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GENERAL AND SPECIFIC COMBINING ABILITY FOR SOME PHYSIOLOGICAL CHARACTERS AND YIELD OF MAIZE (*Zea mays* L.)

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ABSTRACT: **Six inbred lines of maize differ in leaf area, dry weight and physiological characters were employed to obtain half diallel of 15 F_1, excluding reciprocal during summer season of 1998, aiming to study gene action and general (GCA) and specific combining ability (SCA) that control some physiological characters in maize. Fifteen F_1 + 6 inbred lines during summer of 1999 were evaluated in Randomized Complete Block Design in three replications in two different environmental conditions, Sakha (Middle Delta) and Sids (Upper Egypt). During summer season of 2000 F_1,s + F_2 ,s (selfed F_1 plant during 1999) + 6 inbred lines were evaluated in RCBD in three replications for leaf area/plant (LA/P), Total dry weight/plant (TDW), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR), specific leave area (SLA) and grain yield (ard/fed) for the genetics of these characters and detected the program breeding for improving these characters in maize. The collected data were statistically and genetically analyzed according to Griffing (1956) Model-I, Method-2.**

The obtained results indicated that the ratio between variance of general to specific combining ability (σ^2GCA/(σ^2SCA) was more than unity for specific leaf area and relative growth rate in both locations. Meanwhile, values of (σ^2GCA/σ^2SCA) were less than unity for leaf area/plant, total dry weight, crop growth rate, net assimilation rate and grain yield (ard/fed) in both locations.

The inbred lines of maize 2 and 3 showed positive and significant GCA effects for leaf area/plant, total dry weight/plant,

crop growth rate, relative growth rate and net assimilation rate in both locations. Inbred lines No-1 and No-5 for specific leaf area and No-2 and No-4 for grain yield ard/fed, showing that these lines are good general combining for these characters and can be use in breeding program to improving these traits.

Single crosses (2x3, 1x5 and 1x6), (2x3, 2x4 and 4x5), (4x5, 1x5, 2x4 and 4x6), (5x6), (1x2, 2x3, 2x4, 2x5, 3x6, 4x5 and 4x6) gave positive and significant specific combining ability effects in both locations, giving evidence for (LA/plant), (TDW/plant), (CGR), (NAR) and (grain yield ard/fed) to improve these crosses in breeding program, in the same followed order.

These combinations are given valuable information for maize breeder to improve grain yield through physiological characters and this trend one of the greatest interest, nowadays, all over the world to incorporate physiological characters to obtain higher grain yield in maize.

INTRODUCTION

Development of improved inbred lines for commercial use in hybrid combinations is of the most important objectives of maize breeding programs. Harvestable grain yield is usually the main target for improvement. Many plant traits are associated with grain yield and various approaches have been used to explain yield as a function of different traits.

Breeders often wish to improve several traits simultaneously. This can be accomplished by various breeding methods, depending up the prevailed type of gene action. Another way to take into account several plant traits at ones is to measure a complex trait such as physiological characters that is a function of several simple traits. For example, RGR of a plant has been defined as "the increase of plant material per unity of material present per unit of time" Radford, (1967). As a complex trait, it include the simple traits i.e., leaf area/plant (LA/plant), total dry weight (TDW), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and specific leaf area (SLA).

Two assessments are involved in growth analysis:

(i) a measured of the plant material present (Total dry weight of the individual plant) and (ii) a measure of the assimilatory

system of the plant material (Total leaf area/plant). The purpose of calculating growth functions in maize is generally to describe how plants respond to environmental conditions. Many different growth analysis studied have been conducted, but most involve time-consuming, complicated analysis, and entail costs that are impractical for a breeding program (Radfored, (1967), Hardwick, (1984) and Russel *et al.* (1984).

Cross (1986) proposed a method that utilizes leaf number, leaf length and leaf width " the pervious traits that contents of a formula of leaf area/plant" as variables to calculate RGR. This method is easy to apply and can be used as a selection criterion in a practical breeding program, but there is little or non information concerning the use of RGR in maize breeding programs and its relationship with yield.

The general and specific combining ability (GCA and SCA) effects are important indicators of the potential value of inbred in hybrid combinations. Differences in GCA effects have been attributed to additive, additive x additive, and higher order interactions of additive genetic effects in the base population, while, differences in SCA has been attributed to non-additive genetic variance Falconer (1960)

Griffing (1956) outlined procedures for calculating correlations among GCA and SCA components to estimate joint responses as they occur in the parent random- mating population. He stated that these correlations are genetics correlations associated with additive (for GCA correlations) and non-additive (for SCA correlations) pleiotropic effects of gene and not with linkage effects. He revealed to GCA correlations as additive genetic correlations.

Many investigators repeated that additive gene action played a major role in the gene expression of physiological characters i.e. leaf area/plant; El-Hosary *et. al.* (1990); total dry weight Reiter *et. al.* (1990); crop growth rate, Ragheb (1985); relative growth rate, Nevado and Cross (1990); net assimilation rate, Ragheb (1985) for 30-45 days from sowing and grain yield ard/fed , Gado (2000).

Meanwhile, specific combining ability (non-additive) gene action governed physiological characters such as; leaf area/plant and total dry

weight, Ragheb (1985); relative growth rate, Dehghanpour *et al.* (1996); net assimilation rate, Ragheb (1985) for 45-60 days from sowing and grain yield ard/fed, Dawood *et al.* (1994), Mousa (1997); El-Zeir (1998); Aly (1999) and Amer (2002). So, the main targets of this research work are to estimate:

1- The prevailed type of gene action for some physiological characters using diallel analysis under two various environmental locations i.e., Sakha (Middle Egypt) and Sids (Upper Egypt) during two summer seasons in 1999 (F_1) and 2000 (F_1 and F_2).

2- General combining ability GCA (additive gene action) effects for the studied inbred lines.

3- Specific combining ability SCA (non-additive gene action) effects for the studied crosses in F_1 and F_2 and proposing the best breeding program for improving these characters in maize through increasing grain yield.

MATERIALS AND METHODS

Plant materials and experimental design:

Six inbred lines of maize were crossed in diallel fashion, excluding reciprocal to study general and specific combining ability as well as gene action trait control physiological characters in Sakha Research Station during summer season 1998. Pedigree and origin of the studied inbred lines are given in Table (1). The aims of this research work are to study general and specific combining ability and type of gene action for some physiological characters and grain yield (ard./fed.).

During summer season of 1999, 6 inbred lines+15 F_1's were sown in Randomized Complete Block Design (RCBD) in three replications. Sowing date was at 25th May. These materials were sown in two different locations i.e., Sakha (Middle delta) and Sids (Upper Egypt) experimental Stations, Agricultural Research Center (ARC). Each experimental plot consisted of five rows from each parents and F_1 crosses. The row was 6 meters length and 80 cm. apart with 25 cm between hills. The normal agricultural practices for maize production were applied in each location.

F_1 plants were selfed to obtain F_2 seeds during the summer season in each studied location. Additional seeds were obtained for F_1's at both locations to be

employed in the next growing season to investigate combining ability of F_1 and F_2 at both locations.

During summer season of 2000 inbred lines, F_1's and F_2's were sown in Randomized Complete Block Design at 27th May in both locations. F_2 plants were sown in 10 rows.

Collected data:

Three successive samples at 45, 55 and 65 days from sowing, were randomly taken. Five plants were taken from parents and F_1's and from F_2 ten plants were taken in each replication randomly. The plants were pulled and transported to the laboratory, the plants were separated into leaves, stem plus sheaths. The fresh sample was dried to a constant weight at 70 ^{0}C. To calculate physiological characters the following formulae were applied according to Radford (1967):

1 – Leaf area per plant (LA/plant) =

Leaf length x maximum leaf width x 0.75 cm.2

2–Total dry weight per plant (TDW)g.

3 – Crop growth rate (CGR) = $(W_2 - W_1)/(t_2 - t_1)$ g./10 days

4 – Relative growth rate (RGR) = $(\log_e W_2 - \log_e W_1)/(t_2 - t_1)$ g./g./10 days

5–Net assimilation rate (NAR) =

$(W_2 - W_1)(\log_e A_2 - \log_e A_1)/(A_2 - A_1)(t_2 - t_1)$ g./cm.^{2}/10 days

6 Specific leaf area (SLA) = LA/LW cm.^{2}/g./10 days

7– Grain yield (ard./fed.): was estimated from the total yield per row where the, grains were shelled, and adjusted to 15.5% moisture according to Roberts *et al.* (1957)

Biometrical analysis:

Before subjecting to biometrical analysis collected data were subjected to two-way analysis of variance according to Steel and Torrie (1980), general and specific combining ability were estimated according to Griffing (1956), method-2, model-1 for both of F_1 and F_2 generations in both locations.

RESULTS AND DISCUSSION

The obtained results herein could be presented and discussed under the following main topics:

1 – Analysis of variance

2–General combining ability effects

3–Specific combining ability effects

1 - Analysis of variance:

Data in Table (2) show mean squares of genotypes, general and specific combining ability (GCA and SCA) and σ^2GCA/σ^2SCA for F_1 generations and F_2 segregating. Genotypes for leaf area/plant and total dry weight/plant during 1999 (F_1's) and 2000 ($F_1 + F_2$) for the two studied locations.

The obtained results showed that genotypes item showed highly significant variations among the studied genotypes, suggesting the presence of a fair genetic amount of variability for leaf area/plant and total dry weight/plant. So, the data are valid for calculating general and specific combining ability. These results are according with those reported by are in according El-Hosary (1990) and Ilarslan *et al.* (2002).

Mean squares due to general combining ability at 1st sample (45 days) were highly significant for leaf area/plant in the two locations in both seasons, except at Sids 1999, suggesting that additive gene action played a great role in the genetics of this character. As for dry weight/plant no significant differences were observed during 1999 and 2000 seasons showing that environmental variance governed this character at 45 days after sowing.

At 55 days after sowing, variance of GCA for leaf area/plant was significant in 1999 for F_1 in both locations, meanwhile significant mean squares were detected for F_1 and F_2 during 2000 season in all characters, except in Sakha, revealing the importance of additive gene action in the gene expression of leaf area/plant. Concerning total dry weight, insignificant mean squares were detected for F_1 and F_2 either in 1999 or in 2000 seasons, indicating that additive genetic variance played a great role in the genetics of total dry weight/plant.

It is of great interest to note that mean squares due to (GCA) were highly significant in both F_1 and F_2 in the two growing seasons, giving evidence that additive gene played a great role in the gene expression of the leaf area/plant and total dry weight/plant in the third growth stage (65 days) after sowing, Ragheb (1985).

It could be noted that mean squares due to specific combining ability of leaf area/plant and total dry weight/plant are highly significant through the three

studied growth stages, showing that non-additive gene action played a great role in the genetics of these character.

It is of great attention to observe that the ratio of σ^2GCA/σ^2SCA was less than unity for all growth stages and concerning to leaf area/plant and total dry weight/plant, indicating that non-additive gene action is the prevailed type of gene action in the genetics of these characters and could be effectely improved through hybrid breeding methods in maize programs Ragheb (1985), El-Hosary *et al.* (1990) and Suneetha *et al.* (2000) for leaf area/plat and Ragheb (1985) for total dry weight at 60 days after sowing).

Table (3) show analysis of variance of physiological characters i.e., crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR) for genotypes, general and specific combining ability and the ratio between σ^2GCA/σ^2SCA during 1999 (F_1) and 2000 (F_1 and F_2) summer seasons.

Mean squares due to genotypes were highly significant for CGR during (45-55 days) and (55-65 days) for the locations, except for F_1 at Sakha 1999 which was insignificant. Meanwhile, RGR showed significant different for (45-55 days), except F_1 in Sakha 1999 and significant variation in 1999 for F_1 in the two locations. However, F_1 at Sids and F2 at Sakha were insignificant during summer season 2000. These results according to Nevado and Cross (1990).

As for (NAR), the first growth stage was significant in F_1 1999, meanwhile insignificant variation was observed at 1st during 1999 and 2000 growing seasons and 2nd growth stage at the 2nd growth stage. These results showed that this character is more affected by environment and these genotypes should be further tested for this character in more locations and years to less G x E interaction as indicated by Ragheb (1985).

These results showed that these genotypes possessed a fair great and of variability for the physiological characters and could be further employed for testing GCA and SCA effects. Variance due to GCA for physiological characters were variable for years, growth stages and locations, showing that non-additive variance played a great role in the genetics of these characters. The ratio of σ^2GCA/σ^2SCA confirmed the

results, since the value of σ^2GCA/σ^2SCA was less than unity Ragheb (1985), in 45-60 days after sowing).

Mean squares due to SCA for CGR were highly significant in 1st growth stage (45-55 and 55-65 days), years and locations, indicating the predominance of non-additive gene action in the genetic of this character Ragheb (1985), in 45-60 days after sowing under Gemmeiza location). Variance of SCA for RGR and NAR varied from growth stage to another and from year to year, generation to generation and location to location, indicating the predominance of non-additive gene action the genetic of these characters. These results are in a good agreement with those reported by Dehghanpour *et al.* (1996) for RGR and Ragheb (1985) for NAR in 45-60 days after sowing.

. Analysis of variance for genotypes, GCA, SCA and the ratio of σ^2GCA/σ^2SCA for specific leaf area (SLA) and grain yield (ard/fed) at both of Sakha (Middle delta) and Sids (Upper Egypt) locations are shown in Table (4).

The results of mean squares of genotypes for SLA and grain yield were significant in F_1 (Sids and Sakha) 1999 and F_1 and F_2 also in the two locations. These results indicated that the obtained date of SLA and grain yield are valid for estimating general and specific combining ability in both locations and genetic analysis. As for SLA significant variation for F_1 and F_2 in both years and locations are detected at by days after sowing. Analysis of variance at 55 days varied from year to year, genotype to genotype and location to location. Variance due to GCA varied from genotype to genotype, genetic to genetic and location to location. The results showed that GCA was significant in Upper Egypt for the 3rd growth stage, indicating that additive genetic effect played a great role in the genetics of SLA and could be effectively improved through phenotypic selection. The results of GCA variance in locations and years showed that significant mean square were found in Sakha location in both sowing dates, indicating that additive gene action are played for this character.

The obtained results of SCA mean squares revealed that significant Sakha location possessed most significant SCA variance for three growth stages i.e., 45, 55 and 65 days after sowing, showing that non-additive

gene action is the great role in the genetics of this character.

The ratio between σ^2GCA/σ^2SCA was more than unity for the three growth stages 45, 55 and 65 days in Sids for F1 and F2, explaining the importance of additive gene action in the gene expression in this character and could be effectively improved through phenotypic selection.

Mean squares concerning grain yield (ard/fed) for SCA were significant under two locations and both years, showing that non-additive gene action played a great role in the genetics of grain showing grain yield could be improved through hybrids breeding program in maize. these results are in a good connection with those reported by Mousa (1997); Aly (1999); Vekatesh *et al.* (2001); Habtamu (2002) and Sarma and Mukharjee (2002). On the other hand the ratio of σ^2GCA/σ^2SCA which was less than unity under two locations and two years. These results confirmed by Dawood *et al.* (1994), El-Zeir (1998) and Amer (2002).

*General combining ability effects (GCA):

Data of general combining ability effects (GCA) of leaf area/plant (LA/plant cm2) and total dry weight per plant "g" (TDW/plant) through three growth stages i.e., 45, 55 and 65 days after sowing and two different locations i.e., Sakha and Sids for F_1 and F_2 during two growing seasons i.e., 1999 and 2000 are given in Table (5).

The results of GCA effects for the 6 inbred lines showed that inbred lines No-2 and No-3 gave positive and significant GCA effect for leaf area and TDW/plant under the two different locations and years except inbred lines No-2 for Sids 1999(F_1), F_2 2000 after 45 days after sowing, indicating that these inbred lines could be involved in breeding program for improving leaf area/plant and TDW/plant in maize. While, inbred line No-6 possessed negative and significant GCA effects over years, generations and locations through three growth stages.

General combining ability effects of crop growth rate (CGR), Relatively growth rate (RGR) and Net assimilation rate (NAR) for two period of growth; 45-55 period and 55-65 days after sowing for the studied inbred lines over years, locations and generations are shown in Table (6).

In general, results indicated that inbred lines No-2 and No-3 gave positive and significant GCA effects for CGR, RGR and NAR in the growth period, locations and years, giving evidence that these inbred lines could be used in breeding program for improving physiological characters and consequently grain yield.

The results of inbred line No-6 showed that this inbred line possessed negative and significant GCA effects for CGR, RGR and NAR under the two growth primed, locations and years. These results revealed that this line is the poorest general combining for CGR, RGR and NAR physiological characters.

Table (7) present general combining ability effects for specific leaf area (SLA) during growth stages 45, 55 and 65 days after sowing for 6 inbred lines under locations and years and general combining ability effects for grain yield for 6 inbred lines of maize

The results indicated that the inbred line No-4 gave positive and significant GCA effects for SLA in 50% of the studied cases in both locations and years at 55 and 65 days after sowing. Meanwhile, inbred line No-1 gave positive and significant GCA effects for SLA at 45 days after sowing in 4 cases out of 6. These results indicated that inbred lines No-1 and No-5 could be employed to improving SLA in maize and consequently grain yield.

General combining ability effects of grain yield indicated that inbred lines No-2 had positive and significant GCA effects for F_1 and F_2 in the two growing season, so, this inbred line could be employed in maize breeding program to improve grain yield in maize. At the same time, this line possessed positive and significant GCA effects for most studied physiological characters. So, this inbred line is of great inbred to be breed to increase grain yield through physiological characters. This result is confirmed by Nevado and Cross (1990). The inbred line No-4 gave positive and significant GCA effect for grain yield ard/fed in most cases of F_1 and F_2 during summer seasons of 1999 and 2000, giving evidence that the breeder could be employed this inbred line for improving grain yield in maize. These results are of great attention for the maize breeder to improving grain yield through breeding and improving physiological characters that involves, leaf area, TDW, CGR, RGR, NAR and SLA. These

results are in accordance with those of Dawood *et al.* (1994), El-Zeir (1998), Mousa (1997), Aly (1999) and Amer (2002) for grain yield ard/fed.

* Specific combining ability effects (SCA):

Results of specific combining ability effects for various single crosses of maize resulted for half diallel 6 x 6 under two various locations, years and F_1 and F_2 for leaf area/plant and TDW/plant are given in Table (5).

The results of SCA effects for various crosses under different locations during three growth stages 45, 55 and 65 days after sowing for leaf area/plant showed that maize single crosses 2 x 3, 1x5 and 1x6 gave positive and significant SCA effects over years, locations (Sids and Sakha) and generations (F_1) through the three growth stages, indicating that these crosses could be further breed to improve leaf area/plant in maize crosses. Meanwhile, in general maize cross 2x5 possessed positive and significant SCA for F_1 and F_2 in the two locations through three growth stages.

Maize single crosses i.e., 2x3, 2x4 and 4x5 showed positive and significant SCA effects for total dry weight/plant during two summer growing seasons over two locations and generations F_1 and F_2 through three growth stages i.e., 45,55 and 65 days after sowing. These results indicated that these crosses are of great attention for the breeder to improve total dry weight/plant in maize crosses and consequently grain yield in maize.

The results of SCA effects for physiological characters (CGR, RGR and NAR) showed that SCA effects of various maize crosses varied from location to location and year to year as well as from generation to generation, showing that environmental variance played a great role in the gene expression of these characters and could be tested in various locations and years to isolate the high σ^2L and σ^2y and the interaction between them σ^2Lxy and detected the higher genotypic variability that is important for plant breeder to begin effecting breeding program for improving physiological characters, that sure with a great part in growing grain yield of maize.

As for crop growth rate, the results of SCA effects showed that single crosses 4 x 5, 1x5, 2x4 and 4x6 possessed positive and significant SCA effects through locations, years and generations

and giving evidence trend these crosses could be fruitful in breeding program for improving CGR in maize.

It is of great interest to note that no common cross was found for RGR and NAR in both of the two growth stages, either locations or years, showing that these crosses should be further tested in many locations and years.

Also, in Table (7) results of specific combining ability SCA effects of various crosses for SLA through growth stages 45, 55 and 65 days after sowing and grain yield ard/fed over two locations and various genotypes of maize, F_1 and F_2.

SCA effects of SLA show no common crosses that have positive effects over locations and years and growth stages, emphasizing that this character still affected by environmental and should be further tested in many locations and years. These results are emphasizing by Dehghanpour *et al.* (1996).

As for grain yield ard/fed as a resultant of the studied characters; 7 single crosses gave positive and significant SCA effects over years and locations as well as under generations. These crosses are; 1x2, 2x3, 2x4, 2x5, 3x6, 4x5, 4x6 and 5x6. Most of these crosses combinations contain inbred line No-2, which have positive and significant GCA effects for most of the studied physiological characters. These crosses must be tested in many locations and years to explain and evaluate their superiority for grain yield and then further used in Egyptian agricultural breeding programs to increase grain yield of maize.

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Table (1): Pedigree and origin of the studied maize inbred lines.

No	Name	Pedigree	Origin
1	Gemmiza-4	Isolation in Gemmeiza Research Station from different white populations imported from the International Institute of Tropical Agricultural (IITA)	Nigeria
2	Sids-7	Derived from America Early Dent	U.S.A.
3	Sids-34	Derived from America Early Dent	U.S.A.
4	Sids-63	Derived from Tepalcingo No.5 (Tep-5)	U.S.A.
5	Giza-76	Derived from 33gs(PI 221866x 307A)(S.C.14) W.D.93	Egypt
6	Giza-81	Derived from 38gs(PI 221866x 307A)(S.C.14) W.D.86	Egypt

Table (2): Mean squares of genotypes: general combining ability (G.C.A.) and specific combining ability (S.C.A.) for physiological characters; leaf area/plant (LA/plant Cm^2), total dry weight (TDW g./10 days) in half diallel crosses 6 x 6 inbred lines of maize through three growth stages in F_1 and F_2 during two Summer Seasons; 1999 and 2000 in Sakha (Middle Egypt) and Sids (Upper Egypt) locations.

Locations		LA/plant (45 days after sowing)						TDW (45 days after sowing)					
		Sakha			Sids			Sakha			Sids		
Years	D.f	1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F_1	F_1	F_2	F_1	F_1	F_2	F_1	F_1	F_2	F_1	F_1	F_2
Genotypes	20	** 5844070.5	** 6019232	** 4242013	** 2223216	** 3118736	** 1659798.3	** 814.9	** 717.8	** 219.0	** 88.31	** 173.5	** 127.1
G.C.A.	5	** 1540761.3	** 1173849.3	** 1075507.2	129138.9	** 347788.8	** 346156.8	181.93	** 175.91	** 91.51	7.52	18.48	** 47.67
S.C.A.	15	** 7278502.5	** 7634361.6	** 5297500.8	** 2921235.1	** 4042380.6	** 2097666.9	** 1025.89	** 898.46	** 261.59	** 115.24	** 80.96	** 153.65
Error	40	298262.4	77920	40459.1	253483.2	25278.4	47228.8	76.48	32.26	15.81	11.47	8.34	5.78
σ^2gca /σ^2sca		0.211	0.153	0.203	0.044	0.086	0.165	0.18	0.19	0.35	0.06	0.23	0.31
2σgca / {2σgca+2σsca}		0.30	0.23	0.29	0.27	0.17	0.28	0.262	0.281	0.412	0.115	0.313	0.383

Cont.

Locations		LA/plant (55 days after sowing)						TDW (55) days after sowing					
		Sakha			Sids			Sakha			Sids		
Years		1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V		F_1	F_1	F_2	F_1	F_1	F_2	F_1	F_1	F_2	F_1	F_1	F_2
Genotypes	20	** 7790950.5	** 3967923.2	** 1741459.2	** 6840525	** 3296352	** 1149856	** 2111.7	** 4365.9	** 2241.3	** 1321.8	** 1258.6	** 559.4
G.C.A.	5	* 1672089.3	* 964377.3	577536	* 921676.5	* 374898.9	** 941030.4	523.7	** 957.7	** 611.6	173.7	** 202.39	* 112.88
S.C.A.	15	** 9830476.5	** 4969113.6	** 2129394.9	** 8813491.5	** 4270137.6	** 1219449.3	** 2641.1	** 5502.0	** 2784.5	** 1704.5	** 1610.80	** 708.31
Error	40	432371.1	297779.1	307622.4	304960	94377.6	68601.6	284.9	172.6	107.8	148.2	30.81	40.70
σ^2gca /σ^2sca		0.170	0.194	0.271	0.104	0.087	0.771	0.19	0.17	0.22	0.10	0.13	0.16
2σgca / {2σgca+2σsca}		0.31	0.31	0.44	0.17	0.23	0.59	0.284	0.258	0.305	0.169	0.201	0.242

Table (2): Cont.

Locations	D.F.	LA/plant (65 days after sowing)						TDW (65) days after sowing					
		Sakha			Sids			Sakha			Sids		
Years		1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F1	F1	F2	F1	F1	F2	F1	F1	F2	F1	F1	F2
Genotypes	20	** 6696669.2	** 5751267.2	** 2780566.4	** 7941345.7	** 3788300.5	** 2315536.2	** 3343.1	** 7747.2	** 2806.8	** 4338.6	** 5059.95	** 2596.9
G.C.A.	5	** 1725887.7	** 3170784.9	** 2571753.3	** 2716252.7	** 2784606.4	** 3356938.5	* 2356.1	** 1654.9	** 1379.6	* 700.1	** 1087.16	** 2184.2
S.C.A.	15	** 8353696.4	** 6611427.9	** 2850170.8	** 9683043.4	** 4122865.2	** 1968402.1	** 3672.1	** 9777.9	** 3282.5	** 5551.5	** 6384.25	** 2734.6
Error	40	437724.8	255491.4	227873.8	535071.2	77488.3	81222.9	736.5	97.1	93.20	278.3	26.80	195.1
σ^2gca /σ^2sca		0.21	0.48	0.90	0.28	0.68	1.71	0.64	0.17	0.42	0.13	0.17	0.79
2σgca / (2σgca+2σsca)		0.29	0.48	0.64	0.58	0.58	0.74	0.562	0.253	0.457	0.201	0.254	0.615

Table (3) : Mean squares of genotypes; general combining ability (G.C.A.) and specific combining ability (S.C.A.) for physiological characters; crop growth rate (CGR g/10days), relative growth rate (RGR g/g/10 days) and net assimilation rate (NAR g/Cm^2/10 days) in half diallel crosses 6 x 6 inbred lines of maize through three growth stages in F_1 and F_2 during two Summer Seasons; 1999 and 2000 in Sakha (Middle Egypt) and Sids (Upper Egypt) locations.

Locations	D.F.	CGR (45-55 days after sowing)						CGR (55-65 days after sowing)					
		Sakha			Sids			Sakha			Sids		
Years		1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F1	F1	F2	F1	F1	F2	F1	F1	F2	F1	F1	F2
Genotypes	20	446.3*	1684.9**	1230.1**	740.4**	534.7**	198.91**	1000.2**	527.7**	250.3**	980.0**	1358.28**	256.06**
G.C.A.	5	130.2	431.2	371.9*	238.3	144.8*	57.81	1866.8**	204.5	274.9**	308.0*	442.31**	228.79**
S.C.A.	15	551.7**	2102.8**	1516.2**	907.8**	664.67**	245.95**	711.4**	768.8**	242.1**	1204.0**	1663.60**	265.15**
Error	40	207.8	217.1	115.0	172.2	42.90	44.92	228.2	214.0	49.4	103.1	57.57	70.58
σ^2gca /σ^2 sca		0.24	0.21	0.25	0.26	0.22	0.24	2.62	0.27	1.14	0.25	0.27	0.86
2σgca / {2σgca+2σsca}		0.32	0.29	0.33	0.34	0.30	0.32	0.839	0.347	0.694	0.338	0.47	0.633

Cont.

Locations		RGR (45-55 days after sowing))						RGR (55-65 days after sowing))					
		Sakha			Sids			Sakha			Sids		
Years		1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F1	F1	F2	F1	F1	F2	F1	F1	F2	F1	F1	F2
Genotypes	20	0.057	0.254**	0.136**	0.175**	0.118**	0.163**	0.071**	0.013**	0.024	0.018**	0.012	0.049**
G.C.A.	5	0.006	0.031	0.091*	0.261**	0.114*	0.080**	0.048	0.018**	0.014	0.015*	0.028*	0.091**
S.C.A.	15	0.075*	0.328**	0.152**	0.147*	0.120**	0.190**	0.079**	0.012*	0.028	0.018**	0.007	0.035*
Error	40	0.036	0.043	0.028	0.064	0.045	0.020	0.027	0.004	0.015	0.006	0.008	0.017
σ^2gca /σ^2 sca		0.08	0.09	0.59	1.78	0.95	0.42	0.61	1.50	0.50	0.83	4.00	2.60
2σgca / {2σgca+2σsca}		0.138	0.159	0.545	0.780	0.655	0.457	0.548	0.750	0.500	0.625	0.888	0.838

Table (3): Cont.

Locations		NAR (45-55 days after sowing)						NAR (55-65 days after sowing)					
		Sakha			Sids			Sakha			Sids		
Years	D.F.	1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F1	F1	F2	F1	F1	F2	F1	F1	F2	F1	F1	F2
Genotypes	20	29.63*	7.65	11.11*	25.79**	7.84	7.23**	23.45**	5.68	2.65	4.47**	2.52	3.42**
G.C.A.	5	23.1.2	2.89	2.96	7.98**	2.09	2.56	16.41	3.26	1.58	7.29**	2.43	4.97**
S.C.A.	15	31.80*	9.23	13.83**	31.73**	9.76	8.79**	25.79**	6.48	3.00	3.53	2.54	2.90*
Error	40	13.81	7.12	5.11	1.73	6.80	2.63	8.70	4.46	2.68	1.89	1.57	1.36
σ^2gca /σ^2sca		0.727	0.31	0.21	0.25	0.21	0.29	0.64	0.50	0.53	2.07	0.96	1.71
2σgca / (2σgca+2σsca)		0.592	0.385	0.299	0.335	0.299	0.368	0.559	0.502	0.513	0.805	0.657	0.774

Table (4): Mean squares of genotypes; general combining ability (G.C.A.) and specific combining ability (S.C.A.) for physiological character; specific leaf area (SLA Cm^2 /g) and grain yield (ard/fed) in half diallel crosses 6 x 6 inbred lines of maize through three growth stages in F_1 and F_2 during two Summer Seasons: 1999 and 2000 in Sakha (Middle Egypt) and Sids (Upper Egypt) locations.

Locations	D.F.	SLA (45 days after sowing))						SLA (55 days after sowing))					
		Sakha			Sids			Sakha			Sids		
Years		1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F1	F1	F2	F1	F1	F2	F1	F1	F2	F1	F1	F2
Genotypes	20	6125.5	44259**	38590.8**	24369.5*	16872.2**	10536.3**	2965	3012.8**	2711.6**	4785.4	494.6	1918.2**
G.C.A.	5	2598.8	9817	14269.6	29047.3*	5063.3	11956.7*	2476.6	1229.2	824.9	7051.2*	646.3	521.2
S.C.A.	15	7301.0	55739.6**	46697.8**	22810.2*	20808.4**	10062.8*	3127.8	3647.7**	3340.4**	4030.2	444.1	2383.8**
Error	40	6336.4	13221.4	11844.1	11334.9	5064.3	4103.4	2892.6	580.9	831.4	2174.7	454.9	367.3
$\sigma^2 gca / \sigma^2 sca$		0.36	0.18	0.31	1.27	0.24	1.19	0.79	0.34	0.25	1.75	1.46	0.22
$2\sigma gca / (2\sigma gca+2\sigma sca)$		0.416	0.260	0.379	0.718	0.327	0.704	0.613	0.403	0.331	0.78	0.744	0.304

Cont

Locations	D.F.	SLA (65 days after sowing)						Grain yield (ard/fed)					
		Sakha			Sids			Sakha			Sids		
Years		1999	2000		1999	2000		1999	2000		1999	2000	
S.O.V.		F1	F1	F2	F1	F1	F2	F1	F1	F2	F1	F1	F2
Genotypes	20	2483.5*	2363.7**	1305.8**	7952.2**	2515.3**	2256.5**	289.1**	353.4**	112.6**	206.2**	262.4**	146.0**
G.C.A.	5	3118.6*	622.3*	1492.7**	9152.6**	310.2	1159.8**	100.7**	49.4*	14.5*	13.90	11.4**	6.27
S.C.A.	15	2271.8*	2944.1	1243.5*	7552.1**	3250.4**	2622**	351.9**	454.8**	145.3**	270.2**	346.1**	192.6**
Error	40	669.3	203.6	397.1	897.9	132.2	273.7	11.66	17.60	5.24	9.60	2.15	3.29
$\sigma^2 gca / \sigma^2 sca$		1.37	0.21	1.20	1.21	0.09	0.44	0.29	0.12	0.10	0.05	0.03	0.03
$2\sigma gca / (2\sigma gca+2\sigma sca)$		0.733	0.297	0.706	0.708	0.160	0.469	0.36	0.18	0.17	0.09	0.06	0.06

Table (5): General combining ability (GCA) and specific combining ability (SCA) effects for physiological characters: leaf area/plant (LA/plant, Cm^2), total dry weight (TDW g./10 days) in half diallel crosses 6 x 6 inbred lines of maize through three growth stages in F_1 and F_2 during two Summer Seasons: 1999 and 2000 in Sakha (Middle Egypt) and Sids (Upper Egypt) locations.

Characters	LA/plat (45) days after sowing						TDW/plant (45 days) after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)	1999(F_1)	2000 (F_1)	2000(F_2)	1999(F_1)	2000 (F_1)	2000(F_2)
1	-204.3**	-102.0*	-135.2**	18.62	-71.5*	-51.7	-3.703*	-1.444*	-2.439**	0.021	-1.229**	-1.976**
2	416.5**	292.1**	259.7**	-3.62	80.2**	77.1	2.793	0.868	2.857**	0.417*	0.509	1.1276**
3	190.9**	270.0**	268.9**	123.0*	98.7**	134.1*	3.547*	5.014**	1.744*	0.288	1.245**	1.295**
4	-50.4	-132.6*	-101.1**	-36.3	4.3	-31.3	-0.907	-1.599**	-0.264	-0.458*	-0.035	1.022*
5	-128.9*	-115.8*	-65.4	-1.33	93.8**	74.7	-1.728	-2.440**	-0.810	0.596**	0.207	-0.139
6	-224.7**	-211.7**	[illegible]	-200.4*	-205.7**	-196.0**	-0.003	-0.399	-1.089	-0.862**	-0.696	-1.379**
1 x 2	464.8	784.2	371.8	427.1	600.1	302.1	5.35**	11.30**	4.02*	0.52	7.43**	6.20**
1 x 3	760.4	617.8	295.2	229.8	405.8	288.6	-0.06	1.11	4.33**	3.18*	-0.47	4.52**
1 x 4	148.1	187.0	329.7	634.2	500.1	138.4	2.69	4.97	-0.15	4.56**	1.99	-0.77
1 x 5	1063.6	1091.3	888.6	707.4	712.2	768.7	11.38**	8.11**	4.25*	6.37**	3.01*	-1.57
1 x 6	637.4	848.0	784.7	319.3	440.5	351.8	17.52**	12.27**	0.76	4.86**	4.55**	0.56
2 x 3	481.3	1049.0	994.9	680.8	645.8	490.8	9.57**	17.91**	4.30*	2.85*	3.41**	2.23*
2 x 4	1659.9	1309.8	1336.1	696.1	1217.3	986.9	15.23**	3.26	11.31**	5.96**	3.76**	5.24**
2 x 5	1143.8	1121.9	783.3	390.0	468.6	[illegible]	5.95*	9.16**	6.39**	1.41	5.91**	4.43**
2 x 6	1414.9	1038.3	963.3	531.5	352.9	400.7	8.95**	4.29	7.17**	0.13	2.32	2.80**
3 x 4	925.2	927.1	565.8	310.1	748.2	[illegible]	6.37*	17.04**	3.59**	2.19	9.50**	6.02**
3 x 5	393.4	335.5	470.3	462.7	443.2	136.8	15.06**	7.99**	5.2**	1.47	3.72**	3.88**
3 x 6	661.8	802.3	676.1	185.2	281.5	191.6	12.80**	16.34**	9.31**	4.59**	9.34**	4.45**
4 x 5	958.1	930.8	929.2	646.7	706.6	[illegible]	10.68**	4.83	3.98*	6.32**	6.15**	7.79**
4 x 6	1250.9	1361.3	955.6	1064.9	859.5	407.8	15.02**	9.62**	5.69**	0.41	2.52*	5.29**
5 x 6	[illegible]	[illegible]	-278.4	438.1	644.7	[illegible]	2.38	1.86	-1.99	0.75	2.39*	0.69
S.E. (gi)	48.8	82.0	37.4	93.8	39.6	40.4	1.629	0.611	0.741	0.210	0.423	0.448
S.E. S.	140.7	117.9	84.9	212.7	89.1	91.8	2.58	2.90	1.48	1.43	1.22	1.02

Table (5): Cont.

Characters	LA/plat (55) days after sowing						TDW /plant (55) days after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)
1	-125.8	85.6	107.3	2.33	44.8	30.4	-6.085**	0.126	-4.499	2.640**	0.436	-0.985
2	391.1**	133.7*	119.7*	135.91*	177.3**	212.5**	2.919	5.410*	7.285**	1.099	3.199**	2.411**
3	208.63**	294.1**	167.0**	144.87*	8.88	185.7**	6.949**	9.585**	8.51**	-1.418	2.490**	2.319**
4	-298.2**	-200.5**	-212.5**	-383.79**	-49.4	-114.9*	-1.643	-5.107*	-3.119	3.136**	-0.814	1.526*
5	133.4	-154.1**	-41.4	40.87	22.3	5.8	-3.339*	-3.965	-3.499	-1.931*	-0.335	1.365*
6	-309.1**	-158.7**	-140.2*	59.79	-204.0**	-319.6**	1.199	-6.049*	-4.682*	-3.526**	-4.976**	-3.585**
1 x 2	1208.6	676.4	599.7	90.9	648.0	461.5	23.34**	35.69**	5.31	12.72*	20.12**	13.86**
1 x 3	334.4	13.6	-186.1	452.6	549.2	-81.2	-3.82	7.22	18.74**	7.30	4.52	7.11**
1 x 4	424.4	370.7	162.4	919.9	115.9	-164.6	10.36*	22.88**	6.98	17.88**	9.26**	1.49
1 x 5	1194.0	1125.0	700.0	851.6	524.7	19.6	0.03	13.74*	13.72**	21.28**	14.35**	6.00*
1 x 6	1105.2	743.3	447.5	1072.3	273.4	135.8	37.06**	25.69**	22.11**	6.64	8.56**	0.68
2 x 3	1504.7	890.9	150.7	790.0	858.4	404.6	17.40**	37.54**	31.23**	12.41*	13.06**	-1.08
2 x 4	959.0	299.0	373.9	1708.3	889.0	987.9	11.96*	22.89**	34.46**	10.15*	15.53**	15.37**
2 x 5	833.7	975.3	670.6	683.0	347.2	-275.1	7.49	18.19**	2.21	17.75**	8.55**	3.54
2 x 6	748.5	552.8	250.7	909.4	248.6	-129.2	10.19*	11.84	8.59*	8.75	4.40	4.85
3 x 4	653.5	1193.9	218.0	1103.7	868.2	234.4	26.06**	26.72**	5.43	19.94*	17.34**	7.82**
3 x 5	444.5	704.3	915.9	481.1	342.4	-16.5	27.06**	20.21**	11.78**	2.94	2.23	6.19*
3 x 6	864.0	576.0	479.1	868.8	759.5	144.9	2.92	28.69**	13.06**	12.93*	16.94**	7.38**
4 x 5	1985.4	664.0	648.5	1600.1	1220.4	1251.7	18.69**	25.70**	23.74**	18.92**	20.17**	15.31**
4 x 6	1551.7	1246.7	1031.0	1126.8	1102.4	380.8	16.38**	29.02**	28.69**	4.65	13.91**	15.40**
5 x 6	51.9	-294.0	-602.3	437.8	310.3	16.08	16.41**	7.68	0.07	9.71	10.43**	9.50**
S.E. (g_i)	70.8	58.7	59.7	59.4	57.2	48.8	1.701	2.448	1.935	0.756	0.587	0.686
S.E. S_{ij}	277.8	230.5	234.3	233.3	129.8	110.6	4.98	6.72	4.38	5.14	2.34	2.69

Table (5): Cont.

Characters	LA/plant (65) days after sowing						TDW /plant (65) days after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)
1	-48.5	97.8	192.5*	637.4**	207.2**	122.4*	-3.599	1.41	-4.23*	6.671*	-0.093	-1.272
2	353.3**	333.7**	245.0**	-48.5	238.6**	479.7**	16.793**	7.68**	8.49**	1.700	6.74**	8.853**
3	250.8*	454.7**	414.8**	-35.2	372.1**	263.5**	5.331*	10.81**	10.44**	-5.458	6.76**	11.715**
4	-54.4	-78.2	-161.7	-323.2**	-73.0	-133.2*	-11.344**	-5.41**	-1.87	6.142*	1.16	2.211
5	-107.7	-415.1**	-375.8**	-3.5	-200.8**	-143.7**	-1.040	-3.21	-5.28**	-2.700	-3.58**	-9.851**
6	-393.4**	-392.9**	-314.8**	-226.8	-544.1**	-588.5**	-6.140**	-11.27**	-7.54**	-6.354*	-11.00**	-11.656**
1 x 2	518.3	761.1**	377.4	1745.4**	1027.7**	-599.8**	6.88	44.22**	5.52	16.86*	40.30**	28.95**
1 x 3	562.5	-263.5	-208.2	-18.7	206.9**	268.7	22.28**	8.53	15.17**	18.82**	3.67	11.58*
1 x 4	830.2*	845.8**	690.7	925.5*	205.1	-36.5	9.59	28.12**	1.05	22.49**	14.51**	3.18
1 x 5	1220.3**	963.0**	497.2	1695.6**	779.2**	-149.6	8.62	28.03**	8.93*	32.33**	32.72**	7.08
1 x 6	1719.7**	606.1*	423.3	1195.6**	375.8**	527.1**	40.92**	33.66**	14.15**	10.15	9.97**	-0.21
2 x 3	1154.2**	817.9**	115.2	152.5	667.1**	649.4**	21.65**	29.36**	26.28**	17.53*	32.97**	30.96**
2 x 4	445.1	527.0*	376.4	1471.6**	643.3**	941.2**	17.56*	36.34**	36.07**	21.86**	27.27**	22.30**
2 x 5	758.8*	1248.8**	665.6**	-612.9	153.1	568.4**	29.59**	37.68**	6.14	40.37**	22.49**	3.29
2 x 6	1111.4**	481.6	436.5	713.4	312.4*	563.1**	-4.30	20.08**	29.37**	21.62**	8.21**	8.33
3 x 4	839.5	1656.9**	109.1	313.8	718.8**	-288.3*	-3.23	37.39**	14.71**	40.22**	31.71**	25.0**
3 x 5	475.6	645.1*	987.3**	2160.8**	290.2*	-580.1**	37.05**	29.76**	11.05**	7.59	2.16	-1.93
3 x 6	-92.3	746.9**	928.8**	627.6	584.9**	337.7*	-2.94	44.39**	13.24**	16.51*	30.84**	9.66
4 x 5	1814.4**	908.1**	1165.7**	697.4	1557.1**	1763.0**	37.90**	34.28**	32.51**	33.26**	43.76**	32.03**
4 x 6	1013.2**	1112.6**	863.5**	1711.1**	992.1**	-149.9	20.90**	23.68**	22.10**	11.91	35.68**	28.74**
5 x 6	15.5	201.4	-702.3**	71.0	263.5	27.2	7.89	20.02**	10.37*	20.95**	14.83**	4.53
S.E. (g)	103.2	94.1	88.9	78.6	51.8	53.1	2.360	1.836	1.799	3.109	0.982	2.603
S.E. S_i	338.5	258.6	244.2	374.3	142.4	145.8	8.01	5.04	4.08	7.05	2.18	5.90

Table (6). General combining ability (GCA) and specific combining ability (SCA) effects for physiological characters; crop growth rate (CGR g/10days), relative growth rate (RGR g/g/10 days) and net assimilation rate (NAR g/Cm^2/10 days) in half diallel crosses 6 x 6 inbred lines of maize through three growth stages in F_1 and F_2 during two Summer Seasons; 1999 and 2000 in Sakha (Middle Egypt) and Sids (Upper Egypt) locations.

Characters	CGR (45-55) days after sowing						RGR (45-55) days after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)	1999(F_1)	2000 (F_1)	2000(F_2)	1999(F_1)	2000 (F_1)	2000(F_2)
1	-3.140	1.626	1.065	4.125**	1.414*	0.961	0.011	0.050*	0.098**	0.063	-0.096**	0.092**
2	0.197	4.556**	-0.322	2.188	2.818**	1.252*	-0.026	0.010	-0.090**	0.031	0.039	-0.032*
3	3.739*	4.626**	7.357**	-4.571**	1.370*	0.031	-0.010	-0.049*	0.009	-0.009	-0.018	-0.045**
4	-0.624	-3.328*	-2.343*	1.392	-0.653	-1.552**	0.001	-0.015	-0.031*	0.148**	0.034	-0.063**
5	-1.278	-2.011	-2.697*	-1.812	-0.786	1.513*	0.015	0.026	-0.022	-0.105*	-0.083**	0.017
6	1.106	-5.469**	-3.060**	-1.321	-4.161**	-2.204**	0.009	-0.023	0.035*	-0.128**	-0.068**	0.031*
1 x 2	10.67*	24.52**	-6.51	10.93**	12.95**	7.65*	0.031	-0.144	-0.175**	0.062	0.033	-0.195**
1 x 3	-3.00	5.09	15.27**	7.18	5.27	2.47	-0.050	-0.091	-0.081	0.255**	-0.083	-0.199**
1 x 4	5.36	17.87*	8.07	15.76**	7.56*	2.29	-0.043	-0.039	0.046	-0.153*	0.124*	0.036
1 x 5	10.55*	16.26*	9.92	14.43**	8.99**	7.59*	-0.260**	-0.229*	-0.133**	-0.273**	0.151*	0.143*
1 x 6	20.76**	13.38	22.2**	6.63	4.23	0.14	0.008	-0.257*	0.116*	-0.063	-0.083	-0.061
2 x 3	7.82	19.76**	27.6**	12.49**	9.53**	-3.29	0.004	-0.247**	0.037	0.024	0.079	-0.168*
2 x 4	-3.07	19.65**	23.9**	6.63	11.65**	10.10**	-0.181**	-0.015	-0.149**	0.177*	-0.012	-0.104
2 x 5	1.44	8.36	-2.85	15.83**	2.92	-0.88	-0.085	-0.215*	-0.287**	0.326**	0.218**	-0.216**
2 x 6	4.92	7.55	2.20	7.51	1.96	2.05	-0.080	-0.151	-0.269**	-0.030	0.157*	-0.130
3 x 4	19.61**	9.64	1.11	-5.17	7.73*	1.80	0.109	-0.312**	-0.108	0.247**	-0.221**	-0.217**
3 x 5	11.76*	12.86	7.53	0.19	-1.22	2.36	-0.060	-0.176	-0.124*	-0.074	0.189**	-0.156*
3 x 6	-9.71*	12.32	3.13	11.60**	7.51*	2.94	-0.219**	-0.324**	-0.305**	-0.187*	0.318**	0.191**
4 x 5	9.93*	21.38**	19.83**	15.83**	14.29**	7.52*	-0.068	-0.028	-0.004	0.075	0.090	-0.202**
4 x 6	1.54	19.24*	22.80**	6.83	11.30**	10.09**	-0.145**	-0.146	-0.031	-0.331**	0.199**	-0.126
5 x 6	14.23**	6.32	2.11	7.37	8.30*	8.79*	0.074	-0.080	0.043	0.202**	-0.281**	0.054
S.E. (g)	1.726	1.585	1.153	1.411	0.704	0.594	0.036	0.082	0.012	0.047	0.023	0.015
S.E. S_i	4.74	7.54	5.48	3.87	3.35	3.43	0.056	0.106	0.049	0.75	0.062	0.072

Table (6): Cont.

Characters	CGR (55-65) days after sowing						RGR (55-65) days after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)
1	4.065	1.226	-4.236**	0.430*	-0.404	-1.022	0.041	0.020	-0.003	0.038**	0.062**	0.003
2	14.249**	2.056	5.043**	0.385*	3.292**	0.665	0.057**	0.312*	0.023*	-0.015	0.002	0.034*
3	-0.089	4.172**	1.776*	-0.465*	5.154**	3.324**	-0.043*	-0.323	-0.018	-0.021*	0.013	0.080**
4	-12.014**	-3.690*	1.076	0.338	1.729*	3.586**	-0.042	0.028*	0.016	0.024*	-0.017	0.024
5	-1.410	1.856	-0.628	-0.344	-3.496**	-3.910**	0.018	0.006	0.019	-0.025*	-0.026**	-0.091**
6	-4.801	-5.619**	-3.032**	-0.345	-6.275**	-2.643**	-0.032	-0.043**	-0.037**	-0.001	-0.033**	-0.050**
1 x 2	-14.76**	8.36*	0.69	0.912**	20.02**	8.28	-0.177**	-0.050*	-0.042	-0.029	0.093**	0.050
1 x 3	16.87**	3.64	-3.11	1.015**	6.86	-1.04	0.097*	0.045*	-0.075*	0.033	0.085**	0.001
1 x 4	0.13	5.24	-5.44	1.025**	5.08	1.59	-0.104*	-0.033	-0.108**	-0.067**	-0.045	0.017
1 x 5	9.86*	9.79*	-5.63	0.967**	18.21**	1.19	0.016	0.042	0.135**	-0.005	-0.026	-0.014
1 x 6	14.58**	7.97	-7.50*	0.215	1.25	1.09	-0.084	0.001	-0.119**	-0.020	-0.053*	-0.005
2 x 3	2.75	-8.35*	-4.72	0.486	18.99**	-8.42*	-0.063	-0.073**	-0.080*	0.006	-0.019	0.236**
2 x 4	4.71	13.61**	1.74	1.037**	11.95**	8.54*	-0.047	0.019	-0.057	0.037	0.088	0.009
2 x 5	25.87**	19.50**	2.68	2.199**	14.14**	5.23	0.070	0.101	-0.010	0.131**	0.014	0.001
2 x 6	-16.89**	8.40*	2.09	1.253**	4.02	7.17	-0.177**	0.033	0.143**	0.080**	0.002	0.020
3 x 4	-28.11**	10.69*	9.41**	1.980**	13.46**	10.08*	-0.250**	-0.036	0.010	0.135**	0.040	0.090*
3 x 5	12.61**	8.65*	-1.98	0.522	-0.98	-1.68	-0.070	-0.061**	-0.056	0.073**	-0.057	-0.088*
3 x 6	5.94	15.69**	0.82*	0.410	12.99**	7.24	0.064	0.024	-0.001	-0.025	-0.044	0.001
4 x 5	-5.85	7.41	7.58*	1.392**	23.81**	8.58*	0.212**	0.005	-0.023	-0.056*	-0.030	0.081*
4 x 6	4.83	-5.01	-6.44*	0.680*	21.98**	10.42*	-0.108*	-0.060**	0.094**	0.033	0.046	0.127**
5 x 6	-6.90	11.17**	9.12**	1.182**	4.61	-4.35	-0.154**	0.088**	0.060	-0.013	0.035	-0.085*
S.E. (g_i)	2.815	1.573	0.756	0.189	0.816	0.903	0.022	0.013	0.012	0.011	0.010	0.014
S.E. S_i	4.46	4.26	3.59	0.301	3.88	4.29	0.048	0.022	0.036	0.023	0.027	0.038

Table (6): Cont.

Characters	NAR (45-55) days after sowing						NAR (55-65) days after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)
1	-1.300**	-0.031	-0.158	-0.621*	0.342*	0.362**	0.654	-0.008	0.264*	-0.993**	-0.181	-0.731**
2	-1.175**	0.403	0.271	-0.282	-0.083	-0.250*	1.229*	0.479*	0.026	0.079	0.178	0.157*
3	0.428	0.257	0.196	-0.290	-0.004	-0.330**	-0.465	0.200	0.214*	0.651**	0.465**	0.603**
4	0.629	0.065	0.421	0.904**	-0.158	0.401**	-1.069*	-0.204	-0.190	0.317*	0.128	-0.164*
5	0.426	-0.093	-0.225	-0.213	-0.478**	0.072	-0.004	0.242	0.097	-0.067	-0.160	-0.131
6	0.993*	-0.601*	-0.504*	0.502*	0.383*	-0.255	-0.345	-0.708**	-0.411**	0.013	-0.431**	0.265**
1 x 2	2.356*	1.983*	-0.179	0.284	1.965*	1.414*	-3.307**	0.262	-0.260	0.528	0.301	0.167
1 x 3	-1.738	1.696*	-1.104	1.282	0.320	-0.106	4.604**	0.275	0.319	0.866*	-0.353	0.021
1 x 4	-2.996**	2.787**	3.638**	0.198	-0.360	-0.838	-1.615	0.379	-0.243	-0.160	-0.682	0.721*
1 x 5	3.342**	1.721*	-1.117	2.339**	2.095**	2.658**	-0.807	0.433	0.136	0.984*	0.205	0.355
1 x 6	1.325	0.487	-0.137	1.446*	-0.101	-0.865	-0.423	0.750	1.511**	0.663	0.276	1.159**
2 x 3	-1.238	-0.237	0.267	2.447**	0.246	0.653	-1.398	0.121	-0.143	0.611	1.522**	0.501
2 x 4	-3.686**	0.354	0.175	1.333*	-2.435**	-1.959**	-0.551	1.392*	0.561	-0.231	0.960**	-1.699**
2 x 5	-0.120	-1.754*	-3.446**	2.803**	0.420	0.270	1.560	1.579*	0.540	-0.561	0.080	-0.199
2 x 6	-3.220**	-0.046	-0.667	1.697*	0.424	1.097	-3.458**	0.563	0.482	0.419	-0.149	0.805**
3 x 4	5.421**	0.567	-0.317	1.638*	1.353	1.054	-4.886**	0.371	-0.560	0.503	-0.228	-0.679*
3 x 5	-2.160*	0.592	-0.538	2.712**	3.240**	1.383*	0.432	0.291	0.119	0.701	0.026	0.488
3 x 6	-3.676**	-2.500**	-2.058**	2.259**	0.578	-0.023	0.456	1.742**	1.394**	0.240	1.097**	0.892*
4 x 5	-2.855**	1.317	0.571	1.048	0.595	0.152	3.349**	1.529*	0.523	0.799*	0.730*	0.288
4 x 6	-1.408	-0.542	-1.783**	0.629	-0.435	-2.788**	-1.333	-1.021	-1.102*	0.331	0.001	-0.874**
5 x 6	3.282**	-0.650	-1.833**	2.409**	-1.047	0.775	1.795	2.067**	1.277**	1.585**	1.122**	0.759**
S.E. (g_i)	0.423	0.0287	0.242	0.245	0.086	0.101	0.540	0.227	0.104	0.157	0.134	0.072
S.E. S_i	1.098	0.788	0.667	0.673	0.770	0.685	0.871	0.624	0.484	0.406	0.370	0.284

Table (7). General combining ability (GCA) and specific combining ability (SCA) effects for physiological character; specific leaf area (SLA Cm^2 /g) and grain yield (ard/fed) in half diallel crosses 6 x 6 inbred lines of maize through three growth stages in F_1 and F_2 during two Summer Seasons; 1999 and 2000 in Sakha (Middle Egypt) and Sids (Upper Egypt) locations.

Characters	SLA (45) days after sowing						SLA (55) days after sowing					
Location	Sakha			Sids			Sakha			Sids		
Years	1999(F_1)	2000 (F_1)	2000 (F_2)	1999(F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)
1	0.181	33.64**	25.0*	64.20**	24.14**	3.88	3.694	-5.574*	-2.29	-2.181	-4.61*	0.069
2	-0.069	-0.66	-34.7**	-7.79	-18.58*	-12.48	-0.681	-6.382*	-5.08	-7.306	-2.97	-3.681
3	-3.069	-22.24	3.18	-0.33	-0.40	6.09	-12.139**	-5.128*	-7.29*	2.903	-3.72	-7.972**
4	-0.569	-2.09	-11.86	-2.45	-9.51	-29.98	-6.806*	9.881**	7.58*	-23.722**	9.33**	4.278*
5	17.972**	9.39	-10.98	-12.25	5.77	-4.44	17.486**	-0.549	1.95	28.944**	0.103	4.11*
6	-14.444**	-18.0	29.43*	-41.37*	-1.41	36.93**	-1.556	7.751**	5.12	1.361	1.86	3.194
1 x 2	11.1	-47.3	-105.5**	55.7	-66.8**	-73.2**	17.7	-22.1**	5.04	5.6	-1.6	-5.45
1 x 3	76.0**	-1.8	9.8	-52.3	41.2*	-90.8**	47.5**	-12.4	-25.41**	-12.5	8.5	-10.83*
1 x 4	-63.0**	-67.7*	117.1**	-22.6	19.7	43.8*	-40.7*	-25.9**	-19.29*	9.3	-4.2	-28.74**
1 x 5	-20.9	-79.4*	148.3**	-140.4**	-22.1	-44.6*	26.6	1.8	1.66	-44.9**	3.1	-4.91
1 x 6	-49.5*	-111.5**	67.5*	-99.0**	-65.3**	35.6	-67.3**	-16.7*	-13.16	-43.0**	-16.5**	-0.32
2 x 3	-28.6	-114.8**	1.2	-37.0	-11.6	33.1	-17.7	-19.6**	-28.29**	3.8	0.4	3.92
2 x 4	13.5	-10.0	108.9**	-12.9	37.1	-37.0*	4.9	-27.7**	-37.83**	41.4**	10.9	-2.32
2 x 5	31.03	-3.6	105.4**	55.1	-59.4**	16.7	11.6	5.3	15.45	-15.5	9.0	-22.83**
2 x 6	69.3**	-29.3	128.0**	78.3*	-27.4	2.3	25.6	-5.7	-7.37	23.7	3.7	-30.58**
3 x 4	64.1**	-129.7**	-1.9	-48.3	-101.0**	13.0	-9.9	-14.8*	-8.29	19.6	18.1**	-12.37*
3 x 5	-17.6	-108.5**	-28.5	-4.6	-70.2**	-6.8	-9.5	-13.4	-0.66	-33.0*	9.2	-25.54**
3 x 6	-5.9	-135.6**	77.4*	-77.1*	-162.8**	-48.2*	21.4	-24.9**	-19.83*	5.5	4.4	-12.29*
4 x 5	-33.8	-48.6	69.5*	10.1	-21.9	105.1**	-8.8	-32.9**	-31.54**	-3.4	5.8	1.21
4 x 6	-23.4	-39.3	84.7**	136.9**	39.4	22.5	-18.8	-27.1**	-30.70**	35.8**	-6.1	-38.54**
5 x 6	-51.9	-81.6*	14.5	56.4	86.1**	56.6**	-29.4	-23.7**	-25.75**	-32.1*	-23.7**	-9.36
S.E. (g_i)	4.473	12.73	11.70	19.83	7.65	6.89	3.22	2.59	3.10	8.68	2.29	2.06
S.E. S_i	23.5	33.9	32.1	31.4	21.0	18.9	15.8	7.1	8.5	13.7	6.3	5.6

Table (7); Cont.

Characters	SLA (65) days after sowing						Grain yield (ard/fed)					
Location	Sakha			Sids			Sakha			Sids		
Year	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000 (F_2)	1999 (F_1)	2000 (F_1)	2000(F_2)
1	-10.56*	-1.036	-0.86	7.13	3.94**	3.833*	-0.011	-0.238	-0.392	0.144	0.074	-0.087
2	-14.31**	3.293	12.93**	13.34*	-3.99**	-4.780**	2.718**	2.043**	0.871**	0.486**	0.601*	0.414*
3	3.72	-3.249	-3.81	14.59**	-2.53*	-11.293**	0.381	1.113	0.288	-0.158	-0.967	-0.169
4	13.97**	0.885	-2.56	-25.61**	1.94	0.625**	1.557*	0.127	0.646**	0.693**	0.408	0.481*
5	10.59*	-7.240**	-10.11**	14.80**	-3.04*	3.628*	-2.669**	-1.242	-0.154	0.812**	0.303	0.197
6	-3.40	7.347**	4.43*	-24.27**	3.68**	7.988**	-1.976**	-1.807*	-1.258**	-1.982	-1.319**	-0.915**
1 x 2	17.8**	-27.8**	-26.5**	68.6**	-19.9**	-35.5**	7.79**	10.88**	5.02**	7.21**	7.70**	5.06**
1 x 3	2.8	-17.7**	-19.4**	-11.4	-3.9	-8.3	1.20	2.37	2.97*	4.25**	6.60**	5.21**
1 x 4	-7.4	-13.6**	11.6*	-38.2	-20.9**	-12.6**	4.78**	1.84	2.01	2.25	2.66**	1.46
1 x 5	-2.7	-8.7*	4.1	-36.6	-25.7**	-11.9*	4.27**	6.08**	1.81	6.29**	5.99**	3.88**
1 x 6	-26.7**	-13.6**	-3.6	-61.8**	-9.1**	14.7**	4.39**	6.83**	1.98	3.94*	3.68**	3.32**
2 x 3	-15.7*	-18.1**	28.4**	-5.3	-22.5**	-15.4**	8.36**	10.91**	3.71**	7.74**	8.59**	5.99**
2 x 4	-8.6	-26.4**	8.1	6.2	-28.3**	-10.6*	8.68**	6.55**	5.48**	9.02**	7.70**	6.37**
2 x 5	-15.3*	-8.0	-16.6**	-89.1**	-17.0**	-1.6	3.80*	6.17**	3.25**	4.77**	5.00**	4.22**
2 x 6	50.6**	-16.0**	-2.1	-6.4	-8.0*	-18.3**	7.37**	5.91**	4.66**	2.80	3.63**	2.97**
3 x 4	25.9**	-5.4	-15.7**	-53.0*	-15.8**	-29.8**	8.16**	11.26**	3.57**	2.83	6.48**	5.32**
3 x 5	46.3**	-8.6*	1.8	12.2	3.8	-14.8**	3.31	7.05**	5.00**	3.96*	1.69**	-0.12
3 x 6	7.6	-29.2**	-30.0**	-8.6	-21.5**	-10.4*	3.63*	8.39**	4.80**	6.47*	5.47**	4.78**
4 x 5	-23.2**	-18.4**	-15.4**	-20.2	-21.0**	-14.0**	6.00**	4.84*	5.71**	5.07**	7.86**	6.56**
4 x 6	-24.6**	-14.5**	-22.6**	64.1**	-32.1**	-38.7**	8.81**	7.48**	3.68**	5.64**	6.45**	4.20**
5 x 6	-38.5**	-19.1**	0.6	-25.5	-15.0**	11.2*	2.46	1.08	0.184	1.32	4.63**	2.85**
S.E. (g_i)	4.870	2.356	2.143	5.584	1.237	1.779	0.636	0.782	0.146	0.183	0.273	0.210
S.E. (S_i)	6.7	4.2	5.8	10.6	3.3	4.9	1.74	2.14	1.17	1.52	0.75	0.19

القدرة العامة والخاصة للائتلاف لبعض الصفات الفسيولوجية والمحصول فى الذرة الشامية

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تم عمل كل الهجن الممكنة فى نصف ديالل بين ستة سلالات من الذرة الشامية مختلفة وراثيا فى مساحة الأوراق والوزن الجاف للنبات و الصفات الفسيولوجية للحصول على ١٥ هجين فردى فى الموسم الصيفى ١٩٩٨ وذلك بهدف دراسة الفعل الجينى والقدرة العامة والخاصة على الإئتلاف المتحكمة فى وراثة بعض الصفات الفسيولوجية فى الذرة الشامية. وفى الموسم الصيفى ١٩٩٩ تم تقييم ستة اباء وخمسة عشر هجينا فرديا فى قطاعات كاملة العشوائية فى ثلاث مكررات تحت بيئتين مختلفتين محطة البحوث الزراعية سخا (وسط الدلتا) وسدس (مصر العليا) وكذلك تم عمل التلقيح الذاتى للهجن الفردية للحصول على بذرة الجيل الثانى الإنعزالى. وفى الموسم الصيفى ٢٠٠٠ تم تقييم ستة أباء وخمسة عشر هجينا فرديا وكذلك خمسة عشر الجيل الثانى الإنعزالى فى قطاعات كاملة العشوائية تحت نفس المنطقتين لصفات مساحة الأوراق/نبات ، الوزن الجاف/نبات ، معدل نمو المحصول ، معدل النمو النسبى ، صافى معدل النمثيل الضوئى والمساحة النوعية للورقة وكذلك محصول الحبوب إردب/فدان وذلك لمعرفة السلوك الوراثى لهذه التراكيب الوراثية وكيفية استخدامه فى تحسين هذه الصفات فى برامج تربية الذرة الشامية. أمكن تحليل البيانات المتحصل عليها إحصائيا ووراثيا طبقا لطريقة جرفينج (١٩٥٦) الطريقة الثانية - الموديل الأول . أظهرت النتائج أن النسبة بين القدرة العامة على التآلف والقدرة الخاصة على التآلف σ^2GCA/σ^2SCA كانت اكبر من الوحدة لصفة المساحة النوعية للورقة للثلاث مراحل نمو ٤٥ ، ٥٥ و ٦٥ يوم بعد الزراعة بالهجن الفردية تحت ظروف منطقة سدس خلال الموسم الصيفى ١٩٩٩ والجيل الثانى الإنعزالى عند عمر ٦٥ يوم بعد الزراعة تحت

ظروف منطقة سخا . بينما كانت النسبة بين تباين القدرة العامة على التآلف والقدرة الخاصة على التآلف σ^2GCA/σ^2SCA اقل من الوحدة لصفات مساحة الأوراق/ نبات ، الوزن الجاف / نبات ، معدل نمو المحصول ، المعدل النسبى للنمو ، صافى معدل التمثيل الضوئى ومحصول الحبوب أردب/فدان تحت ظروف كلا المنطقتين وخلال كلا من الموسمين الصيفيين ١٩٩٩و ٢٠٠٠ . أظهرت نتائج تأثيرات القدرة العامة على التآلف أن السلالتين (٢) و (٣) ذات تأثير موجب ومعنوى للصفات الفسيولوجية تحت الدراسة (مساحة الأوراق/ نبات ، الوزن الجاف / نبات ، معدل نمو المحصول و معدل النمو النسبى وصافى معدل التمثيل الضوئى تحت ظروف كلا المنطقتين وكذلك أظهرت السلالتين (١) و (٥) تأثيرات موجبة ومعنوية بالنسبة لصفة المساحة النوعية للورقة وأظهرت النتائج ان السلالة (٢) و (٤) ذات تأثير موجب ومعنوى بالنسبة لمحصول الحبوب إردب/فدان تحت ظروف كلا المنطقتين والموسمين الزراعيين ١٩٩٩ و ٢٠٠٠ .

وتعتبر بذلك تلك السلالات أنه يمكن استخدامهما فى تحسين الصفات الفسيولوجية والمحصول فى برامج تربية وتحسين الذرة الشامية. أوضحت النتائج الخاصة لتأثيرات القدرة الخاصة على التآلف أنها كانت موجبة ومعنوية للهجن والصفات التاليـة (٢ x ٣ & ١ x ٤ & ٤ x٢ &٥ x١٠ & ٥ x٤) و (٢ x ٣ & ٤ x ٢ & ٥ x ٤) و(٥ x ١ & ٦ x ١) و (٥ x ٦) و (١ x ٢ & ٣ x ٢ & ٤ x ٢ & ٥ x ٢ & ٣ x ٦ & ٤ x ٥ & ٤ x ٦) لصفات مساحة الأوراق/نبات ، الوزن الجاف /نبات ، معدل نمو المحصول ، صافى معدل التمثيل الضوئى و محصول الحبوب إردب/فدان. أظهرت هذه الدراسة ان تلك الهجن يمكنها ان تمد مربى النبات فى برامج تربية الذرة الشامية ببعض المعلومات الخاصة لتحسين محصول الحبوب من خلال تلك الصفات الفسيولوجية ويعتبر هذا الإتجاة من الاتجاهات الحديثة التى يهتم بها العالم فى الوقت الحاضر باستخدام تلك الصفات الفسيولوجية للوصول لأعلى إنتاجية ممكنة لمحصول الحبوب فى الذرة الشامية.