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GENETIC DIVERGENCE IN RELATION TO HETEROSIS, COMBINING ABILITY AND PERFORMANCE OF SOME MAIZE HYBRIDS

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ABSTRACT

To estimate the genetic parameters for a local maize population *(Zea mays L.)*. Half diallel cross mating design was used. The data showed the best crosses (M10xM11) and (M11xM18) for grain yield /plot; and (M10xM12) for plant height and days to tasseling; (M11xM16) for 100-kernel weight; (M15xM18) for number of rows/ear, number of kernels/row and 100-kernel weight; (M12xM16), (M13xM15) and (M14xM18) for plant height (towards shortness) and ear height (towards low ear placement); and the cross (M16xM18) for days to tasseling towards earliness and grain yield/plot. Generally, most studied traits showed significant differences for G.C.A mean squares except, number of rows/ear and plant height at the two years and combined data. Highly significant specific combining ability (S.C.A) mean squares, were found for most studied traits. For crosses x years interaction mean squares show highly significant differences for most studied traits were found. while for number of rows/ear, plant height, and days to tasseling non- significant differences were observed For G.C.A x years mean squares the data showed divided between the seven traits under study. For S.C.A x years mean squares, highly significant differences for most studied traits were found The ratio between K^2G.C.A / K^2S.C.A. was found to be less than unity at the combined data for most studied traits except for days to tasseling indicating that, the dominance genetic variance controlled the behavior of most studied traits rather than the additive ones. Generally the best inbred line was M18 for ear diameter at the two growing years and the combined data, for 100-kernel-weight at the second year and combined data, and plant height (toward shortness) at the first year and combined data. The best crosses were (M11xM16) for 100-kernel-weight (M13xM15) for ear height (towards low ear placement) at the two years and combined data. The percentages of economic heterosis of F_1 hybrids relative to the check variety (S.c155) were ranged from (1.60% to 33.66%) positive desirable values and from (-5.78%) to (-6.40%) negative desirable values at combined data. Heterosis could not be considered as a function of genetic divergence. Moreover, genetic distance based on morpho-agronomical markers was not significantly correlated with specific combining ability, heterosis and the mean performance. Hence, it is impossible to predict the hybrid performance from genetic distance itself.

INTRODUCIION

One of the main objectives for maize breeders is the development of genotypes, which show superior performance over different environments. The development of more efficient breeding procedures is dependent upon a better understanding of the types of gene action controlling the inheritance of quantitative traits. It was stated that the diallel cross mating design as one of the most important methods used to give genetic information about the parents and their crosses (Jennings *et al.* 1974). Breeders of maize estimated general combining ability (G.C.A.) and specific combining ability (S.C.A.) in their breeding programs to understand the type of gene action controlling their studied traits. Some of them found that (G.C.A.) /(S.C.A.) is more than unity i.e., Nawar and El-Hosary (1985); Mousa (1996); Vicente *et al.* (1998); Dutu (1999); Rameeh *et al.* (2000); Daiyuan *et al.* (2003); Haiqiu *et al.* (2003); and Abd El-Hadi *et al.* (2004).

On the other hand, the ratio (G.C.A.)/ (S.C.A.) was found to be less than unity by Kalsy and Sharma (1970); Nawar *et al.* (2002); Rabie *et al.* (1997); Has (1999); EL-Absawy (2000); Leon (2000); Suneetha *et al.* (2000); Turgut (2001); El-Shenawy *et al.* (2002); Amer (2003); Barakat *et al.* (2003); GuangCheng *et al.* (2003) and Mousa (2003) for grain yield and some of its components .Some others found sharing of (G.C.A.) and (S.C.A.), i.e., Galal *et al.*(1978); Nawar *et al.* (1981); Nawar and Gomaa (1982); Nawar and El-Hosary (1985); and El-Zeir *et al.* (1993); Dawood *et al.* (1994); Ragheb *et al.* (1995); Kumar *et al.* (1998); El-Hosary *et al.* (2001); Mandal *et al.* (2001); Amer (2003); and Abd El- Hadi *et al.* (2004).

Hence, the estimate of genotype x environment interactions is playing a major role for breeding programmes since the environmental factors are usually in a continuous state of changing. Genetic diversity can be considered a source of the genetic variation in germplasm, which provides maize breeders with the best knowledge to success their programs. Many others used genetic diversity at the phenotypic levels to asses maize genetic diversity (Smith, (1986); Melo *et al.* (2001); Mohammdi and Prasanna (2003); Betran *et al.* (2003); Menkir *et al.* (2004) and Mohamed (2005).

Therefore, the main objectives of this study were to:

1) Study the general and specific combing ability and their interactions with years.
2) Estimating economic heterosis % relative the check variety S.c 155.
3) Selecting the most superior or desirable genotypes for utilizing in maize breeding programs.
4) Determine the genetic diversity and the phylogenetic relationship among these lines and their hybrids to asses the possible relationship between combining ability, heterosis and *per* ~~*se* hybrid~~ performance in these lines and their hybrids and the genetic diversity as determined by morpho-agronomic traits.

MATERIALS AND METHODS

This investigation was carried out during three growing seasons 2001, 2002, and 2003 at the Agricultural Research Station of Agronomy Department of the Faculty of Agriculture, Minufiya University. In 2001 season, eight inbred lines namely M10 (P_1), M11 (P_2), M12 (P_3), M13 (P_4), M14 (P_5), M15 (P_6), M16 (P_7) and M18 (P_8) were planted and crosses of all possible combinations, without reciprocals were made among these inbred lines to produce 28 crosses. The previous local inbred lines were produced from the local maize population, which is named as local-٢ The 28 crosses and their eight parents were tested during 2002 and 2003 seasons and the resulted experiments were conducted in a randomized complete block design with three replications. Each entry was represented by five rows, 6m, long and 70 cm apart. The distance among hills was 25 cm with two kernels per hill on one side of the ridge. The seedlings were thined to one plant per hill. Normal agricultural practices of maize were applied during the growing seasons. Data were recorded on, grain yield/plot, number of rows/ear, number of kernels/row, 100-kernel-weight, plant height, ear height and days to tasseling. Random samples of 10 guarded plants in each plot were taken to measure the previous traits except the first trait which was recorded on three guarded rows from the five rows of each plot. The data were analyzed by using Griffing's (1956) scheme, Method-4, Model-1 (fixed model) for each year. The combined analysis of the two years was done whenever homogeneity of variance was not significant.

Grain yield/plot was adjusted based on 15.5% moisture and shelling percentage.

Economic heterosis was estimated as the increasing rates % and was computed relative the check variety S.c155 (C.P).

Studied traits at two years and combined data analysis of variances were done by using Mstat-c computer programs.

All studied morpho-agronomic characters of the maize genotypes were subjected to a multivariate analysis (Johnson and Wichern, 1988). Data were analyzed using the hierarchical Euclidean cluster analysis .The cluster analysis and dendrogram construction were performed using the SPSS (1995).

RESULTS AND DISCUSSION

I- Mean performance:

Mean performances of the 28 single crosses resulted from eight inbred lines over two years and their combined data are presented in Table (1).

For grain yield/plot the best crosses were (M10xM11), (M11xM18) and (M16xM18) where they showed the highest mean values, for number of rows/ear, the best crosses were(M15xM18) followed by (M11xM15), (M11xM14) and(M13xM14), for number of kernels/row (M10xM13), (M10xM18) and (M15xM18), for 100-kernel-weight (M11xM16), (M11xM18) and (M15xM18). For plant and ear heights the best crosses exhibited dwarfism were (M12xM16), (M13xM15) and (M14xM18), while, for days to tasseling and days to silking the best crosses were (M10xM12) and (M16xM18) where they showed lowest mean values towards earliness.

Generally, the best crosses (M10xM11) and (M11xM18) for grain yield/plot; and (M10xM12) for plant height and days to tasseling; (M11xM16) for 100-kernel weight; (M15xM18) for number of rows/ear, number of kernels/row and 100-kernel weight; (M12xM16), (M13xM15) and (M14xM18) for plant height (towards shortness) and ear height (towards low ear placement); and the cross (M16xM18) for days to tasseling towards earliness and grain yield/plot. (Table 1).

Table (1): Mean performance of 28 hybrids resulted from eight inbred lines of maize evaluated in two years and their combined analysis.

Traits / Hybrids	Grain Yield/ Plot			No. of Rows/ Ear			No. of Kernels/ Row			100-kernel-weight (gm.)		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
M 10x M 11	7.84	5.97	6.91	15.33	12.67	14.00	35.33	35.50	35.42	40.67	38.67	39.67
M 10x M 12	6.37	6.78	6.58	14.67	16.00	15.33	37.00	42.00	39.50	38.00	48.67	43.33
M 10x M 13	6.49	6.09	6.29	14.67	14.94	14.81	40.00	40.03	40.01	42.67	40.00	41.33
M 10x M 14	5.55	6.05	5.80	14.67	16.50	15.58	36.00	43.83	39.92	36.67	47.00	41.83
M 10x M 15	5.93	3.78	4.86	14.67	14.67	14.67	39.00	38.67	38.83	34.00	32.67	33.33
M 10x M 16	5.55	6.40	5.97	14.67	15.33	15.00	35.33	37.78	36.56	33.00	46.00	39.50
M 10x M 18	6.53	5.85	6.19	14.00	15.01	14.51	44.33	39.63	41.98	38.00	42.00	40.00
M 11x M 12	7.45	5.76	6.61	13.33	17.17	15.25	37.67	35.06	36.36	38.67	40.00	39.33
M 11x M 13	6.22	4.98	5.60	14.67	14.53	14.60	46.67	30.64	38.66	42.33	40.00	41.17
M 11x M 14	5.67	5.38	5.52	14.67	16.67	15.67	37.67	32.67	35.17	36.00	36.67	36.33
M 11x M 15	6.58	4.35	5.46	16.00	16.13	16.07	30.00	29.67	29.83	42.67	34.67	38.67
M 11x M 16	7.20	6.10	6.65	13.33	14.22	13.78	37.33	30.29	33.81	44.00	48.00	46.00
M 11x M 18	6.99	6.88	6.94	14.67	14.93	14.80	36.33	38.65	37.49	41.67	46.67	44.17
M 12x M 13	6.49	5.58	6.03	13.33	15.60	14.47	35.00	29.45	32.23	39.33	41.33	40.33
M 12x M 14	6.37	5.83	6.10	14.67	16.50	15.58	34.67	40.00	37.33	40.33	33.33	36.83
M 12x M 15	6.26	5.74	6.00	14.67	16.67	15.67	35.00	41.33	38.17	36.33	36.00	36.17
M 12x M 16	5.95	6.46	6.21	14.67	13.83	14.25	29.33	30.50	29.92	34.67	40.00	37.33
M 12x M 18	5.65	6.39	6.02	14.67	13.96	14.31	42.00	31.89	36.95	37.33	38.67	38.00
M 13x M 14	5.54	5.42	5.48	16.00	15.33	15.67	37.50	35.81	36.65	35.67	38.67	37.17
M 13x M 15	5.55	6.76	6.16	13.33	13.60	13.47	34.67	35.33	35.00	38.67	37.33	38.00
M 13x M 16	5.45	6.10	5.78	14.67	14.97	14.82	34.67	35.81	35.24	33.33	37.67	35.50
M 13x M 18	5.20	5.35	5.27	14.67	14.33	14.50	38.67	33.92	36.29	34.67	44.00	39.33
M 14x M 15	6.01	6.10	6.05	16.67	14.09	15.38	33.33	30.60	31.97	40.33	42.67	41.50
M 14x M 16	5.85	6.07	5.96	15.33	14.17	14.75	39.00	34.44	36.72	34.00	38.00	36.00
M 14x M 18	7.31	5.07	6.19	14.67	15.11	14.89	34.00	35.11	34.56	35.67	38.00	36.83
M 15x M 16	6.93	6.13	6.53	15.33	14.00	14.67	39.00	34.00	36.50	41.67	37.33	39.50
M 15x M 18	5.83	3.95	4.89	17.33	16.00	16.67	41.00	41.67	41.33	42.00	48.67	45.33
M 16x M 18	7.92	5.45	6.68	15.33	14.60	14.97	43.67	34.90	39.28	40.67	43.33	42.00
L.S.D.0.05	1.22	1.21	0.68	2.48	2.61	1.43	7.90	7.37	4.27	4.45	7.46	3.44
L.S.D.0.01	1.65	1.63	0.90	3.35	3.53	1.89	10.65	9.94	5.65	6.00	10.06	4.55

Table (1): Cont.

Traits / Hybrids	Plant height (cm.)			Ear Height (cm.)			Days to tasseling (day)		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
M 10x M 11	203.75	189.33	196.54	105.42	99.00	102.21	55.67	49.00	52.33
M 10x M 12	190.42	186.25	188.33	97.08	93.75	095.42	53.33	46.00	49.67
M 10x M 13	198.33	197.50	197.92	101.67	102.67	102.17	56.00	49.33	52.67
M 10x M 14	192.92	190.00	191.46	96.25	90.58	093.42	53.33	51.00	52.17
M 10x M 15	202.50	187.08	194.79	102.92	95.00	098.96	55.00	52.00	53.50
M 10x M 16	186.25	194.58	190.42	88.75	100.00	094.36	56.67	53.00	54.83
M 10x M 18	192.50	190.00	191.25	97.50	99.67	098.58	57.67	50.33	54.00
M 11x M 12	206.67	196.67	201.67	108.33	105.83	107.08	54.67	52.00	53.33
M 11x M 13	195.00	196.67	195.83	96.67	104.58	100.63	53.67	52.00	52.83
M 11x M 14	194.17	200.00	197.08	98.33	111.25	104.79	56.67	52.00	54.33
M 11x M 15	191.67	200.42	196.04	94.58	110.42	102.50	51.33	55.33	53.33
M 11x M 16	188.33	195.42	191.88	95.83	103.75	099.79	57.67	50.33	54.00
M 11x M 18	195.83	187.08	191.46	98.33	95.83	097.08	54.33	50.33	52.33
M 12x M 13	197.08	197.00	197.04	101.25	107.00	104.13	57.33	52.00	54.67
M 12x M 14	191.67	195.83	193.75	93.33	107.08	100.21	57.67	53.00	55.33
M 12x M 15	200.00	199.58	199.79	102.08	113.33	107.71	56.00	49.67	52.83
M 12x M 16	185.00	181.67	183.33	90.83	87.50	089.17	53.67	51.33	52.50
M 12x M 18	189.17	191.67	190.42	87.50	106.25	096.88	53.00	51.00	52.00
M 13x M 14	202.92	199.17	201.04	103.33	114.17	108.75	55.67	51.67	53.67
M 13x M 15	187.50	189.07	188.33	90.00	97.50	093.75	55.33	52.33	53.83
M 13x M 16	195.00	193.00	194.00	97.08	104.33	100.71	57.67	51.67	54.67
M 13x M 18	191.25	188.75	190.00	100.42	94.17	097.29	58.33	49.00	53.67
M 14x M 15	197.92	208.75	203.33	98.75	118.75	108.75	57.00	51.33	54.17
M 14x M 16	190.00	201.25	195.63	92.50	114.17	103.33	55.00	54.00	54.50
M 14x M 18	182.92	181.25	182.08	89.58	89.58	089.58	54.67	51.33	53.00
M 15x M 16	194.17	200.42	197.29	100.00	109.58	104.79	55.00	52.33	53.67
M 15x M 18	177.92	200.42	189.17	79.58	114.58	097.08	56.33	52.00	54.17
M 16x M 18	192.92	196.77	194.84	101.67	106.80	104.23	52.33	51.67	52.00
L.S.D.0.05	15.92	17.04	9.22	10.89	19.38	8.79	5.37	1.94	2.26
L.S.D.0.01	21.48	22.99	12.21	14.70	26.15	11.64	7.24	2.62	2.99

II- Analysis of Variance and Estimates of General and Specific Combining Ability Effects:

The results in Table (2) indicated that years mean squares were highly significant for all studied traits except number of rows/ ear, indicating overall differences between the two years. The mean squares due to hybrids were highly significant for most studied traits at the two years and their combined data i.e., number of kernels/row, 100-kernel–weight, and grain yield/plot. On the other hand, no differences were noticed for number of rows/ plant at the two years and their combined data indicating that no change of the behaviour of the trait at the two years of growing, the same trend was noticed by Nawar *et al.* (1988).

General combining ability (G.C.A) mean squares were highly significant for most studied traits except for few cases i.e., for number of rows/ear and plant height at the two years and combined data; number of kernels/row and ear height at the combined data only; and days to tasseling at the first year and combined data. Generally, most studied traits showed significant differences for G.C.A mean squares except, number of rows/ear and plant height at the two years and combined data.

For specific combining ability (S.C.A) mean squares the data showed highly significant differences for most studied traits either at two years and their combined data or at the first year and the combined date. On the other hand, no differences were noticed for number of rows/ear at the two years and combined data (Table 2).

For crosses x years interaction mean squares the data showed highly significant differences for most studied traits, while for number of rows/ear, plant height, and days to tasseling the data showed non- significant differences. For G.C.A x years mean squares the data showed divided between the seven traits under study. For S.C.A x years mean squares, data showed the highly significant differences for most studied traits except for number of rows/ear, plant and ear heights which showed non-significant differences (Table 2). This result disagreed with those obtained by (Nawar and El-Hosary1985 and Nawar *et al.* 1994); Sadek *et al.* (2000); and Barakat *et al.* (2003); Abd El-Maksoud *et al.* (2003 and 2004) and Abd El-Hadi *et al.* (2004).

The ratio between K^2G.C.A / K^2S.C.A, was found to be less than unity at the combined data for most studied traits except for days to tasseling indicating that, the dominance genetic variance controlled the behavior of most studied traits rather than the additive ones (Table 2). The cases in which this ratio exceeded unity may be due to the general combining ability (additive genetic variance). These results agreed with that obtained by; Nawar *et al.* (1981, 1994, and 2002); (Rabie *et al.* 1997); Has (1999); El-Absawy (2000); Leon(2000); Suneetha *et al.* (2000); Turgut (2001); El-Shenawy *et al.* (2002); Amer (2003); Barakat *et al.* (2003); GuangCheng *et al.* (2003) ; Mousa (2003) and Mohamed (2005) for grain yield and some of its components.

Table (2): Analysis of variance of all traits studied of diallel hybrids of maize evaluated in two years and combined data.

S.O.V	Mean Squares													
	D.F.		Grain yield /plot			No. of rows /ear			No. of kernels /row			100-kernel-weight		
	Y	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
Years (Y)	-	1	-	-	4.74**	5.76	0.63	3.20	-	-	242.60**	-	-	286.36**
Rep/Years	2	4	8.35**	1.12	13.50**	2.60	3.61	2.53	390.36**	94.84*	108.46**	54.76**	517.96**	212.63**
Hybrids	27	27	1.66**	1.81**	1.75**	3.81	3.80	2.97	46.32**	61.55**	56.33	31.89**	62.37**	66.11**
G.C.A	7	7	2.25**	1.87**	1.72**	2.18	3.64	3.24	50.57*	95.18**	41.64	39.69**	59.40**	38.14**
S.C.A	20	20	1.46**	1.78**	2.21**	-	-	3.42	44.83*	36.29*	88.29**	29.16**	63.41**	46.25**
Hybrids x Years	-	27	-	-	1.59**	-	-	2.81	-	-	45.14**	-	-	69.66**
G.C.A x Years	-	7	-	-	1.91**	-	-	4.19	-	-	67.45*	-	-	62.84**
S.C.A x Years	-	20	-	-	1.65**	2.21	2.45	2.91	-	-	35.98*	-	-	33.00**
Error	54	108	0.53	0.52	0.53	1.75	1.08	2.33	22.29	19.43	20.86	7.07	19.90	13.49
K^2 G.C.A/K^2S.C.A	-	-	1.64	1.05	0.78	-	-	0.95	1.13	2.62	0.47	1.36	0.94	0.82
K^2 G.C.A x Y/K^2S.C.A x Y	-	-	-	-	1.16	-	-	1.44	-	-	1.60	-	-	1.60

Table (2): Cont.

S.O.V	Mean Squares										
	D.F.		Plant height			Ear height			Days to tasseling		
	Y	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
Years (Y)	-	1	-	-	2317.13**	-	-	2244.90**	-	-	67.05**
Rep/Years	2	4	1812.22**	2822.05**	25.77	251.41**	4238.39**	1684.38**	133.86**	0.25	696.21**
Hybrids	27	27	128.07*	124.16	155.68*	114.80**	209.90	170.94**	9.93	9.22**	8.26
G.C.A	7	7	165.89	164.98	96.64	106.07*	280.88*	153.76	4.77	13.85**	10.89
S.C.A	20	20	114.83	109.87	190.25*	117.86**	185.05	159.27*	11.73**	7.60**	9.44*
Hybrids x Years	-	27	-	-	143.45	-	-	175.02**	-	-	7.84
G.C.A x Years	-	7	-	-	140.62	-	-	227.69*	-	-	9.19
S.C.A x Years	-	20	-	-	81.25	-	-	127.89	-	-	11.49*
Error	54	108	90.67	103.86	97.27	42.44	134.31	88.38	10.30	1.35	5.83
K^2 G.C.A/K^2S.C.A	-	-	1.44	1.50	0.61	0.90	1.62	0.97	0.41	1.82	1.15
K^2 G.C.A x Y/K^2S.C.A x Y	-	-	-	-	1.73	-	-	1.78	-	-	0.80

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

Estimates of general combining ability effects (ĝi) for eight parental inbred lines at the two years and their combined data which are presented in (Table 3) showed that the best parental inbred lines which had significant differences were detected for inbred line; M12 for number of rows/ear; number of kernels/row the best lines were M10 and M18; M10, M11, M15 and M18 for 100-kernel-weight; M10, M18 for plant height (towards shortness) and ear height (towards low ear placement); M inbred lines M11, M15 for plant height (towards tall plants) and ear height (towards high ear placement); M inbred lines M10, M12 and M18 for days to tasseling (towards earliness) and M14, M15 and M16 (towards lateness); and M11, M12 and M16 for grain yield/plot. Generally the best inbred line M18 for 100-kernel-weight at the second year and combined data, and plant height (toward shortness) at the first year and combined data while for other lines non stable trends were noticed in the estimates of G.C.A effects (ĝi) at the two years for most studied traits. These results agreed with those obtained by EL-Hosary *et al.* (1988) and EL Absawy (2000); Abd El-Hadi *et al.* (2004).

Estimates of specific combining ability effects (Sîj) over the two years and their combined data for twenty eight single crosses are presented in Table(4) and showed that the best crosses were (M15xM18) for number of rows/ear; (M11xM13), (M11xM18), (M12xM15), and (M15xM18) for number of kernels/row; (M10xM12), (M10xM13), (M10xM14), (M11xM16), (M12xM14), (M14xM15) and (M15xM18) for 100-kernel-weight; (M12xM16), (M14xM16) and (M15xM18) for plant height (towards shortness); (M10xM16), (M13xM15), (M14xM18), and (M15xM18) (towards low ear placement); (M10xM11), (M10xM12), (M11xM16), (M12xM15), (M13xM18) and (M14xM15) for days to tasseling (towards earliness); (M11xM18), (M13xM15), (M14xM18), and (M16xM18) for grain yield /plot (Table 4). However, the best crosses were (M11xM16) for 100-kernel-weight (M13xM15) for ear height (towards low ear placement) at the two years and combined data, while the other crosses showed non stable trends in the estimates of S.C.A effects (Sîj) at the two years for most studied traits. These results might be due to the prevalent of additive and non- additive genetic variance in these population.

These results are in partial agreement with those obtained by EL-Hosary *et al.* (1988), EL-Absawy (2000) and Nawar *et al.* (2002).

III- Economic heterosis:

Percentage of economic heterosis relative to the check variety (S.c155) for grain yield/plot and some of its components are presented in Table (5). Desirable and significant heterotic effects were calculated for all crosses at the two years and their combined data. The percentages of economic heterosis of F1 hybrids relative to the check variety (S.c155) ranged from (1.60% to 33.66%) positive desirable values and from (-5.78%) to (-6.40%) negative desirable values at combined data for grain yield/ plot. These results disagreed with those obtained by Mousa (2001 and 2003); Nawar *et al.* (2002); and GuangChang (2003). They obtained either positive or negative non-significant economic heterosis for grain yield/plant relative to the (S.c 129).

Table (3): Estimates of general combining ability (G.C.A.) effects of eight parental inbred lines for the studied traits at the combined data.

Traits / Inbred lines	Grain Yield/ Plot			No. of Rows/ Ear			No. of Kernels/ Row			100-kernel-weight (gm.)		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
M10	0.02	0.12	0.07	-0.17	-0.04	-0.11	0.99	4.61**	2.80**	-0.88	1.83*	0.48
M11	0.63**	-0.13	0.25	-0.28	0.16	-0.06	-0.01	-2.89**	-1.45	2.96**	0.11	1.53
M12	0.06	0.39**	0.23	-0.61*	0.72*	0.06	-1.73	0.07	-0.83	-0.60	-1.00	-0.80
M13	-0.54**	0.01	-0.26	-0.39	-0.35	-0.37	1.02	-1.47	-0.22	-0.26	-0.83	-0.55
M14	-0.31*	-0.05	-0.18	0.50	0.50	0.50	-0.48	0.44	-0.62	-1.60**	-1.61	-1.60
M15	-0.18	-0.65**	-0.37*	0.72*	-0.04	0.34	-1.51	0.25	-0.63	1.24*	-2.44**	-0.60*
M16	0.11	0.42**	0.27	-0.06	-0.71*	-0.38	-0.45	-2.01*	-1.23	-1.15*	1.06	-0.05
M18	0.21	-0.21	0.00	0.82	-0.24	0.02	3.16**	1.00	2.08	0.29	2.89**	1.59*
L.S.D. (gi) 0.05	0.28	0.28	0.32	0.57	0.60	0.67	1.80	1.68	2.00	1.01	1.70	1.61
L.S.D.(gi) 0.01	0.38	0.37	0.42	0.76	0.81	0.88	2.43	2.27	2.64	1.37	2.30	2.13
L.S.D. (gi-gj) 0.05	0.50	0.49	0.48	1.01	1.07	1.01	3.22	3.01	3.02	1.82	3.05	2.43
L.S.D. (gi-gj) 0.01	0.67	0.67	0.64	1.37	1.44	1.33	4.35	4.06	4.00	2.45	4.11	3.21

Table (3): Cont.

Traits / Inbred lines	Plant height (cm.)			Ear Height (cm.)			Days to tasseling (day)		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
M10	2.20	-4.03*	-0.91	2.03	-7.27**	-2.62	-0.01	-1.43**	-0.72
M11	3.66*	1.11	2.39	3.35**	1.06	2.21	-0.63	0.29	-0.17
M12	1.09	-1.71	-0.31	0.50	-0.59	-0.04	-0.35	-0.71*	-0.53
M13	2.27	0.39	1.33	2.17	0.02	1.10	1.04	-0.21	0.42
M14	-0.16	2.89	1.37	-0.89	3.55	1.33	0.38	0.85**	0.61
M15	-0.30	4.49*	2.10	-1.58	5.81*	2.12	-0.29	0.96**	0.33
M16	-3.63*	0.70	-1.47	-1.79	0.31	-0.74	0.04	0.85**	0.44
M18	-5.16**	-3.83	-4.49*	-3.80**	-2.90	-3.35	-0.18	-0.60*	-0.39
L.S.D. (gl) 0.05	3.63	3.89	4.31	2.49	4.42	4.11	1.22	0.44	1.06
L.S.D.(gl) 0.01	4.90	5.25	5.71	3.53	5.97	5.44	1.65	0.60	1.40
L.S.D. (gl-gj) 0.05	6.50	6.96	6.52	4.45	7.91	6.22	2.19	0.79	1.60
L.S.D. (gl-gj) 0.01	8.77	9.39	8.63	6.00	10.67	8.23	2.96	1.07	2.11

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

Table (4): Estimates of specific combining ability effects for all traits studied over two years and their combined data.

Traits / Hybrids	Grain Yield/ Plot			No. of Rows/ Ear			No. of Kernels/ Row			100-kernel-weight (gm.)		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
M 10x M 11	0.88	0.24	0.56	0.97	-2.50**	-0.77	-2.94	-1.91	-2.42	0.26	-3.85	-1.79
M 10x M 12	-0.02	0.52	0.25	0.63	0.27	0.45	0.44	1.64	1.04	1.15	7.26**	4.21*
M 10x M 13	0.71	0.22	0.46	0.41	0.28	0.35	0.69	1.20	0.95	5.48**	-1.57	1.96
M 10x M 14	-0.47	0.23	-0.12	-0.48	0.99	0.26	-0.81	3.10	1.15	0.82	6.20**	3.51*
M 10x M 15	-0.21	-1.52**	-0.86	-0.70	-0.31	-0.50	2.22	-1.87	0.18	-4.68**	-7.29**	-5.99**
M 10x M 16	-0.89	0.12	-0.39	0.08	1.03	0.56	-2.50	-0.50	-1.50	-3.29*	2.54	-0.38
M 10x M 18	0.00	0.19	0.09	-0.92	0.24	-0.34	2.89	-1.65	0.62	0.26	-3.29	-1.52
M 11x M 12	0.45	-0.25	0.10	-0.59	1.23	0.32	2.11	2.19	2.15	-2.02	0.32	-0.85
M 11x M 13	-0.19	-0.64	-0.42	-0.52	-0.33	0.10	8.36**	-0.69	3.84	1.32	0.15	0.73
M 11x M 14	-0.96*	-0.19	-0.57	-0.37	0.96	0.30	1.86	-0.58	0.64	-3.68**	-2.40	-3.04
M 11x M 15	-0.18	-0.70	-0.44	0.75	0.96	0.85	-5.78**	-3.38	-4.58*	0.15	-0.57	-1.71
M 11x M 16	0.15	0.07	0.11	-01.14	-0.29	-0.71	0.50	-0.50	0.00	3.87**	6.26**	5.07*
M 11x M 18	-0.16	1.48**	0.66	-0.14	-0.04	-0.09	-4.11	4.86*	0.37	0.10	3.10	1.60
M 12x M 13	0.65	-0.57	0.04	-0.48	0.17	-0.15	-1.58	-4.84*	-3.21	1.87	2.60	2.23
M 12x M 14	0.31	-0.25	0.03	-0.03	0.22	0.10	0.58	3.80	2.19	4.21**	-4.63*	-0.21
M 12x M 15	0.07	0.17	0.12	-0.25*	0.93	0.34	0.94	5.33*	3.14	-2.63*	-1.13	-1.88
M 12x M 16	-0.53	-0.09	-0.31	0.52	-1.23	-0.36	-5.78*	-3.25	-4.51*	-1.90	-0.63	-1.27
M 12x M 18	-0.93	0.47	-0.23	0.19	-1.58*	-0.70	3.28	-4.86*	-0.79	-0.68	-3.79	-2.24
M 13x M 14	0.08	-0.29	-0.11	1.08	0.13	0.60	0.67	1.14	0.91	-0.79	0.54	-0.13
M 13x M 15	-0.04	1.57**	0.76*	-1.81	-1.07	-1.44	-2.14	0.87	-0.63	-0.63	0.04	-0.29
M 13x M 16	-0.43	-0.08	-0.25	0.30	0.97	0.63	-3.19	3.61	0.21	-3.57*	-3.13	-3.35
M 13x M 18	-0.78*	-0.20	-0.49	-0.03	-0.14	-0.08	-2.81	-1.30	-2.05	-3.68**	1.37	-1.15
M 14x M 15	0.19	0.97*	0.58	0.63	-1.42	-0.39	-0.97	-5.77*	-3.37	2.37	6.15**	4.26*
M 14x M 16	-0.26	-0.04	-0.15	0.08	-0.68	-0.30	3.64	0.33	1.98	-1.57	-2.02	-1.79
M 14x M 18	1.11**	-0.42	0.35	-0.92	-0.20	-0.56	-4.97*	-2.01	-3.49	-1.35	-3.85	-2.60
M 15x M 16	0.96	0.53	0.61	-0.14	-0.31	-0.22	3.67	0.08	1.87	3.26*	-1.85	0.71
M 15x M 18	-0.51	-1.02**	-0.76*	1.52*	1.22	1.37	2.06	4.74*	3.40	2.15	7.65**	4.90**
M 16x M 18	1.27**	-0.51	0.38	0.30	0.50	0.40	3.67	0.23	1.95	3.21*	-1.18	1.01
L.S.D. (Sij) 0.05	0.73	0.72	0.70	1.48	1.56	1.48	4.72	4.41	4.42	2.66	4.46	3.56
L.S.D. (Sij) 0.01	0.99	0.98	0.93	2.00	2.11	1.95	6.37	5.94	5.85	3.59	6.01	4.71
L.S.D. (Sij-Sik) 0.05	1.12	1.11	1.08	2.27	2.39	2.26	7.21	6.73	6.75	4.06	6.81	5.43
L.S.D. (Sij-Sik) 0.01	1.50	1.49	1.42	3.06	3.22	2.98	9.72	9.08	8.94	5.48	9.19	7.19
L.S.D. (Sij-Skl) 0.05	1.00	0.99	0.96	2.03	2.13	2.02	6.45	6.02	6.04	3.63	6.09	4.86
L.S.D. (Sij-Skl) 0.01	1.35	1.33	1.27	2.74	2.88	2.67	8.70	8.12	8.00	4.90	8.22	6.43

Table (4): Cont.

Traits / Hybrids	Plant height (cm.)			Ear Height (cm.)			Days to tasseling (day)		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
M 10x M 11	4.53	-1.88	1.33	3.26	1.74	2.50	0.91	-1.18*	-0.13
M 10x M 12	-6.23	-2.14	-4.19	-2.22	-1.86	-2.04	-1.70	-3.18**	-2.44
M 10x M 13	0.51	7.01	3.76	0.69	6.44	3.57	-0.42	-0.35	-0.38
M 10x M 14	-2.48	-2.99	-2.74	-1.67	-9.17	-5.42	-2.42	0.26	-1.08
M 10x M 15	7.24	-7.51	-0.13	5.69	-7.01	-0.66	-0.09	1.15	0.53
M 10x M 16	-5.67	3.78	-0.95	-8.26*	3.49	-2.39	1.25	2.26**	1.75
M 10x M 18	2.10	3.73	2.92	2.50	6.37	4.43	2.47	1.04	1.75
M 11x M 12	8.56	3.13	5.85	7.71*	1.89	4.80	0.25	1.10	0.67
M 11x M 13	-4.29	1.04	-1.62	-5.63	0.03	-2.80	-2.14	0.60	-0.77
M 11x M 14	-2.69	1.87	-0.41	-0.90	3.17	1.13	1.52	-0.46	0.53
M 11x M 15	-5.69	0.69	-2.18	-3.96	0.07	-1.94	-3.14	2.76**	-0.19
M 11x M 16	-5.05	-0.52	-2.79	2.50	-1.09	-1.80	2.86	-2.13**	0.37
M 11x M 18	3.98	-4.33	-0.17	2.01	-5.80	-1.89	-0.25	-0.68	-0.47
M 12x M 13	0.37	4.19	2.28	1.81	4.10	2.95	1.25	1.60*	1.42
M 12x M 14	-2.62	0.52	-1.05	-3.06	0.65	-1.20	2.25	1.54*	1.89
M 12x M 15	5.85	2.68	4.26	6.39	4.64	5.51	1.25	-1.90**	-0.33
M 12x M 16	-5.81	-11.45*	-8.63	-4.65	-15.69*	-10.17	-1.42	-0.13	-0.77
M 12x M 18	-0.12	3.08	1.48	-5.97	6.27	0.15	-1.87	0.98	-0.44
M 13x M 14	7.45	1.76	4.60	5.28	7.13	6.20	-1.14	-0.29	-0.72
M 13x M 15	-7.83	-9.84	-8.83	-7.36*	-11.81	-9.58*	-0.81	0.26	-0.27
M 13x M 16	3.01	-2.22	0.39	-0.07	0.53	0.23	1.19	-0.29	0.45
M 13x M 18	0.78	-1.94	-0.58	5.28	-6.42	-0.57	2.08	-1.52*	0.28
M 14x M 15	5.02	7.24	6.13	4.44	5.92	5.18	1.52	-1.79**	-0.13
M 14x M 16	0.44	3.53	1.99	-1.60	6.84	2.62	-0.81	0.98	0.09
M 14x M 18	-5.12	-11.94*	-8.53	-2.50	-14.54*	-8.52	-0.92	-0.24	-0.58
M 15x M 16	4.74	1.10	2.92	6.60*	-0.01	3.29	-0.14	-0.79	-0.47
M 15x M 18	-9.98*	5.63	-2.17	-11.81**	8.20	-1.80	1.41	0.32	0.87
M 16x M 18	8.35	5.77	7.06	10.49**	5.92	8.20	-2.92	0.10	-1.41
L.S.D. (Sij) 0.05	9.52	10.18	9.55	6.51	11.58	9.10	3.21	1.16	2.34
L.S.D. (Sij) 0.01	12.84	13.74	12.64	8.78	15.62	12.05	4.33	1.57	3.09
L.S.D. (Sij-Sik) 0.05	14.54	15.56	14.58	9.94	17.69	13.90	4.90	1.77	3.57
L.S.D. (Sij-Sik) 0.01	19.61	20.99	19.30	13.42	23.87	18.40	6.61	2.39	4.72
L.S.D. (Sij-Skl) 0.05	13.00	13.91	13.04	8.90	15.82	12.43	4.38	1.59	3.19
L.S.D. (Sij-Skl) 0.01	17.54	18.77	17.27	12.00	21.35	16.46	5.91	2.14	4.23

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

Table (5): Percentage of economic heterosis effects of the F_1 hybrids relative to consistent parent S.c.155.

Traits / Hybrids	Plant height			Ear height			Days to Tasseling			No. of rows/ Ear		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
10x11	3.64	-4.47	-0.43	5.21	-8.76	-2.05	-0.60	-5.77**	-3.09**	27.78**	-12.04**	6.06**
10x12	-3.15	-6.03	-4.59	-3.11	-13.59*	-8.56	-4.76**	-11.54**	-8.02**	22.22**	11.11**	16.16**
10x13	0.88	-0.35	0.27	1.46	-5.38	-2.16	0.00	-5.13**	-2.54*	22.22**	3.77**	12.52**
10x14	-1.87	-4.14	-3.01	-3.97	-16.51**	-10.48*	-4.76**	-1.92**	-3.40**	22.22**	14.58**	18.06**
10x15	3.00	-5.61	-1.32	2.71	-12.44*	-5.17	-1.79	0.00	-0.93	22.22**	1.85**	11.11**
10x16	-5.26	-1.82	-3.54	-11.43**	-7.83	-9.56*	1.19	1.92**	1.54	22.22**	6.48**	13.64**
10x18	-2.09	-4.14	-3.12	-2.69	-8.14	-5.53	2.98	-3.21**	0.00	16.67**	4.24**	9.89**
11x12	5.12	-0.77	2.16	8.12*	-2.46	2.62	-2.38	0.00	-1.23	11.11**	19.21**	15.53**
11x13	-0.81	-0.77	-0.79	-3.53	-3.61	-3.57	-4.17**	0.00	-2.16	22.22**	0.93	10.61**
11x14	-1.24	0.91	-0.16	-1.86	2.53	0.42	1.19	0.00	0.62	22.22**	15.74**	18.69**
11x15	-2.51	1.12	-0.69	-5.61	1.77	-1.77	-8.33**	6.41**	-1.23	33.33**	12.04**	21.72**
11x16	-4.20	-1.40	-2.80	-4.36	-4.38	-4.37	2.98	-3.21**	0.00	11.11**	-1.23	4.38**
11x18	-0.39	-5.61	-3.01	-1.86	-11.67*	-6.96	-2.98	-3.21**	-3.09**	22.22**	3.70**	12.12**
12x13	0.25	-0.61	-0.18	1.05	-1.38	-0.22	2.38	0.00	1.23	11.11**	8.33**	9.60**
12x14	-2.51	-1.19	-1.85	-6.85*	-1.31	-3.97	2.98	1.92**	2.47*	22.22**	14.58**	18.06**
12x15	1.73	0.70	1.21	1.88	4.45	3.22	0.00	-4.49**	-2.16	22.22**	15.74**	18.69**
12x16	-5.90	-8.34	-7.13	-9.35**	-19.35**	-14.55**	-4.17**	-1.28*	-2.78*	22.22**	-3.94**	7.95**
12x18	-3.78	-3.30	-3.54	-12.67**	-2.07	-7.16	-5.36**	-1.92**	-3.70**	22.22**	-3.08**	8.42**
13x14	3.21	0.49	1.84	3.13	5.22	4.22	-0.60	-0.64	-0.62	33.33**	6.48**	18.69**
13x15	-4.63	-4.56	-4.59	-10.18**	-10.14	-10.16*	-1.19	0.64	-0.31	11.11**	-5.56**	2.02**
13x16	-0.81	-2.63	-1.72	-3.11	-3.84	-3.49	2.98	-0.64	1.23	22.22**	3.94**	12.25**
13x18	-2.72	-4.77	-3.75	0.22	-13.21*	-6.76	4.17**	-5.77**	-0.62	22.22**	-0.46	9.85**
14x15	0.67	5.32	3.01	-1.45	9.45	4.22	1.79	-1.28*	0.31	38.89**	-2.15**	16.50**
14x16	-3.36	1.54	-0.90	-7.68*	5.22	-0.97	-1.79	3.85**	0.93	27.78**	-1.62*	11.74**
14x18	-6.96	-8.55	-7.76	-10.60**	-17.43**	-14.15**	-2.38	-1.28*	-1.85	22.22**	4.93**	12.79**
15x16	-1.24	1.012	-0.05	-0.20	1.00	0.42	-1.79	0.64	-0.62	27.78**	-2.78**	11.11**
15x18	-9.50*	1.12	-4.17	-20.58**	5.61	-6.96	0.60	0.00	0.31	44.44**	11.11**	26.26**
16x18	-1.87	-0.72	-1.30	1.46	-1.57	-0.11	-6.55**	-0.64	-3.70**	27.78**	1.39	13.38**

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

Table (5): Cont.

Traits / Hybrids	No. of kernels/ Row			100-kernel-weight			Grain yield/ plot		
	Y1	Y2	Comb.	Y1	Y2	Comb.	Y1	Y2	Comb.
10x11	10.42**	6.29**	8.31**	16.19**	-14.07**	-0.83	67.44**	4.81**	33.04**
10x12	15.63**	25.75**	20.80**	8.57**	5.15**	8.33**	36.15**	18.91**	26.69**
10x13	25.00**	19.84**	23.04**	21.90**	-11.11**	3.43*	38.76**	6.91**	21.91**
10x14	12.50**	31.24**	22.07**	4.76**	4.44*	4.58**	18.50**	6.18**	11.73**
10x15	21.88**	15.77**	18.76**	-2.86*	-27.41**	-16.67**	26.79**	-33.65**	-6.40**
10x16	10.42**	13.10**	11.79**	-5.71**	2.22	-1.25**	18.50**	12.32**	15.11**
10x18	38.54**	18.66**	28.39**	8.57**	-6.67**	0.00	39.53**	2.58**	19.24**
11x12	17.71**	4.96*	11.20**	10.48**	-11.11**	-1.67	59.23**	1.05**	27.28**
11x13	45.83**	-8.25**	18.21**	20.95**	-11.11**	2.92	32.82**	-12.60**	7.88**
11x14	17.71**	-2.20	7.54**	2.86*	-18.52**	-9.17**	21.15**	-5.68**	6.42**
11x15	-6.25**	-11.18**	-8.77**	21.90**	-22.96**	-3.33	40.51**	-23.72**	5.24**
11x16	16.67**	-9.31**	3.40	25.71**	6.67**	15.00**	53.85**	7.09**	28.17**
11x18	13.54**	15.72	14.65**	19.05**	3.70	10.42**	49.40**	20.74**	33.66**
12x13	9.38**	-11.83**	-1.45	12.38**	-8.15**	0.83	38.68**	-2.19**	16.24**
12x14	8.33**	19.76**	14.17**	15.24**	-25.93**	-7.92**	36.07**	2.35**	17.55**
12x15	9.38**	23.75**	16.72**	3.81**	-20.00**	-9.58**	33.76**	0.71**	15.61**
12x16	-8.33**	-8.68**	-8.51**	-0.95	-11.11**	-6.67**	27.18**	13.40**	19.61**
12x18	31.25**	-4.52*	12.98**	6.67**	-14.07**	-5.00**	20.77**	12.18**	16.05**
13x14	17.19**	7.21**	12.09**	1.90	-14.07**	-7.08**	18.38**	-4.98**	5.55**
13x15	8.33**	5.79**	7.03**	10.48**	-17.04**	-5.00**	18.59**	18.60**	18.59**
13x16	8.33**	7.23**	7.77**	-4.76**	-16.30**	-11.25**	16.50**	7.04**	11.30**
13x18	20.83**	1.55	10.98**	-0.95	-2.22	-1.67	11.11**	-6.21**	1.60**
14x15	4.17	-8.38**	-2.24	15.24**	-5.19*	3.75*	28.42**	6.98**	16.65**
14x16	21.88**	3.12	12.30**	-2.86*	-15.56**	-10.00**	25.04**	6.56**	14.89**
14x18	6.25**	5.20*	5.67**	1.90	-15.56**	-7.92**	56.24**	-11.02**	19.31**
15x16	21.88**	1.80	11.62**	19.05**	-17.04**	-1.25	48.03**	7.58**	25.82**
15x18	28.13**	24.75**	26.40**	20.00**	8.15**	13.33**	24.49**	-30.63**	-5.78**
16x18	36.46**	4.49*	20.13**	16.19**	-3.7	5.00**	68.89**	-4.46**	28.61**

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

IV- Genetic Distance, Cluster Analysis and their Relationship to Heterosis and combining Ability:

The level of genetic diversity based on morpho-agronomical characters among maize genotype was assayed waging the hierarchical Euclidean cluster analysis. A matrix of genetic- distance values for the (36) maize populations is presented in Table (6). The genetic distances for all (630) pairs ranged from (0.79) to (12.33). The highest genetic distance (12.33) was detected between (P_8) and (C_{27}) and was followed by a distance of (11.46)between (P_3) and (C_{27}) .This indicated that (P_8) is the most divergent genotype from all other maize genotypes. The minimum Euclidean distance of (0.79) was observed between the most similar genotypes (C_3) and (C_9), followed by a distance of (0.91), between (C_{21}) and (C_{24}).

The dendrogram produced from genetic distance based on morpho-agronomical characters among maize genotypes is shown in Figure (1). The grouping pattern and distribution of maize genotypes into different clusters is given in Table (7).

Based on the extent of relative dissimilarity among maize genotypes, the 36 maize populations were grouped into four clusters. Cat off point at (6.0) Euclidean distance was fixed as minimum dissimilarity Figure (1).

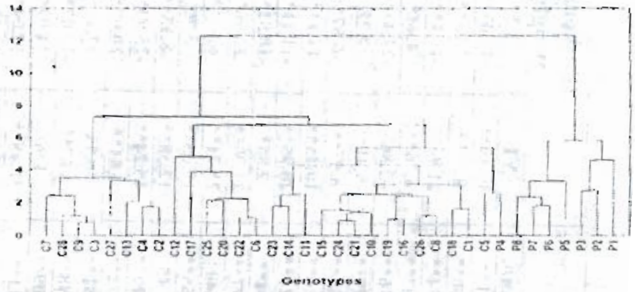

Figure (1): Linkage dendrogram for studied maize genotypes based on their morpho-agronomical traits.

These data showed that P_8 is the most divergent genotype from all the other maize genotypes. Cluster I consisted of six genotype; C_6, C_{12}, C_{17}, C_{20}, C_{22} and C_{25}. Cluster analysis further united C_6 and C_{22} and C_{20} and C_{25}. Cluster II consisted of fifteen genotype; P_4, C_5, C_1, C_8,C_{10}, C_{11}, C_{14}, C_{15}, C_{16}, C_{18}, C_{19}, C_{21}, C_{23}, C_{24} and C_{26}. Cluster analysis further united P_4 and C_5; C_1 and C_{18};C_8 and C_{26}; C_{16} and C_{19}; C_{21} and C_{24};and C_{14} and C_{23}. Cluster III consisted of seven genotype; P_1, P_2, p_3, P_5, P_6, P_7 and P_8. The cluster analysis further united P_2 and P_3; P_6 and P_7. Cluster IV consisted of eight genotype; C_2, C_3, C_4, C_7, C_9, C_{13}, C_{27} and C_{28}. The analysis further united C_2 and C_4; and C_3 and C_9. However, in none cases the hybrids derived from one parent could be grouped together into one cluster. Moreover, the parents were distributed in one cluster except the parent P_4.

Table (6): Euclidean genetic distances among studies maize genotypes based on their morpho-agronomical traits.

	P1	P2	P3	P4	P5	P6	P7	P8	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27
P2	3.52																																		
P3	4.61	2.70																																	
P4	5.27	5.37	4.89																																
P5	5.79	4.65	4.35	4.60																															
P6	4.25	3.01	3.69	5.26	2.51																														
P7	4.38	2.41	2.81	5.01	3.17	1.77																													
P8	4.98	2.74	2.48	6.74	3.30	2.32	2.13																												
C1	6.97	7.19	7.28	4.31	7.36	7.47	6.71	8.37																											
C2	8.74	9.90	10.21	6.35	8.68	9.65	9.56	11.14	3.70																										
C3	8.34	9.23	9.13	5.41	9.16	9.54	8.94	10.39	2.62	2.86																									
C4	8.63	9.45	9.64	6.57	9.01	9.44	9.18	10.87	3.49	1.72	2.20																								
C5	6.49	6.78	6.27	2.69	6.97	7.33	6.62	7.77	3.43	3.08	3.67	4.12																							
C6	7.36	7.61	7.89	4.03	7.17	7.84	7.19	8.49	2.54	3.84	2.76	2.61	3.16																						
C7	8.56	9.14	9.13	6.40	9.47	9.77	9.22	10.46	3.46	3.42	1.67	2.34	3.30	2.87																					
C8	6.26	6.29	7.79	4.30	7.17	8.24	7.53	8.98	1.99	4.09	2.28	3.49	3.70	2.75	3.42																				
C9	8.18	8.61	8.63	5.02	8.89	8.91	8.30	9.79	1.86	2.44	0.79	2.00	3.44	2.18	1.89	2.07																			
C10	7.46	7.31	6.80	2.88	6.17	7.09	6.50	7.89	2.78	5.03	3.51	6.16	2.77	2.88	4.09	1.72	3.19																		
C11	7.63	7.32	7.08	4.29	6.16	6.23	6.80	7.30	3.73	5.80	5.23	6.36	6.20	3.91	6.18	3.43	4.71	2.85																	
C12	8.70	8.84	9.40	6.80	8.92	9.01	8.27	10.93	3.10	4.43	3.93	4.36	6.11	3.63	4.77	3.98	3.36	4.94	4.87																
C13	8.58	9.21	9.68	6.01	8.98	9.28	8.79	10.41	2.63	2.04	2.06	1.93	4.63	2.65	3.02	3.14	1.88	4.21	4.80	2.54															
C14	7.47	7.18	7.06	4.69	6.63	7.08	6.70	7.85	2.03	6.06	3.91	4.64	4.54	2.99	4.82	2.45	3.30	2.72	2.48	2.91	2.56														
C15	7.88	7.86	7.19	3.26	6.50	7.71	7.31	8.28	3.10	4.71	3.04	3.43	2.33	1.83	3.06	2.28	2.77	1.54	3.92	4.92	3.87	3.41													
C16	8.09	8.29	7.49	3.60	7.80	6.28	7.71	4.89	3.04	4.51	2.82	3.81	2.46	3.41	3.47	1.75	2.88	1.79	4.29	8.56	4.73	3.84	2.21												
C17	4.03	5.09	6.05	4.16	4.81	4.80	4.40	6.03	3.83	5.42	5.86	6.51	5.12	3.88	6.42	6.10	6.13	4.54	3.61	4.82	5.01	3.89	4.83	5.73											
C18	6.31	6.93	7.18	2.80	7.14	7.24	6.76	8.70	1.60	3.26	2.49	2.75	2.48	2.02	7.83	2.86	1.92	2.87	4.25	4.04	2.78	3.19	2.86	2.94	3.72										
C19	6.17	8.20	7.38	3.73	7.22	8.09	7.42	8.68	2.77	4.70	2.96	4.01	2.99	3.27	3.80	1.15	2.87	1.82	2.59	5.03	4.07	3.09	2.12	0.87	8.44	3.07									
C20	6.74	6.84	6.44	3.86	6.70	6.80	6.65	7.32	2.23	4.66	3.77	4.00	3.31	2.17	3.78	3.83	3.05	3.53	4.37	3.73	3.55	3.00	3.23	4.26	2.92	1.86	4.13								
C21	6.47	6.26	6.84	2.35	6.88	6.43	6.79	6.97	2.62	5.14	3.63	6.20	2.12	2.23	3.83	7.42	3.16	1.37	3.39	4.81	4.23	2.75	1.94	2.50	3.85	2.29	2.78	2.45							
C22	6.68	7.16	7.34	3.86	7.14	7.41	6.65	8.30	1.57	3.53	2.41	2.70	2.94	1.07	2.75	2.32	1.69	2.69	3.78	3.29	2.37	2.53	2.14	3.08	3.64	1.18	2.97	1.65	2.02						
C23	4.84	6.42	8.06	5.36	7.17	7.96	7.17	8.77	3.08	6.46	4.23	5.06	6.32	3.80	6.41	2.40	3.87	2.80	2.33	3.82	4.04	1.76	3.80	3.90	4.87	4.72	3.02	4.42	3.68	3.65					
C24	7.04	6.91	6.39	2.83	6.75	7.23	6.64	7.72	2.40	4.91	3.05	3.95	1.68	2.33	3.24	1.97	2.70	1.38	2.89	4.79	4.04	2.08	1.34	1.92	4.60	2.26	1.62	7.76	0.91	2.03	3.61				
C25	5.48	6.06	6.58	3.14	5.76	6.99	5.85	7.55	3.23	4.41	4.79	3.69	3.34	2.22	4.30	4.03	3.67	3.41	3.91	4.78	3.88	3.73	3.11	4.28	2.37	2.19	4.23	2.17	2.65	2.21	4.84	3.77			
C26	7.88	7.82	7.87	4.24	7.61	8.0	7.29	8.74	1.75	4.57	2.22	3.43	3.21	2.18	3.00	1.20	1.79	2.03	3.71	3.52	2.94	2.38	2.07	2.36	4.78	2.30	2.00	7.87	2.12	1.73	2.68	1.64	3.65		
C27	10.78	11.44	11.46	7.28	10.62	11.32	11.01	12.35	5.17	3.33	3.37	2.61	5.91	4.02	2.91	4.51	3.62	6.30	6.27	5.03	3.12	5.74	4.60	6.00	7.31	4.89	5.01	5.78	5.70	4.41	6.84	5.34	5.60	4.58	
C28	8.74	9.40	9.29	6.66	9.16	9.60	8.90	10.62	2.47	2.28	0.96	2.19	4.06	3.15	2.41	2.29	1.20	3.63	9.04	3.78	1.19	3.79	3.46	7.93	3.83	2.64	7.98	4.05	3.93	2.65	4.06	3.41	4.43	2.80	3.34

Table (7): Grouping pattern of parents and F1 hybrids based on their morpho-agronomical characters.

Cluster	No. of Genotypes	Maize Genotypes (parents and F1 hybrids) falling in cluster
I	6	C_6:(M_{10}xM_{16}),C_{12}:(M_{11}xM_{16}),C_{17}:(M_{12}xM_{16}), C_{20}:(M_{13}xM_{15}), C_{22}:(M_{13}xM_{18}), C_{25}:(M_{14}xM_{18})
II	15	P_4:(M_{13}), C_5:(M_{10}xM_{15}), C_1:(M_{10}xM_{11}), C_8:(M_{11}xM_{12}), C_{10}:(M_{11}xM_{14}),C_{11}:(M_{11}xM_{15}),C_{14}:(M_{12}xM_{13}), C_{15}:(M_{12}xM_{14}),C_{16}:(M_{12}xM_{15}),C_{18}:(M_{12}xM_{18}), C_{19}:(M_{13}xM_{14}),C_{21}:(M_{13}xM_{16}),C_{23}:(M_{14}xM_{15}),C_{24}: (M_{14}xM_{16}), C_{26}:(M_{15}xM_{16})
III	7	P_1:(M_{10}),P_2:(M_{11}),P_3:(M_{12}), P_5:(M_{14}), P_6:(M_{15}), P_7:(M_{16}), P_8:(M_{18})
IV	8	C_2:(M_{10}xM_{12}),C_3:(M_{10}xM_{13}),C_4:(M_{10}xM_{14}),C_7:(M_{10}xM_{18}),C_9:(M_{11} xM_{13}),C_{13}:(M_{11}xM_{18}),C_{27}:(M_{15}xM_{18}), $_{28}$:(M_{16}xM_{18})

The crosses were distributed over three clusters, which indicated that diversity in crosses was greater than in their inbred lines. These results indicated that the crosses and their inbred lines were distributed into different clusters at random. This distribution was not influenced by parentage distribution. In addition, no considerable genetic divergence was detected by hybridization in this set of maize entries. The wide genetic diversity in this study is in agreement with those obtained by Mohamed (2005) and in partially agreement with Smith and Smith (1992); Dillmann *et al.* (1997); Melo *et al.* (2001); Betran *et al.* (2003); Mohammadi and Prasanna, (2003); and Menkir *et al.* (2004).

The average intra-cluster and inter-cluster genetic distances are presented in Table (8).

The maximum inter-cluster distance was observed between clusters IV and III which were followed by that between cluster III and II and cluster III and I, respectively .The minimum inter-cluster distance was observed between cluster II and I followed by cluster IV and II as well as cluster IV and I, respectively indicating close relationship between the genotypes under study. Generally, the magnitude of inter-cluster distance exhibits the diversity which is found between the maize entries under investigation.

Table (8): Euclidean average intra- and inter- cluster genetic distances among four clusters of studied maize genotypes based on their morpho-agronomical traits.

No. of Cluster	Cluster I	Cluster II	Cluster III	Cluster IV
Cluster I	0.73	0.63	4.20	1.47
Cluster II		0.63	6.00	1.21
Cluster III			0.78	10.27
Cluster IV				0.56

The maximum intra-cluster distance was (0.780) in cluster (III) and followed by that of clusters I and II, respectively, while the minimum (0.558) in cluster IV showed that the eight maize genotypes in cluster IV are to be the most heterogeneous.

The correlation coefficients between genetic distances of parental combination and either heterosis or specific combining ability were all insignificant over all the seven characters. However, the correlation coefficients between genetic divergence among parental genotypes and the hybrid performance showed insignificant values over all characters except for grain yield per plot where it was negative and significant (-0.37).

However, such little magnitude and insignificant association values indicate the absence of correspondence between the diversity measure based on these quantitative characters and its performance.

Similar conclusion is obtained by Karhu *et al.* (1996). Moreover, These results might suggest that it is not possible to differentiate maize lines with different performances and that the classification or clustering of parents according to these quantitative traits are too poor to be predictive for superior hybrids. It might be concluded that diversity measure is not efficient enough as a promising tool for predicting F_1 performance.

It might be concluded from these results that heterosis could not be considered as a function of genetic divergence, rather it is a cross specific phenomenon.

Moreover, the results showed that genetic distance based on morpho-agronomical markers was not significantly correlated with specific combining ability, heterosis and performance of six out of the seven characters. Hereafter, this suggests that it is impossible to predict the hybrid performance from genetic distance itself.

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علاقة التباعد الوراثى بقوة الهجين والقدرة على الائتلاف والسلوك لبعض هجن الذرة الشامية

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اشتملت الدراسة على تجربتين حقليتين خلال أعوام ٢٠٠٢م، ٢٠٠٣م وذلك لدراسة القدرة على التألف العامة والخاصة وتفاعلاتها مع السنوات، وكذا تأثيراتها على الائتلاف وقوة الهجين على أساس الصنف الاختباري هجين فردى ١٥٥ وأيضا علاقات القرابة الوراثية ومعامل الارتباط بين قيم التباعد الوراثي وكلا من القدرة الخاصة على الائتلاف وقوة الهجين والمتوسط من خلال استخدام نظام الهجن التبادلية في اتجاه واحد لعدد ثمانية وعشرون هجينا ناتجة من تلقيح ثمانية سلالات من العشيرة Local المنتجة من قبل وزارة الزراعة المصرية.

وقد أظهرت النتائج ما يلي:

١- تفوقت متوسطات الهجن الفردية (منوفية١٠ × منوفية١١)، (منوفية١١ × منوفية١٨)، وذلك لصفة محصول الحبوب للقطعة التجريبية، بينما كان الهجين (منوفية١٠ × منوفية١٢) لصفة ارتفاع النبات ولأيام التزهير للنورة المذكرة، وبالنسبة لصفة وزن المائة حبة كان الهجين (منوفية١١ × منوفية١٦) بينما لصفات عدد الصفوف للكوز ولعدد الحبوب بالسطر ولوزن المائة حبة كان الهجين (منوفية١٥ × منوفية١٨)، وقد حازت الهجن (منوفية١٢ × منوفية١٦)، (منوفية١٣ × منوفية١٥)، (منوفية١٤ × منوفية١٨) أعلى القيم.لارتفاع النبات تجاه القصر وموقع الكوز المنخفض على النبات، بينما كان الهجين (منوفية١٦ × منوفية١٨) متفوقا لصفات التزهير المبكر ولمحصول الحبوب للقطعة التجريبية.

٢- أظهرت النتائج تباينا عالي المعنوية للقدرة العامة على الائتلاف لمعظم الصفات المدروسة عدا صفة عدد الصفوف بالكوز وارتفاع النبات خلال الموسمين الزراعيين والتحليل التجميعي لهما.

٣- كانت تباينات القدرة الخاصة على الائتلاف معنوية لمعظم الصفات خلال الموسمين الزراعيين والتحليل التجميعي.

٤- كانت متوسطات مربعات الانحرافات للتفاعل بين الهجن × السنوات معنويا لمعظم الصفات المدروسة عدا صفة عدد الصفوف بالكوز وصفتي ارتفاع النبات والكوز على النبات.

٥- كانت النسبة بين القدرة العامة إلى القدرة الخاصة على الائتلاف أقل من الواحد الصحيح عدا صفة ميعاد التزهير للنورة المذكرة مما يدل على أن التباين السيادي هو المتحكم في وراثة تلك الصفات.

٦- أظهرت النتائج أن أفضل السلالات هي السلالة (منوفية١٨) وذلك لصفة قطر الكوز عند مستوى السنوات والتحليل التجميعي، وكذا لصفة وزن المائة حبة في السنة الثانية والتحليل التجميعي، ولصفة ارتفاع النبات تجاه القصر في السنة الأولى والتحليل التجميعي.

٧- كانت أفضل الهجن هو (منوفية١١ × منوفية١٦) لوزن المائة حبة و(منوفية١٣ × منوفية١٥) للموضع المنخفض للكوز على النبات في كلا الموسمين الزراعيين والتحليل التجميعي.

٨- أظهرت النتائج أن قوة الهجين محسوبة على أساس الصنف الاختباري. هجين فردى ١٥٥ كانت موجبة وعالية المعنوية ومرغوبة وقد تراوحت بين (١,٦٠% - ٣٣,٦٦%) بينما كانت هناك أيضا قيما سالبة ومرغوبة لقوة الهجين قد تراوحت بين (-٥,٧٨% - -٦,٤٠%) عند التحليل التجميعي.

٩- أظهرت النتائج أن قوة الهجين والقدرة على الائتلاف لا يمكن التنبؤ بها من خلال التباعد الوراثي المحسوب من الصفات المحصولية.

١٠- أوضحت النتائج أن الارتباط بين مقدار التباعد الوراثي المحسوب من الصفات المحصولية والقدرة الخاصة على الائتلاف وقوة الهجين والمتوسط كان غير معنويا ومن غير الممكن الاعتماد عليه في التنبؤ بسلوك متوسطات الهجن الناتجة لمحصول الذرة الشامية في هذه العشيرة.