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ESTIMATES OF GENETIC PARAMETERS AND HETEROSIS IN MAIZE (*Zea mays* L.) UNDER NORMAL AND DROUGHT CONDITIONS

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ABSTRACT

The objective of this work was to study the genetic systems controlling quantitative traits of maize using a North Carolina Design II mating design among nine parental lines and their 20 F_1's under normal and drought stress conditions. Highly significant differences existed among studied genotypes, revealing a large amount of variability among them under both conditions. The significant values of mean square for parents vs. crosses were observed, indicating the importance of heterotic values and non additive genetic variance in the inheritance of these traits under the two conditions. Some lines and their F_1 crosses showed drought susceptibility index "S" values less than one revealing relative drought resistance. The results showed that the magnitudes of non-additive genetic variance (σ^2D) were larger than those of additive ones (σ^2A) for most studied traits, indicating that the non additive gene action was pronounced in the inheritance of these traits. Therefore, these promising crosses could be utilized in maize breeding program to improve these traits under favorable and drought stress. This finding could be emphasized by the estimate values of narrow sense heritability.

Keywords: Additive; dominance; drought; heritability; Maize (*Zea mays* L.*) and* North Carolina Design II.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in Egypt and all over the world. Maize is particularly sensitive to water stress at the flowering and grain filling periods (Grant *et al.* 1989). Evaluating drought-tolerant germplasm and then developing drought-tolerant varieties are the means by which agriculturists minimize the impact of abiotic stress without causing a substantial yield loss. The development of drought tolerant lines becomes increasingly more important. Phenotype is the result of genotype and environmental interaction, therefore, assessment of desired genotypes is highly dependent on proper environmental conditions. Abiotic stresses (particularly drought, high temperature, salinity and others) generally reduce crop productivity. Stresses can occur at any stage of plant growth and development reducing crop productivity (Ribaut *et al.* 2009). Thus, drought resistance in crops is probably the most difficult trait to understand (Bruce *et al.* 2002 and Ashraf, 2010). Water stress can lead to the closed stomata and consequently decrease carbon dioxide absorption, photosynthesis and dry matter production (Shiri *et al.* 2010). Low heritability of grain yield and the complexity of genotype environment interactions limit the development of cultivars tolerant to water stress. Recent advances in the genetic improvement of crop drought resistance by conventional breeding and molecular techniques have enabled drought-resistant breeding to take a big step, but it also underscores the urgent need for standard evaluation assays and selection criteria for drought resistance, especially when climate change (Campos *et al.* 2004; Moose and Mumm 2008 and Ashraf (2010).

The magnitude of σ^2SCA x E interaction was wider than σ^2GCA x E interaction for most morphological and grain yield traits, indicating that the non-additive type of gene action was more effective than the additive type of gene action by environment (Khaled 2008). On the other hand, Imtiaz (2009) stated that additive gene action was important for plant height and harvest index under normal and stress conditions, whereas dominance type of gene action was found for kernels per ear row and 100-grain weight. Additive gene effects were predominant in controlling the majority of maize traits under deferent environments (Barakat and Abd El-Moula, 2008 and Mahdi *et al*. 2011).

The objective of this work was to study the genetic systems controlling quantitative traits among nine maize lines and their 20 F_1's using a North Carolina Design II in two separate environments (drought and irrigated conditions).

MATERIALS AND METHODS

Field experiments:

This study was carried out at the experimental farm at the Faculty of Agriculture, Sohag University, Egypt during the two successive seasons of 2010 and 2011. The genetic material used in the present investigation consisted of nine parental lines: A3 (B73, provided by ENS de Lyon, France), (B3, B5, B8 and B10) which are Egyptian lines produced by Department of Maize Research Program Field Crops Research Institute, ARC, Egypt and (C1, C12, C15 and C16) are sub-tropical maize produced by The International Maize and Wheat Improvement Center (commonly called by its Spanish acronym CIMMYT for Centro Internacional de Mejoramiento de Maíz y Trigo) in Zimbabwe. The Single cross hybrid-10 (S.C.10) which is produced by the Ministry of Agriculture in Egypt is considered the best yielding maize hybrid in Egypt was used as a check.

In the summer season of 2010, The nine parental lines were arbitrary divided into four parents as males (B3, B5, C1, and C12) which were crossed with five parental lines (A3, B8, B10, C15 and C16) as female parents to produce 20 crosses in North Carolina Design II fashion. All parental lines were self pollinated to obtain additional seed from each one.

In the summer season of 2011, the nine parental lines, their 20 F_1 crosses and the check variety S.C.10, were sown in two contrasting conditions, under irrigated and stressed conditions (15 May). The material was laid out in a Randomized Complete Block Design (RCBD) with three replicates. Each block consisted of 30 plots (nine plots for the parents, 20 plots for the F_1 hybrids and one plot for the S.C. 10). Each plot consisted of three rows of 21 plants spaced 30 cm between hills, while the rows were set 70 cm a part. The irrigation was applied each seven days in the normal irrigated condition, and each 12 days in the drought stressed condition. All other agricultural practices were applied as recommended for maize production.

Data were recorded on five random plants/replicate (size of family, m=15 plants) for pollen shedding date: recorded when the pollen-shedding was completely visible for 50% of plants; plant height (cm); total biomass per plant (g): roots was excluded; grain weight per plant (g); the grain weight was adjusted to 15.5% moister content; ear length (cm); ear diameter (cm); ear weight (g); number of rows per ear and drought susceptibility index (S).

Statistical and biometrical analyses:

Data of the different measured traits for the nine parental lines and their 20 F_1 crosses were subjected to the conventional statistical analysis. The North Carolina Design II analysis (Table 1) was performed for the 20 inter-lines crosses according to the method of (Mather and Jinks 1971).

Table 1: Analysis of variance and E.M.S for the North Carolina Design II mating system:

S.V.	d.f.	M.S.	E.M.S.
Replicates	r-1	MSr	
Between Fathers	n_1-1	MSn1	$\sigma^2_w+m\sigma^2_{fm}+n_2\sigma^2_f$
Between Mothers	n_2-1	MSn2	$\sigma^2_w+m\sigma^2_{fm}+n_1\sigma^2_m$
Fathers × mothers	$(n_1-1)(n_2-1)$	MSn1n2	$\sigma^2_w+m\sigma^2_{fm}$
Within families	$n_1n_2(m-1)$	MSw	σ^2_w

Where; r= Number of replications; n_1= Number of "Fathers"; n_2= Number of "Mothers" and m= Size of family.

The genetic parameters were calculated as:

$\sigma^2_f = \frac{1}{8}$ A; $\sigma^2_m = \frac{1}{8}$ A; $\sigma^2_{fm} = \frac{1}{16}$ D

The heritability in narrow sense was calculated as:

$$h^2 = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 W}$$

Drought susceptibility index (DSI) is calculated according to the method of Fischer and Maurer (1978). Yield of individual genotypes is determined under drought stressed (Yd) and well-irrigated (Yw) conditions. Data on average yield of all varieties under drought (Xd) and well-irrigated conditions (Xw) are used to calculated drought intensity (D) as:

$$D = 1 - \frac{Xd}{Xw}$$

Then the DSI of individual genotypes is calculated as: Yd= Yw (1-SD); DSI = $\frac{Yw - Yd}{YwD}$

Genotypes with average susceptibility or resistance to drought have a DSI value of one. Values less than one indicate less susceptibility and greater resistance to drought. Meanwhile, a value of DSI=0 indicates maximum possible drought resistance (no effect of drought on yield).

Heterosis was calculated using the Mid-parent % as: H% = $\frac{\overline{F1} - \overline{MP}}{\overline{MP}}$ X 100

Where; H% = Heterosis %, $\overline{F1}$ = Mean of the F_1 crosses and $M\overline{P}$ = Mid-parent value.

RESULTS AND DISSCUSION

Analysis of variance

Analysis of variance for all studied traits under normal (N) and drought stress (D) conditions is presented in Table 2. Differences existed among genotypes (parents and their 20 F_1 crosses) under normal and drought stress conditions were highly significant for all studied traits, revealing a large amount of variability among them. Parents vs. crosses, as an indication of average heterosis over crosses, were highly significant under the two environments for all studied traits

Analysis of variance of North Carolina Design II for all studied traits is presented in Table 3. The two main effects of “fathers” and “mothers” were highly significant under normal and drought stress conditions for all studied traits, reflecting the existing of additive gene variance. The mean square due to the “fathers X mothers” interaction was also highly significant under both environments for all studied traits, revealing the importance of dominance variance in the inheritance of these traits.

Mean performances :-

Mean performances of the parental lines and their respective 20 crosses for all studied traits under normal (N) and stress (D) conditions are shown in Table 4.

The results showed that the range of mean performance of the nine parental lines was quite wide extending from extreme earliness of line A3 (55.7 days in irrigated and 53.3 days in stressed conditions) to lateness of line C12 (84 days in irrigated and 80.3 days in stressed environment). As for plant height, the parental lines under normal environment ranged from 92.1 to 183.3 cm for lines A3 and B5, respectively. Under drought stress for the same traits, the range extended from 72.1 to 129.9 cm for lines A3 and C15, respectively. The mean performance of lines for biomass trait was quite wide extending and the mean values were 130.7 and 278.5 g, for B8 and C15, respectively under normal conditions. The range was 72.0 and 171.3 g for B3 and C15, respectively in stressed conditions. The parental lines range for ear diameter extended from 8.3 to 10.9 cm and from 7.3 to 9.9 cm under normal and stressed conditions, respectively. The means of ear length ranged from 10.5 to 15.3 cm under both conditions. Number of rows per ear means ranged from 9.1 to 11.9 rows/ear for the same parents under both conditions.

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Ear weight of lines means were extended from 43.3 to 60.6 g and from 29.1 to 39.9 g under irrigated and stressed conditions, respectively. The average of grain yield per plant for parental lines under normal conditions ranged from 24.0 to 37.5 g for lines B8 and B5, respectively. While, under stressed conditions, the mean values were narrower extending from 15.9 to 22.1 g for B10 and B5 lines, respectively.

Concerning mean performances of the 20 crosses for No. of days to Pollen- shedding, the range of crosses means in the irrigated conditions extended from 54.3 days for the cross (A3 X B3) to 91.7 days for the cross (C15 X B3 and C16 x C1). Under drought stress, the range extended from 52.7 days for cross (A3 X B3) to 89.7 days for cross (C15 X B3). In the normal environment, plant height reached to 160.2 cm for (B8 X B5) and to 198.3 cm for (B8 X B3). Under drought condition, the range of plant height extended from 132.3 cm for the cross B10 X C1 to 186.7 cm for the cross B8 X C1. The largest means values of biomass trait for crosses were 343.0 and 292.7 g for C15 X B3 and C15 X C12, under normal and drought stressed conditions, respectively. The range of the F_1 crosses for ear diameter extended from 9.5 to 11.9 cm and from 7.9 to 11.2 cm under normal and stressed conditions, respectively. For ear length, the means of crosses ranged from 11.9 to 19.2 cm and from 10.7 to 14.8 cm under irrigated and stressed conditions, respectively. The mean of crosses for number of rows/ear ranged from 9.5 to 13.0 cm and from 9.3 to 12.1 cm under normal and stressed conditions, respectively. The F_1 crosses means for ear weight were extended from 69.8 to 99.9 g and from 53.3 to 84.7 g under irrigated and stressed conditions, respectively. The grain yield average of crosses in the irrigated conditions ranged from 42.5 to 88.5 g for (A3 x B5) and (C16 x C12), respectively. Under drought, the average was reduced and ranged from 35.6 g to 69.1 g for (C15 x B3) and (B10 x B3) crosses, respectively. It could be noticed that, three particular crosses namely (B10 x B3), (C15 x C12), and (C16 x C12) exhibited an excellent performance under drought conditions with the mean grain yield per plant approaching closely that of the check variety (S.C.10.).

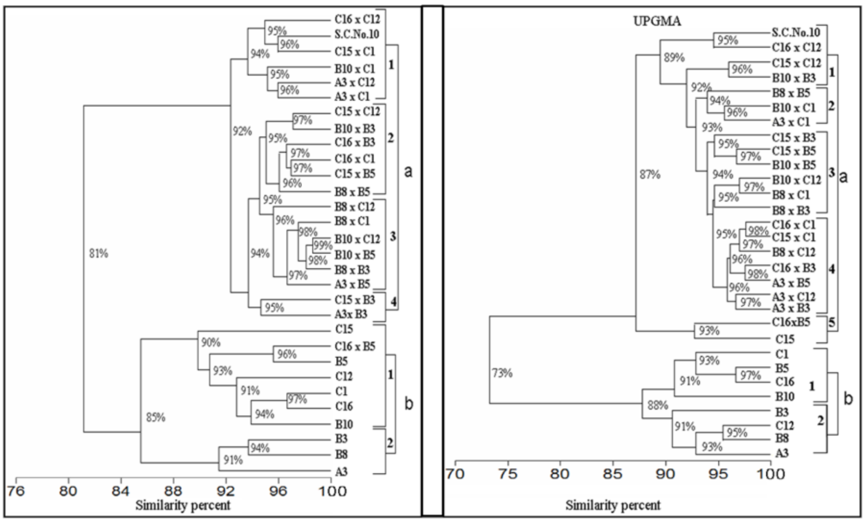
Drought susceptibility index (DSI):-

Drought susceptibility index (Table 4) indicated that the parental lines A3, B8, C12 and C16 showed DSI mean values of 0.39, 0.38, 0.74, and 0.99, respectively, revealing relative drought resistance. Maciej *et al.* (2012) showed that the variation of DSI for maize ranged from 0.38 to 0.65 and for triticale from 0.35 to 0.58. On the other hand, C1 and B10 parental lines were found to be the most susceptible. As for the F_1 crosses, nine out of the 20 F_1 crosses showed relative drought resistance (DSI<1). In general, the crosses that involved A3 as a common "mother" were, on average, relatively tolerant to drought indicating that this trait is transmissible to progeny. In this direction, three particular crosses, namely (B10 x B3), (C15 x C12) and (C16 x C12) exhibited an excellent performance under drought conditions with the mean grain yield/plant approaching closely that of the check SC.10 that displayed relative susceptible to drought with DSI value being 1.43. Similar results were obtained by Stanisław (2001) and Shirinzdeh *et al*. (2010)

between maize hybrids. The intensity of drought was rather strong with grain yield/plant being reduced by 26% under drought.

Similarity percent analysis based on means of the studied traits:

In this study, to find out relationship among the nine parental lines, their F_1 crosses and the check variety (S.C.10), the similarity percent was calculated based on the means of all studied traits. Under irrigated conditions, the parental lines (A3 and C15) and (C1 and C16) showed similarity percent ranged from 78 to 97%, respectively (Figure 1A). Under the same condition, the crosses (C16 x B5 and A3 x B3) and (B10 x C12 and B10 x B5) showed similarity percent ranged from 85 to 99%, respectively. Under drought condition, the parental lines(A3 and C15), and (C16 and B15) showed similarity percent ranged from 77 to 97%, respectively, while among crosses, these percent increased to 85% between (C15 x C12) and (C16 x B5), and to 98% between (C16 x C1) and (A3 x B5) (Figure 1B). This variability is not surprising because the accessions were colleted from different environments. The evaluation of these genotypes representing the existing diversity and cultivation conditions has been performed based on ten morphological traits. Goodman and Paterniani (1969), and Miguel *et al.* (2008) had documented by the adequacy of morphological traits to identify and classify maize landraces.



(A) (B)

Figure 1. Dendrograms generated by UPGMA cluster analysis based on the means of characters of the nine parental lines, F_1 crosses and the check variety (S.C.10) under (A) normal irrigated and (B) drought conditions.

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Estimates of heterosis :-

Estimates of heterosis over mid parents for each cross under normal (N) and drought stress (D) conditions for all studied traits are presented in Table 5. The results showed that, nine and ten out of 20 crosses were significant flowered than their mid-parents with negative heterosis values ranging from (–2.26 to –20.56%) and (–2.94 to –19.29%) under irrigated and drought conditions, respectively. Concerning plant height, all crosses showed undesirable heterosis values with positive highly significant values under both environments. Most crosses showed significant values than their mid-parents for biomass trait with positive significant heterosis values under both environments. As for ear diameter, 18 and 14 out of 20 crosses were highly significant with positive heterotic values, under normal and drought conditions, respectively. Nineteen crosses for ear length were highly significant with positive values desirable under both conditions. Highly desirable significant positive heterotic values were obtained for 15 and 17 crosses under normal and drought stress conditions, respectively for number of rows per ear. All crosses for ear weight exhibited significant positive heterosis values relative to mid-parents with values ranged from 16.53 to 97.47% and from 41.57 to 135.06% under irrigated and stressed conditions, respectively. For grain yield, estimates of heterosis were positive highly significant values for all crosses under both environments. Heterotic values ranged from 28.45 to 208.36% for the crosses (C16 x B5) and (C16 x C12), respectively under normal conditions. Whereas, the heterotic values were increased and ranged from 78.45 to 286.03% for (C15 x B3) and (B10 x B3) crosses, respectively under drought conditions. Generally, the superiority of some crosses over their mid-parents reflects the important role of non additive genetic variance in the inheritance of these traits.

Estimates of genetic parameters

Estimates of all types of gene action for all studied traits under the two environments are found in Table 6. The results showed that the magnitudes of non-additive genetic variance (σ^2D) were larger than those of additive ones (σ^2A) for number of days to pollen shedding under both environments. These results reflect low narrow-sense heritability estimates of 0.12 and 0.08 under irrigated and drought conditions, respectively. These results are in accordance with those of Shafey *et al.* (2002); Abd El-Maksoud *et al.* (2003) and Fu *et al.* (2008).

However, additive component of genetic variance was more important in controlling plant hieght, which was two times larger than the dominance one under both environments. This finding reflects the high narrow-sense heritability estimates obtained (0.80 and 0.83) under irrigated and drought conditions, respectively.These results are in accordance to those obtained by Bukhari (1986); Mahmoud *et al.* (2001); Tabassum (2004); Barakat and Abd El-Moula (2008); Imtiaz (2009) and Mahdi *et al*. (2011).

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Genes with mainly dominance effects were controlling biomass per plant under normal conditions with a low heritability of 0.24. However, under drought conditions both additive and dominance gene effects were involved in the inheritance of this trait with the heritability being increased to 0.64, in accordance with the results of Khaled. (1997); Shabir and Saleem, (2002); Betrán *et al.* (2003); Abd El-Maksoud *et al.* (2003); and Mahdi *et al*. (2011).

Concerning yield components, the magnitudes of additive genetic variance (σ^2A) were larger than those of non additive ones (σ^2D) under normal condition for grain yield, ear weight and number of rows per ear traits. Whereas, dominance effects were strongly operating ear diameter and ear length traits under drought conditions. Narrow-sense heritability estimates for grain yield, ear weight, ear diameter, ear length and number of rows per ear amounted to 0.91, 0.63, 0.21, 0.17 and 0.32, respectively, under normal environment, and 0.55, 0.43, 0.54, 0.50 and 0.11 under drought conditions for the same traits, respectively. Similar results were reported by Turgut *et al.* (1995); Hui *et al.* (1995); Malvar *et al.* (1996); Khaled. (1997); John *et al.* (2007) and Khaled. (2008).

In conclusion, highly significant differences existed among genotypes, revealing a large amount of variability among them under both environments. The significace of mean square of parents vs. crosses observed indicated the importance of heterotic values and non additive genetic variance in the inheritance of these traits under the two environments. Some lines and their F_1 crosses showed (S) values less than one revealing relative drought resistance. The magnitudes of non-additive genetic variance were larger than those of additive ones for most studied traits, indicating that non additive gene action was pronounced in the inheritance of these traits. Therefore, these promising crosses could be utilized in maize breeding program to improve these traits. This finding could be emphasized by the estimate values of narrow sense heritability.

REFERENCES

Abd El-Maksoud, M. M; G. A. R. El-sherbeny and A.H. Abd El-Hadi (2003). Evaluation of some exotic yellow maize inbred lines for combining ability using local open-pollinated testers. J. of Agric. Sci., Mansoura Univ., 28 (10):7273-7280.

Ashraf, M. (2010). Inducing drought tolerance in plants: Recent advances. Biotech. Adv. 28: 169–183.

Barakat, A. and M. A. Abd El-Moula (2008). Combining ability in maize top-crosses for grain yield and other traits. Minia J. of Agric. Res. & Develop. 28: 129-147.

Betrán F.J.; D. Beck; M. Bänziger and G.O.Edmeades (2003). Secondary traits in parental inbreds and hybrids under stress and non-stress environments in tropical maize. Field Crops Research. 83: 51-65.

Bruce W.B.; G.O. Edmeades and T.C. Barker (2002). Molecular and physiological approaches to maize improvement for drought tolerance. J. Exp. Bot. 53: 13–25.

Bukhari S.H. (1986). Diallel analysis of yield and yield components in maize. M.Sc. (Hons) Thesis, Department of Plant Breading and Genetics, University of Agriculture Faisalabad, Pakistan.

Campos H.; M. Cooper; J.E. Habben; G.O. Edmeandes and J.R. Schussler (2004). Improving drought tolerance in maize: a view from industry. Field Crops Res. 90: 19–34.

Fischer R. A. and R. Maurer (1978). Drought resistance in spring wheat cultivars. I- Grain yield responses. Aust. J. Agric. Res., 29 :897-912.

Fu F.; Z. Feng; S. Gao; S.Zhou and W. Li (2008). Evaluation and quantitative inheritance of several drought-relative traits in maize. Agricultural Sciences in China, 7(3): 280-290.

Goodman M. M. and E. Paterniani (1969). The races of maize: III. Choices of appropriate characters for racial classification. Econ. Bot., 23: 265–273.

Grant R. F.; B.S. Jackson; J.R. Kiniry and G.F. Arkin (1989). Water deficit timing effects on yield components in maize. Agron. J., 81:61-65.

Hui. C.Y.; Z.C. Zhen and X.H. Jie (1995). Studies on maize heterosis population and model: I- Genetic analysis of the quantitative traits for maize heterosis population abstracted from the exotic germplasms. Acta. Agri. Boreali-Sinica, 10, (1) :17-21.

Imtiaz H. (2009). Genetics of drought tolerance in maize (*Zea mays* L.). Ph. D. Thesis, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.

John D.; T. Pangirayi; S.V. Bindiganavile and D.L. Mark (2007). Gene action controlling grain yield and secondary traits in southern African maize hybrids under drought and non-drought environments. Springer Science Business Media B.V.

Khaled A. G. A. (1997). Genetic structure *of Zea mays* L. populations adapted to dry conditions. M.Sc., Thesis. Genetics Department, Faculty of Agriculture, Assiut University.

Khaled A. M. I. (2008). Combining ability and types of gene action in yellow maize (Zea mays L.). Ph. D. Thesis, Agron. Dept., Faculty of Agric., Assiut Univ., Egypt.

Maciej T.G.; Wi. Piotr; J. k.Franciszek; M. Izabela; K. Hura; S. Piotr and G. Tomasz (2012). The relations between drought susceptibility index based on grain yield (DSI_{GY}) and key physiological seedling traits in maize and triticale genotypes. Acta Physiologiae Plantarum, 34 **:**1757-1764.

Mahdi Z.; C. Rajab.; M. H. Eslam.; R. B. Mohammad and O. Kourosh (2011). Gene action of some agronomic traits in corn (*Zea mays* L.) using diallel cross analysis. African Journal of Agricultural Research, 6 (3): 693-703.

Mahmoud A.A.; A. A. Abd El-Aziz; F.H.S. Soliman and K.I. Khalifa (2001). Selection among S3 maize lines *(Zea mays* L.) using testcrosses. Egypt. J. Plant Breed., 5: 21-49.

Malvar R.A.; A . Ordás.; P. Revilla and M. E. Cartea (1996). Estimates of genetic variances in two Spanish populations of maize. Crop Sci., 36: 291-295.

Mather K. and J.L. Jinks (1971): Biometrical genetics, Chapman and Hall, London.
Miguel A.; C. Pinheiro; F.T.G Jose; A. Ivo; F.S. Nelia; M.M.S. Teresa; R.C.V. Maria and M Mario (2008). Evaluation of the maize (*Zea mays* L.) diversity on the Archipelago of Madeira. Genet. Resour. Crop Evol., 221–233.
Mooseo S.P. and R.H. Mumm (2008). Molecular plant breeding as the foundation for 21st century crop improvement. Plant Physiol., 147: 969–977.
Ribaut J.M.; J. Betran; P. Monneveux and T. Setter (2009). Drought tolerance in maize. In: Bennetzen, J.L. and S.C. Hake (eds.) Handbook of Maize: Its Bilogy, Springer, New York, pp. 311–314.
Shabir G. and M. Saleem (2002). Gene action for protein content of maize grain in diallel cross. Pak. J. Seed Tech., 1(2): 53-56.
Shafey S. A.; H. E. Yassien; I. E. M. El-Beially and O. A. M. Gad-Alla (2002). Estimates of combining ability and heterosis effects for growth earliness and yield in maize (*Zea mays* L.). J. of Agric. Sci., Mansoura Univ., 27 (3): 1023-1033.
Shiri M.; R.T. Aliyev and R. Choukan (2010). Water stress effects on combining ability and gene action of yield and genetic properties of drought tolerance indices in maize. Res. J. Environ. Sci., 4: 75-84.
Shirinzadeh A.; R. Zarghami; A.V. Azghandi; M.R. Shiri and M. Mirabdulbaghi (2010). Evaluation of drought tolerance in mid and late mature corn hybrids using stress tolerance indices. Asian Journal of Plant Sciences, 9: 67-73.
Stanisław G. (2001). Genotypic variation between maize (*Zea mays* L.) single cross hybrids in response to drought stress. Acta Physiologiae Plantarum, 23 :443-456.
Tabassum, M. I. (2004). Genetics of physio-morphological traits in *Zea mays* L. under normal and water stress conditions. Ph.D. Thesis, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan.
Turgut, L.; S. Yüce and M. Altinbas (1995). Inheritance of some agronomic traits in a diallel cross of maize inbreds. II-Grain yield and its components. Anadolu, 5(1): 74-92. [C.F. Plant Breed. Abst. No. 12612, 1995].

تقدير المقاييس الوراثية وقوة الهجين فى الذرة الشامية تحت الظروف العادية وظروف الجفاف

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أجريت هذه الدراسة في مزرعة كلية الزراعة بجامعة سوهاج بهدف دراسة الأنظمة الوراثية المتحكمه فى بعض الصفات الكمية فى الذرة الشامية. حيث تم إختيار تسعة سلالات أبويه للتهجين بينهم في نظام التزواج الثانى نورث كارولينا للحصول علي 20 هجين . وتم تقييم التراكيب الوراثية (تسعة سلالات والـ 20 هجين بالاضافة الي الهجين الفردي التجاري رقم 10) تحت ظروف الرى العادى وظروف الجفاف.

أوضحت النتائج ما يلي:

- وجود إختلافات عالية المعنوية بين التراكيب الوراثية المدروسة تحت الظروف العادية وظروف الجفاف .
- وجود معنوية عالية لتباين الآباء مقابل الهجن الذى دل على أهمية كلا من التباين الوراثى غير المضيف فى توريث هذه الصفات مما يؤدى إلى وجود وقوة هجين وذلك عند تقديرها تحت الظروف العادية وظروف الجفاف .
- أظهرت بعض السلالات وهجنها مقاومة نسبية للجفاف حيث أنها أظهرت معامل حساسية للجفاف أقل من الواحد الصحيح.
- أوضحت النتائج أن التباين الوراثى السيادى كان أكبر من التباين الوراثى الراجع إلى الإضافة لمعظم الصفات المدروسة ويؤكد ذلك صغر قيم معامل التوريث فى معناه الضيق ، مما يدل على أن التباين غير المضيف يلعب دورا هاما فى توريث هذه الصفات.
- لذلك فمن الممكن استخدام هذه السلالات لإنتاج هجن متفوقة تستخدم فى برامج التربية تحت الظروف البيئية العادية وظروف الجفاف.

قام بتحكيم البحث

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Table 2: The mean square for all studied traits for 20 F_1 crosses in normal irrigated (N) and drought (D) conditions.

S.V.	d.f	No. of days to pollen-shedding		Plant height (cm)		Biomass (g)		Ear weight (g)		Ear diameter (cm)		Ear length (cm)		Number of rows/ ear		Grain yield / plant (g)	
		N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Blocks	**2**	0.3	2.7**	421.1**	409.2**	703	456.5**	352.5**	495.3**	4.1**	4.4	4.1**	4.4	2.4	8.1*	330.9**	459.7**
Between Entries:	**28**	1884.3**	1854.9**	15939.2**	17443**	52568.1**	63774.1**	4269.3**	3900.7**	19.9**	9.6**	19.9**	9.6**	10.7**	9.7**	5877.1**	3846.3**
Among Parents	**8**	1248.9**	1104.6**	5492.3**	5164.2**	33280.9**	17458.6**	704.7**	239.1**	27.8**	9.2*	27.8**	9.2*	23.2**	14.3**	354.5**	111.0**
Among F_1s	**19**	2180.5**	2240.0**	2523.9**	3475.3**	17976.8**	10640.3**	1723.7**	1188.6**	12.1**	1.4	12.1**	1.4	5.7	4.9**	3382.3**	1666.0**
Among Parents vs. F_1s	**1**	1341.0**	539.8**	354403.9**	381062.7**	864099.1**	1443841**	81150.7**	84722.3**	103.7**	168.7**	103.7**	168.7**	7.3	64.1**	97459.3**	75154.4**
Error	**406**	1.3	1.0	6.3	55.8	502.00	19.00	62.0	5.1	1.1	1.7	1.1	1.7	3.7	1.8	13.6	5.0

****, * Significant at 0.01 and 0.05 levels, respectively and (Non-Significant).**

Table 3: The mean square of North Carolina DesignII for all studied traits for 20 F1 crosses in normal irrigated (N) and drought (D) condition.

S.V.	d.f	No. of days to pollen-shedding		Plant height (cm)		Biomass (g)		Ear weight (g)		Ear diameter (cm)		Ear length (cm)		Number of rows/ ear		Grain yield / plant (g)	
		N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
Blocks	**2**	0.42	2..07	214	150.84	531.00	319.78	161.6	423.3**	3.2	5.0	19.9*	27.0**	2.5	2.6	257.0	387.6*
Between Fathers	**3**	2446.95**	665.78**	1684.97**	3558.57**	7172.67**	16080.85**	2694.5**	1394.3**	6.3**	31.3**	40.0**	20.6**	20.5**	5.9*	9799.3**	2332.3**
Between Mothers	**4**	1767.46**	1999.78**	4082.23**	6343.94**	21999.75**	8160.14**	1335.6**	976.5**	11.0**	6.9*	19.8*	48.3**	1.4	10.0**	1875.4**	847.2**
Fathers × Mothers	**12**	2336.68**	1957.24**	1970.42**	2448.58**	19553.17**	9967.45**	1413.5**	1105.56**	9.9**	4.3*	34.7**	31.3**	11.9**	8.9**	2110.5**	1655.4**
Blocks × Fathers	**6**	6.69	1.97	93.14	7.46	358.50	24.41	40.2	8.9	0.5	2.9	8.2	2.5	5.5	4.7	35.0	11.6
Blocks × Mothers	**8**	4.39	2.11	10.99	14.15	352.25	25.68	58.2	9.2	0.9	1.6	3.0	1.0	3.2	3.1	23.0	20.7
Blocks × Fathers × Mothers	**24**	7.40	4.25	104.01	12.29	566.79	43.10	85.0	15.9	7.4	2.7	6.0	5.7	5.6	3.9	63.5	26.2
Within Families	**280**	0.44	0.48	0.52	2.5	651.00	20.50	64.3	3.4	0.4	1.6	3.2	2.3	3.0	1.4	3.2	2.5

****, * Significant at 0.01 and 0.05 levels, respectively and (Non-Significant).**

Table 4: Mean performances of all studied traits and drought susceptibility index (DSI) for the nine parental lines and their 20 F_1 crosses under normal (N) and drought (D) conditions.

Genotypes	No. of days to pollen-shedding		Plant height (cm)		Biomass (g)		Ear weight (g)		Ear diameter (cm)		Ear length (cm)		Number of rows/ ear		Grain yield / plant (g)		(DSI)
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	
A3	55.7	53.3	92.1	72.1	154.1	88.7	43.8	36.5	9.1	9.0	15.0	15.0	11.3	11.3	24.8	21.5	**0.39**
B8	74.3	71.7	100.6	83.7	130.7	96.3	47.7	37.4	9.0	8.0	13.7	13.7	9.1	9.1	24.0	20.9	**0.38**
B10	68.7	64.7	119.5	101.3	236.5	161.6	47.9	31.7	8.3	8.2	12.6	12.6	10.1	10.1	28.2	15.9	**1.28**
C15	80.7	77.3	149.7	129.9	278.5	171.3	54.3	39.0	9.2	7.9	13.6	13.6	10.2	10.2	32.2	20.0	**1.11**
C16	82.7	79.3	122.4	101.5	209.0	126.5	60.6	39.9	10.9	9.9	15.3	15.3	11.0	11.0	32.1	21.3	**0.99**
B3	81.0	77.3	117.0	97.3	141.9	72.0	51.7	36.3	10.6	8.9	11.0	11.0	11.9	11.9	31.7	19.9	**1.09**
B5	80.0	72.0	183.3	104.1	202.7	132.9	59.2	36.0	8.6	8.3	10.5	10.5	10.6	10.6	37.5	22.1	**1.21**
C1	78.0	73.3	131.8	107.5	204.1	99.9	49.7	29.1	9.1	7.8	12.8	12.8	10.7	10.7	30.4	16.4	**1.35**
C12	84.0	80.3	100.9	73.7	188.1	95.4	48.5	33.4	9.3	7.3	10.9	10.9	10.6	10.6	25.3	18.9	**0.74**
A3 x B3	54.3	52.7	190.7	162.2	333.5	242.2	76.5	69.7	11.3	9.5	15.7	13.0	11.1	11.7	62.1	40.1	**1.43**
A3 x B5	70.0	65.3	181.9	152.4	294.4	230.5	79.1	61.3	10.6	9.7	15.0	13.5	10.7	11.3	42.5	40.8	**0.16**
A3 x C1	68.0	63.7	172.8	147.7	266.0	243.2	88.6	77.1	10.6	9.9	14.7	12.8	11.7	12.1	59.8	55.1	**0.31**
A3 x C12	71.7	70.0	176.9	160.5	250.8	247.7	71.7	60.4	11.6	10.3	12.8	12.6	11.7	11.3	61.2	43.6	**1.15**
B8 x B3	78.0	70.0	198.3	173.6	298.4	213.7	70.3	56.0	9.5	8.0	11.9	11.7	11.1	9.5	55.6	37.2	**1.32**
B8 x B5	87.0	85.7	160.2	133.9	302.6	261.3	89.7	75.1	11.1	7.9	12.9	12.8	11.3	12.0	69.7	50.5	**1.10**
B8 x C1	73.0	66.0	197.9	186.7	302.9	255.5	81.3	60.0	9.9	9.7	13.9	13.1	10.6	10.9	66.8	51.9	**0.89**
B8 x C12	90.0	85.3	185.9	164.7	276.9	232.7	76.6	62.0	10.1	9.7	13.6	12.9	10.2	10.6	55.6	38.9	**1.20**
B10 x B3	79.3	61.0	198.0	172.9	305.9	262.6	93.7	78.5	11.9	11.2	19.2	14.6	13.0	11.5	79.4	69.1	**0.52**
B10 x B5	74.7	71.7	191.7	169.9	299.7	275.7	70.2	55.5	10.1	10.0	13.2	12.7	12.5	10.1	50.3	36.7	**1.08**
B10 x C1	66.3	62.7	163.2	132.3	231.1	219.0	79.7	71.1	10.5	10.4	15.9	13.0	11.2	10.5	66.7	52.5	**0.85**
B10 x C12	70.0	64.7	197.8	183.1	300.8	233.5	76.5	62.9	10.3	9.5	13.8	11.9	12.3	10.3	49.0	45.1	**0.32**
C15 x B3	91.7	89.7	192.1	174.4	343.0	254.1	69.9	53.3	11.1	8.5	13.6	13.5	9.7	9.3	46.5	35.6	**0.94**
C15 x B5	73.7	67.3	171.1	155.9	305.4	274.3	84.3	63.7	9.9	9.9	15.5	14.8	10.7	10.3	73.6	48.2	**1.38**
C15 x C1	83.7	81.7	181.3	161.5	263.9	231.7	80.9	71.1	10.3	10.2	16.3	13.8	11.2	10.9	82.9	47.5	**1.71**
C15 x C12	79.0	75.0	185.6	175.5	322.0	292.7	99.9	80.9	10.8	9.7	15.2	14.0	11.3	10.3	85.7	63.5	**1.04**
C16 x B3	80.0	76.0	170.5	153.2	311.7	219.7	76.7	59.1	9.5	9.3	14.3	14.2	11.1	10.8	54.3	43.0	**0.83**
C16 x B5	78.0	75.7	163.5	142.9	209.1	182.7	69.8	57.2	9.5	9.4	14.1	13.0	9.5	10.5	44.7	40.5	**0.38**
C16 x C1	91.7	86.3	174.1	154.1	318.4	240.8	80.9	71.1	9.7	9.7	15.8	11.0	12.1	10.3	69.5	44.4	**1.44**
C16 x C12	71.0	62.7	166.6	148.0	281.4	200.1	99.9	80.9	9.7	9.5	13.5	10.7	11.5	10.9	88.5	65.1	**1.06**
S.C.No.10	78.0	68.0	198.1	173.8	257.5	176.8	99.5	84.7	11.1	10.9	14.5	13.3	11.9	11.0	80.9	61.1	**1.43**

Table 5: Heterosis over mid-parents% of all studied traits for each crosses under normal (N) and drought (D) conditions.

Crosses	No. of days to pollen-shedding		Plant height (cm)		Biomass (g)		Ear weight (g)		Ear diameter (cm)		Ear length (cm)		Number of rows/ ear		Grain yield / plant (g)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
A3 x B3	-20.56**	-19.29**	82.49**	91.26**	125.34**	201.43**	60.21**	91.48**	14.72**	5.73**	20.77**	16.07**	-4.31**	13.04**	119.82**	93.72**
A3 x B5	3.17**	4.23**	32.09**	72.99**	65.02**	108.03**	53.59**	69.10**	19.77**	11.71**	5.88**	33.93**	-2.28**	8.65**	36.44**	87.16**
A3 x C1	1.72**	0.63	54.35**	64.48**	48.52**	157.90**	89.52**	135.06**	25.44**	8.91**	5.76**	17.97**	6.36**	21.00**	116.67**	190.77**
A3x C12	2.65**	4.79**	83.32**	119.75**	46.58**	169.09**	55.36**	72.82**	41.46**	12.13**	7.23**	12.28**	6.85**	13.57**	144.31**	115.84**
B8 x B3	0.45	-6.04**	74.56**	84.82**	118.93**	153.95**	41.45**	51.97**	-3.06**	-5.33**	-5.26**	10.19**	5.71**	-4.04**	99.64**	82.35**
B8 x B5	12.77**	19.28**	22.35**	60.81**	81.52**	128.01**	67.82**	104.63**	26.14**	-3.07**	6.61**	18.52**	14.72**	20.60**	126.67**	134.88**
B8 x C1	-4.14**	-8.97**	53.06**	63.66**	80.94**	160.45**	66.94**	80.45**	17.86**	13.45**	4.91**	25.36**	7.07**	14.14**	145.59**	178.28**
B8x C12	13.71**	12.24**	81.20**	111.39**	73.71**	142.78**	59.25**	75.14**	23.93**	12.14**	16.22**	23.64**	3.55**	11.58**	125.56**	95.48**
B10x B3	5.95**	-14.08**	67.44**	74.12**	61.68**	124.83**	88.15**	130.88**	25.93**	30.99**	62.71**	28.07**	18.18**	19.79**	165.11**	286.03**
B10x B5	0.47	4.90**	26.62**	65.43**	36.48*	87.23**	31.09**	63.96**	19.53**	21.21**	9.96**	15.79**	20.77**	4.66**	53.12**	93.16**
B10x C1	-9.61**	-9.13**	29.88**	26.72**	4.90	67.49**	63.32**	133.88**	29.19**	21.39**	2.36*	43.89**	7.69**	13.51**	127.65**	225.08**
B10x C12	-8.32**	-10.76**	79.49**	109.26**	41.69*	81.71**	58.71**	93.24**	21.79**	17.71**	12.79**	18.97**	18.84**	11.96**	83.18**	159.19**
C15x B3	13.41**	16.04**	44.06**	53.52**	63.18**	108.88**	31.89**	41.57**	20.00**	-6.08**	10.57**	20.54**	-12.22**	-7.46**	45.54**	78.45**
C15x B5	-8.28**	-9.85**	2.76**	33.25**	26.93	80.34**	48.55**	69.87**	20.00**	13.14**	22.82**	38.39**	2.88*	1.98*	111.19**	128.97**
C15x C1	5.48**	8.49**	28.81**	36.06**	9.37	70.87**	84.42**	91.19**	29.94**	12.57**	4.55**	50.23**	7.18**	12.37**	164.86**	160.98**
C15x C12	-4.07**	-4.82**	48.12**	72.39**	38.02*	119.49**	97.47**	116.29**	42.11**	4.86**	37.56**	22.81**	8.65**	6.74**	198.09**	226.48**
C16x B3	-2.26**	-2.94**	42.44**	54.12**	77.66**	121.36**	36.59**	55.12**	-11.63**	-1.06	8.75**	29.09**	-3.06*	7.46**	70.22**	108.74**
C16x B5	-4.12**	0.07	6.97**	39.01**	1.58	40.86**	16.53**	50.72**	-3.59**	4.39**	9.30**	18.18**	-12.04**	3.96**	28.45**	86.64**
C16x C1	14.13**	13.11**	36.98**	47.46**	54.15**	112.72**	46.69**	106.09**	3.74**	2.11*	12.46**	3.29**	11.52**	6.19**	122.4**	135.54**
C16x C12	-7.62**	-16.04**	49.22**	68.95**	41.73*	80.35**	83.13**	120.74**	4.39**	1.04	13.45**	-4.46**	6.48**	12.95**	208.36**	223.88**

***, * Significant at 0.01 and 0.05 levels, respectively and (Non-Significant).**

Table 6: Estimates of genetic parameters for all studied traits under normal (N) and drought (D) conditions.

S.V.	No. of days to pollen-shedding		Plant height (cm)		Biomass (g)		Ear weight (g)		Ear diameter (cm)		Ear length (cm)		Number of rows/ ear		Grain yield / plant (g)	
	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D
σ^2_f	22.05	-258.29	-57.09	222.00	-2476.1	1222.68	256.21	57.76	-0.72	5.40	1.07	-2.14	1.71	-0.6	1537.77	135.38
σ^2_m	-142.31	10.64	527.95	1423.80	611.65	-451.83	-19.48	-32.27	0.27	0.65	-3.73	4.26	-2.63	0.28	-58.78	-202.05
σ^2_{fm}	155.8	130.45	131.33	163.20	1260.15	663.13	89.94	73.47	0.64	0.18	2.10	1.93	0.60	0.97	140.49	110.19
σ^2w	0.44	0.48	0.52	2.50	651.00	20.50	64.30	3.40	0.36	2.36	3.02	2.30	3.00	1.40	3.20	2.50
A	176.4	85.08	4223.62	6583.2	873.2	9781.44	2049.68	462.06	0.18	24.24	3.73	34.08	13.68	0.26	12302.16	1083.07
D	2492	2087.20	2101.28	2611.2	20162.4	10610.08	1335.02	1175.52	10.24	2.88	51.68	30.88	9.60	15.52	2247.84	1763.04
h^2	0.12	0.08	0.80	0.83	0.24	0.64	0.63	0.43	0.21	0.54	0.17	0.50	0.32	0.11	0.91	0.55