى النبات أن يستخدم هذه الصفات لتصميم برنامج تربية مناسب من اجل إنتاج سلالات محسنة في الأجيال الانعزالية المتقدمة لأحد الهجن المتفوقة.