

Heterotic Patterns for Twelve Exotic and Local Yellow Maize Populations in Egypt

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ABSTRACT

The concept of heterotic groups and patterns is fundamental to hybrid breeding theory and practice, the objective of this study was to determine heterotic patterns among twelve yellow maize populations, eight of these populations were exotic germplasm, six from China (Ch2, Ch6, Ch8, Ch12, Ch14, and Ch15), one from France (Fr.), and one from CIMMYT (DTPY); and four local populations contain mixture of Local and exotic germplasm (NYP, NDTYP, Sk21, and Gm YP). Half diallel was performed among the populations at 2018 summer season. Twelve parents and their 66 crosses were evaluated at three locations in 2019 summer season. Data were collected for grain yield, number of days to mid-sulking, plant and ear heights. Results showed that High significant differences were observed among locations, entries and their partition i.e., general and specific combining abilities (GCA and SCA) effects for all the studied traits. Also, locations by entries interaction was significant or high significant for all studied traits, while location by GCA effects interactions was highly significant and significant for plant height and ear height respectively. In addition, location by SCA effects interaction was highly significant to differ for plant height. This study showed that, Ch2, Ch12, Gm YP and Sk 21 have good Potentials for use in the National Maize Research Program (NMRP) as new heterotic patterns to develop new yellow diverse inbred Lines. The combinations (Ch14xSk21), (Ch2xGmYP), and(Ch2XDTPY) Showed desirable Specific Combining ability effects for grain yield and therefore, recommended to use in inter and intra population breeding program.

Key words: Heterotic Patterns, Half Diallel, Combining Ability, Exotic.

INTRODUCTION

In the first phase of the selection procedure breeders must decide which populations are more suitable for their purposes. Neither breeding methods nor cutting edge technology will be useful if populations chosen are not well chosen, (Hallauer *et al.*, 2010). The single most important element of a breeding program is the recognition and utilization of heterotic pattern; this

recognition both simplifies and increases the efficiency of all subsequent operations (Sprague, 1984). The ability to efficiently determine the heterotic grouping and heterotic patterns as well as to identify new alternative heterotic groups for introduced germplasm is critical to the success of maize hybrid breeding programs (Richard *et al.* 2016).

Mid-parent heterosis values provide the basis for the indication of the 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 mid-parent heterosis values. While specific heterosis indicates the heterosis observed in certain crosses, (Hallauer and Miranda, 1981). Therefore, the utilization of midparent heterosis values is both practical and effective method to identify heterotic responses among parents, (Melani and Carina, 2005). The crosses between populations also provide valuable information relative to heterosis and combining ability. When a set of varieties or populations are available, information can be obtained from use of the diallel cross analysis, (Hallauer *et al.* 2010). The potential of exotic germplasm can also be evaluated by diallel crosses. This mating system provides data to allow the prediction of means and an adequate knowledge of the combining ability of the materials studied. It also helpful to identify heterotic patterns for hybrid programs, (Nass and Paterniani, 2000). Crossa *et al.* (1987) pointed out that the knowledge of parentage in heterotic patterns among populations are essential to identify and space the heterotic groups. Heterotic patterns do not preclude identify superior crosses within populations, but the chances are greater between populations of identified heterotic pattern (Hallauer *et al.* 1988). The objectives of this study were to investigate the heterosis between 12 exotic and local maize populations, and identify the potential use of some populations in the National Breeding Program.

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MATERIALS AND METHODS

Twelve yellow maize populations were used in this study obtained from the germplasm bank of the National Maize Research Program (NMRP), Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Egypt. Eight of these populations were exotic germplasm, six were obtained from China in 2011 (Ch2, Ch6, Ch8, Ch12, Ch14, and Ch15), one from France (Fr.), and one (DTPY) was obtained from the international Maize and wheat Improvement center (CIMMYT) at Mexico, in addition four local populations contain Mixture of Local and exotic germplasm, two populations from them developed at Nubaria Research Station, (NYP, and NDTPY), one population developed at Sakha Research Station (Sk21), and the last one was developed at Gemma Research Station (Gm YP).

A half diallel mating was performed between twelve yellow maize populations in the growing Nursery at Nubaria Agric. Res. St., in 2018. Crosses were made between parents, using bulk pollen from about 50 plants to pollinate about 20 plants in the opposite parent; seeds of pollinated ears from each cross were bulked for use in the evaluation trials.

The 12 parents, and their 66 F₁ crosses were evaluated at three locations (Nubaria, Gemmiza, and Sids) in 2019 season. Experimental design was a randomized complete block with three replicates, experimental unit consisted of one row 6 m. length and spaced 0.8 m a part. Plots were hand – planted using two seeds/hill, and thinned to one plant per hill, with 0.25 m between hills providing a population density of approximately 50000 plants/hac. All agronomic practices were applied as recommended in the proper time.

Data were recorded for days to mid-sulking (number of days from planting to 50% extruded silks); plant

height (the distance between soil surface and the point where tassel begins); ear height (the distance between soil surface and node of the first ear). Yield per plot (plots were hand harvested, ears were shelled and yield was adjusted to ton per hectare at 15.5% grain moisture content).

Analysis of variance (ANOVA) was performed for studied traits at each location, as well across locations after homogeneity test, using SAS procedure (SAS Institute, Inc. 1990). General and specific combining ability effects were calculated using diallel mating (Zhang and Kang, 1997) for Griffing's method 2, model 1.

RESULTS AND DISCUSSION

Combined analysis of variance over the tested locations is presented in Table 1. High significant differences were observed among locations, entries and their partition general and specific combining abilities (GCA and SCA) effects for all the studied traits. Also, locations by entries interaction was high significant for all studied traits, while location by GCA effects interaction was high significant for plant height and significant for ear height. In addition, location by SCA effects interaction was significantly differ for plant height and highly significant differ for days to mid-sulking.

Grain yield: -

Grain yield (t/ha) population means, their general combining ability (GCA) effects, their resulted crosses and specific combining ability (SCA) effects of these tested populations are presented in Table 2. Among the parent populations; NDTPY, DTPY and FR populations had highest grain yield per se (7.62, 7.40 and 7.29 t/ha respectively). On the other hand, Ch-2, Ch-8 and Ch-12 populations had lowest grain yield means (4.07, 4.40 and 4.53 t/ha, respectively).

Table1. Mean squares for studied traits of the 78 entries across three locations in 2019.

S.O.V	d.f.	Grain yield	Days to mid-sulking	Plant height	Ear height
Location (Loc.)	2	8585.6**	1894.12**	11351.056**	16603.531**
Replicates (Rep/Loc)	6	79.599	15.567	925.473	451.380
Entries	77	77.874**	15.338**	1124.576**	703.451**
GCA	11	67.183**	32.103**	4062.989**	3331.170**
SCA	66	79.655**	12.544**	634.840**	265.497**
Loc.x Entries	154	9.43	2.400**	224.77**	119.58*
Loc.x GCA	22	10.207	1.660	327.49**	152.990*
Loc.x SCA	132	9.303	2.526**	207.661*	114.02
Pooled error	462	10.640	1.405	163.333	98.559

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

Table 2. Grain yield (t/ha) of population per se means at diagonal, crosses means above the diagonal and specific combining ability (SCA) effects below the diagonal, and general combining ability (GCA) effects for twelve population parents across three locations.

parent	Ch2	Ch6	Ch8	Ch12	Ch14	Ch15	DTPY	NDTPY	NYP	Sk21	GmYP	Fr	GCA
Ch2	4.07	8	7.39	7.46	8.11	8.23	8.41	7.88	7.09	7.69	9.27	8.31	0.001
Ch6	2.03*	5.03	7.98	7.68	8.15	7.12	8.2	7.53	7.32	7.74	7.63	7.78	-0.19
Ch8	1.26	3.21**	4.4	5.5	7.98	8.18	7.16	7.52	7.19	7.2	7.97	7.22	-1.24**
Ch12	1.16	2	-3.3**	4.53	7.65	7.31	7.81	8.18	7.47	7.66	8.23	7.52	-0.94**
Ch14	1.91*	2.22*	2.76**	1.48	5.01	7.31	7.22	7.93	7.51	9.67	8.12	7.53	0.27
Ch15	2.62**	-0.81	3.71**	0.81	-0.37	5.18	8.22	7.88	6.89	8.3	7.49	8.35	-0.09
DTPY	2.6**	2.13*	0.09	1.72*	-1.23	2.1*	7.4	6.85	7.26	7.53	7.28	7.47	0.47
NDTPY	0.94	0.11	1.12	2.78**	0.85	1.04	-2.58**	7.62	6.48	7.96	7.1	7.9	0.52
NYP	0.19	1.07	1.73*	2.26**	1.19	-0.32	0.22	-2.15*	6.33	6.51	7.54	7.05	-1.06**
SK21	0.22	0.57	0.01	1.07	5.86**	2.14*	-0.71	0.5	-2.22*	6.64	7.92	7.75	0.69*
GmYP	4.78**	0.09	2.16*	2.63**	1.08	-0.43	-1.61	-2.2*	0.71	0.07	6.67	8.01	0.83**
Fr	-7.85**	-6**	-6.37**	-6**	-8.16**	-4.14**	-1.85*	-0.06	-1.68*	-3.92**	-3.49**	7.29	0.74*

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

LSD for entries 0.05 = 2.83

0.01=3.73

LSD for gi 0.05 = 0.56

0.01=0.76

LSD for Sij 0.05 = 1.69

0.01=2.23

Meanwhile Gm YP, FR and Sk21 populations had highest GCA effects values (0.83, 0.74 and 0.69 respectively), while Ch-8 and NYP populations had the lowest GCA effects values (-1.24 and -1.06). The crosses; Ch.14 x Sk.21 and Ch.2 x Gm YP gave the significant highest grain yield means (9.67 and 9.27 t/ha., respectively). On the other wise, Ch.8 x Ch.12, NDTPY x NYP, and NYP x Sk21 crosses gave the lowest grain yield means (5.5, 6.48, and 6.5 ton/ha respectively).

For SCA effects, the crosses of Sk21 x Ch14 and Gm YP x Ch2 had the highest values (5.86 and 4.78 respectively). These results are in correspondence with those obtained by Goodman (1956), Moll *et al.* (1965), Bridges and Gardner (1987) and Crossa *et al.* (1987), which showed that genetic diversity in breeding programs can be increased by using exotic germplasm. Habliza (2004) found good heterotic divergence between exotic germplasm and local Egyptian sources as output from diallel between local and exotic populations.

Number of days to mid-sulking

Number of days to mid-sulking population means (SCA) effects, their general combining ability (GCA) effects, their resulted crosses and specific combining ability (SCA) effects of these tested populations are presented in Table 3. Among the parent populations; Ch2 population had the highest number of days to mid-sulking per se (66.1 days). While, Ch-6, DTPY, and NYP populations had the lowest number of days to mid-sulking means (59.2, 59.2 and 59 days respectively). It is noticed that Ch2 population had the highest GCA effects value (1.11**), while Ch-6 population had the lowest GCA effects value (-0.74**). The crosses; Ch.2 x Ch12, Ch.8 x Ch12 and Gm YP x FR gave the highest Number of days to mid-sulking means (62.9, 62.1 and 62.1 days, respectively). On the other wise, Ch.6 x Ch.8, Ch6 x Ch12, Ch12 x DTPY, Ch14 x DTPY, Ch2 x NYP, and Ch14 x NYP crosses gave the lowest number of days to mid-sulking means (57.6, 57.4, 57.8, 58.3, 58.3, and 58.3 days respectively). For SCA effects, the crosses of FR x Ch14 had the highest value (3.15) and Ch6 x Ch8 had the lowest SCA effects (-1.63).

Plant height

Plant height population means, their general combining ability (GCA) effects, their resulted crosses and specific combining ability (SCA) effects of these tested populations are presented in Table 4. Among the parent populations; DTPY, NDTPY, Sk21 and FR populations had the highest plant height per se (211.7, 215, 218.9 and 213.3 cm, respectively). While the populations Ch-2, Ch-6 and Ch-8 had the lowest plant

height means (175, 166.7 and 178.3 cm, respectively). It is noticed that NDTPY population had the highest GCA effects value (6.52), while Ch-8 population had the lowest GCA effects value (-9.35). The crosses; Ch8 x NDTPY, Ch15 x NDTPY, Ch15 x FR, and Gm YP x FR gave the highest plant height means (222.2, 229.4, 221.7 and 222.8 cm, respectively). On the other wise, Ch2 x Ch6, Ch6 x Ch8, Ch8 x Ch12 and Ch8 x DTPY crosses gave the lowest plant height means (187.2, 193.3, 185 and 190.6 cm, respectively). For SCA effects, the crosses of Ch6 x Ch12, Ch6 x DTPY, Ch8 x NDTPY and Ch15 x NDTPY had the highest values (11.87, 13.34, 16.99 and 11.24, respectively) but Ch6 x FR and NYP x FR had the lowest SCA effect values for plant height (-21.6 and -20.44, respectively).

Ear height

Ear height population means, their general combining ability (GCA) effects, their resulted crosses and specific combining ability (SCA) effects of these tested populations are presented in Table 5. Among the parent populations; DTPY, NDTPY, Sk21, Gm YP and FR populations had the highest ear height per se (121.7, 118.3, 117.8, 115 and 117.2 cm, respectively). Meanwhile, Ch-2, Ch-6 and Ch-8 populations had the lowest ear height means (90.6, 84.4 and 83.9 cm respectively). The crosses; DTPY x NDTPY, DTPY x Sk21, and DTPY x FR gave the highest ear height means (120, 119.75 and 119.45 cm, respectively). While, Ch2 x Ch6, Ch2 x Ch8, and Ch6 x Ch8 crosses gave the lowest ear height means (87.5, 87.25 and 84.15 cm, respectively). For SCA effects, the crosses of Ch6 x Ch12 and Ch8 x NDTPY had the highest values (10.52 and 11.16 respectively). Meanwhile, Ch6 x FR and FR x NYP had the lowest SCA values for ear height (-13.81 and -11.24, respectively).

Also, cluster analysis using population means for all studied traits showed that Chinese populations clustered in three groups, where, cluster I contained Ch2, cluster II contained Ch6 and Ch8, and cluster III contained Ch12, Ch14 and Ch15; while all local populations (DTPY, NYP, Sk21, and GmY) and adapted exotics (DTPY and Fr) were clustered in one cluster in the other side of the dendrogram (Figure 1). Therefore, the crosses between local and Chinese populations may be useful in future breeding program.

Table 3. Number of days to mid-silking of population *per se* means at diagonal, their crosses means above the diagonal and SCA effects below the diagonal and GCA effects for twelve population parents across three locations.

	Ch2	Ch6	Ch8	Ch12	Ch14	Ch15	DTPY	NDTPY	NYP	Sk21	GmYP	Fr	GCA
Ch2	66.1	59.9	59.9	62.9	60.4	60.4	59.4	60.7	60.6	60.7	60	60.1	1.11**
Ch6	-1.53**	59.2	57.6	57.4	59.7	59.9	60.2	60.1	58.3	60.1	59.7	60	-0.74**
Ch8	-1.15*	-1.63**	61.1	62.1	59.4	59.9	59.6	60.3	59.6	59.6	59.6	59.3	-0.12
Ch12	-1.15*	-1.47**	2.57**	60.9	59.1	58.9	57.8	58.8	58.8	59	59.4	59.2	-0.39**
Ch14	-0.51	0.56	-0.28	-0.34	62.1	60	58.3	58.9	58.3	59.1	59.4	60.8	-0.21
Ch15	-1.31**	-0.01	-0.63	-1.36**	-0.44	64.2	60.1	59.6	60.3	60.6	60.7	60.2	0.59**
DTPY	-1.39**	1.24**	-0.05	-1.55**	-1.18**	-0.21	59.2	59.3	60.1	61.2	60.2	61.3	-0.33**
NDTPY	-0.35	0.95*	0.55	-0.74	-0.81	-0.94*	-0.24	60	59.8	59.9	61.1	60.2	-0.15
NYP	-0.21	0.59	0.02	-0.49	-1.12*	0.08	0.78	0.26	59	60.2	60.8	60.4	-0.39**
SK21	-0.56	0.73	0.44	-0.73	-0.8	-0.16	1.43**	-0.09	0.49	60.8	60.4	59.3	0.07
GmYP	-1.48**	0.03	-0.7	-0.54	-0.72	-0.3	0.18	0.88*	0.79	0	60.9	62.1	0.32**
Fr	2.53**	1.07*	0.44	0.92*	3.15**	2.3**	1.17**	0.29	0.25	-0.47	1.66**	60.7	0.26*

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

LSD for entries 0.05 = 1.98

0.01=2.60

LSD for gi 0.05 = 0.22

0.01=0.30

LSD for Sij 0.05 = 0.88

0.01=1.16

Table 4. Plant height of population per se means at diagonal, their crosses means above the diagonal and SCA effects below the diagonal and GCA effects for twelve population parents across three locations.

	Ch2	Ch6	Ch8	Ch12	Ch14	Ch15	DTPY	NDTPY	NYP	Sk21	GmYP	Fr	GCA
Ch2	175	187.2	198.3	201.7	200	208.9	214.4	213.9	203.3	211.1	208.3	206.2	-7.24**
Ch6	-5.04	166.7	193.3	208.3	204.4	203.3	216.7	207.2	211.7	203.9	208.3	207.2	-8.56**
Ch8	6.86	3.18	178.3	185	202.2	201.1	190.6	222.2	203.3	201.1	211.7	208.3	-9.35**
Ch12	3.89	11.87**	-10.67**	186.7	201.7	213.3	216.1	215.6	210	207.2	213.3	216.7	-3.04
Ch14	-0.24	5.52	4.09	-2.77	193.9	214.4	211.7	211.7	216.7	216.7	218.9	210.6	-0.58
Ch15	4.44	0.21	-1.22	4.69	3.34	195.6	216.11	229.4	220.8	221.1	214.2	221.7	3.62*
DTPY	9.8*	13.34**	*11.98**	7.27	0.36	0.6	211.7	216.1	215.6	208.9	217.2	211.7	3.82*
NDTPY	6.55	1.2	16.99**	4.02	-2.33	11.24**	-2.29	215	210.6	213.3	209.4	216.7	6.52**
NYP	0.98	10.63**	3.09	3.44	7.65	7.55	2.13	-5.56	199.4	217.8	212.2	205.6	1.54
SK21	5.55	-0.35	-2.33	-2.53	4.45	4.69	-7.73	-5.98	3.44	218.9	215.6	216.7	4.73**
GmYP	3.67	4.98	9.11*	4.47	7.56	-1.31	1.49	-8.98*	-1.22	-1.09	203.3	222.8	3.85*
Fr	-17.88**	-21.26**	-6.1	-8.37*	-14.64**	-14.48**	-8.96*	-8.72*	-20.44**	0.52	-6.26	213.3	4.7**

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

LSD for entries 0.05 = 13.85

0.01=18.23

LSD for gi 0.05 = 3.18

0.01=4.35

LSD for Sij 0.05 = 8.02

0.01=10.55

Table 5. Ear height of population per se means at diagonal, crosses means above the diagonal , specific combining ability effects below the diagonal, and GCA effects for twelve population parents across three locations.

	Ch2	Ch6	Ch8	Ch12	Ch14	Ch15	DTPY	NDTPY	NYP	Sk21	GmYP	Fr	GCA
Ch2	90.6	87.5	87.25	93.65	93.9	99.2	106.15	104.45	97.8	104.2	102.8	103.9	-6.37**
Ch6	-3.84	84.4	84.15	90.55	90.8	96.1	103.05	101.35	94.7	101.1	99.7	100.8	-5.58**
Ch8	0.32	1.75	83.9	90.3	90.55	95.85	102.8	101.1	94.45	100.85	99.45	100.55	-8.63**
Ch12	-0.91	10.52**	-4.2	96.7	96.95	102.25	109.2	107.5	100.85	107.25	105.85	106.95	-2.4*
Ch14	-2.69	2.62	8.46**	-2.22	97.2	102.5	109.45	107.75	101.1	107.5	106.1	107.2	-3.95**
Ch15	0.88	1.75	-2.42	0.8	1.79	107.8	114.75	113.05	106.4	112.8	111.4	112.5	4.14**
DTPY	5.62	5.39	-3.79	-1.12	-2.35	2.89	121.7	120	113.35	119.75	118.35	119.45	3.29**
NDTPY	6.12*	3.1	11.16**	4.93	-1.3	7.27*	-4.1	118.3	111.65	118.05	116.65	117.75	6.13**
NYP	0.72	4.37	5.76	2.86	4.41	4.09	-6.16*	-5.67	105	111.4	110	111.1	0.41
SK21	8.85**	-0.83	-2.77	2.66	0.32	6.67*	-3.03	-5.87	2.62	117.8	116.4	117.5	5.07**
GmYP	-0.6	4.17	5	-0.67	-0.23	-3.88	2.53	-7.53*	4.85	-0.35	115	116.1	3.39**
Fr	-6.99*	-13.81**	-9.65**	-3.34	-3.14	-8.54**	-0.19	-3.38	-11.24**	-5.16	-0.72	117.2	4.52**

*, **, ** Significant at P=0.05 and 0.01 probability, respectively.

LSD for entries 0.05 = 10.10

0.01=13.29

LSD for gi 0.05 = 2.13

0.01=2.97

LSD for Sij 0.05 = 5.94

0.01=7.81

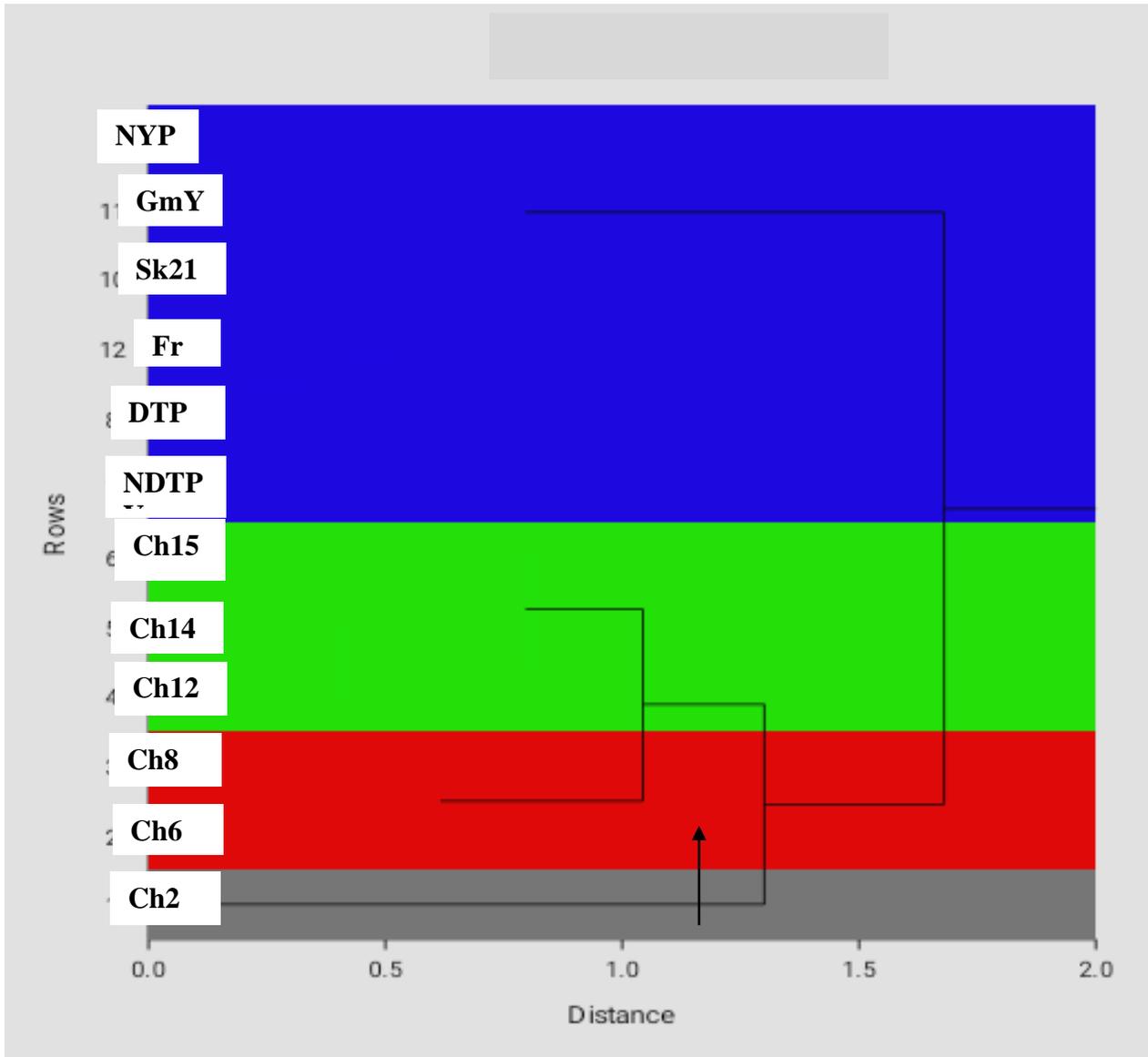


Figure 1. Cluster analysis (Euclidean distance) for twelve used parent populations using grain yield, number of days to mid-silking, and plant and ear height population means per se.

Finally, we can conclude that the highest crosses mean for grain yield, plant and ear heights were found for (Ch14xSk21 and Ch15xNDTPY respectively) and it's clear that crosses between exotics (Chinese sources) and local germplasm which had highlighted the heterotic effect between them. For their results in crosses, Ch2, Ch12, GmYP and Sk 21 have good Potentials for use in the National Maize Research Program (NMRP) as new heterotic patterns to develop new yellow diverse inbred Lines, the identification of populations as sources of inbred lines is based on their agronomic performance, presence of useful genetic variance, high population

mean, and heterosis observed form using them in crosses, (Melani and Carena 2005).

The combinations (Ch14xSk21), (Ch2xGmYP), (Ch6xch8), (Ch8xch15), (Ch12XNDTPY) and (Ch12xGmYP) Showed desirable Specific Combining ability effects for grain yield, therefore, recommended to use in intra-population breeding program as new composts in the National Maize Research Program of Egypt. Crossa *et al* 1987 pointed out that the knowledge of parentage in heterotic patterns among populations is essential to identify and separate the heterotic groups. Nelson (1972) has used exotic germplasm in an applied

breeding program developing lines for use in hybrids in the southern part of the USA. He has developed lines that have played a prominent role in the production of hybrids grown in the area, Hallauer et al. 2010. Wellhausen *et al.* (1952), Broun (1953), Wellhausen (1956, 1965), and Leng *et al.* (1962) have emphasized the importance of exotic germplasm and thought US maize breeders were in an excellent position to make use of exotic germplasm.

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الملخص العربي

دراسة المجموعات المتباعدة وراثيا بين اثنتي عشرة عشيرة ذرة شامية صفراء محلية ومستوردة في مصر

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الوراثيه معنوى او عالي المعنوية لكل الصفات المدروسة كان التفاعل بين المواقع والقدرات العامة علي الائتلاف عالية المعنوية ومعنوى لارتفاعات النباتات وارتفاع الكوز علي التوالى وبينما التفاعل بين القدرة الخاصة علي الائتلاف والمواقع كان عالي المعنويه ومعنويا لصفة عدد الأيام حتي ظهور ٥٠٪ من الحريرة وارتفاع النباتات علي التوالى. هذه الدراسة أوضحت أن العشائر ٢١ Ch2, Ch12, GmYP, Sk هي عشائر مبشرة لاستخدامها في البرنامج القومي لتربية الذرة الشامية كمصادر متباعدة وراثيا لعزل واستنباط سلالات جديدة كما بينت الدراسة أن الهجن الصنفيه (Ch14xSk21), (Ch2xDTPY), (Ch2xGmYP) هي هجن مبشرة ذات قدرة خاصة علي الائتلاف عالية لصفه المحصول ويمكن استخدامها في برامج تحسين عشائر او كمصدر لاستنباط سلالات جديدة في برنامج التربية.

يعتبر مبدأ تقسيم الذرة الشامية الي مجموعات متباعدة وراثيا أساسيا في تربية الذرة الشامية من الناحيتين النظرية والعملية. كان الهدف من هذا البحث هو تحديد المجموعات المتباعدة وراثيا بين ١٢ عشيرة ذرة شامية صفراء منها ست عشائر من الصين (Ch2, Ch6, Ch8, Ch12, Ch14, Ch15)، وعشيرة فرنسية (Fr). وعشيرة من المركز العالمي لتربية الذرة والمقح (CIMMYT DTPY محلية) وأربع عشائر محلية (NYP, NDTYP, Sk21, GmYP). تم اجراء التهجين التبادلي بين العشائر وتم تكوين ٦٦ هجين بين العشائر في موسم ٢٠١٨ وفي الموسم التالي ٢٠١٩ تم تقييم الأباء والهجن معا وتم تسجيل بيانات محصول الحبوب، عدد الأيام حتي ظهور ٥٠٪ من الحريرة، ارتفاعات الكيزان والنباتات. أظهرت النتائج وجود فروق عالية المعنوية بين المواقع والتراكيب الوراثيه ومجزئاتها (القدرة العامة والخاصة علي الائتلاف) لكل الصفات محل الدراسة، كان التفاعل بين المواقع والتراكيب