HETEROTIC RELATIONSHIPS AMONG DIFFERENT LOCAL AND EXOTIC YELLOW MAIZE (*Zea mays* L.) POPULATIONS

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ABSTRACT

Development of maize inbred lines is based on the identification and utilization of heterotic groups and patterns. A diallel mating design was done, includes different four local and three exotic maize populations, selected as parents to be used in this study. Parental populations and their 21 crosses were evaluated in four environments; i.e., Sakha, Gemmeiza, Nubaria and Mallawy Agriculture Research Stations. The objective of this study was to assess heterotic relationships among different local and exotic populations, and to evaluate combining ability among these populations to determine their potential as source germplasm to enhance grain yield. Results showed that environments effects were significantly different for all studied traits. SK21 and GMY populations produced the highest mean grain yield among the tested populations (7.26 and 7.05 Mg ha^{-1}), while, the crosses, having FRY population, had the highest mean grain yield (8.28 Mg ha^{-1}). The largest mid-parent heterosis (23.6%) was observed for FRY population. The mid-parent heterosis, among the crosses, ranged from 7% (SK21 x DT2) to 29% (GMY x FRY), with an average of 16.1%. The crosses, GMY X FRY, DT2 x FRY, FRY X POP59, SK21 X POP59 and SK21 X FRY, produced the highest mean grain yield among crosses, being 8.73, 8.43, 8.41, 8.34 and 8.24 Mg ha^{-1}, respectively. All these crosses had, at least, one exotic parent. FRY had the lowest parental mean plant height and the second largest significant GCA effect in the downward direction. Cluster analysis was done with mid-parent heterosis for grain yield to identify the diversity among the seven populations. Cluster I included the local populations (SK21, NDT, NY, and GMY), in addition to POP59. Cluster II included DT2 population, while, cluster III included FRY population. The highest SCA effect was observed among populations in cluster I x populations in cluster III. Average heterosis for FRY was 23.6.The present study suggested that the two exotic populations; i.e., FRY and POP59 on one side, with SK21 and GMY as the second one, represented a good germplasm source for the developing of new yellow hybrids. It is possible to create two base populations; i.e., A consisted of SK21 x GMY and B included FRY and POP59. Heterosis among A and B new populations would be the optimum for producing high yield hybrids

Key words*: Maize, Corn, Zea mays, GCA, SCA, Heterotic pattern, Diallel.*

Abbreviations*: GCA, general combining ability; SCA, Specific combining ability; NMRP, National Maize Research Program; Mg ha^{-1}, ton/hectare.*

INTRODUCTION

Choice of appropriate germplasm for inbred line development is critical for the success of crop breeding programs. In maize, a broad range of germplasm, from locally adapted to exotic material, has been used for breeding purposes. The success of maize breeding programs is based on the identification and utilization of heterotic groups and their patterns.

The importance of genetic diversity has been emphasized since the shift from double-cross to single-cross hybrids (Duvick, 1981; Hallauer and Miranda, 1988). Improved open-pollinated populations are valuable for the development of inbred lines, especially when considering the importance of having genetic diversity in the germplasm pool. Differences in background, origin and level of heterozygosity within and among populations are the basis of that diversity.

The identification of populations, as sources of inbred lines, is based on their agronomic performance, presence of useful genetic variance, high population mean and the heterosis observed from using them in crosses. Mid-parent heterosis values provide the basis for the identification of heterotic patterns among a fixed set of populations, and average heterosis and specific heterosis are the components in the expression of mid-parent heterosis. Average heterosis is indicative of the superiority of population crosses over the mid-parent values, while, specific heterosis indicated the heterosis observed in certain crosses (Hallauer and Miranda, 1988). Therefore, the utilization of mid-parent heterosis values, in both a practical and effective method, to identify heterotic responses among parents.

The use of exotic germplasm to broaden the germplasm base, used by maize breeders, has been widely emphasized (Beck *et al.*, 1991; Vasal *et al.*, 1992; Ron Parra and Hallauer, 1997), and introgression exotic germplasm is often suggested as an approach to increase genetic differences among opposing heterotic populations, thereby, potentially increasing heterotic response. Mungoma and Pollak (1988) reported that introgression has been used to introduce exotic germplasm to the Corn Belt Region, but, it is not clear how much exotic germplasm should be incorporated into an adapted germplasm. Hallauer and Miranda (1988) showed that plant breeders were faced with the task of identifying parents that, when crossed, might express maximum heterosis.

Genetic diversity can be increased by using exotic germplasm, as suggested by Goodman (1965), Moll *et al* (1965), Bridges and Gardner (1987) and Crossa *et al* (1987). Hallauer (1978) reported high levels of heterosis, expressed among exotic

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germplasm. Habliza (2004) reported that introduction of exotic germplasm into national maize research program could help in providing new heterotic patterns to maize breeders. Ismail (1999) indicated that several exotic populations were well adapted to the Egyptian environment and were directly utilized to develop some high yielding varieties and varietal crosses during the period, 1970 – 1980.

Several authors have reviewed heterotic patterns, used in the major maize production regions of the world (Wellhausen, 1978; Ron Parra and Hallauer, 1997). Heterotic patterns among European maize populations are strongly affected by genetic x environment interactions (GE) and no single heterotic pattern has been identified so far that is not subjected to GE effects. Therefore, to select the most suitable heterotic pattern across environments, it would be advisable not only to consider the two main effects (G and E), but also the GE interaction effects, to chose high and stable grain yielding population crosses.

The diallel mating design has been used as a method to analyze crosses, or parents and crosses, for estimating general combining ability (GCA) and specific combining ability (SCA) (Griffing, 1956), providing an assessment of their relative merits to guide selection and testing schemes.

A main objective of this study was to assess heterotic relationships among different local and exotic populations, while, the second objective was to evaluate combining ability among seven populations to determine their potential as source germplasm to enhance grain yield.

MATERIALS AND METHODS

The National Maize Research Program (NMRP) has developed high performance germplasm adapted to their environmental conditions. Out of them, four different local, in addition to three exotic maize populations (Table 1) were selected as parents to be used in this study. These populations were crossed in a diallel mating design at the breeding nursery of Nubaria Agriculture Research Station during 2007 season. Parental populations and their 21 crosses were evaluated in 2008 at four different environments; i.e., Sakha, Gemmeiza, Nubaria, and Mallawy Agriculture Research Stations, in a randomized complete block design at each environment, with four replications. Each plot included two 6-m rows, spaced at 0.80 m, with one plant, hills spaced at 0.25 m. Plots were planted and thinned to a density of 5.2 plants m^{-2} with one plant per hill (55000 plants ha^{-1}).

Data were recorded for grain yield (Mg ha^{-1}), ear length (centimeters from the bottom to the ear top), ear diameter (centimeters from the right to the ear left at mid-ear), number of days to mid-silking (number of days from planting to 50% of plants had extruded silks), plant height (centimeters from the soil surface to the node below the tassel), ear height (centimeters from the soil surface to the node below the upper ear) and percentage of late wilt resistance (number of resistant to total plants). Plots were hand-harvested, the ears were shelled and adjusted to grain moisture of 155 g kg^{-1}.

Data were analyzed by Griffing's diallel analysis (Griffing, 1956) Model 1 (fixed effects), Method 2 (parents and crosses together), according to the following model:

$$Y_{ijk} = \mu + b_k g_i + g_j + s_{ij} + e_{ijk}$$

Where, Y_{ijk} is the observed measurement for the ij^{th} cross grown in the k^{th} replication/environment combination; μ is the overall mean; g_i and g_j are the GCA effects for the i^{th} and j^{th} parents, respectively; s_{ij} is the SCA effect for the ij^{th} cross, b_k is the block effect and e_{ijk} is the error term associated with the ij^{th} cross evaluated in the k^{th} replication/environment. Entries were considered as fixed effects and replications and environments were considered as random effects. Because error mean squares were found to be homogeneous, means from the four locations were combined. Therefore, a combined analysis of variance was completed for each trait by the general linear model procedure, using SAS; PROC GLM (SAS system, Release 8.1, 2002). The entries sum of squares was, then, partitioned into the components of a diallel analysis Method 2. Test of significance for GCA and SCA was calculated, using GCA x E and SCA x E as dominator, respectively. Percent of heterosis was calculated with respect to the mid- parent, as the differences between cross mean and the mean of the two parent populations (Fehr, 1987) divided by the midparent value.

Table 1. Population, population abbreviation and germplasm description of the seven studied populations.

Population	Population abbreviation	Germplasm description
Gemmeiza Yellow population	GMY	Subtropical, semident grain, local population derived from different local and exotic germplasms.
Sakha-21	SK21	Subtropical, semident grain, local population derived from 21 different local and exotic germplasms.
Nubaria yellow population	NY	Subtropical, semident grain, local population derived from 15 different local and exotic germplasms.
Nubaria drought tolerant population	NDT	Subtropical, semident grain, local population derived from different drought tolerance local and exotic germplasms.
Drought tolerant population-2	DT2	Subtropical, semident grain, exotic population derived from different drought tolerance CIMMYT germplasms.
French yellow population	FRY	Temperate, flint grain, exotic population derived from different French F_2-hybrids.
Population-59	POP59	Semident grain, high oil germplasm, exotic population imported from Thailand.

RESULTS AND DISCUSSION

Combined mean squares for the studied traits are presented in Table 2. Results showed that environments were significantly different for all studied traits (Table 2), reflecting the variation among their environmental conditions. Environments x GCA interaction were significantly different for all studied traits except for ear diameter and plant height. Effects of SCA were significantly different for grain yield, ear length, ear diameter and number of days to mid-silking, while, the Env x SCA interactions were significantly different for all studied traits except for ear diameter and ear height. In addition, environments x GCA interaction were significantly different for ear height.

The ratio of K^2gca to K^2sca substantiates the relatively more important role of SCA effect for grain yield, ear length, ear diameter and number of days to mid-silking, reflecting the role of non-additive effects in determining these traits. Also, the ratio of K^2gca x Env to K^2sca x Env interactions reflected the relatively more important role of non-additive effects with environments interaction in inheritance of grain yield, ear length, number of days to mid-silking and plant height. On the opposite, this ratio reflected the more important role of additive effects in inheritance of ear length and late wilt disease resistance.

Grain yield:

All sources of variation of main effects, for grain yield, were significantly different, including their interaction with environment, except for GCA effect. SCA effects and their interaction with environments were significantly different. Parental grain yield means ranged from 6.43 Mg ha^{-1} for NY up to 7.26 Mg ha^{-1} for SK21, with an average of 6.83 Mg ha^{-1} (Table 3). A positive correlation coefficient between grain yield of the populations *per se* and their corresponding GCA values was found ($r = 0.78$). Therefore, selection of populations for this trait would be equally effective, using either the performance of the populations per se or their GCA values. The largest negative GCA effect was contributed by NY, with a value of -0.233 Mg ha^{-1}, while, the largest positive GCA effect of 0.172 Mg ha^{-1} was contributed by SK21 population (Table 4). The highest grain yield mean was found for FRY (8.28 Mg ha^{-1}) crosses, while, the lowest grain yield was observed for DT2 (7.64 Mg ha^{-1}) crosses, with an average of 7.92 Mg ha^{-1}, which significantly differed from the mean grain yield of parents.

Table 2. Mean squares for grain yield and other traits of the seven populations evaluated at four environments in 2008.

Source of variation	df	Grain yield	Ear length	Ear diameter	Number of days to mid-silking
Environments (Env)	3	303.03**	801.26**	11.62**	292.10**
Replications / Env	12	1.41	13.56	0.54	5.60
GCA	6	4.02	2.44	0.06	7.99
SCA	21	6.34**	3.48*	0.12**	11.72**
Env x GCA	18	2.53**	2.53**	0.07	7.73**
Env x SCA	63	1.36**	1.76**	0.04	5.04**
Combined error	324	0.35	0.91	0.06	0.45
CV		7.7	5.0	5.5	1.2
K^2gca		0.0	0.0	0.0	0.0
K^2sca		3.2	1.3	0.005	0.42
K^2gca x Env		0.08	0.06	0.0	0.26
K^2sca x Env		0.25	0.21	0.0	1.15

Source of variation	df	Plant height	Ear height	Late wilt resistance
Environments (Env)	3	114548.19**	55805.96**	9664.01**
Replications / Env	12	1977.49	1376.47	77.34
GCA	6	372.47	479.49	224.21
SCA	21	316.34	368.10	63.63
Env x GCA	18	225.75	500.26**	140.40**
Env x SCA	63	305.89*	216.46	40.47*
Combined error	324	214.06	171.46	28.75
CV		6.2	10.0	5.8
K^2gca		0.0	0.0	0.0
K^2sca		0.0	0.0	0.0
K^2gca x Env		0.0	11.7	3.99
K^2sca x Env		23.0	0.0	2.93

*,** Indicate significance at 0.05 and 0.01 levels of probability, respectively.

The crosses, GMY X FRY, DT2 x FRY, POP59 X FRY, SK21 X POP59 and SK21 X FRY, produced the highest mean grain yield among crosses, 8.73, 8.43, 8.41, 8.34 and 8.24 Mg ha^{-1}, respectively (Table 3). It is noticed that, at least, one parent of these crosses was an exotic germplasm. It is expected that, the heterotic effects among populations, were comparable to be less than the crosses among inbred lines, because each parent population was largely heterozygous in genetic makeup. However, large SCA effects were observed for a few population crosses. The largest SCA effects of 0.771^{*}, 0.756^{*}, 0.706^{*} and 0.630 Mg ha^{-1} were observed for the crosses, FRY X DT2, FRY X GMY, NDT X NY, and FRY x POP59, respectively (Table 4). Heterosis is expected among divergent crosses (Hallauer and Miranda, 1988). The superiority of these four crosses could be explained on the basis that they represented two divergent germplasm groups, since each cross had, at least, one exotic parent. The mid-parent heterosis for these crosses was 25, 29, 22, and 26 %, respectively, which were comparable to the heterosis exhibited by F$_1$ hybrids (Table 3). The highest average mid-parent heterosis was observed for FRY (23.6%), while, the lowest one was found for DT2 (11.3%). Melani and Carena (2005) found 19.6%, as the average mid-parent heterosis among ten maize populations. Also, Hallauer and Miranda (1988) reported similar results about heterosis, where they reported a value of 19.5% mid-parent heterosis as an average of forty experiments from 1893 to 1979. Soengas *et al.*, (2006) reported that the average heterosis was 11% for a diallel of ten flint and dent varieties. Because heterosis has been described as one of the best measures of genetic diversity (Hallauer and Eberhart, 1966; Hallauer and Miranda 1988; Mungoma and Polak, 1988) parental populations of the top performing crosses were expected to be genetically more diverse than the populations that exhibited little, absent, or negative heterosis. Results of the present study showed that three crosses showed heterosis values greater than 20%, which included GMY x FRY; FRY x POP59 and DT2 x FRY crosses (29, 26 and 25%, respectively). Falconer (1960) showed that heterosis was a function of difference in gene frequency, as well as dominance effect. These results are in correspondence with those obtained by Goodman (1965), Moll *et al*, (1965), Bridges and Gardner (1987), Crossa *et al* (1987), Habliza (2004) and Glover *et al.*, (2005), which showed that genetic diversity, in breeding programs, could be increased by using exotic germplasm.

It could be concluded that heterosis was independent from parental mean, as it was a function of the interaction between the two parents of the hybrid.

Table 3. Means of the seven populations (diagonal) and their F_1 crosses for grain yield (Mg ha^{-1}) (upper half) and their mid-parent heterosis (lower half) as averages of four environments.

Population	GMY	SK21	NY	NDT	DT2	FRY	POP59
GMY	(7.05)	8.15	7.86	7.87	7.72	8.73	8.12
SK21	14	(7.26)	7.77	8.11	7.62	8.24	8.34
NY	17	14	(6.43)	8.07	7.25	7.79	7.51
NDT	13	15	22	(6.84)	7.44	8.09	7.46
DT2	11	7	9	8	(6.92)	8.43	7.41
FRY	29	20	20	21	25	(6.52)	8.41
POP59	17	19	14	9	8	26	(6.79)
Average heterosis	16.8	14.8	16.0	14.6	11.3	23.6	15.5

$LSD_{0.05}$ for parents and crosses = 0.90.

Table 4. General combining ability (GCA) (diagonal), specific combining ability effects (SCA) (upper half), for the seven populations for grain yield under the four environments.

Population	GMY	SK21	NY	NDT	DT2	FRY	POP59
GMY	(0.149)	0.177	0.289	0.122	0.087	0.756^{*}	0.356
SK21		(0.172)	0.178	0.336	-0.035	0.248	0.557
NY			(-0.233)	0.706^{*}	-0.005	0.208	0.129
NDT				(-0.054)	0.008	0.324	-0.098
DT2					(-0.165)	0.771^{*}	-0.030
FRY						(0.171)	0.630
POP59							(-0.041)
SE (s_{gi})	0.35						

* Significant from zero at the 0.05 level.

Ear length:

Ear length averaged 18.2 cm, across four environments with a coefficient of variation of 5.0%. Mean squares for environments were highly significant, in addition, SCA effects and Env. x GCA and Env. x SCA interactions were significant (Table 2).

Results in Table 5 showed that DT2 parent had the largest mean ear length (18.7 cm), while, FRY had the lowest mean (17.4 cm). SK21 parent had the largest crosses mean ear length (18.6 cm), and GCA effect (0.18^{**}), contributing to increasing ear length in its crosses, while, NY parent had the lowest crosses mean (17.9 cm), and the lowest GCA effect (-0.21^{**}).

The largest SCA effects were observed for the crosses, NDT x NY, FRY x GMY, DT2 x GMY and DT2 x SK21, (0.67^{**}, 0.59^{**}, 0.54^{*}, and 0.53^{*}, respectively). The lowest SCA effects were detected for the crosses, NY x GMY, DT2 x NY, DT2 x NY and POP59 x DT2, (-0.76^{**}, -0.69^{**}, -0.58^{**}, and -0.58^{**}, respectively). The largest ear length among the 21 diallel crosses was associated with SK21 x DT2 cross (19.0 cm), while, the lowest ear length was found for GMY x NY cross (17.3 cm).

Table 8. Means of the seven populations (diagonal) and their F_1 crosses for plant height (cm) (upper half), specific combining ability effects (s_{ij}) (lower half), and general combining ability effects (g_i), as average of four environments.

Population	GMY	SK21	NY	NDT	DT2	FRY	POP59
GMY	(236.8)	240.2	228.6	237.3	244.1	240.9	234.7
SK21	0.23	(241.6)	235.1	240.1	244.5	242.9	235.9
NY	-7.27 **	-3.27	(236.7)	239.8	242.4	229.4	236.1
NDT	0.65	0.96	4.83 **	(233.1)	230.6	239.2	238.4
DT2	4.89 **	2.77	4.77 **	-7.75 **	(235.9)	241.9	239.9
FRY	4.98 **	4.48 **	-4.83 **	4.15 *	4.21 *	(227.7)	235.6
POP59	-2.19	-3.50	0.81	2.42	1.23	0.31	(236.7)
GCA effect	0.05	2.55 **	-1.57 *	-0.80	1.82 *	-1.51 *	-0.53
SE (g_i)	0.65						
SE (s_{ij})	1.89		SE ($s_{ij} - s_{kl}$)		2.22		

*,** Indicate significance from zero at o.o5 and 0.01 levels of probability, respectively.
$LSD_{0.05}$: crosses and parents = 12.0.

Ear height:

Ear height averaged 130.4 cm across the four environments, with a coefficient of variation of 9.5%. Mean squares for environments and Env. x GCA interaction were highly significant (Table 2).

Ear height among the parental populations, in the diallel, was quite variable, leading to several significant GCA effects (Table 9). GMY and SK21 parents had the largest mean ear height (135.4 and 130.8 cm), while, FRY had the lowest parental mean ear height. The largest GCA effects in the downward direction were for FRY, POP59 and NY (-0.24, -1.86 and -1.15). The largest SCA effects were in the negative direction, for the crosses of POP59 x GMY and NY x GMY (-7.20**, and -4.72**), decreasing ear height by 12.3 and 9.2 cm.

Table 9. Means of the seven populations (diagonal) and their F_1 crosses for ear height (cm) (upper half), specific combining ability effects (s_{ij}) (lower half), and general combining ability effects (g_i), as average of four environments.

Population	GMY	SK21	NY	NDT	DT2	FRY	POP59
GMY	(135.4)	135.3	126.2	132.1	136.9	134.2	123.1
SK21	0.64	(130.8)	130.5	135.9	137.4	135.8	129.7
NY	-4.72 **	-1.25	(126.5)	136.8	131.2	126.8	128.2
NDT	-0.19	2.78	7.41	(122.2)	128.7	133.2	133.4
DT2	3.94	3.54	1.05	-2.73	(127.5)	129.0	132.9
FRY	4.31	5.09	-0.21	4.89	-0.04	(117.4)	129.2
POP59	-7.20 **	-1.42	0.84	4.68	3.44	2.93	(125.1)
GCA effect	1.71	2.55	-1.15	0.13	0.87	-2.24	-1.86
SE (g_i)	0.45						
SE (s_{ij})	1.31		SE ($s_{ij} - s_{kl}$)		1.54		

*,** Indicate significance from zero at o.o5 and 0.01 levels of probability, respectively.
$LSD_{0.05}$: crosses and parents = 11.8.

Late wilt resistance:

Overall mean of late wilt resistance was 92.1%, with a coefficient of variation of 5.8%,. Effects of environments and environments with GCA and SCA interactions were the only significant variations (Table 2).

SK21 parent population had the largest significant GCA of 1.36, and had the highest mean of the late wilt resistance (93.68%), (Table 10). The largest SCA effects were observed for the crosses, FRY x DT2, POP59 x SK21, NDT x GMY and DT2 x NY (3.50, 2.87, 2.74, 2.57 and 2.45, respectively). The crosses mean ranged from 90.70% (NY) to 93.62% (SK21). The highest late wilt resistance, among the 21 diallel crosses, was associated with the cross, SK21 x POP59 (97.07%), while, the lowest value was associated with the cross, NY x FRY (88.19%).

Table 10. Means of the seven populations (diagonal) and their F_1 crosses for late wilt disease resistance (%) (upper half), specific combining ability effects (s_{ij}) (lower half), and general combining ability effects (g_i), as average of four environments.

Population	GMY	SK21	NY	NDT	DT2	FRY	POP59
GMY	**(90.26)**	93.71	90.59	94.91	93.91	92.29	95.30
SK21	-0.25	**(93.68)**	90.77	93.72	93.37	93.10	97.07
NY	0.46	-0.24	**(85.23)**	92.13	92.72	88.19	89.84
NDT	2.57 **	0.51	2.74 **	**(88.99)**	90.35	93.15	92.26
DT2	0.70	-0.71	2.45 **	-2.11	**(92.23)**	95.75	91.85
FRY	0.18	0.11	-0.98	1.78	3.50 **	**(89.48)**	91.10
POP59	1.98 **	2.87 **	-0.52	-0.31	-1.59	-1.24	**(92.96)**
GCA effect	0.49	1.36	-2.46	-0.26	0.62	-0.47	0.72
SE (g_i)	0.38						
SE (s_{ij})	0.62		SE ($s_{ij} - s_{kl}$)		0.96		

*,** Indicate significant at o.o5 and 0.01 levels of probability, respectively.
$LSD_{0.05}$: crosses and parents = 5.59.

Cluster analysis for heterosis among populations:

Cluster analysis was done with mid-parent heterosis for grain yield to identify the diversity among the seven populations. The procedure classified the seven populations into three clusters for a distance of 0.5 (Fig. 1).

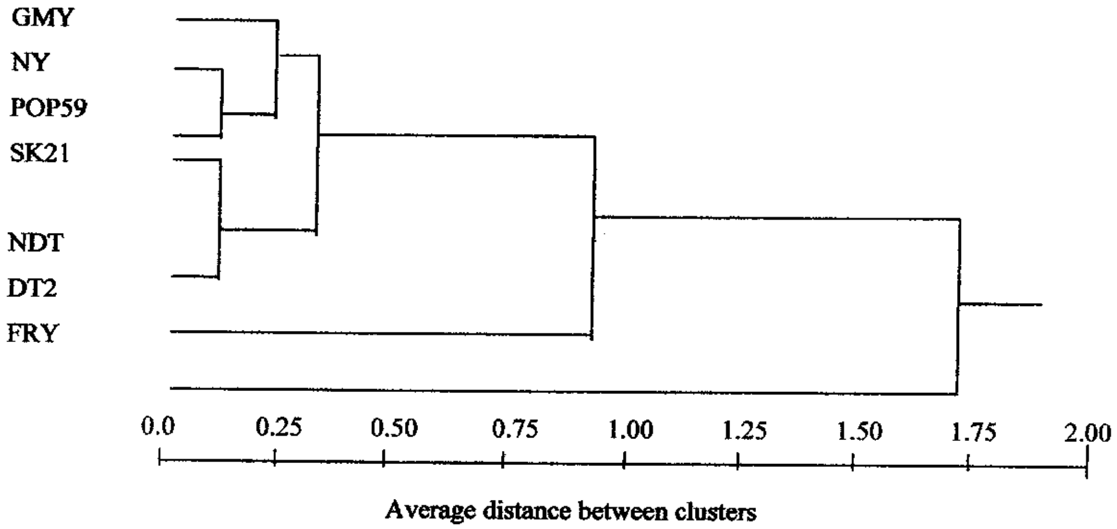

Fig. 1. Cluster analysis using midparent heterosis for grain yield.

Cluster I included the local populations (SK21, NDT, NY and GMY), in addition to POP59. Cluster II included DT2 population, which was derived from CIMMYT, Mexico. Cluster III included FRY population, which derived from different French F_2 hybrids, imported from France. Genetic divergence among the local populations might be smaller because of a possible common structural of the populations. The highest SCA effect was observed among populations in cluster I x populations in cluster III. Average heterosis for FRY was 23.6.

CONCLUSIONS

The value of K^2GCA to K^2SCA suggested that SCA was more important than GCA and consequently, non-additive than additive effect, in inheritance of grain yield, ear length, ear diameter and number of days to mid-silking. Also, the ratio of K^2GCA x Env. to K^2SCA x Env. interactions suggested that SCA was more affected by environment than GCA, except for ear height and late wilt resistance.

The GCA effect for grain yield fluctuated from one environment to another. The highest grain yield mean was found for crosses having FRY as a parent (8.28 Mg ha^{-1}). The crosses, GMY X FRY, DT2 x FRY, FRY X POP59, SK21 X POP59 and SK21 X FRY, produced the highest mean grain yield among crosses, being 8.73, 8.43, 8.41, 8.34 and 8.24 Mg ha^{-1}, respectively. The largest SCA effects were observed for the crosses, FRY X DT2, FRY X GMY, NDT X NY and FRY x POP59, respectively. The highest mid-parent heterosis for these crosses was 25, 29, 22, and 26 %, respectively, indicating that SCA was important to the grain yield of the superior crosses.

DT2 parent had the largest mean ear length (18.7 cm), while SK21 parent had the largest crosses mean for ear length (18.6 cm), with GCA effect (0.18**). DT2, FRY and POP59 parents had the highest mean ear diameter (4.5 cm for each). The crosses of FRY had the highest mean ear diameter (4.55 cm). FRY had the lowest parental mean plant height and the second largest significant GCA effect in the downward direction. FRY had the lowest population mean ear height.

Finally, the present study suggested that the two exotic populations; i.e., FRY and POP59 on one side with SK21 and GMY as the second one represented a good germplasm source for developing new yellow hybrids. It is possible to create two base populations namely, A consisted from SK21 x GMY and B included FRY and POP59. Heterosis among A and B new populations would be the optimum for producing high yield hybrids.

REFERENCES

Beck, D.L., S.K Vand J. Crossa. 1991. Heterosis and combining ability of CIMMYT's tropical and intermediate maturity maize germplasm. Maydica 35 : 279- 285.

Bridges,W.C.,Jr. and C.O.Gardner. 1987. Foundation populations for adapted exotic crosses. Crop Sci. 27:501-506.

Crossa, J., C.O.Gardner and R.M. Mumm. 1987. Heterosis among populations of maize (*Zea mays* L.) with different levels of exotic germplasm. Theor. Appl. Genet. 73:445-450.

Duvick,D.N. 1981. Genetic Diversity in Corn Improvement. P. 48-60. In H.D. Loden (ed.) Proc. 36th Annu. Corn Sorghum Res. Conf., Chicago, IL. 9-11 Dec. 1981. Am. Seed Trade Assoc., Washington, DC. USA.

Falconer,D.C. 1960. Introduction to Quantitative Genetics. Ronald Press, New York, USA.

Fehr,W.R. 1987. Principals of Cultivar Development. Mc. Millan Publishing, Co., NY, U.S.A.

Eberhart,S.A. 1971. Regional maize diallels with U.S. and semi-exotic varieties. Crop Sci. 11:911-914.

Glover,M.A., D.B.Willmot, L.L.Darrah. B.E.Hibbaed and X.Zhu. 2005. Diallel analysis of agronomic traits using Chinese and U.S. maize germplasm. Crop Sci. 45:1096-1102.

Goodman , M.M. 1965. Estimates of genetic variance in adapted and exotic populations of maize. Crop Sci. 5:87-90.

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

Hallauer, A.R. 1978. Potential of exotic germplasm for maize improvement. In: International Maize Symposium, W.L.Walden, ed., pp. 229-247. McGraw-Hill, New York, USA.

Hallauer, A.R. and J.B. Miranda, 1988. Quantitative Genetics in Maize Breeding. 1st ed., Iowa State Univ. press, Ames, IA, USA.

Habliza,A.A. 2004. Heterotic patterns among eight exotic and local yellow maize populations. J. Agric. Sci. 29: 2951-2961. Mansoura Univ.,.

Ismail,A.A. 1999. History of maize development in Egypt. In: Proc. 1st Plant Breed. Conf., Egypt. J. Plant Breed., 3:149-158.

Melani,M.D. and M.J.Carena. 2005. Alternative maize heterotic patterns for the northern corn belt. Crop Sci. 45:2186-2194.

Mickelson,H.R., H.Cordova, K.V.Pixley and M.S.Bjarnason. 2001. Heterotic relationships among nine temperate and subtropical maize populations. Crop Sci. 41:1012-1020.

Moll, R.H., J.H.Lonnquist, J.Velez-Fortuno and E.C.Johnson. 1965. The relationship of heterosis and genetic divergence in maize. Genetics 52:139-144.

Mungoma,C. and L.M.Pollak. 1988. Heterotic patterns among ten Corn Belt and exotic maize populations. Crop Sci. 28:500-504.

Ron Parra,J. and A.R.Hallauer. 1997. Utilization of exotic maize germplasm. Plant Breed. Rev. 14:165-187.

SAS. 2002. The SAS System. Version 8.1. SAS Institute Inc., Cary, NC.

Soengas,P., B.Ordas, R.A.Malvar, P.Revilla and A.Ordas. 2003. Heterotic patterns among flint maize populations. Crop Sci. 43:844-849.

Vassal, S.K., G.Srinivasan, J. Crossa and D.L.Beck. 1992a. Heterosis and combining ability of CIMMYT's subtropical and temperate early-maturity maize germplasm. Crop Sci. 32:884-890.

Vassal, S.K., G.Srinivasan, F.C.Gonzalez, G.C.Han, S. pandey, D.L.Beck and J. Crossa. 1992b. Heterosis and combining ability of CIMMYT's tropical x subtropical maize germplasm. Crop Sci. 32:1483-1489.

Vassal, S.K., G.Srinivasan, S. pandey, F.C.Gonzalez, J. Crossa and D.L.Beck. 1993. Heterosis and combining ability of CIMMYT's quality protein maize germplasm: I. Lowland tropical. Crop Sci. 33:46-51.

Wellhausen,E.J. 1978. Recent developments in maize breeding in the tropics. P.59-91. *In*: D.B.Walden (ed.) Maize Breeding and Genetics. John Wiley & Sons, N. Y, USA.

الملخص العربى

العلاقة الائتلافية بين عشائر صفراء محلية مختلفة ومستورده من الذره الشامية

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أجريت هذه الدراسة على سبع عشائر مختلفة المصدر الوراثى (أربع عشائر محلية وثلاث مستوردة) وذلك بهدف دراسة العلاقة بينها. تم عمل كل الهجن الممكنة بين العشائر تحت الدراسه فى تصميم تبادلى فى موسم ٢٠٠٧. تم تقييم العشائر والهجن الناتجة (٢١ هجينا) فى تصميم قطاعات عشوائيه كامله فى أربع محطات بحثية (سخا والجميزة والنوبارية وملوى) خلال موسم ٢٠٠٨.

- أوضحت النتائج فروقا معنوية بين المواقع المختلفة وذلك لكل الصفات تحت الدراسة. كانت قيم K^2SCA أكبر منها لقيم K^2GCA لصفات محصول الحبوب و طول الكوز و قطر الكوز وعدد الأيام حتى منتصف التزهير مما يوضح أهمية التأثير الوراثى غير المضيف ، كذلك كانت قيم K^2SCA x Env. أكبر منها لقيم K^2GCA x Env. لنفس الصفات السابقة بالاضافة الى صفة ارتفاع النبات عدا صفة قطر الكوز. بينما كانت قيم K^2GCA x Env. أكبر منها لقيم K^2SCA x Env. لصفتى ارتفاع الكوز والمقاومة لمرض الذبول المتأخر مما يوضح أهمية التأثير الوراثى المضيف مع البيئات المختلفة لهذه الصفات.
- أعطت العشائر " SK21 وGMY " أعلى القيم لمتوسط محصول الحبوب للعشائر المختبرة (٧,٢٦ و٧,٠٥ طن/هكتار) ، بينما اعطت العشيرة " FRY " أعلى القيم لمتوسط محصول الحبوب للهجن الناتجة (٨,٢٨ طن/هكتار). كما ظهرت أعلى قيمة لقوة الهجين بالنسبة لأعلى الاباء بين العشائر فى العشيرة " FRY " حيث أعطت متوسط تفوق قدرة ٢٣,٦%. أعطت الهجن" GMY X FRY ، SK21 X POP59 وFRY X POP59 و DT2 x FRY و SK21 X FRY " حيث أعطت ٨,٣٧ و ٨,٤٣ و ٨,٤١ و ٨,٣٤ و ٨,٢٤ طن/هكتار على التوالى.
- أظهرت العشيره " SK21 " أعلى قيمة للقدرة العامة على التآلف (GCA) لصفة محصول الحبوب ، بينما أعطت العشيرة "NY " أقل قيمة. بينما أظهرت العشيرة " FRY " أعلى قيمة للقدرة الخاصة على التآلف (SCA) لصفة محصول الحبوب مع كل من العشيرتين " SK21 و "POP59 ".
- أعطت العشيرة " NY " أعلى القيم السالبة لتأثيرات GCA لصفة عدد الأيام لظهور ٥٠% من الحرائر ، بينما أعطت العشيرة "FRY " أقل القيم لمتوسط ارتفاع النبات واحتلت المرتبة الثانية لقيم GCA فى اتجاة خفض ارتفاع النبات.
- أعطت العشيرة " SK21 " أعلى متوسط لنسبة النباتات المقاومة لمرض الذبول المتأخر بالاضافة الى أعلى القيم لتأثيرات GCA لهذه الصفة.
- أوضحت هذه الدراسة أن العشائر المستوردة " FRY و POP59 " من جانب والعشائر المحلية " SK21 و GMY " من جانب آخر يمكن الاستفاده منها فى استنباط هجن صفراء جديدة. ويمكن تكوين عشيرتين أساس جديدة هما العشيرة (A) وتشمل SK21 x GMY والعشيرة (B) والتى تتكون من FRY x POP59 ومن المتوقع ان تكون قوة الهجين بينها مناسبة لانتاج هجن عالية المحصول.