EVALUATE THE PERFORMANCE OF DOUBLE, SINGLE HYBRIDS AND INBREDS OF MAIZE UNDER DIFFERENT PLANT DENSITIES AND ESTIMATE THE PERCENTAGE OF HETEROSISAND HYBRID VIGOR((yield and its components))

A.N.Abdel-Amir *[1] **B.H.Hadi[2]**

[1]Directorate of Agriculture Karbala

[2]Department of Field Crops, College of Agriculture, University of Baghdad

ABSTRACT

A field experiment was conducted during the fall Season 2017 at the fields of Field Crop Department, College of Agriculture, University of Baghdad in order to evaluate the performance of double and Single hybrids, and their inbreds of maize in two plant densities. The Study included the comparison among five inbreds (ZM43WIZE, ZM60, ZM49W3E, ZM19 and CDCN5), ten single hybrids, and fifteen double hybrids , resulting from their crossing with two plant densities (60000, 80000 plant.ha^{-1}). The experiments were conducted according to the randomized complete block design (RCBD) with three replications, using the spilt plots arrangement, where the two densities (60000, 80000 plant.ha^{-1}) were represented in the main plots and the 30 genotypes in the sub-plots. The results showed the superiority of the single and double hybrids over their inbreds in all the studied traits. The double hybrids (2x3) (4x5) gave the highest length of ear amounted of (19.98 cm), number of rows per ear (15.38), number of grains per ear (38.98), number of grains per plant (667.1), number of ear per plant (1.17), and the plant yield increased the accordingly reaching185.8 g per plant. The single hybrids (5 × 3) has excelled by giving it the highest plant yield amounted of 184.2 g. This was due to the superiority of the length of ear, which reached (18.42 cm), number of rows per ear (15.42), number of grains per row (35.24), number of grains per plant (653.6) and number of ears per plant (1.20).These two hybrids had highly positive heterosis and hybrid vigor in the desired direction where amounted (6.36%, 3.53%), (9.47%, 87.0%), (5.27%, 3.36%), (7.47%, 0.15%) and (14.2%, 1.44%) for the length of ear, number of rows per ear, number of grains per row, and number of grains per plant, respectively. The heterosis and hybrid vigor for the hybrid (2x3)(4x5) recorded the highest value for the trait of grain yield amounted of (30.2%, 29.2%), respectively, While the hybrid (3x5) gave heterosis and hybrid vigor (5.66%, 17.4%), (26.9%, 35.5%), (20% ,20%), (8.35%, 15.4%), (1.44%, 4.18%), (13.4%, 23.3%), (44.9%, 54%) for the same traits, respectively, and it gave the highest value of total grain yield amounted of (93.8%, 90.2%). The fifth inbred excelled on the others inbred by giving it the highest yield (96.8 g). Increasing in the plant densities from 60 to 80 thousand plants ha^{-1} led to a decrease in the number of ears, length of ear, number of grains per row, number of grains per plant, and the individual plant yield. The interaction between genotypes and plant densities was significant for all traits except number of ears per plant.

Keywords: (Zea maize L.) Maize, Hybrid vigor, Plant densities.

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تقويم أداء هجن زوجية وفردية وسلالاتها من الذرة الصفراء في كثافات نباتية مختلفة وتقدير نسبة التهجن وقوة الهجين((الحاصل ومكوناته))

أحمد نعمة عبد الامير * **بنان حسن هادي**

مهندس زراعي **أستاذ مساعد**

مديرية زراعة كربلاء **كلية الزراعة – جامعة بغداد**

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المستخلص

بهدف تقويم أداء هجن زوجية وفردية وسلالاتها من الذرة الصفراء في كثافتين نباتيتين. أجريت تجربة حقلية خلال الموسم الخريفي 2017 في حقل تجارب قسم المحاصيل الحقلية – كلية الزراعة – جامعة بغداد وتضمنت الدراسة مقارنة خمس سلالات نقية (ZM43WIZE و ZM60 و ZM49W3E و ZM19 و CDCN5) وعشرة هجن فردية وخمسة عشر هجيناً زوجياً ناتجاً من تضريبها وبكثافتين 60 ألف نبات هـ$^{-1}$ و 80 ألف نبات هـ$^{-1}$. استخدم تصميم القطاعات الكاملة المعشاة بثلاثة مكررات , بترتيب الألواح المنشقة مثلت الكثافات النباتية 60 و 80 ألف نبات هـ$^{-1}$ الألواح الرئيسة فيما مثلت التراكيب الوراثية الألواح الثانوية. أظهرت النتائج تفوق الهجن الفردية والزوجية على أبائها في الصفات المدروسة جميعها وأعطى الهجين الزوجي (5×4)(3×2) طول العرنوصبلغ 19.98 سم وعدد الصفوف العرنوص 15.38 صف وعدد حبوب الصف 38.98 حبة وعدد حبوب النبات 667.1 حبة وعدد العرانيص للنبات 1.17 عرنوص وازداد حاصل النبات تبعا لذلك إذ بلغ 185.8 غم . تفوق الهجين الفردي (5×3) بإعطائه أعلى حاصل للنبات بلغ 184.2 غم وكان ذلك نتيجة لتفوقه بطول العرنوص اذ بلغ 18.42 سم وعدد صفوفه 15.42 صف وعدد حبوب الصف 35.42 حبة وعدد حبوب النبات 653.6 حبة.نبات$^{-1}$ وعدد العرانيص 1.20 عرنوص كما أمتلك هذان الهجينان نسبة تهجن وقوة هجين موجبة وعالية بالاتجاه المرغوب إذ كانت (6.36% و 3.53%) و(9.47% و8.70%) و(5.27% و3.36%) و(7.47% و0.15%) و(14.2% و3.26%) لعدد العرانيص وطول العرنوص وعدد صفوفه وعدد حبوب الصف وعدد حبوب النبات بالتتابع وأعلاها لحاصل النبات إذ بلغت نسبه التهجن وقوة الهجين 30.2% و 29.2% بالتتابع للهجين الزوجي (5×4)(3×2), في حين أعطى الهجين الفردي (5×3) نسبة تهجن وقوة هجين (20% و20%) و(15.4% و8.35%) و(4.18% و1.44%) و(23.3% و13.4%) و(54% و44.9%) لعدد العرانيص وطول العرنوص وعدد صفوفه وعدد حبوب الصف وعدد حبوب النبات وأعطى أعلى نسبة تهجن وقوة هجين لحاصل النبات بلغت (93.8 % و90.2%). وتفوقت ألسلالة 5 بين السلالات بإعطاء أعلى حاصل للنبات بلغ96.8 غم. أدت زيادة الكثافة النباتية من 60-80 ألف نبات هـ$^{-1}$ إلى انخفاض عدد العرانيص وطول العرنوص وعدد حبوب الصف وعدد حبوب النبات وحاصل النبات الفردي .كان التداخل بين التراكيب الوراثية والكثافات النباتية معنويا لجميع الصفات باستثناء عدد العرانيص.

الكلمات مفتاحية: الذرة الصفراء ،قوة الهجين ،الكثافات النباتية

*مستل من رسالة ماجستير للباحث الاول

1. INTRODUCTION

The studies that conducted by both Shull and East separately from 1907-1912 and Beal (1877-1882), the Suggestions of Jones (22) on the use of single hybrid and what resulting from it of hybrid Vigor that has been used commercially,One of the first studies on the effect of crossing on yield of maize, Beal indicated that the increase in the first generation with ratio of 40% due to the use of Diallel Crosses for the production of single hybrids. The aims of plant breeders are limited to three general principles: removing a defect from the crop or increasing or raising it for a specific purpose (31). The cultivation of maize in Iraq is still below the required level despite the prevalence of some single and three way hybrids and synthetic cultivars .It was found that following the reality of crop production in Iraq, the yield rate was low compared to the global production. This may be due to the fact that the farmer got used to cultivate the cultivars with open pollination and synthetic cultivars, and not adopt the cultivation of single hybrids seeds for the difficulty of importing them and the weak techniques of crop service operations. Therefore, the cultivation and improvement of this crop should be given to increase the grain yield and improve its quality by implementing breeding and improvement programs for this crop. Hybrid Vigor is considered one of the most important scientific phenomena that have attracted the interest of geneticists and researchers in the field of plant breeding and improvement, In order to understand the reasons for their acquisition and rules for their importance in improving plant traits and increasing production (9).It can be defined by the superiority of first-generations resulting from the mating of two genetically divergent strains from the best parents. Dhanoon and Al-Jumaily (12) found that the hybrid vigor between the negative and positive values for the trait of the length of the ear for the maize. Five positive hybrids were found for the hybrid vigor. The hybrid (7 x 5) gave the highest positive hybrid vigor amounted of (12.71%), Thirteen negative hybrids were found for hybrid vigor and the hybrid (7 × 1) gave the lowest negative hybrid vigor amounted of (-14.81%).The results of Abel-Moneam et al., (4)

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showed a significant positive hybrid vigor for the trait of the length of the ear for the hybrid(P4 × P1) for the Mean of parents and the best parents amounted of (56.67%, 67.65%), respectively. Al-Amery (8) confirmed that all single hybrid were characterized by a positive hybrid vigor ranging between (1.74%, 33.76%).As for the single hybrids, their value ranged between negative and positive, which amounted of (27.93%, 23.87%) for the two hybrids [(6 × 5) (3 × 2) and (6 × 4) (3 × 2)], respectively, Lahmode et al., (23) found similar results. The hybrid vigor differed for the number of rows in the ear for all single hybrids locally derived from the maize.The hybrids (145 × 153) gave the highest positive hybrid vigor amounted of 34.74% while the hybrids (3 × 4) gave the lowest negative hybrid vigor amounted of (-8.61%) (23). Baktash and Abedl Al-Hameed (3) obtained a positive hybrid vigor to 21 hybrids, the hybrid (5 × 4) recorded the highest percentage amounted of (21.67%), similar results obtained by Sumathi et al., (32).El-Badawy (14) confirmed the existence of a positive hybrid vigor which amounted of (51.81%) for the hybrids (2 × 1).The hybrid vigor for the trait of the number of grains per row for all single hybrids locally derived from maize .The hybrid (145 x 200) gave the highest positive hybrid vigor in the desired direction amounted of (51.23%) while the hybrid (153 × 145) had the lowest negative hybrid vigor amounted of (-0.54%) (24), similar results obtained by (Ghallab and Al-Dulami, (18)).Wuhaib et al., (35) found in a comparative experiment of a number of inbreds with single hybrids resulting from their diallel hybrids, that the hybrids was excelled on their parents in the number of grains for the plant, Which led to a positive hybrid vigor which was highest for the hybrid (4 × 1) where amounted of 67%.The number of plant grains for the first generation F1 excelled on the parents for all the used hybrid which gave positive values for the hybrid vigor and the percentage of heterosis. This indicates to the genetic heterogeneity for the parents, in other words, there is a Genetic Diversity and genetic variations. This confirms the values of the hybrid vigor and the high percentage of heterosis for this trait. The genetic improvement of the genotypes is due to the gradual increase in plant density as a source of the a biotic stresses for the development of inbreds and common hybrids. Genetic improvement has been achieved by strengthening and improving the source and sank components, balancing between them and thus preserving the genotypes in a wide range of densities of (30-79 thousand. ha^{-1} plants) (22).Roekl and Coulter (30) determined the relationship between the yield of the maize hybrids and the plant density. He indicates that the studied hybrids gave the highest yield of plant density amounted of (81.7 thousand. ha^{-1} plants).Plant density has a significant impact on the growth of maize and its yield, due to differences in the competitiveness of plants at increasing densities. Balanced growth and its increase for plants require optimal plant densities that enable them to make more efficient use of nutrient elements availability, water in soil, Better absorption of light, and other growth factors affecting plants (16). Muranyi (27) tested eight double hybrids under three plant densities (50, 70 and 90 thousand plants. ha^{-1}) and showed that the hybrids performance was better with a density of (70 thousand plants. ha^{-1}). The genetic improvement for the yield of yellow crop is associated with an increase in yield potential by increasing the tolerance of the stresses. Where the yield potential is estimated at three times the calculated yield and the understanding of the interaction between genetics and field processes is important for testing the genotypes under increasing plant densities (13).The study aims to evaluate the performance of double and Single hybrids through crossing several genetically diverged inbreds, to obtain one hybrid or more highly productive in two plant densities, to estimate the percentage of heterosis and hybrid vigor.

2. MATERIALS AND METHODS

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A field experiment was conducted in the fields of Field Crop Department, College of Agriculture, University of Baghdad, to estimate some genetic parameters and hybrid vigor by comparing the performance of five parents (ZM43WIZE, ZM60, ZM49W3E, ZM19, CDCN5) with their single and double hybrids using 30 genotypes obtained from (Dr.Banan Hassan Hadi) By conducting all the Diallel Crosses between the inbreds to produce ten single hybrids according to the method of Griffing (1956) the second fixed model, At the same time, selfing for parental inbreds was conducted to propagation their seeds, double hybrids were also produced in a later season (fall of 2016) by crossing between single hybrids to produce 15 double hybrids. At the same time, parents were propagated in the above manner and a Diallel Crosses was conducted between parents to produce single hybrids.

Agricultural operations:

All soil service operations were conducted by plowing, smoothing, settling and dividing as recommended. Calcium superphosphate fertilizer was added to 46% P_2O_5 by (200 kg.ha^{-1}) P_2O_5 when soil preparation. Urea fertilizer was added to 46% with amount of (300 kg N.ha^{-1}) in three doses at cultivating and one month after adding the first dose and at flowering. The thicket control in all seasons was conducted with the use of Atrazine substance (85%) (effective substance at 3.25 kg.ha^{-1}), (Sesamia criteco was treated using 10% Diazinon, with rate of (4 kg.ha^{-1}) on the two doses, the first one when the plant reached the four leaves stage and the second one after twenty days from the first control. Crop service operations were also applied from irrigation and weeding whenever needed.

The evaluating experiment (Fall 2017)

In this season, a evaluating experiment was conducted to evaluate the performance of single and double hybrids plants with their parents (inbreds) on 21-7-2017. Their seeds were cultivated (5 inbreds, 10 single hybrids and 15 double hybrids) and with two densities (60, 80 thousand plants. ha^{-1}), the cultivation was conducted on 21/7/2017 on the furrows with length of (5 m), the distance between furrow and another is 0.75 m, the distance between plant and the other (0.222, 0.166 m) for the two densities mentioned, respectively. The randomized complete block design (RCBD) was used with three replications, using the spilt plots arrangement, where the two densities (60000, 80000 plant.ha^{-1}) were represented in the main plots while the genotypes were sub-plots. Soil and crop service operations were conducted as mentioned above. A random sample consisting of five intermediate plants was collected from each experimental unit to study the field traits which included the following traits:

1- The mean of ear length (cm).
2- The mean of rows number .ear^{-1}.
3- The mean of grain number . row^{-1}.
4- The mean of grains number . plant^{-1}.
5- The mean number of ears.
6- The mean of grain weight (g) after weight correction on moisture content 15.5% (14).
7- The mean of plant yield (g / plant) after weight correction on moisture content 15.5% (14).

The statistical analysis of each trait was analyzed by using the RCBD design, using the spilt plots arrangement, a significant was tested by using F test. The means were compared using the least significant difference (L.S.D), with a significant level of 0.05 and for all the traits using Excel program 2014 and statistical program Gestate 2014.

Estimation of Hybrid vigor (%) and the percentage of Heterosis (%)

The percentage of Heterosis was estimated on the basis of the deviation of the first generation from the mean parents for the traits under study and according to the following equation:

$$H\% = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} \times 100 \quad (33)$$

Where

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H% = The percentage of Heterosis

$\overline{F1}$ = The first generation

$\overline{MP}$ = mean parent

The hybrid vigor H.V% was calculated on the basis of the first generation deviation from the mean of the highest parents as a percentage.

According to the following equation:

H.V%= $\frac{\overline{F1}-\overline{HP}}{\overline{HP}}$ ×100(17)

HV% = Hybrid vigor

$\overline{F1}$ = The first generation

$\overline{HP}$ = mean of the highest parent

3. RESULTS AND DISCUSSION

The ear length (cm)

Table (1) shows significant differences between genotypes where parent 3 gave the highest mean for the trait of the length of the ear compared to the rest of the parents amounted of (17.00 cm) and did not differ significantly from parent 4,while parent 1 gave the lowest mean for this trait amounted of 13.10 cm. The hybrid (3 × 1) recorded the highest mean for this trait amounted of (19.88 cm) and did not differ significantly from the single hybrids except the two hybrids (4 × 3) and (2 × 1), which gave the lowest mean for the length of the ear was (17.72, 17.30 cm),This increase is due to the superiority of this hybrid by increasing plant height and increasing the leaf area and its index (2),This means forming a strong source and optimal distribution of the area, resulting in optimal utilization of the falling sun rays, increasing the efficiency of Carbon fixation and accumulation of dry matter, Giving a longer ear. Table (7) indicates that this hybrid has a positive percentage of heterosis and hybrid vigor in the desired direction amounted of (32%, 28.8%). Table (1) also shows that the general mean for the mean parents for the length of the ear was less than the general mean for the mean of double hybrids where amounted of 15.06 cm for parents and 18.60 cm for double hybrids with an increase of 23.5%.The double hybrids did not differ significantly between them in the traits of the length of the ear except the double hybrids (5 x 4) (2 x 1), (5 x 4) (3 x 1), 5 x 2 (4 x 1) and (5 x 3) (4 x 1), and the double hybrid (4×3)(5×2) gave the longest ear amounted of (20,30 cm) followed by the two double hybrids (5 × 2) (3 × 1) and (5 × 4) (3 × 2) where the length of the ear amounted of (19.98 cm).This superiority may be attributed to have this hybrid a percentage of heterosis and positive hybrid vigor for the first and third hybrid (9.02%, 3.99%), (1.42% and 0.50%), positive percentage of heterosis (1.02%) and zero hybrid vigor for the second hybrid. The positive percentages for the values of the hybrid vigor denote the dominance of the super-dominance genes in the transmission and inheritance of the trait and the zero value for the hybrid vigor for the two hybrid (5 × 3) (4 × 2), This is evidence on the absence of the dominance for genes in influencing on the trait. In addition, the double hybrids, which gave the lowest length for the ear, had a percentage of heterosis and negative hybrid vigor, in the direction of reduce the length of the ear as shown in Table (7), similar results obtained by Al-Amery (8) and Abed et al., (6).Table (1) indicates an inverse relationship between the length of the ear and the increase in the plant density.The significant differences were showed in the length of the ear by giving it the highest value for the length of the ear at the lowest density amounted of (18.76 cm), with the increase of 8.8% when the plant density decreased from (80 to 60 thousand plants. ha^{-1}). The reason for this relationship may be due to increased competition between plants in increasing densities, which reduced the leaf area and their number (22) and which have a positive relation with the length of the ear. This result agrees with Hadi (20).The response of Genotypes varied with plant density, The single hybrids (3 × 1) gave the highest mean for the trait in the low density amounted of 21.93 cm and did not differ significantly from the fourteen single and double hybrids, while the

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parent 1 gave the lowest mean for this trait amounted of (13.20 cm), while in the high density, the single hybrid (5 × 1) excelled by giving it the highest mean amounted of (20.90 cm) and not significantly different from the hybrid (4 × 1) and the double hybrids (5 × 2) (3 × 1), (5 × 4) (3 × 1), (3 × 2) 5 × 1), (5 × 4) (3 × 2), (4 × 3) (5 × 2)), respectively. While the parent himself gave the lowest length of the ear amounted of 13 cm, Which demonstrates the possibility of hybrids to give ear with larger length under the environmental stress represented by the increasing plant densities to increase SCC in their plants.

Number of rows in ear

The number of rows in ear is determined when its size is determined. This trait is affected by the genotypes firstly and by the environmental conditions secondly.It is considered one from the Components of the Secondary yield with high Heredity.The results indicated in Table (2) that there is a significant difference between the genotypes under study. Parent 5 gave the highest mean for this trait amounted of (15.20 row.ear^{-1}) and did not differ significantly from parents (3 and 2), while parents (1, 4) gave the lowest mean amounted of (13.47, 13.92 row.ear^{-1}).The single hybrids did not differ significantly between them, which the two hybrids (3 × 1) and (5 × 3) gave the highest mean number of rows amounted of (15.43, 15.42 row.ear^{-1}), respectively.For the possession of these hybrids the highest percentage of heterosis and positive hybrid vigor amounted to (10.7%, 7.15%), and (4.18%, 1.44%) as shown in Table (8).Table (2) shows that the general mean for the mean parents for the number of rows in ear was less than the general mean for the means double hybrids, which amounted of (14.23 row.ear^{-1}) for the parents and (15.01 row.ear^{-1}) for double hybrids, with decrease rate of 5.07%, The double hybrids (3 × 2) (5 × 1), (5 × 2) (4 × 1) and (5 × 4) (3 × 2) gave the highest number of rows in ear amounted of (15.92, 15.40, 15.38 row.ear^{-1}), respectively. These hybrids were all higher than the general mean, mean parents and the mean of double hybrids, and did not differ significantly from the rest of the double hybrids except for the double hybrids (5 × 3) (2 × 1), (5 × 4) (3 × 1), (4 × 3) (5 × 1) and (4 × 3) (5 × 2). The hybrid (4 × 3) (5 × 1) gave the lowest number of rows amounted of (14.02 row.ear^{-1}), similar results obtained by (Abdel-Hameed, (3); Majeed et al., (26),the hybrids (3 × 2) (5 × 1), (5 × 2) (4 × 1) and (5 × 4) (3 × 2) had a percentage of heterosis and positive hybrid vigor amounted of (9.19%, 7.42%) (2.39%, 1.85%), (5.27%, 3.36%), respectively as shown in Table (8).Similar results obtained by (Wuhayb et al., (36).Plant density did not significantly affect in the number of rows in ears.While the interaction was significant in this trait due to different response patterns of the genotypes to increase the plant density, The single hybrid (5x2) has excelled by giving it the highest mean at the low plant density amounted of (16.20 row.ear^{-1}) while the parent 3 gave the lowest mean amounted of (14.00 row.ear^{-1}). In the high density, the double hybrids (3 × 2) (5 × 1) has excelled by giving it the highest mean for the trait of the number of rows in ear amounted of (16.20 row.ear^{-1}), While parent 1 gave the lowest mean for this trait amounted of (11.60 row.ear^{-1}),This shows the importance of selecting genotypes under increasing densities to explore their actual potential and to understand the interplay between genetics and field processes, (13). This is similar to what (Abdulla and Harchan, (5); Nomr and Al-Hosari, (29) found.

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Table 1: Means of ear length (cm) for inbreds and hybrids of maize under two plant densities for the fall season 2017.

Genotypes	plant density (1000 plant.ha^{-1})		Mean
	60	**80**	
1	13.20	13.00	13.10
2	16.60	13.40	15.00
3	18.00	16.00	17.00
4	14.00	16.60	15.30
5	13.80	16.00	14.90
(1x2)	17.47	17.13	17.30
(1x3)	21.93	17.83	19.88
(1x4)	18.30	18.90	18.60
(1x5)	16.63	20.90	18.77
(2x3)	20.13	16.10	18.12
(2x4)	20.33	17.27	18.80
(2x5)	20.90	18.13	19.52
(3x4)	19.03	16.40	17.72
(3x5)	19.67	17.17	18.42
(4x5)	19.87	16.90	18.38
(1x2) (3x4)	20.50	16.30	18.40
(1x2) (3x5)	21.7	17.63	19.35
(1x2) (4x5)	17.13	16.47	16.80
(1x3) (2x4)	20.10	17.10	18.60
(1x3)(2x5)	19.93	20.03	19.98
(1x3)(4x5)	18.03	18.23	18.13
(2x3)(1x4)	18.73	17.97	18.35
(2x5)(1x4)	18.57	16.10	17.33
(3x5)(1x4)	17.37	16.40	16.88
(1x5) (2x3)	18.67	19.07	18.87
(1x5) (2x4)	19.73	17.57	18.65
(1x5) (3x4)	19.40	17.93	18.67
(2x3) (4x5)	21.63	18.33	19.98
(2x4) (3x5)	21.73	15.87	18.80
(2x5) (3x4)	20.47	20.13	20.30
LSD 0.05	**2.78**		**1.97**
Mean	**18.76**	**17.23**	
LSD 0.05	0.39		
Mean of inbreds	15.06		
Mean of single Hybrids	18.55		
Mean of double Hybrids	18.60		
General mean	18.00		

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Table 2: Means of rows in ear for inbreds and hybrids of maize under two plant densities for the fall season 2017.

Genotypes	**plant density (1000 plant.ha^{-1})**		**Mean**
	60	**80**	
1	15.33	11.60	13.47
2	14.00	14.40	14.20
3	15.60	13.20	14.40
4	14.14	13.66	13.92
5	15.60	14.80	15.20
(1x2)	14.43	15.33	14.88
(1x3)	16.00	14.86	15.43
(1x4)	14.93	15.00	14.97
(1x5)	14.83	14.80	14.82
(2x3)	14.86	13.83	14.35
(2x4)	15.06	14.70	14.38
(2x5)	16.20	14.03	15.12
(3x4)	15.43	14.23	14.83
(3x5)	15.20	15.63	15.42
(4x5)	15.13	14.63	14.88
(1x2) (3x4)	15.73	15.03	15.38
(1x2) (3x5)	14.33	14.93	14.63
(1x2) (4x5)	14.73	15.30	15.02
(1x3) (2x4)	14.56	15.13	14.85
(1x3)(2x5)	15.46	15.03	15.25
(1x3)(4x5)	13.80	14.93	14.37
(2x3)(1x4)	15.93	15.06	15.50
(2x5)(1x4)	15.66	15.13	15.40
(3x5)(1x4)	14.66	15.13	14.90
(1x5) (2x3)	15.63	16.20	15.92
(1x5) (2x4)	15.33	14.43	14.88
(1x5) (3x4)	14.06	13.96	14.02
(2x3) (4x5)	15.26	15.50	15.38
(2x4) (3x5)	14.53	15.43	14.98
(2x5) (3x4)	14.53	14.96	14.75
LSD 0.05	**1.65**		**1.16**
Mean	**15.03**	**14.69**	
LSD 0.05	NS		
Mean of inbreds	14.23		
Mean of single Hybrids	14.90		
Mean of double Hybrids	15.01		
General mean	14.86		

Number of grains in rows

The results of Table (3) for the mean number of grains in row for the genotypes under study indicated that there were significant differences between the parents and their hybrids for this trait, where the parent 3 had excelled by giving it the highest mean for this trait amounted of (31.22 grain.row^{-1}) and did not differ significantly for the rest of the parents, Except for the parent 1

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who gave the lowest mean amounted of (19.70 grain.row^{-1}). The single hybrid (3 × 1) has excelled by giving it an mean of (41.00 grain.row^{-1}) and did not differ significantly from hybrids (4 × 1), (5 × 1), (5 × 2) and (5 × 4).This increase is due to the increase in the length of ear for this hybrid as shown in Table (1).Similar results were obtained by (Baktash and Abdel-Hameed (9); Majeed et al., (24).These hybrids were characterized by highly positive heterosis and hybrid vigor, which amounted of (61.3%, 31.3%), (55.5%, 30.5%), (63.1%, 42.8%), (37.3%, 36.9%) and (41.3%, 34.9%), respectively, which are the highest percentage of heterosis and hybrid vigor between single and double hybrids as shown in Table (7).Table (3) shows that the general mean for the mean parents for the number of grain in the row was less than the general mean for the mean of double hybrids, which amounted of (26.74 row.ear^{-1}) for parents and (36.64 row.ear^{-1}) for double hybrids and an increase rate of 27.02%.The double hybrids (5 × 2) (3 × 1) has excelled by giving it the highest number of grains for the row amounted of (40.65 grain.row^{-1}) because the single hybrid (3 × 1) is one of his parents and although the double hybrid gave a hybrid vigor and the percentage of heterosis is negative, The single involved in its composition gave a hybrid vigor and highly positive percentage of heterosis, The double hybrids did not differ significantly from eight of the double hybrids, While differ from the other six (5 x 4) (2 x 1), (5 x 4) (3 x 1), (5 x 2) (4 x 1) and (5 x 3) (4 x 1), and the lowest mean number of grains in row for the hybrids (5 × 3) (4 × 1) where gave (34.53 grain.row^{-1}) and The decrease in the number of its grains was due to the low length of the ear as shown in Table (1). These hybrids also had a negative percentage of heterosis and positive hybrid vigor (-5.50% and -8.33%) as shown in Table (8).This result agrees with (AL-Amery, (8). The density (60 thousand. plant^{-1}) gave the highest mean for the number of grain in row amounted of (36.75 grain.row^{-1}),This increase was due to the reduction in plant density to increase the number of leaves and their area, although the increase was insignificant as shown in table (2), As well as increase opportunity for fertilization due to lack of shading and lack of competition, which led to an increase in the number of grain in row, which is similar to what (Qatia, (30) found.The number of grains in row with the effect of both densities and genotypes responded to a significant response and the single hybrid (3 × 1) achieved the highest mean for the trait under the low density amounted of (45.63 grain.row^{-1}) while parent 1 gave the lowest mean for this traits amounted of (14.27 grain.row^{-1}),As for the high density, the double hybrid (5 × 2) (3 × 1) has excelled by giving it the highest mean amounted of (39.53 grain.row^{-1}) while the parent 2 gave the lowest mean for the trait of the number of grain in the row which amounted of (21.43 grain.row^{-1}).

Number of grains. Plant^{-1}

This component is the function of the physiological condition that is exposed to the crop at the critical stage to the silking formation, where the low growth rates decreases at the beginning of the silking formation, and the number of grains causes the lack of the presence of metabolic material for the duration of filling. Table 4 shows the difference between the genotypes. Parent 3 gave the highest mean for the trait of the number of plant grains which amounted of (450.9 grain) and did not differ significantly from the rest of the inbreds with the exception of the inbred 1, which gave the lowest number of plant grains amounted of (254.7 grain).The mean superior inbreds were higher than the general mean for the inbreds which amounted of 379.2.The hybrid (5 × 3) was characterized by giving it the highest mean for this quality amounted of (653.6 grain) followed by single hybrid (5 × 4), (3 × 1), (5 × 2) and (5 × 1), which amounted (646.0, 645.8, 633.3, 602.2), respectively, Which is higher than the general mean, mean inbreds and mean of single hybrid, this result agree with (Hamdan and Baktash, (10). The reason for the superiority of these single hybrids may be attributed to having a highly positive heterosis and hybrid vigor amounted of (61.8%, 61.1%), (83.0%, 43.2%), (60.3%, 59.2%) and(84.6%, 51.4%) as shown in Table (17).The

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double hybrids (5 × 2) (3 × 1) has excelled by giving it the highest mean for number of plant grains amounted of (691.2 grain and then the hybrids (3 × 2) (4 × 1) and (5 × 4) (3 × 2) where the number of grain for plant amounted of (688.8, 667.1), respectively, and did not differ significantly from the remaining double hybrids except for hybrids (5 × 3) (2 × 1), (5 × 4) (3 × 1), (5 × 3) (4 × 1), (5 × 3) (4 × 2) and (4 × 3) (5 × 2). All of these superior hybrids had a higher number of grains than general mean and mean of inbreds and single and double hybrids. The three double hybrids were characterized by positive heterosis and hybrid vigor amounted of (8.08% , 7.03%), (23.9%, 16.6%) and (14.2%, 3.21%), respectively. Table (4) indicates that there is a significant effect of plant density in the number of grains, where the increase in plant density from (60000 to 80,000 $plant.ha^{-1}$) led to reduce the number of plant grains, with ratio of 14.57%.The reason may be due to the fact that increasing densities reduced the source capacity of the number of leaves and their area and led to reduce the availability of C4 carbon fixation products and Cause ovarian abortions, Which led to reduce the sink capacity representing by reducing the length of the ear and the number of rows and the number of grains in row as shown in Table (1, 2, 3) and the number of ear as shown in Table (5), Which led to a reduction in the number of plant grains. Similar results were obtained by (William, (35); Fanadzo et al.,(16); Hamdan and Baktash, (10).There was a significant interaction between the hybrid and its parents and plant densities in this trait, The single hybrid combination (5 x 3) with the lowest plant density gave the highest number of grains amounted of (773.3 grains), while the parent 1 gave the lowest mean for this trait amounted of (218.3 grain), While in the high density the double hybrid (4 × 2) (3 × 1) gave the highest mean for this trait amounted of (638.2 grain) while the parent 1 gave the lowest mean for this trait amounted of (291.2 grain).

Number of ears

The number of grains is one of the main components for the yield of maize, which is an inherent trait for the cultivar but it is influenced by certain growth factors. Table (5) indicates significant differences between the parents and their hybrids, and the parents did not differ significantly among each other for this, where the parents gave means amounted of (1.00 $ear.plant^{-1}$). The single hybrid (5 x 3) gave the highest mean for this trait amounted of (1.20 $ear.plant^{-1}$) followed by the two hybrids (5x4) and (5x2,) with an mean of (1.13 $ear.plant^{-1}$) which is higher than the general mean for trait and general mean for parents and general mean for single hybrids, The reason for the superiority of these single hybrids may be attributed to their superiority in the area of the leaves and their index (22), which helped to intercept the sun and then increase photosynthesis units and increase its efficiency to give a more ears number. This result agree with (Abed et al., (6). It also had a percentage of heterosis and positive hybrid vigor amounted of (24%, 20%), (13%, 13%), (5%, 15%), respectively as shown in Table (7). Similar results were obtained by (Mazal et al., (27); Abd-Gapar and Taha (1); Abed et al., (6). Table (5) shows that the overall mean for the means of the double hybrid was higher than the general mean, the mean parents and the mean of the single hybrids, where it amounted of (1.10), while the general mean amounted of (1.08), the mean parents was (1.00), the mean of hybrid was (1.09), The double hybrid (5 × 4) (3 × 1) gave the highest number of ear amounted of (1.18) followed by the two hybrids (3 × 2) (4 × 1), (5 × 4) (3 × 2), which it gave (1.17 $ear.plant^{-1}$) and then double hybrids (4 × 2) (5 × 1), (4 × 3) (2 × 1) and (4 × 3) (5 × 1) where the number of their ear amounted of (1.15, 1.13, 1.12), respectively, This may be due to the fact that these hybrids have a highly positive heterosis and hybrid vigor amounted of (7.27%, 4.42%), (10.3%, 9.43%), (6.36%, 3.53%), (6.48%, 6.48%), (7.61%, 7.61%) and (5.66%, 3.70%), respectively as shown in Table (8). This refers to the occurrence of the characteristic under the control of the super-dominance genes and this is similar to what Al-Amery, (8) found .Table (5) shows a significant difference in the effect of plant densities, where increasing the plant density, the number of ears in

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the plant decreased. We note that the mean low density was higher than the mean of the high density, where amounted of (1.10 $ear.plant^{-1}$) for low density and (1.05 $ear.plant^{-1}$) For high density, It may be due to the fact that low plant density leads to reduce shading between plants and increasing light influence, resulting in increasing photosynthesis yields, This reflected positively on the increase in the number of ears in the plant. The response of the parents and their hybrids was similar to the variation of the plant densities for this trait. These results agree with what Hadi (20) found.

Table 3: Mean of number grains in row for inbreds and hybrids of maize under two plant densities for the fall season 2017.

Genotypes	**plant density (1000 $plant.ha^{-1}$)**		**Mean**
	60	**80**	
1	14.27	25.13	19.70
2	34.00	21.43	27.72
3	32.40	30.03	31.22
4	27.03	30.67	28.85
5	24.07	28.40	26.23
(1x2)	33.90	37.00	35.45
(1x3)	45.63	36.37	41.00
(1x4)	39.20	36.13	37.67
(1x5)	36.80	38.13	37.47
(2x3)	38.13	29.10	33.62
(2x4)	38.00	33.60	35.80
(2x5)	38.13	35.97	37.05
(3x4)	37.13	33.40	35.27
(3x5)	39.30	31.53	35.42
(4x5)	41.13	36.70	38.92
(1x2) (3x4)	39.60	32.03	35.82
(1x2) (3x5)	39.78	33.50	36.68
(1x2) (4x5)	33.30	35.30	34.30
(1x3) (2x4)	39.93	37.07	38.50
(1x3)(2x5)	41.77	39.53	40.65
(1x3)(4x5)	34.63	33.43	34.03
(2x3)(1x4)	38.63	36.97	37.80
(2x5)(1x4)	37.23	33.23	35.23
(3x5)(1x4)	35.17	33.90	34.53
(1x5) (2x3)	37.97	34.70	36.33
(1x5) (2x4)	39.73	36.13	37.93
(1x5) (3x4)	41.17	33.77	37.47
(2x3) (4x5)	41.17	36.80	38.98
(2x4) (3x5)	41.20	29.13	35.17
(2x5) (3x4)	42.00	30.57	36.28
LSD 0.05	**7.17**		**5.07**
Mean	**36.75**	**33.32**	
LSD 0.05	0.19		
Mean of inbreds	26.74		
Mean of single Hybrids	36.76		
Mean of double Hybrids	36.64		
General mean	35.04		

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Table 4: Mean of number grains in row for inbreds and hybrids of maize under two plant densities for the fall season 2017.

Genotypes	plant density (1000 plant.ha^{-1})		Mean
	60	80	
1	218.3	291.2	254.7
2	476.0	308.4	392.2
3	505.3	396.4	450.9
4	382.9	418.7	400.8
5	374.9	420.3	397.6
(1x2)	487.6	606.6	547.1
(1x3)	751.7	539.9	645.8
(1x4)	603.2	579.4	591.3
(1x5)	583.7	620.6	602.2
(2x3)	636.4	407.1	521.8
(2x4)	648.4	511.0	579.7
(2x5)	655.3	611.3	633.3
(3x4)	609.7	494.6	552.2
(3x5)	773.3	534.0	653.6
(4x5)	736.7	555.4	646.0
(1x2) (3x4)	741.9	510.6	626.3
(1x2) (3x5)	567.5	533.6	550.6
(1x2) (4x5)	601.3	576.6	588.9
(1x3) (2x4)	580.3	638.2	609.3
(1x3)(2x5)	750.5	631.9	691.2
(1x3)(4x5)	561.6	591.6	576.6
(2x3)(1x4)	756.1	623.5	689.8
(2x5)(1x4)	687.8	502.9	595.3
(3x5)(1x4)	549.0	536.4	542.7
(1x5) (2x3)	636.1	582.2	609.2
(1x5) (2x4)	747.8	554.3	651.0
(1x5) (3x4)	705.1	471.9	588.5
(2x3) (4x5)	703.4	630.8	667.1
(2x4) (3x5)	601.6	489.3	545.5
(2x5) (3x4)	669.7	465.8	567.8
LSD 0.05	**151.16**		**106.89**
Mean	**610.1**	**521.1**	
LSD 0.05	22.55		
Mean of inbreds	379.2		
Mean of single Hybrids	597.3		
Mean of double Hybrids	606.6		
General mean	565.6		

The grain weight

Table (6) shows the difference the genotypes between them in the trait of the grain weight, where the parent 3 has excelled by giving it the highest mean weight of the grain amounted of (0.372 g), while the parents 2 and 5 gave the

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lowest mean for the trait amounted of (0.265, 0.275 g),As for single hybrids, the hybrids (3 × 2) and (4 × 3) gave the highest mean for this trait amounted of (0.350 g) and did not differ significantly from the rest of the single hybrids except for the hybrid (5 × 1) and (5 × 4), which gave means lower than General mean and mean inbreeds and mean of single hybrids, The decrease in grain weight for these hybrids may be due to an increase in the number of grains in the plant and an increase in competition for metabolic materials as shown in Table (4).Table (15) indicates that the general mean for the mean parents was slightly lower from the general mean for the mean of the double hybrids, where amounted of (0.308 g) for parents and (0.309 g) for double hybrids, The double hybrid (4 × 3) (5 x 2) gave the highest mean amounted of (0.35 g) and did not differ significantly from the double hybrids (4 × 2) (3 × 1), (5 × 4) (3 × 2), (3 × 2) (4 × 1) and (4 × 3) (5 × 1) where the mean weight of the grain amounted of (0.333, 0.333, 0.328 and 0.323), respectively, Similar results were obtained by (Abd al-Hameed and Baktash (10), Abed et al., (6).The hybrids differed in their hybrid vigor. The single hybrids (3 x 2) and (4 x 3) had positive percentage of heterosis and negative hybrid vigor amounted of (10.0%, 5.9%), (1.44%, -5.91%), respectively,While the hybrid (4 × 2) showed percentage of heterosis and positive hybrid vigor amounted (17.5%, 7.5%) while the hybrid (3 × 1) gave percentage of heterosis and negative hybrid vigor amounted of (-0.58%, 8.60%) as shown in Table (7).The negative values for the hybrid vigor indicate to reduction the mean trait for hybrid than the best of its parents, where Its parents were characterized by high means weight of the grain, As for the percentage of negative heterosis, it Indicates to a lower trait than the mean of its parents, The double hybrid (4 × 3) (5 × 2) had a positive percentage of heterosis amounted of 3.55% and a zero hybrid vigor, wherever the mean weight of grain for the hybrid was equal to its parents, The same table showed that the two double hybrids (4 × 2) (3 × 1) and (4 × 3) (5 × 1) had a negative percentage of heterosis and hybrid vigor amounted of (-1.75%, -2.04%) and (-10.2%, -10.7%), respectively. As for the two hybrids (2 x 4) (3 × 2) and (3 × 2) (4 × 1) had positive percentage of heterosis and negative hybrid vigor amounted of (2.14%, -4.85%) and (2.67%, -6.28%), respectively. This result agree with what Oujda Chung et al., (11) and Abed et al., (6) found.It is clear from Table (5) that there are no significant differences between the parents and their hybrids in this trait due to the effect of plant density, While the yield differed according to different genotypes and different plant densities. The parent 3 achieved the best response at high density by giving it the highest weight for grain amounted of 0.433 g while the parent 5 gave the lowest mean for inbreds amounted of 0.230 g at the same density, In the low density, parent 1 gave the highest mean amounted of 0.380 g and did not differ significantly from the single hybrids (4 × 2), (4 × 3) and (3 × 2) and the double hybrids (3 × 2) (4 × 1), (4 × 3) (5 × 2) and (5 × 4) (3 × 2), which is similar to what Al-Khazaali et al., (6) found.

Mean of the individual plant yield (g)

The grain yield is considered the final result for the components of the yield based on the total functional processes in the plant is the result of genetic-environmental interaction. The results of Table (6) showed significant differences between genotypes. Parent 5 gave the highest mean for the trait of the individual plant yield amounted of 96.8 g and did not differ from parents 2, 3 and 4, while Parent 1 gave the lowest mean for this trait amounted of 66.3 g. The single hybrid (5 × 3) has excelled by giving it the highest mean for this trait amounted of 184.2 g followed by the hybrids (2 × 1), (4 × 2) and (4 × 3), which amounted of (153.7, 152.8, 151.5 g), The increase in yield may be attributed to the increase in the crop growth rate (CGR) for the hybrid than its parents and the weight of the dry matter (22) and its fragmentation into sinks such as the number of ears, the number of grains and the weight of the grainas shown in Tables (4, 5,

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6).The increase in phenotypic components is an inevitable consequence of increasing their physiological components (DTM, TDM, CGR, and HI).The double hybrids (5 × 4) (3 × 2) gave the highest yield amounted of (185.8 g) and did not differ significantly from the hybrid (5 × 4) (3 × 1), (5 × 3) (2 × 1) and (5 × 2) (4 x 1) where gave a yield amounted of (182.3, 177.3, 170.8 g) respectively, This result agree with what Baktash and Abdel Al-Hameed (10) and Abdul-Hamed et al., (3) found.The single hybrids had a highly highly positive percentage of heterosis and hybrid vigor amounted of (93.8%, 90.2%), (91.1%, 62.6%), (68.2%, 51%) and (79.9%, 62.3%) for single hybrids (5 x 3), (2 × 1), (4 × 2) and (4 × 3), respectively, and (30.2%, 29.2%), (28.1%, 27.6%) and (18.2%, 11.7%) for hybrids (5 × 4) (3 × 2), (5 × 4) (3 × 1) and (5 × 2) (4 × 1), respectively.While the hybrid (5 × 3) (2 × 1) gave positive percentage of heterosis and negative hybrid vigor (4.97% and -3.74%), The reason for the negative hybrid vigor may be due to the rise of the single hybrid yield (5 x 3) from its best parent as shown in Table (7), Similar results were obtained by (Wuhaib et al., (36).The increase in plant density from 60000 to 80000 plant.ha^{-1} led to a decrease in the grains yield of individual plant by increasing plant density, The reason may be attributed to the increased competition between plants for light and nutrients, which causes a decrease in the capacity of the source and hence the decrease in the number of sinks, Representing by the number of ears, the number of grains and the weight of the grain as shown in Tables (4, 5, 6) Which reduced the grains yield of individual plant , but this does not mean a decrease the yield in the unit area because the number of plants compensates for the decline of the yield of individual plant. The response of the trait differed according to the different genotypes and different plant density. The best response for the double hybrid (5 × 2) (4 × 1) was obtained in the low plant density and gave a yield amounted of 221.3 g and did not differ significantly from the two double hybrids (5 × 2) (4 × 1), (5 × 4) (3 × 1) and the single hybrid (5 × 3) and the lowest value for response to the parent 1 in the same density, while in the high density was better response to the double hybrid (5 × 3) (2 × 1) where it gave (170.0 g) and did not differ significantly from the double hybrids (5 x 4) (3 x 1), (3 x 2) (4 x 1), (5 x 4) (3 x 2), (4 x 3) (5 x 2) and (4 x 2) 3 × 1), and single hybrids (5 × 3), (2 × 1) and (5 × 2), While the lowest value for response to parent 1 which amounted of 58.0 g, and these results were similar to those found by Qatia (30).

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Table 5: Mean grain weight (g)for inbreds and hybrids of maize under two plant densities for the fall season 2017.

Genotypes	plant density (1000 plant.ha^{-1})		Mean
	60	80	
1	0.380	0.246	0.313
2	0.283	0.246	0.265
3	0.310	0.433	0.372
4	0.316	0.320	0.318
5	0.320	0.230	0.275
(1x2)	0.323	0.343	0.333
(1x3)	0.333	0.346	0.340
(1x4)	0.310	0.340	0.325
(1x5)	0.300	0.300	0.300
(2x3)	0.340	0.360	0.350
(2x4)	0.376	0.306	0.342
(2x5)	0.283	0.370	0.327
(3x4)	0.360	0.340	0.350
(3x5)	0.286	0.356	0.322
(4x5)	0.306	0.296	0.302
(1x2) (3x4)	0.266	0.290	0.278
(1x2) (3x5)	0.266	0.323	0.295
(1x2) (4x5)	0.293	0.303	0.298
(1x3) (2x4)	0.323	0.346	0.335
(1x3)(2x5)	0.283	0.323	0.303
(1x3)(4x5)	0.253	0.346	0.300
(2x3)(1x4)	0.373	0.283	0.328
(2x5)(1x4)	0.270	0.360	0.315
(3x5)(1x4)	0.313	0.266	0.290
(1x5) (2x3)	0.273	0.346	0.310
(1x5) (2x4)	0.326	0.293	0.310
(1x5) (3x4)	0.306	0.340	0.323
(2x3) (4x5)	0.353	0.313	0.333
(2x4) (3x5)	0.280	0.276	0.278
(2x5) (3x4)	0.360	0.340	0.350
LSD 0.05	**0.050**		**0.035**
Mean	**0.312**	**0.319**	
LSD 0.05	NS		
Mean of inbreds	0.308		
Mean of single Hybrids	0.329		
Mean of double Hybrids	0.309		
General mean	0.316		

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Table 6: Mean of the individual plant yield (g)for inbreds and hybrids of maize under two plant densities for the fall season 2017.

Genotypes	**plant density (1000 plant.ha^{-1})**		**Mean**
	60	**80**	
1	74.7	58.0	66.3
2	88.7	100.3	94.5
3	98.3	88.3	93.3
4	80.3	70.0	75.2
5	100.0	93.7	96.8
(1x2)	162.7	144.7	153.7
(1x3)	163.3	122.3	142.8
(1x4)	140..7	132.0	136.3
(1x5)	160.7	135.7	148.2
(2x3)	169.3	118.0	143.7
(2x4)	159.0	126.3	142.7
(2x5)	164.3	141.3	152.8
(3x4)	173.7	129.3	151.5
(3x5)	215.7	152.7	184.2
(4x5)	162.7	120.7	141.7
(1x2) (3x4)	174.7	116.7	145.7
(1x2) (3x5)	184.7	170.0	177.3
(1x2) (4x5)	139.0	118.0	128.5
(1x3) (2x4)	127.3	147.0	137.2
(1x3)(2x5)	180.3	135.0	157.7
(1x3)(4x5)	196.3	168.3	182.3
(2x3)(1x4)	180.7	150.3	165.5
(2x5)(1x4)	221.3	120.3	170.8
(3x5)(1x4)	132.3	111.7	122.0
(1x5) (2x3)	146.3	135.0	140.7
(1x5) (2x4)	164.3	126.3	145.3
(1x5) (3x4)	163.0	126.7	144.8
(2x3) (4x5)	220.7	151.0	185.8
(2x4) (3x5)	145.7	116.7	131.2
(2x5) (3x4)	170.0	150.3	160.2
LSD 0.05	**33.90**		**23.97**
Mean	**155.4**	**125.9**	
LSD 0.05	5.45		
Mean of inbreds	85.2		
Mean of single Hybrids	149.7		
Mean of double Hybrids	153.0		
General mean	140.6		

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Table 7: Percentage of heterosis (top), hybrid vigor (bottom) and standard errors for single and double hybrids for some studied traits.

Crosses	Length of the ear	Number of rows	Number of grains in row	Number of grains in plant	Number of ears	Weight of the grain	Yield of individual plant
(1x2)	23.1 15.3	7.59 4.78	49.5 27.8	69.1 39.4	5 5	15.2 6.38	91.1 62.6
(1x3)	32.0 28.8	10.7 7.15	61.0 31.3	83.0 43.2	8 8	-0.58 -8.60	78.9 53.0
(1x4)	30.9 21.5	9.34 7.54	55.2 30.5	80.4 47.5	5 5	3.1 2.20	92.7 81.2
(1x5)	34.0 25.9	3.41 -2.5	63.1 42.8	84.6 51.4	8 8	2.04 -4.15	81.8 53.0
(2x3)	13.2 6.58	0.34 -0.34	14.0 7.68	23.7 15.7	7 7	10.0 -5.9	53.0 52.0
(2x4)	24.0 22.8	2.27 1.26	26.5 24.0	46.2 44.6	8 8	17.5 7.54	68.2 51.0
(2x5)	30.5 30.1	2.85 -0.52	37.3 36.9	60.3 59.2	13 13	21.1 18.9	59.8 57.8
(3x4)	9.72 4.23	4.73 2.98	17.4 12.9	29.6 22.4	5 5	1.44 -5.91	79.9 62.3
(3x5)	15.4 8.35	4.18 1.44	23.3 13.4	54.0 44.9	20 20	-0.30 -13.4	93.8 90.2
(4x5)	21.7 20.1	2.19 -2.10	41.3 34.9	61.8 61.1	13 13	2.02 -5.03	64.7 46.3
(1x2) (3x4)	4.80 3.83	3.56 3.36	1.30 1.04	13.9 13.4	7.61 7.61	-18.4 -20.5	-4.52 -5.20
(1x2) (3x5)	8.34 5.04	-3.43 -5.12	3.52 3.46	-8.27 -15.7	-8.03 -14.1	-9.78 -11.4	4.97 -3.74
(1x2) (4x5)	-5.82 -8.59	0.94 0.94	-7.74 -11.8	-1.27 -8.83	5.50 1.76	-5.99 -10.5	-12.9 16.3
(1x3) (2x4)	-3.82 -6.43	-0.33 -3.75	0.26 -6.09	-0.55 -5.65	-0.92 -0.92	-1.75 -2.04	-3.85 -3.92
(1x3)(2x5)	1.42 0.50	-0.13 -1.16	4.17 -0.85	8.08 7.03	1.81 -0.88	-9.00 -10.8	6.69 3.20
(1x3)(4x5)	-5.22 -8.80	-5.14 -6.86	-14.8 -17	-10.7 -10.7	7.27 4.42	-6.54 -11.7	28.1 27.6
(1x4)(2x3)	-0.05 -1.34	5.72 3.54	6.06 0.34	23.9 16.6	10.3 9.34	2.67 -6.28	18.2 15.1
(1x4)(2x5)	-9.07 -11.2	2.39 1.85	-5.70 -6.47	-2.74 -6.00	-0.91 -4.42	-3.37 -3.66	18.2 11.7
(1x4)(3x5)	-8.80 -9.24	-1.90 -3.37	-5.50 -8.33	-12.8 -16.9	-6.25 -12.5	-10.2 -10.7	-23.8 -33.7
(1x5) (2x3)	2.33 0.53	9.19 7.42	2.22 -3.04	8.39 1.16	-1.86 -2.77	-4.61 -11.4	-3.56 -5.06
(1x5) (2x4)	-0.69 -0.79	1.91 0.40	3.54 1.22	10.1 8.10	6.48 6.48	-3.42 -9.35	-0.06 -1.95

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(1x5) (3x4)	2.35 -0.53	-5.39 -5.46	3.02 صفر	1.95 -2.27	5.66 3.70	-0.61 -7.71	-3.33 -4.42
(2x3) (4x5)	9.47 8.70	5.27 3.36	7.47 0.15	14.2 3.26	6.36 3.53	2.14 -4.85	30.2 29.2
(2x4) (3x5)	1.02 صفر	0.53 -2.85	-1.23 -1.75	-11.5 -16.5	-7.89 -12.5	-16.2 -18.7	-19.7 -28.7
(2x5) (3x4)	9.02 3.99	-1.46 -2.44	0.33 -2.07	-4.20 -10.3	-1.83 -5.30	3.55 صفر	5.32 4.84
(1x2)	23.1 15.3	7.59 4.78	49.5 27.8	69.1 39.4	5 5	15.2 6.38	91.1 62.6
(1x3)	32.0 28.8	10.7 7.15	61.0 31.3	83.0 43.2	8 8	-0.58 -8.60	78.9 53.0
(1x4)	30.9 21.5	9.34 7.54	55.2 30.5	80.4 47.5	5 5	3.1 2.20	92.7 81.2
(1x5)	34.0 25.9	3.41 -2.5	63.1 42.8	84.6 51.4	8 8	2.04 -4.15	81.8 53.0
(2x3)	13.2 6.58	0.34 -0.34	14.0 7.68	23.7 15.7	7 7	10.0 -5.9	53.0 52.0
(2x4)	24.0 22.8	2.27 1.26	26.5 24.0	46.2 44.6	8 8	17.5 7.54	68.2 51.0
(2x5)	30.5 30.1	2.85 -0.52	37.3 36.9	60.3 59.2	13 13	21.1 18.9	59.8 57.8
(3x4)	9.72 4.23	4.73 2.98	17.4 12.9	29.6 22.4	5 5	1.44 -5.91	79.9 62.3
(3x5)	15.4 8.35	4.18 1.44	23.3 13.4	54.0 44.9	20 20	-0.30 -13.4	93.8 90.2
(4x5)	21.7 20.1	2.19 -2.10	41.3 34.9	61.8 61.1	13 13	2.02 -5.03	64.7 46.3
standard errors for single hybrids	2.554 2.802	1.010 0.779	5.42 2.832	6.754 4.326	1.177 1.177	1.944 1.473	4.315 4.236
double hybrids	0.859 0.981	0.640 0.513	0.934 1.207	1.576 1.345	0.776 0.249	1.316 1.393	2.583 2.933

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