GENE ACTION OF SOME AGRONOMIC TRAITS IN MAIZE BY HALF DIALLEL CROSS AT TWO LOCATIONS IN SULAIMANI -IRAQ

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ABSTRACT

This research was aimed to study combining ability for growth, kernel yield, and its components, for maze (*Zea mays* L.) inbred lines, which evaluated in 8×8 diallel crosses. At two locations, Dukan and Qlyasan, at the Sulaimani region. Significant genetic variability was found in all genotypes for all characters except no. of ears/plant. Highest significant general and specific combining ability were observed for most characters, revealing the importance of both additive and non-additive gene action, at the same time a low ratio of $\sigma^2_{GCA}/\sigma^2_{SCA}$ was recorded for all traits at both locations vice versa the average degree of dominance was more than one, this indicates to the high contribution of a non-additive gene effect. Heritability in broad sense was found to be high, while a narrow sense, it was low for all traits at both locations. Significant differences were noticed between both locations for kernel yield and most of its components, confirming the exceeding Dukan location.

Keywords: diallel analysis, combining ability, heterosis, heritability, kernel yield
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التحليل الوراثي للجيل الاول بأستعمال تصميم التهجينات التبادلية النصفية للذرة الصفراء في بيئتين مختلفتين ضمن محافظة السليمانية – العراق

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المستخلص

تم تقيم القدرة على النمو والحاصل ومكوناته وفقا لطريقة التضريب التبادلى 8×8 بأستثناء الهجن العكسية فى الذرة، فى موقعين دوكان وقلياسان ضمن محافظة السليمانية. وجد تباين وراثى كبير بين التراكيب الوراثية و لجميع الصفات بأستثناء عدد العرانيص لكل نبات. ولوحظ وجود معنوية القدرة العامة والخاصة على الائتلاف لمعظم الصفات. اظهرت أهمية كل من الفعل الجيني الاضافي وغير الاضافي في توريث الصفات المدروسة، بينما تم تسجيل نسبة منخفضة أقل من الواحد الصحيح لـ $\sigma^2_{GCA}/\sigma^2_{SCA}$ لجميع الصفات في كلا الموقعين وعلى العكس تماما فان قيمة معدل درجة السيادة كانت أعلى من واحد الصحيح لجميع الصفات، وهذا يشير الى المساهمة العالية التأثير الفعل الجينى غير الأضافي. درجة التوريث في معناها العام كانت عالية، بينما فى معناها الضيق كان منخفظا لجميع الصفات وفي كلا الموقعين. هناك فروقات معنوية بين كلا الموقعين في الحاصل ومعظم مكوناته مما يؤكد تفوقع موقع دوكان.

الكلمات المفتاحية: التهجينات التبادلية، القدره الاتحادية، قوة الهجين، درجة التوريث، حاصل الحبوب

جزء من اطروحة الدكتورا للباحث الأول.

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INTRODUCTION

Maize (*Zea mays* L.) plays a significant role in human and livestock nutrition worldwide (7). It is the world's most widely grown cereal and is the primary staple food in many developing countries. It is a versatile crop with wider genetic variability and can be able to grow successfully throughout the world, covering and tropical, subtropical, and temperate agro-climatic conditions (42). Maize is the solely cultivated species of the genus *Zea* and the tribe Maydeae. It is the oldest crop species domesticated as a food crop in the world, a C4 crop. Being a C4 crop, maize possesses the most potential of ensuring food security during the coming days (15). The suitability of maize to diverse environments is unparalleled to any other crop (25). Maize had a very broad, and variety utilization and because of that, the main objective of all maize breeding programs is to obtain new inbred lines and hybrids that will outperform the existing hybrids concerning a several traits. In working towards this aim, particular attention is paid to grain yield as the most important agronomic trait (32,38). The development of high- yielding and widely adapted hybrids of maize depends on, the performance of the inbred lines and their combining ability for yield and traits contributing to yield. Information about combining ability of parents and crosses facilitates breeders in the selection and development of single-cross hybrids (33). A genetic study in maize-germplasm development is an important step to understand the genetic variability and complementary between heterotic groups, as well as additive and dominance genetic effects. Thus, diallel analyses have been widely adopted with the aim of identifying the best parental lines and the best crosses. In addition, different environmental conditions make genetic selection difficult (16). The combining ability is a result of the alleles combination of an individual with the alleles of other individuals, and it is expressed by the performance of the generated progeny. In this case, there are two combining abilities. General combining ability (GCA) is regarded to additive effect, is the mean performance of particular individual progenies in combination with many others. Specific combing ability (SCA), which is the performance of a progeny produced by the combination from two specific genitors less the GCA of the genitors. As it is discounted the additive effects when excluding the GCA effects from the genitors, the SCA depends on the non-additive gene action, in other words, dominance and epistasis effects (45,47,48). The aim of the present study is to compare individuals and combined analyses of a diallel design for maize breeding for the purpose of understanding the genetic effects, divided into additive and dominance effects, and the interaction between these effects with the environmental effects

MATERIALS AND METHOD

Eight maize inbred lines were crossed in a diallel cross, excluding the reciprocals during the spring season in 2020. The experiments were carried out at two locations in Sulaimani Governorate between April 3 to August at Dukan location, while at the Qlyasan location, it was carried out between April 8 to August during 2020. The climate of the Sulaimani Governorate is considered a semi-arid environment: cold and wet in winter, hot and dry in summer. The average temperature from July to August are between 39-43C^0 and often reach nearly 50C^0. October means high temperatures are 24-29C^0, and slightly cooling down in November. The rainfall is limited during winter and spring months. (Kurdish Regional Government, Director of Agriculture/Agriculture of Meteorology, Bakrajo, 2021). The 28 F_1s with their parents were used in each location using a completely randomized block design with three replications. The trial consisted of 36 plots for each replication (28 F1s +8 parents). Each plot consisted one row 3m long 0.75m spacing between the rows, and 0.25m spacing between plants. Standard agronomic practices were followed. Observation were recorded on five randomly plants from each plot for days to tasseling, days of silking, plant height (cm), No. of ears/plant, ear length(cm), ear width(cm), ear weight(g), No. of rows/ear, No. of kernels/row, 300 kernel weight (g), and kernel yield. The maize genotypes used comprised 8 inbred lines obtained from the University of Baghdad College Agricultural Engineering Sciences. Genetic materials of eight parental inbred lines were selected based on grain and biomass yields, maturity periods, and grain size. The present study examined these genotypes, (NADH 905, NADH 102, NA 106, SARA NA, NA 225, NAHD 503, ZM12 NAPI 5012) and their progenies. These genetic materials had phenotype variation. All data collected were subjected to analysis of variance to determine the significance of genetic variability among the entries. Diallel analysis for GCA and SCA was conducted following Griffith's Method 2 and Model 1. Variance components attributable to general combining ability (σ^2GCA), specific combining ability (σ^2SCA), and error variance (σ^2e) were computed using mean squares for GCA, SCA, and error extracted from the analysis of variance. These obtained by equating observed means squares to their expected means squares values and solving the resulting equations for the variance component.

ANOVA of method 2 giving expectations of mean squares for the assumptions of models I and II

Source	D.F.	Sum of Squares*	Mean Squares	Expectation of Mean Squares	
				Model I	Model II
General combining ability	$p-1$	S_g	M_g	$\sigma^2+(p+2)\left(\frac{1}{p-1}\right)\Sigma g_i^2$	$\sigma^2+\sigma_s^2+(p+2)\sigma_g^2$
Specific combining ability	$p(p-1)/2$	S_s	M_s	$\sigma^2+\frac{2}{p(p-1)}\sum_i \sum_j s_{ij}^2$	$\sigma^2+\sigma_s^2$
Error	m	S_e	M_e'	σ^2	σ^2

* Where

$$S_g = \frac{1}{p+2}\left\{\sum_i (X_{i.}+x_{ii})^2-\frac{4}{p}X_{..}^2\right\},$$

$$S_s = \sum_{i<j}\sum x_{ij}^2-\frac{1}{p+2}\sum_i (X_{i.}+x_{ii})^2+\frac{2}{(p+1)(p+2)}X_{..}^2.$$

RESULTS AND DISCUSSION

Dukan Location

Data in Table (1) illustrates the mean squares of genetic analysis in this location, the mean squares for genotypes were highly significant for the characters (date to 50% silking, ear width, and 300 kernels weight, but it was significant for a date to 50% tasseling, ear length, No. of rows/ear, No. of kernels/row and kernel yield. The mean squares due to GCA and SCA were highly significant for all characters. Baktash (12) revealed significant differences in all the studied traits and heterosis. Previous workers indicated that the analysis of variance showed significant differences among generations for all traits; therefore, generation mean analysis was carried out to reveal the mode of inheritance in these traits (41). The analysis of variance to test the significance of differences among the genotypes revealed highly significant differences for most of the traits reflected adequate diversity in the genetic material chosen for the study (26). Machado, et.al (34) observed a lack of significant mean square estimates of SCA×ENVI interaction for some traits tested and suggested that expressions of such traits among the single cross hybrids were consistent across environments and concluded that good selection progress for improvement of such traits was feasible under any environment. General combining ability and specific combining ability variance were highly significant for all the characters studied, which indicated that these characters were controlled by both additive and non-additive gene action.

Table 1. Analysis of variance for studied characters at Dukan location

Source of variation	Mean Squares				
	Replication	Crosses	GCA	SCA	σ^2 e
Characters	Dukan location				
d.f	2	35	7	28	70
50 %tasseling	2.260	4.255*	8.639**	3.159**	2.502
50% Silking	0.500	5.772**	10.946**	4.478**	2.085
Plant height (cm)	96.706	798.686**	1546.539**	611.723**	145.506
No. of ears /plant	0.533	0.037^{ns}	0.059**	0.032**	0.019
Ear length(cm)	1.762	11.921*	7.067**	13.135**	6.987
Ear width(cm)	2.491	12.515**	10.533**	13.011**	0.823
No. of rows/ear	3.592	4.303*	3.952**	4.391**	2.487
No. of kernels/row	86.787	95.514*	71.454**	101.528**	57.196
300 kernel Wt. (g)	208.456	160.416**	98.372**	175.927**	57.996
Kernel yield	0.028	2.605*	2.383**	2.660**	1.620

Data in the table (2) illustrate the average of the characters of F_1 crosses and their parents for the Dukan location, the earlier cross date to 50% tasseling and silking produced by the cross (1×5) reached 62.778 and 67.000 days, respectively. The cross (2×3) exhibited maximum value for plant height, number of rows/ears, and kernel yield reached 199.667cm, 18.000 rows, and 7.191 t/h, respectively. The highest number of ears /plant reached 1.333 ears recorded by the cross (2×7), the cross (3×8) gave the highest value for ear length, and ear width reached 24.000 and 5.867 cm, respectively. A maximum number of kernels/row was 42.333 produced by the cross (2×6), while the highest weight of 300 kernel was 86.723gr recorded by the cross (5×6). Regarding parent's mean value, parent 1 showed the minimum days to tasseling and silking, and also, the maximum weight of 300 kernels reached 62.666, 67.889 days and 75.408gr, respectively. Parent 7 recorded the highest height for plants, reaching 169.889cm. The parent 5 gave a maximum number of ears/plant, and the ear length reached 1.444 ears and 21.000 cm, respectively. The highest widths of the ear, number of rows/ear, and kernel yield reached 4.227cm, 18.667row, and 6.423 t/h respectively recorded by parent3. The highest No. of kernels/row was 37.333 kernel recorded by parent 4. The highest grain yield per plant may be the main selection criteria to develop higher-yielding maize hybrids for better crop production and productivity (28, 35,39, 22). It was recommended to select maize inbreeds to create new variations for better traits provided using large inbred populations (5). The significant effects of environment and genotype for grain yield observed indicated that a combination of distinctive test environments and adequate genetic variability among the inbred line was used (11).

Table 2. Means performance of studied characters due to genotypes at Dukan location

Genotypes	%50 tasseling	%50 silking	Plant height	No. of ear/ plant	Ear length	Ear width	No. of. row /ear	No. of kernel/ row	300 Kernel Wt.	Kernel yield
1×2	64.889	69.333	179.333	1.000	15.833	3.567	16.000	29.333	62.867	4.832
1×3	64.889	69.222	170.555	0.889	16.667	3.653	15.333	27.000	67.504	4.290
1×4	65.889	70.778	173.333	1.000	21.000	3.377	13.333	19.667	71.253	4.720
1×5	62.778	67.000	178.000	1.111	17.667	2.837	15.333	31.333	68.269	4.805
1×6	64.444	67.222	192.778	1.000	18.833	4.013	17.333	33.667	68.202	5.447
1×7	65.444	70.666	182.778	1.111	20.333	3.977	14.667	34.333	79.046	6.120
1×8	66.667	70.556	186.556	1.111	18.167	4.010	17.333	30.000	64.505	5.100
2×3	65.000	67.778	199.667	1.000	20.500	4.333	18.000	37.000	74.598	7.191
2×4	63.111	67.556	192.334	1.111	21.000	3.907	17.333	29.333	78.103	6.608
2×5	63.333	68.222	175.111	1.111	21.167	4.107	17.333	38.333	68.778	6.187
2×6	64.889	68.444	185.000	1.000	20.333	4.273	14.667	42.333	67.831	6.694
2×7	63.555	68.889	168.000	1.333	22.667	4.047	15.333	33.333	71.945	4.889
2×8	64.667	69.000	168.444	1.000	19.667	4.217	17.333	32.333	74.966	4.948
3×4	66.555	71.444	151.111	1.000	18.000	3.647	16.000	28.333	43.953	4.964
3×5	65.667	72.111	161.778	1.000	19.667	4.720	16.667	31.000	78.719	4.921
3×6	66.111	71.556	163.000	1.111	17.167	3.807	14.667	31.333	83.490	4.865
3×7	64.555	70.444	163.000	1.111	19.667	3.777	16.000	36.667	66.666	4.875
3×8	67.000	71.444	136.333	1.111	24.000	5.867	16.667	38.667	74.958	6.593
4×5	63.667	69.222	134.333	1.222	18.500	3.337	14.000	30.000	83.411	6.026
4×6	63.222	68.778	165.889	1.111	16.833	3.380	16.667	33.000	71.970	5.871
4×7	63.444	68.666	151.666	1.111	18.500	3.503	15.333	38.667	76.105	5.417
4×8	65.111	69.556	148.889	1.111	15.667	3.503	16.000	28.333	62.004	3.751
5×6	64.667	68.667	155.667	1.000	20.667	4.183	16.667	41.333	86.723	6.651
5×7	63.222	67.666	169.556	1.222	19.000	4.210	16.000	35.000	70.073	5.840
5×8	63.111	67.556	170.000	1.000	18.000	3.867	15.333	28.333	86.232	6.230
6×7	64.000	68.222	162.778	0.889	15.500	3.297	15.333	27.333	65.996	4.656
6×8	64.111	68.111	167.111	1.111	18.333	4.533	17.333	36.333	67.030	5.442
7×8	64.667	69.111	173.555	1.111	18.833	4.070	16.667	33.667	72.556	4.853
1	62.666	67.889	152.333	1.000	17.333	4.200	14.667	32.000	75.408	5.321
2	63.556	68.333	166.556	1.000	15.767	3.723	15.333	22.333	73.411	4.117
3	66.111	71.111	141.667	1.000	18.667	4.227	18.667	29.333	58.562	6.423
4	65.000	69.334	141.667	1.000	19.667	4.103	16.667	37.333	63.985	4.434
5	65.667	70.111	164.444	1.444	21.000	4.213	16.000	37.000	67.960	5.588
6	65.778	70.666	160.000	1.222	17.500	3.690	15.333	23.000	62.584	3.764
7	64.555	69.222	169.889	1.111	16.667	3.813	16.000	31.667	55.799	4.196
8	66.222	71.000	135.000	0.667	17.667	3.013	14.000	17.667	70.647	3.485
LSD $_{(p\leq0.05)}$	**2.576**	**2.350**	**19.642**	**N.S**	**4.304**	**1.478**	**2.568**	**12.313**	**16.292**	**2.073**

Data in Table (3) illustrates the heterosis values for studied characters at Dukan location, estimated as the percentage of F1s deviated from mid-parental values. Positive and negative heterosis values were recorded for characters. Maximum negative heterosis value was recorded for days to tasseling and silking by the crosses (5×8) with-4.297, and-4.252%, respectively. Maximum positive heterosis for plant height, No. of ears/plant, and No. of rows/ear recorded by the cross (1×8) reached 29.853, 33.32 and 20.93% respectively. Maximum heterosis for ear length, and ear width were 39.77 and106.61% recorded by the crosses (2×7) and3×8 respectively. The cross (2×6) showed maximum heterosis for No. of kernels/row, and kernel yield reached 86.76, and 69.89% respectively. The highest percentage of heterosis due to 300 kernel weight was 37.83% recorded by the cross (3×6). The negative heterosis and heterobeltiosis indicate the decrease in trait may occur in the next generation; therefore, the selection could be made to fix decrease in specific trait for the indirect improvement of crop plant yield and productivity (3, 4, 8, 18, 21). Significant mid-parent heterosis and heterobeltiosis were reported for most of the F1 cross for grain yield and its related traits (29). The selection based on ear length may improve grain production (4, 6, 30, 43, 51).

The higher ear diameter indicated that the grain to Stover ratio might be higher. If the grain size is large then selection could be made based on ear diameter to improve grain yield in maize (27, 36, 54, 57).

Table 3. Heterosis percentage of F_1s diallel crosses for studied characters at Dukan location.

Genotypes	%50 tasseling	%50 silking	Plant high	No. of ear/ plant	Ear length	Ear width	No. of rows /ear	No. of kernel/ row	300 kernel Wt.	Kernel yield
1×2	2.817	1.795	12.474	0 .00	-4.33	-9.97	6.67	7.98	-15.51	2.39
1×3	0.777	-0.400	16.024	-11.10	-7.41	-13.29	-8.00	-11.96	0.77	-26.94
1×4	3.220	3.157	17.914	0 .00	13.51	-18.67	-14.89	-43.27	2.23	-3.23
1×5	-2.164	-2.898	12.382	-9.10	-7.83	-32.57	0.00	-9.18	-4.76	-11.91
1×6	0.346	-2.967	23.444	-9.99	8.13	1.73	15.56	22.42	-1.15	19.92
1×7	2.882	3.079	13.448	5.26	19.61	-0.75	-4.35	7.85	20.49	28.60
1×8	3.448	1.600	29.853	33.31	3.81	11.18	20.93	20.81	-11.67	15.83
2×3	0.257	-2.789	29.560	0 .00	19.07	9.01	5.88	43.23	13.05	36.45
2×4	-1.816	-1.856	24.802	11.10	18.53	-0.17	8.33	-1.68	13.69	54.56
2×5	-1.978	-1.438	5.807	-9.10	15.14	3.49	10.64	29.21	-2.70	27.49
2×6	0.344	-1.518	13.304	-9.99	22.24	15.29	-4.35	86.76	-0.24	69.89
2×7	-0.781	0.162	-0.132	26.29	39.77	7.39	-2.13	23.46	11.36	17.61
2×8	-0.343	-0.957	11.717	20.00	17.65	25.19	18.18	61.67	4.08	30.18
3×4	1.524	1.740	6.667	- .00	-6.09	-12.44	-9.43	-15.00	-28.27	-8.56
3×5	-0.337	2.124	5.699	-18.18	-0.84	11.85	-3.85	-6.53	24.44	-18.07
3×6	0.253	0.941	8.067	0.00	-5.07	-3.83	-13.73	19.75	37.83	-4.49
3×7	-1.191	0.396	4.636	5.26	11.32	-6.05	-7.69	20.22	16.59	-8.19
3×8	1.259	0.547	-1.446	33.32	32.11	106.61	2.04	64.54	16.03	33.09
4×5	-2.551	-0.717	-12.232	-0.01	-9.02	-19.76	-14.29	-19.28	26.43	20.25
4×6	-3.314	-1.746	9.981	0 .00	-9.42	-13.26	4.17	9.39	13.72	43.24
4×7	-2.059	-0.883	-2.639	5.26	1.83	-11.49	-6.12	12.08	27.07	25.54
4×8	-0.763	-0.871	7.631	33.31	-16.07	-1.55	4.35	3.03	-7.89	-5.26
5×6	-1.606	-2.446	-4.041	-24.99	7.36	5.86	6.38	37.78	32.87	42.23
5×7	-2.901	-2.871	1.429	-4.36	0.88	4.90	0.00	1.94	13.24	19.37
5×8	-4.297	-4.252	13.544	-5.26	-6.90	7.01	2.22	3.66	24.43	37.32
6×7	-1.790	-2.462	-1.313	-23.79	-9.27	-12.13	-2.13	0.00	11.50	16.99
6×8	-2.862	-3.843	13.296	17.65	4.27	35.26	18.18	78.69	0.62	50.15
7×8	-1.104	-1.426	13.848	25.00	9.71	19.24	11.11	36.49	14.76	26.37
LSD $_{(p\leq0.05)}$	**0.389**	**0.386**	**1.897**	**3.110**	**2.600**	**4.700**	**1.880**	**5.660**	**2.89**	**4.460**

Table 4 illustrates some genetic parameters for studied characters at Dukan location. All studied characters indicated that the ratio of σ^2gca/σ^2sca was less than one, confirming the importance of non-additive gene action in controlling the inheritance of these characters. The average degree of dominance for all traits was found to be more than one; this confirms the role of over dominance genes action, which controlled the inheritance of these characters. The nature and magnitude of gene action is an important factor in developing an effective breeding program. Combining ability analysis is useful to assess the potential inbred lines and also helps in identifying the nature of gene action involved in various quantitative characters. This information is helpful to plant breeders for formulating hybrid breeding programs (2). Heritability in a broad sense was found to be high, while in a narrow sense, it was found to be low for all traits. (29) reported that the broad-sense heritability, and narrow-sense heritability was recorded higher for most of the traits studied. The traits plant height, ear height, ear length, ear diameter, kernels per ear row, kernel rows per ear, grain per plant and grain yield per plant were highly controlled by the additive gene action’s type.

Table 4. Some genetic parameter for studied characters at Dukan location

Parameters	%50 date of tasseling	%50 date of silking	Plant height	No. of ear/ plant	Ear length	Ear width	No. of rows /ear	No. of kernel/ row	300 kernel Wt.	Kernel Yield
$\sigma^2_{GCA}/\sigma^2_{SCA}$	0.335	0.270	0.265	0.209	0.043	0.080	0.087	0.063	0.050	0.086
σ^2_E	0.834	0.695	48.502	0.006	2.329	0.274	0.829	19.065	19.332	0.540
SE_E	0.139	0.115	8.083	0.001	0.388	0.045	0.138	3.177	3.222	0.090
σ^2_A	0.520	0.683	99.869	0.003	0.315	0.683	0.208	3.492	5.269	0.122
SE_A	0.271	0.344	48.606	0.001	0.223	0.331	0.124	2.255	3.098	0.075
σ^2_D	0.775	1.261	187.740	0.008	3.602	4.245	1.187	27.487	52.198	0.706
SE_D	0.275	0.387	52.717	0.002	1.137	1.119	0.380	8.802	15.179	0.230
σ^2_G	1.295	1.944	287.609	0.012	3.191	4.929	1.395	30.980	57.467	0.829
σ^2_P	2.129	2.639	336.111	0.018	6.247	5.204	2.224	50.045	76.800	1.370
$H^2_{N.S}$	0.244	0.258	0.297	0.191	0.050	0.131	0.093	0.069	0.0686	0.089
$H^2_{B.S}$	0.608	0.736	0.855	0.648	0.627	0.947	0.627	0.619	0.748	0.605
$\bar{a}$	1.922	1.726	1.939	2.309	22.869	3.525	3.378	3.967	4.451	3.402
GA	0.627	0.740	9.587	0.045	0.222	0.527	0.245	0.868	1.058	0.184
GA%	0.970	1.068	5.792	4.267	1.183	12.579	1.5372	2.728	1.486	3.499

Qlyasan Location

Data represents in Table (5) indicate that the mean squares due to genotypes were highly significant for plant height, No. of kernels/row and kernel yield, but it was significant for the date to 50% tasseling, date to 50% silking, No. of ears/plant, ear length, ear width, No. of row/ear, and 300 kernel weight. The mean squares due to GCA and SCA were highly significant for all characters. The mean squares due to SCA were much higher than GCA for plant height, ear height, and days to silking which, revealed the predominance of non-additive gene action for controlling these characters. The higher magnitude of GCA variance was found for days to maturity, grains/ear, and 1000-grain weight, which indicated the predominance of additive gene action (2).

Table 5. Analysis of variance for studied characters at Qlyasan location

Source of variation	Mean Squares				
	Replication	Crosses	GCA	SCA	$\sigma^2 e$
Characters	Qlyasan location				
d.f	2	35	7	28	70
%50 Tasseling	0.752	3.973*	3.797**	4.017**	2.440
%50 Silking	45.195	4.455*	4.445**	4.583**	2.783
Plant height (cm)	827.436	447.316**	663.431**	393.288**	138.854
No. of ears/plant	0.021	0.032*	0.663**	0.024**	0.018
Ear length(cm)	27.107	6.524*	12.912**	4.927**	3.638
Ear width(cm)	0.774	0.284*	0.187**	0.308**	0.166
No. of row/cob	20.333	9.009*	5.152**	9.973**	4.695
No. of kernel/row	76.509	35.586**	12.476**	41.363**	11.528
300 kernel Wt. (g)	37.044	148.273*	136.205**	151.290**	98.752
Kernel yield	0.157	0.811*	0.453**	0.900**	0.399

Data in Table (6), confirmed that the earliest date to tasseling and silking were recorded by the crosses (2×5) and (2×8), 57.333 and 68.889 days, respectively. The cross 1×4 showed maximum value for plant height and ear length with 188.883 and 21.83cm, respectively. The highest number of ears/plant is 1.333 ears recorded by the cross (5×7). The maximum value for ear length and ear width was 21.83, and 4.397cm produced by the crosses (1×4) and (1×2), respectively. The maximum number of rows/ear was 18.667 recorded by both crosses 3×7 and 6×8. The highest kernels/rows were 35.667 produced by the cross (1×7). The cross 4×8 gave the highest weight of 300 kernels reached 67.170gr. The highest kernel yield was 4.777 t/h produced by the cross (1×8). Concerning the parental values, parent1 showed the minimum days to tasseling 59.222 days, and the maximum value for plant height, and 300 kernel weight reached176.663cm, and 75.640gr, respectively. Parent 4 showed the minimum days to silking 70.778days, and the highest value for ear length, ear width, number of rows/ear, number of kernels/row, and kernel yield reached 20.67, 3.873cm, 16.667rows, 35.667 kernels, and 5.030 t/h respectively. Parent 5 recorded the highest value for the number of ears/plant reached 1.444 ears). It was concluded that the modified mass selection could be used successfully in improving the grain yield and some yield components of synthetic corn varieties (13) that the contribution of the additive variance effect was greater in the inheritance of these characters (14, 46, 56). Other researchers suggested higher dominance as selection criteria for developing higher-yielding maize hybrids (24, 49).

Table 6. Means performance of studied characters due to genotypes at Qlyasan location

Genotypes	%50 tasseling	%50 silking	Plant height	No. of ear/ plant	Ear length	Ear width	No. of. row /ear	No. of kernel/ row	300 Kernel Wt.	Kernel yield
1×2	64.889	69.333	179.333	1.000	15.833	3.567	16.000	29.333	62.867	4.832
1×3	64.889	69.222	170.555	0.889	16.667	3.653	15.333	27.000	67.504	4.290
1×4	65.889	70.778	173.333	1.000	21.000	3.377	13.333	19.667	71.253	4.720
1×5	62.778	67.000	178.000	1.111	17.667	2.837	15.333	31.333	68.269	4.805
1×6	64.444	67.222	192.778	1.000	18.833	4.013	17.333	33.667	68.202	5.447
1×7	65.444	70.666	182.778	1.111	20.333	3.977	14.667	34.333	79.046	6.120
1×8	66.667	70.556	186.556	1.111	18.167	4.010	17.333	30.000	64.505	5.100
2×3	65.000	67.778	199.667	1.000	20.500	4.333	18.000	37.000	74.598	7.191
2×4	63.111	67.556	192.334	1.111	21.000	3.907	17.333	29.333	78.103	6.608
2×5	63.333	68.222	175.111	1.111	21.167	4.107	17.333	38.333	68.778	6.187
2×6	64.889	68.444	185.000	1.000	20.333	4.273	14.667	42.333	67.831	6.694
2×7	63.555	68.889	168.000	1.333	22.667	4.047	15.333	33.333	71.945	4.889
2×8	64.667	69.000	168.444	1.000	19.667	4.217	17.333	32.333	74.966	4.948
3×4	66.555	71.444	151.111	1.000	18.000	3.647	16.000	28.333	43.953	4.964
3×5	65.667	72.111	161.778	1.000	19.667	4.720	16.667	31.000	78.719	4.921
3×6	66.111	71.556	163.000	1.111	17.167	3.807	14.667	31.333	83.490	4.865
3×7	64.555	70.444	163.000	1.111	19.667	3.777	16.000	36.667	66.666	4.875
3×8	67.000	71.444	136.333	1.111	24.000	5.867	16.667	38.667	74.958	6.593
4×5	63.667	69.222	134.333	1.222	18.500	3.337	14.000	30.000	83.411	6.026
4×6	63.222	68.778	165.889	1.111	16.833	3.380	16.667	33.000	71.970	5.871
4×7	63.444	68.666	151.666	1.111	18.500	3.503	15.333	38.667	76.105	5.417
4×8	65.111	69.556	148.889	1.111	15.667	3.503	16.000	28.333	62.004	3.751
5×6	64.667	68.667	155.667	1.000	20.667	4.183	16.667	41.333	86.723	6.651
5×7	63.222	67.666	169.556	1.222	19.000	4.210	16.000	35.000	70.073	5.840
5×8	63.111	67.556	170.000	1.000	18.000	3.867	15.333	28.333	86.232	6.230
6×7	64.000	68.222	162.778	0.889	15.500	3.297	15.333	27.333	65.996	4.656
6×8	64.111	68.111	167.111	1.111	18.333	4.533	17.333	36.333	67.030	5.442
7×8	64.667	69.111	173.555	1.111	18.833	4.070	16.667	33.667	72.556	4.853
1	62.666	67.889	152.333	1.000	17.333	4.200	14.667	32.000	75.408	5.321
2	63.556	68.333	166.556	1.000	15.767	3.723	15.333	22.333	73.411	4.117
3	66.111	71.111	141.667	1.000	18.667	4.227	18.667	29.333	58.562	6.423
4	65.000	69.334	141.667	1.000	19.667	4.103	16.667	37.333	63.985	4.434
5	65.667	70.111	164.444	1.444	21.000	4.213	16.000	37.000	67.960	5.588
6	65.778	70.666	160.000	1.222	17.500	3.690	15.333	23.000	62.584	3.764
7	64.555	69.222	169.889	1.111	16.667	3.813	16.000	31.667	55.799	4.196
8	66.222	71.000	135.000	0.667	17.667	3.013	14.000	17.667	70.647	3.485
LSD $_{(p\leq 0.05)}$	2.576	2.350	19.642	N.S	4.304	1.478	2.568	12.313	16.292	2.073

Data in Table (7) confirmed that the maximum negative heterosis for days to tasseling and silking was -5.29 and -5.13% for crosses (4×8), and (2×8), respectively. The cross 5×8 showed the highest positive heterosis for plant height reached22.54%. The cross gave the highest positive heterosis for No. of ears/plant and ear length with 33.32 and 14.85% respectively, while for ear width, it was 25.62% for the cross (1×2), but it was 33.33% for No. of rows/ear due to the cross 6×8. The highest positive heterosis for No. of kernels/row, 300 kernels weight, and kernel yield was 84.61, 6.09 and 25.54% recorded by the crosses (1×7), (4×7), (1×8), respectively. Previous workers indicated significant mid-parent heterosis for most the F_1 crosses for grain yield and its related traits (29). The higher plant height indicated of the respective hybrids could be used for fodder production (9). Other researchers and maize breeders have suggested grain rows per ear as the main selection criterion (20, 37, 53). The hybrids with a higher 300 kernels weight indicated that the kernel size might be larger or bold seeds will be produced, which leads to improving kernel yield (50).

Table 7. Heterosis percentage of F_1s diallel crosses for studied characters at Qlyasan location

Genotypes	50% tasseling	50% silking	Plant height	No. ear/ plant	Ear length	Ear width	No. rows /ear	No. kernel/ row	300 Kernel Wt.	Kernel yield
1×2	4.66	-2.08	-4.13	0.00	-11.11	25.62	26.83	13.16	-17.75	6.75
1×3	2.42	-0.55	6.23	0.00	-1.83	4.22	7.32	0.58	-23.41	-0.68
1×4	0.92	-1.64	12.77	0.00	10.08	-1.86	4.55	1.66	-16.90	-21.21
1×5	1.39	-0.16	12.15	-9.10	-5.73	-4.73	2.33	5.95	-36.28	-2.29
1×6	-0.65	3.19	5.85	-9.99	-3.64	3.28	17.07	6.59	-16.03	7.20
1×7	2.79	-1.40	3.67	5.26	2.37	6.35	10.00	48.61	0.04	18.52
1×8	-3.23	-1.23	15.33	33.31	0.94	-2.17	25.64	18.47	-28.99	25.54
2×3	0.92	-0.78	16.93	0.00	-14.42	-20.87	-4.55	-25.71	-19.55	-26.85
2×4	-1.10	-1.55	2.80	11.10	-1.28	-2.49	-10.64	-11.35	3.63	-26.38
2×5	-4.89	-1.93	9.72	-9.10	-5.36	-2.73	-8.70	11.63	-18.79	-16.51
2×6	-3.23	-0.46	11.50	-9.99	8.76	5.44	13.64	14.62	0.88	-21.32
2×7	1.11	-2.55	12.66	15.77	9.62	13.15	20.93	16.22	-1.32	-17.90
2×8	-3.74	-5.13	21.08	20.00	-1.44	11.03	26.19	8.07	-15.83	-29.07
3×4	0.00	4.07	7.88	0.00	-12.28	-14.29	-10.64	-18.63	-29.71	-0.48
3×5	-0.64	0.86	4.78	-18.18	-15.21	2.95	-26.09	-29.84	-20.13	-3.22
3×6	1.93	3.12	12.60	0.00	2.86	-9.96	-18.18	-5.26	-22.64	-5.58
3×7	-0.55	3.04	10.92	5.26	-6.47	2.91	30.23	-7.78	-19.83	-13.96
3×8	-3.20	1.78	18.61	33.32	14.85	-4.18	19.05	2.22	-20.42	-16.13
4×5	-0.27	3.51	15.95	-0.01	-2.11	-14.92	-6.12	-19.40	-10.73	-17.25
4×6	0.09	0.78	10.84	0.00	-9.57	-24.03	-2.13	-17.00	-10.68	-25.22
4×7	0.73	0.23	-2.64	5.26	-1.36	4.82	4.35	-0.56	6.09	-16.40
4×8	-5.29	0.70	5.63	33.31	-2.70	0.18	-6.67	-28.42	3.42	-29.06
5×6	0.55	0.86	13.76	-24.99	-8.68	6.86	13.04	-5.88	-15.34	-7.63
5×7	0.46	2.79	17.04	4.33	-5.71	-9.76	-11.11	-2.44	-9.38	9.78
5×8	-3.45	0.00	22.54	-5.26	7.11	1.23	-4.55	7.34	-11.01	-16.79
6×7	0.64	-0.39	8.26	-14.27	-1.28	6.93	11.63	-7.98	-4.88	10.49
6×8	-3.82	-2.08	17.60	17.65	-8.82	4.89	33.33	2.27	-15.88	5.55
7×8	-2.85	-3.23	18.36	25.00	3.59	-2.73	17.07	32.03	-7.40	24.57
LSD $_{(p\leq0.05)}$	**0.470**	**0.430**	**1.26**	**2.88**	**1.44**	**1.96**	**2.97**	**3.34**	**2.03**	**3.06**

Some genetic parameters represent in table (8) at Qlyasan location, it was calculated that the ratio of σ^2gca/σ^2sca was less than unity for all traits, vice versa the value of the average degree of dominance was more than unity for all traits, the highest value for this parameter was 6.595 obtained from No. of kernels/row, and followed by No. of rows/ear, and kernel yield, reaching 4.842 and 4.629, respectively. Heritability in broad sense was moderate to high, while in narrow sense it was low for all traits. The classification of heritability stands low when it is 50% (52). Some studies have reported high, narrow-sense heritability at 73% (55) and moderate at 40.65% for yield (23). High narrow sense heritability indicated that the contribution of the additive variance effect was greater in the inheritance of these characters (56, 14, 46). Various researchers suggested higher dominance as selection criteria for developing higher-yielding maize hybrids (49, 24, 31, 10).

Table 8. Some genetic parameter for studied characters at Qlyasan location

Parameters	%50 date of tasseling	%50 date of silking	Plant height	No. of ear/ plant	Ear length	Ear width	No. of rows /ear	No. of kernel/ row	300 kernel Wt.	Kernel Yield
$\sigma^2_{GCA}/\sigma^2_{SCA}$	0.093	0.096	0.177	0.336	0.314	0.520	0.042662	0.023	0.087	0.041
σ^2_E	0.813	0.927	46.284	0.006	1.212	0.055	1.565079	3.842	32.917	0.133
SE_E	0.135	0.154	7.714	0.001	0.202	0.009	0.260847	0.640	5.486	0.022
σ^2_A	0.198	0.234	41.143	0.004	0.779	0.008	0.239153	0.575	6.885	0.021
SE_A	0.119	0.140	20.855	0.002	0.406	0.005	0.162855	0.394	4.296	0.014
σ^2_D	1.067	1.218	115.667	0.005	1.238	0.084	2.80291	12.507	39.457	0.255
SE_D	0.348	0.397	33.946	0.002	0.429	0.026	0.862801	3.566	13.148	0.077
σ^2_G	1.266	1.453	156.811	0.009	2.018	0.093	3.042063	13.082	46.343	0.277
σ^2_P	2.080	2.381	203.095	0.016	3.231	0.148	4.607143	16.925	79.260	0.410
$H^2_{N.S}$	0.095	0.098	0.202	0.249	0.241	0.059	0.051	0.034	0.086	0.052
$H^2_{B.S}$	0.608	0.610	0.772	0.619	0.624	0.626	0.660	0.772	0.584	0.675
$\bar{a}$	3.282	3.226	2.371	1.581	1.783	4.583	4.842	6.595	3.358	4.629
GA	0.242	0.267	5.081	0.055	0.763	0.040	0.196	0.246	1.361	0.058
GA%	0.401	0.373	3.023	5.135	4.301	1.104	1.288	0.855	2.312	1.509

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