

BREEDING BEHAVIOUR OF SOME MORPHOLOGICAL AND YIELD CHARACTERS IN YELLOW CORN

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ABSTRACT

A full diallel cross-based on four yellow maize inbred lines was performed during 1996 summer season. During 1997 season all entries 16 genotypes (6F₁'s + 6F₁ reciprocals + 4 parents lines) were evaluated at two locations; Sids and Giza. The aim of this study is to define; crosses mean performance and the potentiality of heterosis expression, the magnitude of general, specific combining abilities and reciprocal effects, components of genetic variation and type of gene action for some morphological, yield and yield components.

Data confirmed that variance due to SCA was more important than GCA. Maternal effect was noted in the inheritance of plant height, stem diameter, number of rows per ear. The parental D₁ line was found to be the best based on general combining ability. Two crosses namely, D₂ X L₂ were on the top of other crosses. The dominance component (H₁) and (H₂) were found to be significant at both locations, whereas additive effect of inheritance was negligible. While, both dominance and additive genetic effects controlled the inheritance of number of leaves/plant, Moreover, maternal effects were also involved in the inheritance of this trait, as indicated by L₁ X D₁ cross. L₂ X D₂ and L₂ X L₁ manifested desirable heterosis. However, ear height showed, dominance components with greater values than additive genetic variance. The common parent in these crosses was L₂ line that showed the highest general combining ability for such trait. Total grain yield / plant and number of ears/plant proved that, environmental conditions played major role in the inheritance of this character. However, dominant gene action was highly significant, whereas additive gene action had no detected role in controlling this trait. Maternal effect was clear in L₁X D₁ cross. D₁ line was a good general combinator, and heterosis was clearly detectable in cross D₁x L₁ and D₂x L₂.

Keywords: *Zea mays* L, Heterosis, General combining ability, Diallel cross, Morphological, yield characters.

INTRODUCTION

In Egypt, yellow corn (*Zea mays* L.) deserves special attention from plant breeders, because it is one of the major constituents as dry food for domestic animals (55-65%). It is grown in 75349 feddans and produced 1730559 ardabs of grain with an average of 22.67 Ardabs per feddan (Anon., 1997). About 4 million tons of yellow corn were imported to meet increasing animal consumption. Improving yellow corn productivity by breeders could offer a solution.

The first step for planning breeding program in maize is evaluating genetic properties for parental stocks related to its combining ability. General combining ability (GCA) variance is mainly attributed to additive gene effects, while specific combining ability (SCA) variance is mainly due to non-additive

gene effects as dominance and / or epistasis. Due to the importance of the role of maternal or cytoplasmic effect, reciprocal effects were studied herein to clear this point. GCA/ SCA ratio indicate the nature and type of the genetic variance in the present investigation. Good GCA combinator inbred capable to transmit potentiality of the gene affecting the trait to their progeny while good SCA is related to heterosis that manifested in specific combinations. To determine the merit of each parental stock involved in a diallel system, related to GCA, the statistical parameter (g_j) must be zero if the parent stock is much better one. A significant deviations from zero, either positive or negative indicates the goodness of the line from the overall average of the parental stocks. So, it is necessary to collect data from a number of successive generations or from a number of different mating system, such as crossing lines in all possible combinations including crossing each line to itself (diallels). The aim of the present study is to examine the extent of variability and heterosis in all possible hybrid combinations as well as determination of general and specific combining ability and reciprocal effects in addition to compute variance components and their genetic estimates.

MATERIALS AND METHODS

The yellow corn (*Zea mays* L.) plant material of the current research include inbred lines of the dent and the flint types, as well as all their possible single crosses and reciprocals. These inbred lines were developed by the Corn Breeding Programs at the Department of Maize Research, Field Crop Research Institute, Agriculture Research Center, Giza, ARE. The used yellow inbred lines in the current investigation were given accession numbers as follow: Flint lines; L₁ and L₂ and 2- Dent lines; D₁ and D₂. The pedigree, the kernel types and the origin of the used four inbred lines are shown below: -

Access no.	Parents	Pedigree	Kernel type	Origin
D ₁	P ₁	RC-103	Dent	U.S.A
D ₂	P ₂	BS-102	Dent	India
L ₁	P ₃	CM-103	Flint	India
L ₂	P ₄	CM-202	Flint	Imported

The four yellow inbred lines were sown on the 15th of May 1996 in separate plots at the Experimental Station of Faculty of Agriculture; Cairo University, Giza. The plot was 20 ridges, 6 meter long, 75 cm apart and the hills were spaced 20 cm. Grains were hand planted, 2-kernels per hill and plant stand was later thinned out one plant per hill. Land preparation, fertilizer applications and cultural operation followed the normal practices of corn cultivation. The four inbred lines were crossed in all possible combination by hand crossing to obtain hybrid grain of 12 genotypes i.e. 6F₁ straight crosses and 6F₁ reciprocal, in addition to selfed grains of parental lines.

In the second growing season (1997), the 16 genotypes (6F₁'s + 6F₁ reciprocals + 4 parents lines) were evaluated at 2 locations namely; Sids

Experimental Station Maize Research Section, Agriculture Research Center (ARC) and Experimental Station of Faculty of Agriculture, Cairo University, Giza. The sowing dates were 8th and 23rd of May 1997 at Sids and Giza, respectively. The 16 entries were sown in a Complete Randomized Block Design with 4 replications. The experimental plot was 1 row. Readings of each studied trait were recorded on plants taken at random from the interior hills, excluding the 2 distal hills in each ridge. Forty plants from each entry, 10 plants per replicate were labeled in the field and assigned for recording data on the following characters:- Stem length, number of leaves per plant, stem diameter at the mid-point of the 6th internode, ear height, number of ears/plant, number of rows of the apical ear and average grain yield per plant.

For mean performance calculations data obtained for each trait were analyzed on basis of mean plot. An appropriate analysis of variance was performed for each location separately. The average heterotic effects overall the studied crosses (parents) vs. (crosses) were calculated by partitioning the genotypes sum of squares and its component (parents, crosses and parents vs crosses). Heterosis for each trait of individual cross relative to either mid or better parent was estimated according to (Marini, 1968). General (GCA) and specific (SCA) combining abilities as well as reciprocal effects were estimated according to Method (1), Model (I) of Griffing diallel crosses analysis (1956 a&b) at each location and for combined data across the two locations. In the present study, the genetic components for all studied attributes were estimated according to Jinks (1954) and Hyman (1954 a and b) for parents and F1's. Components of genetic variance were calculated and used to estimate genetic ratios as follows:-

- (\hat{E}) = The expected environmental components of variation
- (\hat{D}) = Additive genetic variance
- (\hat{H}_1) =Variance due to the dominance effect of genes
- (\hat{H}_2) = Dominance variance among parents
- (\hat{h}^2) = Dominance effects overall heterozygous loci
- (F) = Covariance of additive and dominance gene effects
- (\hat{H}_1/D) =the mean degree of dominance
- $(\hat{H}_2/4H_1)$ =the proportion of genes with positive and negative effects.
- $(KD/KR)=(4DH_1)^{1/2}+F/(4DH_1)^{1/2}$
- (F) =the proportion of both dominant and recessive alleles in the parents.
- $(K)= h/H_2$ the number of genes or gene groups exhibiting dominance.
- (r^2) = prediction for measurements of completely dominant and recessive parents.

RESULTS AND DISCUSSION

A- Mean performance and heterosis

Mean performance of full diallel including parents, F1 crosses and reciprocals for all studied characters are presented in Table (1). Regarding sources of variation, it is noted that location mean squares were highly significant for all studied characters. This indicates that these characters were

affected by environmental factors related to the two locations. Genotype mean squares values were found to be highly significant for all studied characters at each location and their combined analysis. This indicates differences among entries forming the diallel complete set. Non-significant dent vs. flint mean square also noted for total grain yield when the two locations were averaged. Parent vs. hybrids, showed highly significant mean squares for all studied characters but, again, not significant for protein at Sids. Generally, morphological characters showed significant variability, when source of variation is partitioned into its components in each location and combined data.

The mean performance and heterotic effects for all studied characters are presented in Tables (1&2). Mean performance of these characters differed from one location to another because of environmental components, so combined data would be mainly regarded in the following discussions. The mean values of plant height ranged from 166.72 cm. for tallest L₁ inbred to 144.85 cm for L₂ inbred. On the other hand, the range for hybrids was 223.2 cm for hybrid D₁xL₂ to 210.15cm for hybrid L₁xD₂. These differences between the ranges of parent's height and their hybrids indicate considerable positive and significant heterosis. However, the comparative means for number of leaves/plant proved that dent lines possessed more leaves than flint inbred. However, hybrids promote more leaves 14.24 than parent averages 12.65. With regard to stem diameter, L₁ line showed the highest mean 21.78mm among all parent lines, when this values compared with average hybrid means for stem diameter 21.20 mm no significant differences could be noted. Whereas, the corresponded values through hybrids L₁xL₂ and L₂xD₂ hybrids were of 23.56 mm and 23.53 mm respectively, which exhibited positive and significant heterosis. In the mean time, the average mean performance of ear height of parent lines was 70.44 cm and encountered with hybrid mean values 113.85 cm, a highly significant difference could reflect notable amount of heterosis. The hybrid L₂ x D₂ announced the highest value of 122.02cm. Nevertheless, number of ears/plant of flint inbred were 1.40 for L₂ and 1.41 for L₂, whereas dent inbred was 1.13 for D₁ and 1.18 for D₂, the average of hybrids 1.13 towards dent inbred. Only one hybrid, namely L₂xD₂ showed a contradicting value of 1.51 among all hybrids, but this value was near to flint inbred. Number of rows of the apical ear of parental lines was 14.24, whereas, average of hybrids was 15.91. However, the two hybrids, D₁xL₂, and its reciprocal L₁xD₁ showed the highest values of 17.67 and 17.47 among all diallel entries. While, total grain yield is the last outcome of several serves as its components, so fluctuation among diallel set under the two locations were easily observed in respect to parental lines or their hybrids. Total grain yield at Giza showed dramatic decrease as compared with Sids. This reflects that this character was unstable and affected with environmental conditions. Parent lines average was 39.22gm as compared with hybrid averages 154.26 gm/plant. The diallel cross method is the set of all possible matting between several genotypes (Hyman, 1954 a). The statistical technique using second degree of statistics such a variance and covariance was successfully applied to investigate the genetical properties of homozygous lines for continuous variation.

However, diallel method or statistical technique allows explanation and recognition of inheritance associated with Mendelian genetics. Consequently, well identifications of heritable properties for different homozygous genetic stocks supply plant breeders and/or geneticists with basic helpful information in further improving or investigating plans. The obtained results are in harmony with those of Krolkowski (1973), El-Kady (1974), Radovic (1979), Kassem *et al.* (1978 a&b), Soliman (1992), Gabr (1997), Motawea (1997) and Saafan (1998).

B- Combining ability

B-1- Plant height

General combining ability (GCA) means square, specific combining ability SCA and reciprocal effects for plant height are shown in Table (3). GCA, SCA and reciprocal effects were highly significant for this trait except in one case; in respect to reciprocal effects at Giza. This finding indicates that both additive and non-additive gene effects as well as maternal effects were responsible for the inheritance of stem length. Same findings reported by Landi *et al.* (1986), Gabr (1997) and Saafan (1998).

Comparisons between the magnitude of the GCA, SCA and reciprocal variance, it is clear when data were averaged that the SCA variance was the greatest (15418.26) followed by GCA (367.00) and reciprocal effect (68.72), whereas the ratio between GCA / SCA were less than unity. This revealed that, non-additive gene effects played the greater part than additive gene effects while, maternal effects had the smallest part. The obtained results agree with the findings of Abo-Dheaf (1987), Soliman (1992 and 1997), and Saafan (1998), who reported that the non-additive components predominated and played the major role in the inheritance of stem length. However, Mousa *et al.* (1989) and Gabr (1997) found that, GCA effects were more important than SCA for plant height.

The reciprocal mean squares were highly significant at Sids and average data, showed the presence of maternal effects. In this regard, Soliman (1992 and 1997) also reported significant reciprocal differences for plant height. On the contrary Mann and Pollmer (1981) and Soliman (1997) reported the absence of maternal effects belong to plant height.

Data presented In Table (3) show that, GCA effects in respect to plant height parental line D_1 and L_1 were of positive and significant values, additive genes responsible for increasing plant height characterized i.e. these two parents. Whereas, GCA for D_2 and L_2 parents were negative and significant. This revealed that D_2 and L_2 parent posses additive genes that decrease plant height.

Regarding SCA for plant height data in Table (3) prove that cross $D_2 \times L_2$ has the greatest SCA average followed by $L_1 \times L_2$ among crosses set, so these two crosses deserve special attention in respect to stem length. Reciprocal effects for plant height (Table, 10) show $L_2 \times D_2$ and $D_2 \times D_1$ were of positive and significant values, while non of the remaining crosses showed significant reciprocal effects. Thus, it could be stated that only L_2 and D_2 parents should be used as female parent when crossed with D_2 and D_1 parents respectively.

B-2 Number of leaves / plant

Regarding the number of leaves/plant, data presented in Table (3) show the results of GCA, SCA and reciprocal effects of this trait. These three parameters were positive and highly significant. SCA mean square (11.9) was greater than GCA. In addition the ratio GCA/ SCA was (6.5). Therefore, both additive and non-additive gene effects were involved in the inheritance of number of leaves / plant but the non additive gene effects played greater part than additive gene effects in the genetic control of this character. Moreover, maternal effects were of fewer roles in the genetic control as indicated by lower averaged lower mean square of 0.25. In this respect, the genetic variance was previously reported to be mostly due to non-additive type of genetic variation for number of leaves per plant (Mahajan and Khehra, 1991). On the other hand Motawea (1997) detected a high GCA for number of leaves per plant.

Table (3) illustrate GCA effects of the combined data and their significance levels. It is clear that D₂ was of greatest positive average GCA effects (0.32). In this parent, most of genes affected number of leaves/plant are additive and responsible for increasing number of leaves /plant. Meanwhile, the negative GCA effects for averaged data of L₂ parent (0.44), indicated that additive genes herein were responsible for decreasing number of leaves/ plant.

SCA effects for combined data revealed that the best combination was D₂xL₂ (0.77) followed with L₁xL₂ (0.62). Only one cross namely, D₂xL₁ showed negative and negligible value, which is considered as a bad combinator. Regarding reciprocal effects for number of leaves/ plant as shown in Table (3) only L₁xD₁ hybrid showed significant value for the combined data. Generally, maternal effects for number of leaves / plant proved absent except in the case of L₁ in the cross L₁xD₁.

B-3- Stem diameter:

GCA, SCA and reciprocal mean squares for two locations and averaged data were highly significant except one case at Giza location for GCA. The magnitude of mean square values showed that GCA was greater than that of SCA and the ratio between GCA and SCA was more than unity and had lowest magnitude for reciprocal mean square, revealing the importance of additive gene type for stem diameter inheritance. These findings are in agreement with results obtained by Mohajan and Khehra (1991) where, the non-additive effects were more important than GCA or the additive effects. On the other hand, Motawea (1997) reported the importance of GCA in the inheritance of this trait.

With regard to data of GCA effect for stem diameter (Table 3), only L₁ parent was of positive and significant value. This indicated that most of additive genes for increasing stem diameter were found in L₁ parent. On the other hand, D₁, D₂ and L₂ parents were of negative and significant GCA effects, so they possess additive gene effect for decreasing stem diameter.

SCA effects for combined data for stem diameter indicated that D₂xL₂ (0.981) and L₁xL₂ were good combinations for stem diameter. Most reciprocal

effects for stem diameter were of negative and significant values indicating absence of maternal effects in all these hybrids.

B-4 Ear height:

The mean squares for GCA, SCA and reciprocals, for ear height was of highly significant values. This indicated that both additive and non-additive gene effects were of considerable role in the inheritance of this trait. Similar results were also noted by Hassaballa *et al.* (1980), Landi *et al.* (1986), Gabr (1997) and Bhalla *et al.* (1997). Generally The magnitude of mean squares for averaged data for SCA was the highest indicating that non additive gene affected in great part in the genetic control of this characters, compared with GCA of mean square value of low magnitude. This was indicated also through the ratios of GCA/SCA. These results indicated the predominance of non-additive genetic effects for the expression of this trait. In this respect, Soliman (1992) and Saafan (1998) reported the same results. The reciprocal mean squares were highly significant at Giza and average, significant only at Sids. In this respect, same results were noted by Mann and Pollmer (1981), Soliman (1992). Opposite findings were detected (Landi *et al.*, 1986). GCA effect examined two parents namely, L₂ and D₁ have positive and significant values of 1.09 and 0.61, respectively. These two parents characterized with additive gene action effects that increase ear height. On the other side L₁ parent showed negative and significant values for the two locations and their combined data indicating that this parent has additive genes but responsible for decreasing ear height.

It is clear that positive result at Giza and, negative result at Sids and negligible combined results showed contradicting GCA effects for D₂ parent in respect of the two locations. So, no trend could be noticed in respect to this parent. Most of SCA effects for ear height were of highly significant values at the two locations and combined data, except one case only at Giza for D₂xL₁ hybrid. However, the averaged data revealed that D₂xL₁ and L₁xL₂ were the good combinations in respect to ear height. Moreover, reciprocal effects for ear height were mostly of negative or negligible values, except one case only for combined data of hybrid D₂xD₁. This finding indicated generally the absence of maternal effect for this character in the parental stock.

B-5 Number of ears / Plant:

Estimates of GCA, SCA and reciprocal mean squares for number of ears per plant are given in Table (11). It is clear that both GCA and SCA were highly significant in respect to the two locations and their combined data revealing the importance of both additive and non-additive gene effects in the expression of number of ears per plant. The results are in agreement with Soliman (1997) who reported that the GCA and SCA effects were involved in the inheritance of number of ears per plant. Ratio of GCA/SCA revealed more additive than non-additive genes controlling this character. In this respect, Abo-Dheaf (1987) and Soliman (1997) also noted similar results. Reciprocal mean squares were highly significant in Giza location, and not so in Sids, whereas it was significant and with comparatively low value as compared to both GCA and / or SCA.

Data proved that, L_2 line had positive and highly significant GCA value of -0.11 which indicated that this line contains most additive genes that increased number of ears / plant. D_1 and L_1 parents were of negative and highly significant GSA values of -0.09 and -0.02, respectively, so these lines had additive genes for decreasing number of ear / plant.

SCA effects result for the two locations and their average data are given in Table (3). Only the best combination for number of ears / plant was $D_2 \times L_2$ at the two locations and as manifested by combined data. This finding showed that, this cross-manifested highly useful heterosis, however, the most of remaining crosses except $D_1 \times L_1$ at Giza only were of negative values of SCA effects indicating no superiority for this character. Reciprocal effects at two locations and their combined data proved absence of maternal effects for number of ears / plant.

B-6 Number of rows of the apical ear:

Data on number of rows of the apical ear as shown in Table (3), prove that, the mean squares for GCA, SCA and reciprocal were highly significant. This indicated that both additive and non-additive gene effects were responsible for the inheritance of this trait, and the maternal effects were also involved. These results agree with the findings of Mousa *et al.*, (1989), Gabr (1997) and Saafan (1998). Regarding to GCA/SCA ratio at both locations and their averaged data, results indicated that additive gene effects were mainly of great part in the inheritance of such character. In this connection, Abo-Dheaf (1981), Gabr (1997) and Soliman (1997) reported similar results. Estimates of GCA effect are given in Table (3). The two parental lines D_1 and L_1 were of positive and significant values at the two locations and combined data indicating the usefulness of these parental lines for improving this character. On contrary D_2 and L_2 lines has a negative and significant result at the two locations and their average, revealing no use for these parents to improve this character. SCA effects indicate the superiority of $D_1 \times D_2$, $D_1 \times L_1$ and $D_2 \times L_1$ hybrids as concluded from their high positive and highly significant SCA effects in respect to the two locations and the averages. Maternal effects could be manifested by combined data presented in Table (3) for $L_2 \times D_1$, $L_1 \times D_1$ hybrids.

B-7 Total grain yield / plant:

Combined data in Table (3) represent mean squares for GCA, SCA and reciprocal effects for total grain yield/ plant at two locations and averaged means. The mean squares for GCA and SCA were highly significant at the two locations and their combined data. These outcomes revealed the importance of additive and non-additive effects in the inheritance of grain yield per plant. In this respect, similar outcomes have been also recorded by landi *et al.* (1986), Damborsky *et al.* (1994) and Gabr (1997). It is of interest to mention that values of SCA were larger than those of GCA. Indicating that, the non-additive gene effects played the major role in the inheritance of grain yield. In this connection Atia (1986), Abo Dheaf (1987) and Soliman (1992 and 1997) reported the same outcomes. On the other hand, Mousa *et al.* (1989), Abd El-Aziz (1991) and El-Diasty (1996) reported that, GSA mean

squares were larger than SCA in this trait. The reciprocal mean square was larger than SCA in this trait. The reciprocal mean squares were highly significant for grain yield per plant at the two locations and their combined indicating the presence of maternal effects for this character. Mann and pollmer (1981) have recorded similar findings. Opposite outcomes have been recorded by Soliman (1992) where reciprocal mean squares for grain yield were not significant. These results are in agreement with the findings of Bhalla *et al.* (1997).

Data in Table (3) show that D₁ parental line had positive and highly significant GCA effects as indicated by estimates recorded at the two locations and their average. Moreover, L₂ parent showed highly significant values at Sids and combined data. On the other hand D₂ and L₁ were of negative and highly significant values. This indicated that, the genetic potential of D₁ and L₂ was good for improving total grain yield / plant (4.56) and (2.34), respectively. The best two combinations were D₂ x L₂ and D₁ x L₁ as noted among all positive and highly significant values at two locations and their averages for total grain yield / plant. The averages of reciprocal effects were negative and highly significant value for L₂ x L₁, (15.2). These results suggested absence of maternal effects in respect to this character.

C- Variance and its components

C-1-Plant height

Results of variance components of plant height (Table 4) indicated that additive genetic variance (D) was insignificant at Giza and Sids locations, indicating that additive genetic variance had a minor contribution in plant height. Whereas, H₁, for this character was highly significant at both locations, which revealed that dominance variance was the major source of genetic variation. These results are in accordance with the findings of Soliman (1992) and Gabr (1997), who concluded the importance of the dominance effects in the inheritance of this character. However, El Diasty (1996) stated that, additive gene effects were the predominant type in the genetic expression for plant height.

The dominance effects correlated to gene distribution (\hat{H}_2) were highly significant at the two locations, indicating a symmetrical distribution of gene with positive and negative effects controlling plant height. As \hat{H}_1 and \hat{H}_2 were approximately equal, so it could be concluded that both positive and negative alleles controlled such character were of equal frequencies, (Hyman, 1954 a & b).

The overall dominance effect of heterozygous h^2 was highly significant for this trait (Table 4) at the two locations indicating that dominance was unidirectional and due to heterozygosity. Since the covariance of additive and dominance effect (F) was positive and non-significant, the excess of dominant alleles could be attributed to stem length inheritance. The average degree of dominance (\hat{H}_1 / D)^{1/2} was greater than unity at the two locations, this indicated the presence of over dominance. Motawea (1997) reported that over dominance controlled the inheritance of these trait detected similar findings.

The estimates of crude frequencies at non-additive loci ($\hat{H}_2/4\hat{H}_1$) were nearly equal to 0.25, indicating that the positive and negative alleles frequencies were about equal. Investigating the ratio of dominant to recessive alleles (KD / KR) showed that their value at Giza location was 1.31 and 1.17 at Sids which revealed the excess of dominant genes controlling plant height. Soliman (1992) and Motawea (1997) also noticed similar findings. It could be concluded from estimated K that number of gene groups exhibiting dominance was about two. Results obtained by Soliman (1992) confirm the results of this study. The negative and high value of correlation coefficient between parental mean and ($wr + vr$) at two locations, indicated that most dominant and recessive alleles acts on two opposite directions, i.e, dominant genes were operating toward increasing plant height. As t^2 estimates near unity, it is possible to predict the completely dominant and recessive parent.

C-2 Number of leaves / plant

Variance components for number of leaves / plant at two locations are presented in Table (4). Data showed significant value at both locations for variance due to additive allele (D), indicating the importance of additive gene effects controlling this character. Moreover, H_1 , was also significant at the two locations so the magnitude of dominance was larger than that of additive variance in the inheritance of this trait. Motawea (1997) and Saafan (1998) stated similar outcomes. The dominant effects correlated to gene distribution (\hat{H}_2) were significant at Giza and highly significant at Sids, accordingly asymmetrical distribution of genes with positive and negative effects controlling number of leaves / plant. Estimated value of h^2 was highly significant at both locations, indicating that dominance was unidirectional and variability is mainly due to heterozygosity, where, the estimated F value showed non-significant values at both locations revealing excess of dominant alleles related to inheritance of number of leaves / plant. The value $(\hat{H}_1/D)^{1/2}$ was greater than unity at both locations, suggesting over dominance in respect to the genetics of number of leaves/plant (1.91) and (1.75) for Giza and Sids, respectively. In this connection, Motawea (1997) and Saafan reported that over dominance was found to control the inheritance of number of leaves per plant.

Regarding $H_2 / 4H_1$, it was obvious that, their values were 0.25 and 0.25 at Giza and Sids locations, respectively, so positive and negative alleles were not equally distributed. Motawea (1997) and Saafan (1998) also noticed such results. Moreover, KD/ KR exceeded unity at both locations, indicating excess of dominant genes. It is also noted that, number of gene groups controlling this trait was about 2 as shown by K value at Sids. The correlation coefficient between the parental means and ($wr + vr$) was negative with high values of both locations indicating that dominant genes were toward increasing number of leaves / plant. Estimated r^2 were negative and very near to unity making it possible to predict the measurement of the completely dominant and recessive parents and suggesting the possible limits of selection among genes showing dominance.

C-3- Stem Diameter

Stem diameter parameters related to the components of variation and a ratio of genetical components is shown in Table (4). Data proved that the additive genetic variance (D) was highly significant at Giza location and non-significant at Sids. The same findings were noted for F, H_1 , H_2 and h^2 this made no complete conclusion with regard to these parameters. Nevertheless, $(\hat{H}_1 / D)^{1/2}$ values were greater than unity in both locations indicating over dominance genetic case for stem diameter, whereas, $\hat{H}_2 / 4 \hat{H}_1$ ratio were below 0.25 at the two locations indicating that positive and negative alleles controlling this character were not equally distributed. Contradict results were observed for KD/KR ratio of the two locations. These outcomes made no conclusion for how ratio of dominant to recessive alleles acted for controlling such trait.

C-4- Ear height:

Variance components of ear height at Giza and Sids locations are presented in Table (4). The additive genetic component of variation (D) was not significant at both locations. Soliman (1992) recorded similar results. These finding assured the major role of additive effects in the inheritance of ear height. Dominance variations, as indicated by significant \hat{H}_1 and \hat{H}_2 estimated at both locations, exhibited highly significant values. In addition, the values of dominance component were larger in magnitude than those of additive components in all instances. These results indicated that the dominance variance was the major source of genetic variation, controlling the inheritance of ear height. In this respect, Soliman (1992) also detected similar findings. The dominance effects correlated to gene distribution (\hat{H}_2) were highly significant at the two locations, indicating symmetrical distribution of gene with positive and negative effects controlling ear height. Estimated value of h^2 was positive and highly significant at locations, indicating that, dominance was unidirectional due to heterozygosity. Covariance of additive and dominance effects (F) were positive and non-significant, the excess of dominant alleles could be attributed to ear height inheritance. The mean degree of dominance $(\hat{H}_1/D)^{1/2}$ was greater than unity at both locations, suggesting over dominance in respect to the genetics of ear height. The obtained results are in agreement with the findings of Mousa *et al*, (1989), Soliman (1992) and Motawea (1997).

Regarding $(\hat{H}_2/4\hat{H}_1)$, their values were 0.24 and 0.25 at Giza and Sids locations, respectively indicating that, the frequencies of positive and negative alleles were about equal. This view was also supported by insignificant F values (The relative frequencies of dominant and recessive alleles in the parents). KD/KR was more than unity at the two locations, indicating that, both dominant and recessive genes were of equal proportion in the parent. Number of gene or gene groups exhibiting dominance (K) were found to be 2 genes or 2 gene groups controlling the inheritance of ear height. Similar finding were also reported by Safaan, (1998). The estimates of correlation coefficients between the parental means and $(W_r + V_r)$ were negative and significant at the two locations indicating that dominant genes were operating towards increasing ear height. The Value of (r^2) for ear height

was close to unity at the two locations suggesting the possible limits of selection among genes showing dominance. The order of dominance of parents (OR_1) determined by the value of $(Wr + Vr)$ and the order of the parents (OR_2) based on mean performance indicated that P_2 contained most dominant alleles operating in the direction of increasing the ear placement.

C-5- Number of ears per plant

Variance components of number of ears per plant (table 4), showed that additive genetic variance (D) was significant at Sids indicating importance of additive effects, whereas it was insignificant at Giza. In this respect, the additive genetic variance constituted the main component in the inheritance of ear number as stated by Mousa *et al.* (1989). The dominance components of variation (\hat{H}_1 and \hat{H}_2) for number of ears per plant exhibited high significant values at Sids only. It is important to mention that, both additive and dominance genetic variations were involved in the inheritance of number of ears per plant. Mousa *et al.* (1989) and Soliman (1992) reported that both additive and dominance genetic effects were important in the inheritance of number of ears per plant. The over-all dominance effects of heterozygous loci (\hat{H}_2) were not significant at Giza location, indicating that the effects of dominance were not due to heterozygosity. However, (\hat{H}_2) exhibited highly significant value at Sids location, confirming that dominance was unidirectional. The (F) estimates were positive at Sids, negative at Giza but insignificant at the two locations, which indicated an insignificant excess of dominant alleles at Sids and recessive alleles at Giza. Regarding $(\hat{H} \ 1/D)^{1/2}$ it was greater than unity, indicating over dominance for number of ears per plant at the two locations. Similar findings were detected by Soliman (1992), Motawea (1997) and Mousa (1997), who reported that, over dominance was found to control the inheritance of number of ears per plant. However, Mousa *et al.* (1989) found that complete dominance was detected for this character. Concerning, $H_2 / 4H_1$, it was below 0.25 indicating that positive and negative alleles were not equally distributed. The proportion of dominant and recessive genes KD / KR , were less or more than 1, indicating that both dominant and recessive gene were of equal proportions in the parents. Soliman (1992) stated similar findings. He also realized that, both dominance and recessive genes were involved in the inheritance of this trait. The estimated (K) values were nearly equal to one at the two locations indicating that one gene or one group of gene controlled this trait. Soliman (1992) stated that, two genes or group of genes controlled the number of ears per plant. Non significant correlation coefficients (r) for this character was found at the two locations, indicating that dominance was oscillating in direction. The order of dominance of the parents (oR_1) determined by the value of $(Wr + Vr)$ and the order of parent (oR_2) based on the mean performance showed that parent P_4 contained the most dominant alleles responsible for increasing number of ears per plant.

C-6- Number of rows per ears

Data pertaining to number of rows per ears as shown in Table (4) revealed that the components of variation and ratios of genetically

components additive component (D) were highly significant at the two locations indicating the importance of additive component. Also (\hat{H}_1) for this character was highly significant at both locations. These results assured that both additive and dominance were involved in the inheritance of this trait. Results of Mousa *et al.* (1989), Soliman (1992), and Galal *et al.*, (1994), agree with the above mentioned results. Regarding dominance effects correlated for gene distribution (\hat{H}_2) values were highly significant at both locations. Indicating asymmetrical distribution of genes with positive and negative effects controlling this character. Estimated (\hat{H}_2) was similar (\hat{H}_1) at the two locations, indicating that the positive and negative alleles were not equal in proportion in the parents. Positive and highly significant (\hat{h}^2) estimates at both locations indicated that the effect of dominance due to heterozygosity and positive dominance. The (F) estimates for number of rows per ear were negative and insignificant at both locations, indicating an insignificant excess of recessive alleles controlling this trait.

Regarding average degree of dominance (\hat{H}_1/D)^{1/2} it was found that its values were larger than unity at Giza but than unity at Sids indicating that over dominance and partial dominance controlled the inheritance of this character at Giza and Sids respectively. Soliman (1992) reported that, partial dominance played an important role in the inheritance of number of rows per ear. The proportion of dominant and recessive genes (KD / KR) was less than one at both locations, suggesting that, recessive alleles exceeded dominant alleles in the parents. This was supported by the pertaining result that $H_2 / 4H_1$ ratio was less than 0.25 at both Giza and Sids indicating unequal distribution of positive and negative alleles in the parents. Soliman (1992) reported similar findings. So, it is obvious that, nearly two genes or two groups of genes controlled this character as seemed from estimated (K). In this connection the minimum number of genes was found to be one pair for number of rows per ear (Galal *et al.*, 1994). In addition, Soliman (1992) stated that, one to two genes controlled this trait.

The estimates of correlation coefficients (r) concerning number of rows per ear between the parental order of dominance (W_r, v_r) and parental measurements (Y_r) did not reach the level of significance at both Giza and Sids, indicating that the dominance was ambidirectional. The order of dominion of the parents (OR_1) determined by the value of ($w_r + v_r$) and the order of the parents (OR_2) based on mean performance as indicated in Table (4), Showed that parents. P_1 and P_3 contains the most dominant alleles that responsible for increasing number of rows per ear.

C-7- Total grain yield per plant

Table (4) represents variance components of number of total grain yield per plant at Giza and Sids. The results reveal that the additive genetic component of variation (D) for this character was found to be insignificant at both locations. On the other hand, dominance components of variation (\hat{H}_1 and \hat{H}_2) for grain yield exhibited highly significant values. This indicates that the dominance variance is the major source of genetic variation controlling the inheritance of grain yield per plant. Many investigators reported that, dominance variance was the major component controlling grain yield per

plant such as Atia (1986), Soliman (1992), El-Diasty (1996) and Gabr (1997). However, Motawea (1997) and Mousa (1997) reported that, both additive and non-additive gene effects involved in controlling the inheritance of maize grain yield. It is likely that \hat{h}^2 , as a measure of the over all dominance effects of heterozygous loci were of highly significant values at Giza and Sids, which confirmed that dominance, was unidirectional. In addition, the values of H_2 were approximately equal to that of H_1 , indicating that both positive and negative alleles were of equal to that of h_1 , indicating that both positive and negative alleles were equal frequency (Hyman, 1954 a & b). Motawea (1997) and Mousa (1997) reported that the dominance effects made up to most part of total genetic variance. The estimate (F) for grain yield per plant was found to be positive and insignificant, indicating an insignificant excess of dominance alleles controlling this trait.

The average degree of dominance (\hat{H}_1 / D) $\frac{1}{2}$ was greater than unity, indicating over dominance or epistasis for grain yield per plant at the two locations. In this respect Krolowski (1973) reported that over dominance was most important for grain yield. In addition, similar findings were reported by Galal *et al.* (1994), Soliman (1992), Motawea (1997) and Mousa (1997). Investigating $\hat{H}_2 / 4 \hat{H}_1$, it was found to be about 0.25 indicating that positive and negative alleles frequencies controlling this trait were about equal. This view was also supported by insignificant (F) value. The ratios of dominance to recessive alleles KD / KR , proved that whether there were equal or more equal or more than one indicating that both dominance and recessive gene were of equal proportion in the parents since the F value were not significant. In this respect Soliman (1992) reported that, both dominance and recessive genes are involved in the inheritance of grain yield per plant; where, there are approximately two genes or groups of genes controlling this character as estimated by (K). In this regard. Soliman (1992) stated that, number of genes controlling grain yield was two genes in the F_1 generation of yellow maize and from two to three in the white maize. The estimates of correlation coefficients (r) between parental mean and $(wr + vr)$ were negative and high value and indicated that most dominant and recessive alleles acts on two opposite directions, i.e., dominant genes were operative towards increasing grain yield per plant. As (r^2) estimates are near unity. So it is possible to predict the completely dominant and recessive parent.

CONCLUSION

The two dent inbred lines were predominant in plant height, number of leaves and ear height. Meanwhile, the two flint inbred lines, showed superiority on the rest of studied traits. Highly significant differences were detected among both inbred lines and their hybrids in most characters under investigation. It is also important to indicate that, mean squares of both general and specific combining abilities as well as maternal effects were highly significant differences. The importance of additive and non-additive genetic variance for most of characters was shown from its significance. The dominance effects (\hat{H}_1 & \hat{H}_2) for plant height, ear height and yield showed an

important role in inheritance of such traits. The number of gene groups or genes of which controlled these characters ranged between 2-3 genes or gene groups.

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سلوك التربية للصفات المورفولوجية و المحصولية في الذرة الصفراء

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**قسم الوراثة - المركز القومي للبحوث

تم عمل جميع التهجينات الممكنة بما فيها الهجن العكسية بين ٤ سلالات أبوية نقية من الذرة الشامية الصفراء سلالتين منغوزتين و سلالتين صوانتين و تقيمهما خلال الموسم الصيفي ١٩٩٦ و الموسم ١٩٩٧ وذلك في محطة التجارب الزراعية التابعة لكلية الزراعة جامعة القاهرة - محطة التجارب الزراعية بسدس بنى سويف التابعة لمركز البحوث الزراعية حيث تم دراسة الصفات التالية :- طول النبات - عدد الأوراق - قطر الساق - ارتفاع الكوز - عدد الكيزان على النبات - عدد صفوف الكوز - محصول النبات.

وكانت أهم النتائج

- ١- السلالتين المنغوزتين في عدد من الصفات:- طول النبات و عدد الأوراق و ارتفاع الكوز في حين تفوقت السلالتين الصوانتين في باقي الصفات . بينما كانت الفروق عالية المعنوية لجميع الصفات بين الهجن و الأباء عدا قطر الساق في سدس و عدد الكيزان /نبات بالجيزة.
- ٢- كانت الهجن بصفة عامة أفضل في المتوسط العام للصفات الخضرية و المحصول.
- ٣- الصفات التالية (طول النبات- عدد الأوراق/النبات- ارتفاع الكوز) كان التباين الراجع للقدرة الخاصة على الانتلاف أكثر أهمية ن القدرة العامة للانتلاف و لوحظ أيضا تأثير الوراثة السيتوبلازميه. تعتبر السلالة الأبوية D_1 هي الأفضل من حيث القدرة العامة على الانتلاف . و قد تأكدت أهمية تأثير السيادة عن التأثير المضيف من خلال معنوية H_1 & H_2 في كلا الموقعين . وكان أفضل الهجن لهذه الصفة $D_1 \times D_2$, $L_1 \times L_2$.
- ٤- صفة عدد الأوراق على النبات أظهرت أن كلا من القدرة العامة و الخاصة على الانتلاف تلعب دورا رئيسيا في وراثتها و كذلك تأثير الأم كان واضحا في الهجين $L_1 \times D_1$. أفضل الهجن لهذه الصفة كان $D_2 \times L_2$ - $L_1 \times D_2$ و أفضل سلالة أبوية كانت D_2 .
- ٥- أظهرت الدراسة إن صفة عدد الكيزان تتأثر بوضوح بكلا من تأثير السيادة و التأثير المضيف للجين حيث أظهرت تباين في المعنوية بين كلا من سدس و الجيزة مما يدل بوضوح مدى تأثير التباين البيئي على وراثة تلك الصفة. أفضل الهجن لهذه الصفة كان $L_1 \times D_2$ من حيث القدرة الخاصة على التآلف و كانت السلالة D_1 هي أفضل السلالات من حيث القدرة العامة على التآلف.
- ٦- أظهرت صفة محصول النبات تأثرا كبيرا بالبيئة فقد لوحظ انخفاض معنوي في المحصول في الجيزة عن سدس بالنسبة لكل من الأباء و الهجن كان تأثير السيادة للجينات معنوي جدا بينما كان تأثير الجينات المضيف غير معنوي. كانت الوراثة السيتوبلازمية ذات دورا واضحا في وراثة تلك الصفة خاصة الهجين $L_1 \times D_1$ و كانت أفضل سلالة D_1 من حيث القدرة العامة على التآلف بينما كانت أفضل الهجن $L_1 \times D_1$, $D_2 \times L_2$.
- ٧- تراوحت عدد مجاميع الجينات أو الجينات المتحكممة في غالبية الصفات من ٢-٣ جين أو مجموعة جينية كما كانت كفاءه التوريث في معناها العام مرتفعة أما كفاءة التوريث في معناها الخاص كانت مرتفعة لصفة عدد الصفوف في الكوز و متوسطة نسبيا لصفة عدد الكيزان و منخفضة لباقي الصفات.

