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المجلة العراقية لبحوث السوق وحماية المستهلك

STUDY OF YIELD AND ITS COMPONENTS OF INTRODUCED VARIETIES OF MAIZE UNDER DIFFERENT PLANTING DENSITIES

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ABSTRACT

In order to evaluate the performance of introduced varieties of maize and test them under different levels of plant density, and to determine which of the introduced varieties give a high yield and at what plant density, a field experiment was carried out at Station A in the Department of Field Crops- College of Agricultural Engineering Sciences - University of Baghdad- Jadiriyah, for the fall season 2021, the RCBD design was used with four replications, in a split plot arrangement, the three plant densities (50.000, 70.000, and 90.000 Plant s ha^{-1}) were the main plates, while the varieties represented the secondary factor, which is six varieties of maize, class 2 = 5783 DKC, Class 3 = 6315 DKC, Class 4= 6590 DKC, which are introduced and compared with three local varieties: Fajr, Sarah and Al-Maha, The traits of yield components (the ear length, the number of rows ear^{-1}, the number of grains row^{-1}, the number of grains ear^{-1}, the number of ears, the weight of 100 grain) and their relationship to the plant yield were studied, The plant density significantly affected all the studied traits except for the number of ears, it was not significant. Low plant density outperformed the highest plant yield (157.2 g) due to its superiority in ear length, number of rows ear^{-1}, number of grains row^{-1}, number of grains ear^{-1} and weight of 100 grains. The plant over the local varieties, especially variety 3, which gave the highest plant yield (168.2 g), followed by variety 4 (155.4 g), due to their superiority in ear length, number of grains row^{-1}, number of grains ear-1, number of ears, and weight of 100 grains. The interaction between varieties and plant density was significant in all studied traits. We suggest planting the introduced varieties at different planting dates and locations to show their ability to environmentally imprint Iraq's climate and study them in the spring season, and test them under other abiotic stresses such as drought.

Keywords: Maize, plant density, local varieties.

دراسة مكونات الحاصل وعلاقتها بحاصل النبات لاصناف مدخلة من الذرة الصفراء ومقارنتها باصناف محلية تحت ثلاث كثافات نباتية

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الخلاصة

بهدف تقييم اداء اصناف مدخلة من الذرة الصفراء واختبارها تحت مستويات مختلفة من الكثافة النباتية، وتحديد اي الاصناف المدخلة تعطي حاصلاً عالياً وعند أي كثافة نباتية، نفذت تجربة حقلية في المحطة A في قسم المحاصيل الحقلية - كلية علوم الهندسة الزراعية– جامعة بغداد- الجادرية، للموسم الخريفي 2021، تم استخدم تصميم RCBD باربعة مكررات، بترتيب الالواح المنشقة Split plot، مثلت الكثافات النباتية الثلاث (50000، 70000، 90000 نبات هكتار) الالواح الرئيسية ، فيما مثلت الاصناف العامل الثانوي، وهي ستة اصناف من الذرة الصفراء، صنف2 =DKC 5783، صنف3 =DKC 6315، صنف 4 =DKC 6590، وهي اصناف مدخلة ومقارنتها مع ثلاث أصناف محلية هي صنف فجر وصنف سارة وصنف المها، تم دراسة صفات مكونات الحاصل (طول العرنوص وعدد صفوفه وعدد حبوب الصف وعدد حبوب العرنوص وعدد العرانيص ووزن 100 حبة) وعلاقتها بحاصل النبات، اثرت الكثافة النباتية معنوياً في جميع الصفات المدروسة ما عدا عدد العرانيص لم يكن تأثيرها معنوياً، تفوقت الكثافة النباتية الواطئة باعلى حاصل نبات (157.2 غم) بسبب تفوقها بطول العرنوص وعدد صفوفه وعدد الحبوب في الصف وعدد الحبوب في العرنوص ووزن 100 حبة، تفوقت الاصناف المدخلة بحاصل النبات على الأصناف المحلية، خاصة الصنف 3 الذي اعطى اعلى حاصل نبات (168.2 غم) يليه الصنف 4 (155.4 غم)، بسبب تفوقهما بطول العرنوص وعدد حبوب الصف وعدد حبوب العرنوص وعدد العرانيص ووزن 100 حبة، كان التداخل بين الاصناف والكثافة النباتية معنوياً في جميع الصفات المدروسة، نقترح زراعة الاصناف المدخلة في مواعيد زراعة ومواقع مختلفة لبيان مدى قدرتها على التطبع البيئي لمناخ العراق ودراستها في الموسم الربيعي، واختبارها تحت شدود لا حيوية أخرى كالجفاف.

الكلمات المفتاحية: الذرة، كثافة النبات، الاصناف المحلية.

INTRODUCTION

Maize (*Zea mays* L.) is grown in many countries of the world north and south of the equator, and in environments with high variations in many growth factors, Maize is one of the important economic grain crops and comes third in terms of productivity and cultivated area after wheat and rice, in addition to its entry into many fields as food for humans and the production of vegetable oils, in addition to its use as green fodder or silage for animals because it contains a large forage group compared to other crops, or the use of its seeds as a concentrated ration because it contains a high energy of carbohydrate materials, proteins and oil. It is an important crop for plant breeders as it is a bisexual and monogamous plant **(Terefe *et al*., 2019; Elsahookie & Daoud, 2021)**. The maize crop has a wide genetic base and a high environmental adaptation, which makes it a model for studying genetic regulation, as well as characterized by high genetic and phenotypic variance **(Amanah & Hadi, 2021)**. The global average production of maize is about 5.5 tons ha^{-1}, with a cultivated area of about 184 million hectares **(FAO, 2018)**. However, its production rate in Iraq is still low and below the required level, as it does not exceed 4,054 tons ha^{-1} despite the increase in its cultivated area from 572,500 thousand hectares in 2015 to 1013.50 thousand hectares in 2020 **(Central Statistical Organization, 2021)**. The reason for this is the lack of local genetic resources and the dependence of agriculture on open-pollinated and synthetic varieties for several generations without taking into account genetic purity **(Abd & Baktash, 2016)**. One of the most important in the world today in order to promote the cultivation of the maize crop and increase the grain yield per unit area is the introduction or development of new, heterogeneous varieties that are tolerant of environmental stresses, and among these stresses is the intensity of plant density, as the increase in grain yield comes 50% from genetic improvement and 50% from improving soil and crop service operations, the variations between varieties is very necessary for plant breeders to obtain plants with high yield and tolerant to environmental stresses through selection, if there are local varieties that have genetic variations and are to the environment, but in the absence of these variations, it is necessary to introduce varieties from outside the country which are grown in different environments to select the best ones **(Elsahookie & Daoud, 2021)**. The process of developing and introducing new varieties or hybrids of maize requires the study of agricultural processes, including the distance between the cultivated plants, in order to reach the best plant density, through which the hybrid or the new variety can give the highest grain yield, knowing that the optimum plant density varies according to the environmental conditions **(Hamdi, 2021)**. To increase the productive capacity of any crop, it is necessary to search and inspect to find new superior genetic sources, to evaluate its productive and genetic performance by comparing it with local varieties and selecting the best ones **(Mahmood *et al.,* 2017)**. The introduction of the genetic structures of maize and the use of modern agricultural techniques led to a significant increase in the yield over the past forty years, and the increase in the grain yield of modern varieties or hybrids resulted from their tolerance to biotic and abiotic stresses, especially the intensity of plant density, as the plant density in the field of agriculture is one of the important stress factors, since the competition between maize plants is very strong **(Greveniotis *et al.,* 2019**). The potential yield of the maize is estimated to be three times the actual yield, and in order to reduce the gap between the actual and the potential yield, it is necessary to understand the interaction between genetic and environmental factors, as well as to test varieties and hybrids under high plant densities, and that the maize plants have a good response to the increasing plant densities **(Al -Mowsawi, 2019; Amanah, 2021**). The balanced growth of maize requires optimum plant densities, to take advantage of nutrients, water and light more efficiently, in addition to other growth factors, as plant density greatly affects the growth and yield of maize due to the competitiveness between plants when increasing plant density, the optimum plant density is one of the important methods in field crop management as it is closely related to increasing the grain yield **(Hadi *et al.,* 2018).** In order to increase the yield (ton h^{-1}) in maize, it is necessary to use modern methods in soil and crop service operations, the most important of which are genetic structures with high yield under optimal plant densities, as the development of agricultural operations, including the use of optimal plant density, led to an increase in grain yield by 40% **(Bender *et al.,* 2013)**. Therefore, the study aimed to evaluate the performance of introduced varieties of maize and test them under different levels of plant density, to determine the best introduced varieties that give a high yield and at what plant density.

MATERIALS AND METHODS

In order to evaluate the performance of introduced varieties of maize and test them under different levels of plant density, calculate their genetic parameters, and determine which introduced varieties give a high yield and at what plant density, a field experiment was carried out at station A in the department of field crops, college of agricultural engineering sciences, university of Baghdad, for the fall season 2021, The land was prepared for cultivation for the experiment site by orthogonal tillage, smoothing and leveling according to the recommendations. The RCBD design was used with four replications, in the split plots. The three plant densities represented the main plates, (50.000, 70.000, and 90.000 plants hectares), while the cultivars represented the, which is Six cultivars of yellow corn, they are type 2 = 5783 DKC, type 3 = 6315 DKC, type 4 = 6590 DKC, which are varieties introduced from America and compared with three local varieties: Fajr, Sarah and Al-Maha. The land was divided into 72 experimental units. change to the plot design was (2 × 2.5 m), the plot was divided into 4 lines, the distance between one line and another is 75 cm, and between one plant and another 26.7, 19.0 and 14.8 cm, to represent plant densities of 50, 70 and 90 thousand plants per hectare, Sowing was done on 13/7/2021 by placing 2-3 seeds in the hole, replace by Where plants reached two leaves thinning process were done, it was fertilized with triple superphosphate fertilizer (46% P2O5) at an amount of 200 kg P2O5 H-1 in one change to time before planting, Nitrogenous fertilizer 350 kg N H-1 in the form of urea (46% N) change to in three times during its growth cycle, change to once when the plants are 2 weeks old, once when a plant height of 90 cm and a final time before flowering period, weeding and removing the bushes and the rest of the field operations whenever needed, five medium plants were taken for each experimental unit randomly selected with the exclusion of the terminal plants, harvested on 28/10/2021, The traits were measured: the main ear length , the number of rows ear^{-1}, the number of grains row^{-1}, the number of grains ear^{-1}, the number of ears $plant^{-1}$, the weight of 100 grains, and the individual plant yield. Statistical analysis was done for each of the traits according to the analysis of variance ANOVA in the order of the split plates and the significance was tested by F-test at the level of significance 0.05 and the arithmetic means were compared using LSD (the least significant difference) with a level of significance of 0.05 for all means according to what was stated by **Steel & Torrie (1980)** using the Genestat 2014 program.

RESULTS AND DISCUSSION

Ear length (cm)

The ear length in the plant is greatly affected by the environmental conditions at the beginning of its up growth in addition to being affected by the genetic genes that characterize the variety, and it is one of the traits on which the number of grains row^{-1} depends, which is a major component of the number of grains in the ear **(Elsahookie & Daoud, 2021)**.

The results of the averages table 1 indicate that the ear length was significantly affected by the different plant densities and varieties and the interaction between them, the trait of the ear length was affected by the different plant densities, and the low density (50,000 plants ha^{-1}) was significantly outperformed by giving it the highest average of the trait reached to 18.88 cm, while the medium density (70,000 plants ha^{-1}) gave ear length of 17.70 cm, which did not differ significantly from the the high density (90,000 plants h^{-1}), which gave the minimum ear length of 17.25 cm, the reason for this difference is attributed to the increase in shading and competition for light and the products of carbon representation between the plants grown in high densities, especially at the beginning of the formation of the ears and this leads to make the plant to form shorter ear lengths when compared to plants grown in low plant densities, and this is consistent with the findings of **Al-Mowsawi (2019); Amanah (2021),** as they found that the ear length decreases with increasing plant density.

As for the varieties, (Table, 1) shows that they differed significantly between them, as the introduced varieties outperformed the local varieties in the trait of ear length, and the introduced variety 4 gave the highest average of the ear length of 18.77 cm, and it did not differ significantly from the two introduced varieties 2 and 3 which gave an average of this trait reached 18.36 and 18.73 cm respectively, while the lowest average the ear length was given by the local variety Fajr, which was 17.13 cm, and it did not differ significantly from the other two varieties, Al Maha and Sarah, the reason for the difference in the ear length can be attributed to the presence of genetic differences between the varieties in this trait, and this is consistent with the findings of **Allak (2001); Al-Mowsawi (2019); Amanah (2021)**. They found that the genetic structures vary among themselves in the length ear.

As for the interaction, (Table 1) shows that the response of the introduced cultivars and the local cultivars to plant densities was similar, and the varietal response was towards a decrease in the ear length with an increase in the plant density, the highest ear length was for low density plants (50000 plants ha^{-1}) of the introduced variety 4, giving an average of 19.70 cm, while the lowest average ear length was for high density plants (90000 plants ha^{-1}), the local variety Fajr gave the lowest average for the trait, which was 16.48 cm.

Table (1): Means of Ear length average (cm) for varieties of maize at three plant densities for the fall season 2021.

Varieties	Plant densities (plant ha $^{-1}$)			
	50000	70000	90000	Mean
2	19.52	18.10	17.45	18.36
3	19.54	19.15	17.51	18.73
4	19.70	18.90	17.71	18.77
Fajr	17.20	17.70	16.48	17.13
Al-Maha	18.75	17.00	16.55	17.43
Sara	18.58	15.32	17.82	17.24
L.S.D 0.05	**1.15**			**0.66**
Mean	**18.88**	**17.70**	**17.25**	
L.S.D 0.05	**0.90**			

Number of rows ear^{-1}

The results of the table of averages 2 indicate that the trait of the number of rows ear^{-1} was significantly affected by the difference in plant densities and varieties and the interaction between them, as the trait of the number of rows ear^{-1} was significantly affected by the difference in plant densities, and the plants of low plant density (50000 plants ha^{-1}) were significantly outperformed by giving the highest average for the trait it was 16.23, and it did not differ significantly from the average density (70,000 plants ha^{-1}), which gave its plants the number of rows ear^{-1} reached 15.78, While the high density (90000 plants ha^{-1}), gave the lowest number of rows for the ear was 15.37. The superiority of low-density plants in the number of rows ear^{-1} is due to the fact that the trait of the number of rows ear^{-1} is one of the components of the secondary yield and this trait is affected by environmental stresses represented by high plant densities and drought and may negatively affect them due to the failure of the development of full flowers of one or more rows ear^{-1}, and this is consistent with the results of **Al -Mowsawi (2019); Hamdi (2021); Amanah (2021)**.

The results in (Table, 2) showed that they differed significantly between them, as the introduced cultivar 4 outperformed it by giving it the highest number of rows ear-1 amounting to 16.63, and it did not differ significantly from the local variety Al-Maha whose plants gave the number of rows ear^{-1} amounted to 16.12, while the introduced variety 2 gave the lowest average The trait was 15.28, and it did not differ significantly from the two varieties, the introduced 3 and the local Fajr, as each of them gave the number of rows ear-1 amounted to 15.50 and 15.33 respectively, and the reason for the difference in the trait of the number of rows ear^{-1} between the varieties is attributed to the genetic nature of each variety, these results agreed with **Al-Mowsawi (2019); Hamdi (2021); Amanah (2021)**.

As for the interaction, (Table 2) shows that the response of the introduced varieties and the local varieties to plant densities was different and fluctuating, and the varietal response was towards a decrease in the number of rows ear^{-1} with an increase in plant density, as the highest number of rows ear^{-1} was at the average density (70,000 plants ha^{-1}) and for the introduced variety 4, which gave the highest mean for the trait that reached 17.70, and it did not differ significantly from the local trait Al-Maha at low density (50,000 plants ha^{-1}), as it gave the number of rows ear^{-1} of 17.60. Whereas, the lowest average number of rows ear^{-1} was at high density (90000 plants ha^{-1}), as the introduced variety 2 gave the lowest mean for the trait that reached 14.45.

Table (2): Means number of rows ear-1 for varieties of maize at three plant densities for the fall season 2021.

Varieties	**Plant densities (plant ha $^{-1}$)**			
	50000	**70000**	**90000**	**Mean**
2	16.20	15.20	14.45	15.28
3	16.00	14.92	15.60	15.50
4	16.20	17.70	16.00	16.63
Fajr	15.20	15.60	15.20	15.33
Al-Maha	17.60	15.75	15.00	16.12
Sara	16.20	15.50	16.00	15.90
L.S.D 0.05	**0.99**			**0.57**
Mean	**16.23**	**15.78**	**15.37**	
L.S.D 0.05	**0.51**			

Number of grains row^{-1}

The results of the averages (Table 3) indicate that the trait of the number of grains row^{-1} was highly affected by the different plant densities and varieties and the interaction between them, The trait of the number of grains row^{-1} was significantly affected by the difference in plant densities, and the low density plants (50000 plants ha^{-1}) were significantly outperformed by giving them the highest average number of grains row^{-1} reached to 36.07 grains row^{-1}, and it differed significantly from the medium density plants (70000 plants ha^{-1}), which gave the number of grains row reached to 33.90 grains row^{-1}, while the high density plants (90000 plants h^{-1}) gave the lowest number of grains row^{-1} reached to 32.15 grains row^{-1}, the reason for this increase in the number of grains row^{-1} at the low plant density is attributed to the significant increase in the number of leaves of the plant, which created a good source that increased the efficiency of carbon representation, which was reflected along the ear length , as it gave the plants of this density the highest ear length (18.88 cm), and the lack of shading between plants gave a percentage of pollination and fertilization, and this is consistent with the results of **Shenawa (2018); Hamdi (2021); Amanah (2021)**.

As for the varieties, Table 3 shows that they differed significantly between them, as the introduced variety 3 outperformed by giving the highest average number of grains row^{-1} of 35.97 grains row^{-1}, and it did not differ significantly from the introduced variety 4, which gave the average number of grains row^{-1} reached to 35.83 grains row^{-1}, as for the local varieties , the variety Al Maha gave the highest number of grains row^{-1}, which reached to 34.47 grains row^{-1}, while the local variety Fajr gave the lowest average of the trait reached 31.77 grains row^{-1}, the reason for the difference in the number of grains row^{-1} is attributed to the genetic variation between the varieties, as each genetic structure has a different ability to produce a certain number of grains, and the two introduced varieties (3 and 4) have excelled in this trait as a result of their superiority by giving the highest ear length, and this is consistent with the results of **Mahmood *et al*. (2017); Al-Mowsawi (2019); Hamdi (2021); Amanah (2021)**.

Table (3): Means of number of grains row^{-1} for varieties of maize at three plant densities for the fall season 2021.

Varieties	Plant densities (plant ha $^{-1}$)			
	50000	70000	90000	Mean
2	36.40	32.70	32.30	33.80
3	37.10	35.70	35.10	35.97
4	37.00	37.40	33.10	35.83
Fajr	32.30	33.60	29.40	31.77
Al-Maha	38.00	37.12	31.30	34.47
Sara	35.60	30.00	31.70	32.43
L.S.D 0.05	**2.10**			**1.21**
Mean	**36.07**	**33.92**	**32.15**	
L.S.D 0.05	**1.09**			

As for the interaction, (Table, 3) shows that the response of the introduced and local varieties to plant densities was similar, and the varietal response was towards a decrease in the number of grains row^{-1} with increasing the plant density, the highest number of grains row^{-1} was at low density (50000 plants ha^{-1}) and for the local variety Al Maha, which gave the highest average for the trait reached to 38.00 grains row^{-1}, and it did not differ significantly from the introduced variety 3 at the same plant density, as it gave the number of grains row^{-1} reached 37.10 grains row^{-1}, and this introduced variety is the best in terms of its low sensitivity to increase in plant density, as the percentage of decrease in the number grains row^{-1} was only 5.39%, while the lowest average number of grains row^{-1} at high density, given by the local variety Fajr, was 29.40 grains row^{-1}, and the best response to the decrease in the number of grains row^{-1} was an increase in the plant density of the local variety Al Maha, which reached to 6.70 grains with a significant decrease percentage (17.63%), as the number of grains row^{-1} decreased from 38.00 to 31.30 grains row^{-1} with an increase in plant density from 50000 to 90000 plants h^{-1}, meaning that this variety is highly sensitive to increased plant density.

Number of grains ear^{-1}

The results of the table of averages 4 indicate that the trait of the number of grains ear^{-1} was significantly affected by the different plant densities and varieties and the interaction between them. The plants of low plant density (50,000 plants ha^{-1}) were significantly superior by giving them the highest average number of grains ear^{-1}, which amounted to .0587 grains ear^{-1}, with an increase of 9.41% and 18.56% over the two medium and high densities respectively. The reason for this is that the small number of plants in the unit area, it increased the efficiency of the source represented by the number of leaves, which led to an increase in the efficiency of carbon representation and thus an increase in the percentage of pollination and fertilization, which increased the capacity of estuaries represented by the ear length (Table, 1), the number of rows ear^{-1} (Table, 2) and the number of grains row^{-1} (Table, 3), which increased the number of grains ear^{-1}, and this is in agreement with the results of **Hamdan & Bactash (2014); Al-Mowsawi (2019); Amanah (2021)**.

As for the traits, (Table, 4) shows that they differed significantly among them, as the introduced trait 4 achieved the highest number of grains eat^{-1} that amounted to 598.3 grains ear^{-1}, and it differed significantly from all the studied traits , followed by the introduced trait 3 with the number of grains ear^{-1} that amounted to 558.6 grains ear^{-1}. It did not differ significantly from the local variety Al-Maha, which gave the number of grains amounted to 558.5 grains ear^{-1}, while the local variety Fajr gave the lowest average number of corn grains amounted to 487.7 grains ear^{-1}. The reason for the superiority of the introduced variety 4 by giving it the highest average number of grains ear^{-1} may be attributed to the superiority of this variety in the ear length (Table, 1) and in the number of rows ear^{-1} (Table, 2). It also gave high average of the number of grains row^{-1} (Table, 3) and therefore these components were translated to be in the trait the number of grains ear^{-1}. This confirms the findings of **Al-Mowsawi (2019); Kazem (2020); Hashim (2021); Amanah (2021)**, as they show that the differences between the varieties are evidence of the divergence of their genetic base.

As for the interaction, (Table 4) shows that the response of the introduced and local varieties to plant densities was different, and the response of the introduced and local varieties was similar towards a decrease in the number of grains eat^{-1} with an increase in plant density, with the exception of some of them whose response was fluctuating, the response of the varieties (4 and Fajr) was different, as The number of grains ear^{-1} increased by increasing the plant density from 50000 plants h^{-1} to 70,000 plants h^{-1} by 60.8 and 33.7 grains ear^{-1} for the two varieties respectively, and returned to decrease at high densities. The variety was most affected by the increase in plant density, and the number of grains eat^{-1} in it decreased by increasing the plant density from (50,000 plants h^{-1}) to (90,000 plants h^{-1}) the local variety Al-Maha, which amounted to 199.1 grains ear^{-1}, with a high drop rate of 29.77%. The number of grains ear^{-1} decreased from 668.7 to 469.6 grains ear^{-1}, followed by introduced variety 2, in which the number of grains decreased by 122.9 grains ear^{-1}, with a decrease of 20.83%, as the number of grains ear^{-1} decreased from 589.9 to 467.0 grains ear^{-1}. The highest average number of grains ear^{-1} at low density (50,000 plants ha^{-1}) was given by the local variety Al-Maha, which amounted to 668.7 grains ear^{-1}, while the lowest average number of grains ear^{-1} at high density was for the local variety Fajr, which amounted to 447.00 grains of ear $^{-1}$.

Table (4): Means of number of grains eat^{-1} for varieties of maize at three plant densities for the fall season 2021.

Varieties	**Plant densities (plant ha $^{-1}$)**			
	50000	**70000**	**90000**	**Mean**
2	590.0	497.0	467.0	518.0
3	593.6	533.0	549.2	558.6
4	601.6	662.4	531.0	598.3
Fajr	491.3	525.0	447.0	487.7
Al-Maha	668.7	537.3	469.6	558.5
Sara	577.0	465.0	507.2	516.4
L.S.D 0.05	**57.35**			**33.11**
Mean	**587.0**	**536.5**	**495.1**	
L.S.D 0.05	**34.46**			

Number of ears plant^{-1}

The trait of the number of ears plant-1 is one of the direct components of the yield. The ear originates under the armpit of the leaf in most varieties of maize, and when good conditions of growth factors and lack of competition and shading between plants are available, we get two or more ears plant^{-1} **(Elsahookie & Daoud, 2021)**.

The results of the table of averages 5 indicate that there are no significant differences between plant densities and their significance between varieties and the interaction between them and plant densities in the trait of the number of ears plant^{-1}.

The results in (Table 5) shows that the varieties differed significantly among themselves, and the introduced varieties outperformed the local varieties in trait of the number of ears plant^{-1}, as the introduced variety 3 achieved the highest number of ears plant^{-1} that reached 1.20 ears plant^{-1}, followed by the two introduced varieties 2 and 4 with the same number of ears plant^{-1} that amounted to 1.10 ears Plant^{-1}, and the introduced varieties differed significantly from all local varieties , with an increase of 6.80, 16.50 and 6.80% for the introduced varieties 2, 3 and 4, respectively. The reason for the difference in the number of ears plant^{-1} among the varieties is attributed to the genetic nature of each variety as it is a trait linked to the genetic structure, and this is consistent with the results of both **Al-Mowsawi (2019); Kazem (2020); Amanah (2021)**.

As for the interaction, (Table, 5) shows that the response of the introduced traits and the local traits to the plant densities was different and fluctuating, and most of them showed a decrease in the number of ears plant^{-1} when the plant density increased, and the response (decrease) from low density to high density was 0.1 for traits 2, 3, 4 and Al-Maha sequentially, with a decrease of 8.33, 7.70, 9.09 and 9.09%, respectively, as the highest average number of ears plant^{-1} was 1.30 ears plant^{-1}, at low density of the introduced variety 3, while the lowest average number of ears plant^{-1} was 1.00 ears plant^{-1}. At high density (90,000 plants ha^{-1}), for the introduced trait 4 and for the two local traits , Al Maha and Sarah.

Table (5): Means number of ears plant^{-1} for varieties of maize at three plant densities for the fall season 2021.

Varieties	**Plant densities (plant ha $^{-1}$)**			
	50000	**70000**	**90000**	**Mean**
2	1.20	1.00	1.10	1.10
3	1.30	1.10	1.20	1.20
4	1.10	1.20	1.00	1.10
Fajr	1.00	1.00	1.10	1.03
Al-Maha	1.10	1.00	1.00	1.03
Sara	1.00	1.10	1.00	1.03
L.S.D 0.05	**0.10**			**0.06**
Mean	**1.12**	**1.07**	**1.07**	
L.S.D 0.05	**N.S**			

Grain weight

The results of the table of averages 6 indicate that the trait of weight of 100 grains was significantly affected by the difference in plant densities and traits and the interaction between them, as the trait of weight of 100 grains was significantly affected by the difference of plant densities, and the low plant density plants (50,000 plants ha^{-1}) outperformed the trait of weight of 100 grains, with an average reached 31.65 g, and did not differ significantly from high density plants, The reason for its superiority is due to the fact that its plants were early in male and female flowering, so the plants of low density were characterized by a long grain filling period and thus gave the weight of 100 grains heavier. These results are in agreement with the findings of **Al-Mowsawi (2019); Amanah & Hadi (2021); Hamdi & AL-Rawi (2021).**

As for the traits, (Table, 6) shows that they differed significantly among them, as the introduced variety 4 achieved the highest average weight of 100 grains that reached 34.04 g, and did not differ significantly from the introduced variety 3, which gave an average of 33.11 g, while the local variety Al-Maha gave the less average weight of 100 grains was 28.19 g, The reason for the superiority of the introduced trait 4 by giving it the highest average weight of 100 grains is attributed to the superiority of this trait in the length of grain filling period, as well as the genetic factors that characterize the trait and its impact on environmental factors. These results confirm the findings of **Kazem (2020); Amanah (2021); Hamdi & AL-Rawi (2021).**

As for the interaction, (Table, 6) shows that the response of the introduced varieties and the local varieties to plant densities was different, and the response of the introduced varieties was similar towards a decrease in the weight of 100 grains with an increase in the plant density, and that the decrease in the weight of the grains was not significant with an increase in the density from 50000 to 70000 plants ha^{-1}, Then it was increased from 70,000 to 90,000 plants ha^{-1}, while the response of local traits was fluctuating, as the local variety Fajr showed the same behavior as the introduced varieties , but its response was significant when the plant density was increased from 70,000 plants ha^{-1} to 90,000 plants ha^{-1}, while the two local varieties, Al Maha and Sarah, exhibited a different behavior, the weight of 100 grains increased with an increase in plant density.

Table (6): Means weight of 100 grains (gm) of varieties of maize at three plant densities for the fall season 2021.

Varieties	**Plant densities (plant ha $^{-1}$)**			
	50000	**70000**	**90000**	**Mean**
2	31.44	30.76	30.80	31.00
3	33.81	33.15	32.37	33.11
4	35.52	32.90	33.72	34.04
Fajr	32.20	31.83	28.78	30.94
Al-Maha	26.80	27.01	30.76	28.20
Sara	30.13	27.44	31.80	29.80
L.S.D 0.05	**1.94**			**1.12**
Mean	**31.65**	**30.51**	**31.37**	
L.S.D 0.05	**0.80**			

Plant yield (g)

The grain yield represents the final outcome of the processes of growth and development of the plant, which is linked to a complex degree with its basic components, which are the number of ear plant^{-1}, the number of grains ear-1, and the weight of grains, which is greatly affected by environmental and genetic factors and the interaction between them **(Hamdi, 2021)**.

the results of the averages (Table, 7) indicate that the trait of the plant yield was highly affected by the difference in plant densities and varieties and the interaction between them, as the average plant yield decreased with the increase in plant density, as the low density (50,000 plants h^{-1}) was significantly outperformed by giving it the highest average plant yield of 157.2 g, with an increase of 11.77% and 15.59% over the medium and high density respectively. The average plant yield for the medium density was (138.7 g) and (132.7) g) for high density. The reason for the increase in plant yield with a decrease in plant density is attributed to the increase in its secondary components represented by the ear length, the number of its rows, and the number of grains row^{-1}, as well as the increase in its main components, which represent the number of ear plant^{-1}, the number of grains ear^{-1}, and the weight of 100 grains in the low density, which led to an increase in the plant yield. This is consistent with the findings of **Al-Mowsawi (2019); Hamdi (2021); Amanah (2021).**

As for the varieties, (Table, 7) shows that they differed significantly between them, and the introduced varieties outperformed the local varieties in the trait of plant yield, as the introduced variety 3 achieved the highest average of the trait of plant yield reaching to 168.2 g, and it was significantly superior to the two introduced varieties (2 and 4), which gave an average of this trait reached 135.6 and 155.4 g, respectively, whereas, the lowest average of the plant yield was for the local variety Fajr, which was 130.1 g, and it did not differ significantly from the two local varieties, Al Maha and Sarah. The reason for the different varieties in the trait of plant yield is attributed to the presence of genetic differences between them, as well as the superiority of the introduced variety 3 and the rest of the introduced varieties over the local varieties due to the early male and female flowering and their difference in their secondary components (the ear length, the number of rows ear^{-1} and the number of grains row^{-1}), as well as their difference in their basic components (number of ears plant^{-1}, number of grains ear^{-1} and weight of 100 grains), this is consistent with the results of **Al-Mowsawi (2019); Kazem (2020); Hamdi (2021); Amanah (2021)**. They indicated that there were significant differences in the individual plant yield between the studied variety.

As for the interaction, (Table, 7) shows that the response of the introduced varieties and the local varieties to plant densities was different and fluctuating, and the varietal response was towards a decrease in plant yield with an increase in plant density (from 50,000 plants h^{-1} to 90,000 plants h^{-1}), except for the local variety Sarah, in which the yield increased insignificantly when the plant density was increased, and the response to the decrease in plant yield was at the high plant density compared to the low density of 37.7, 29.1, 23.7, 2.3 and 57.4 g for varieties 2, 3, 4, Fajr and Al Maha respectively, with a decrease percentage reached 23.02, 14.94, 15.25, 1.88 and 32.91%, respectively, the highest average of the trait at low density (50,000 plants h^{-1}) for the introduced variety 3 was 194.8 g, while the lowest average of plant yield at the medium density (70,000 plants h^{-1}) for the introduced variety 2 was 117.0 g, and it did not differ significantly from the high density plants (90000 plants h^{-1}) for the two introduced varieties 2 and 4, which gave an average of 126.1 and 131.7 g of plant yield, respectively, as for the local varieties, they behaved the same as the introduced varieties in their response, as the variety Al Maha gave the highest yield compared to the studied local varieties, which reached to 174.4 g at the low density, while the lowest average for the trait at the medium density of the same variety was 116.7 g, and it did not differ significantly from the high density and for the same trait as well.

Table (7): Means of plant yield (g) for varieties of maize at three plant densities for the fall season 2021.

Varieties	Plant densities (plant ha $^{-1}$)			
	50000	**70000**	**90000**	**Mean**
2	163.8	117.0	126.1	135.6
3	194.8	144.0	165.7	168.2
4	155.4	178.3	131.7	155.1
Fajr	122.3	148.1	120.0	130.1
Al-Maha	174.4	116.7	117.0	136.0
Sara	132.7	128.0	136.2	132.3
L.S.D 0.05	**16.66**			**9.62**
Mean	**157.2**	**138.7**	**132.7**	
L.S.D 0.05	**4.30**			

CONCLUSIONS

1. The introduced cultivars responded to the high density, as it gave the highest yield at the density (90,000 plants hectare $^{-1}$).
2. Plant densities are one of the a biotic stress factors that affect the nature of the genetic action of the trait, as the genetic action changed by increasing the plant density for some studied traits, while some other traits retained their genetic expression and this is called Gene Ecology.
3. The best introduced varieties in terms of suitability for growth and production under Iraqi conditions is 3 = 6315 DKC.
4. The most stable cultivarsfor stress conditions of increasing plant density is cultivar 3 = 6315 DKC, which gave the highest grain yield per unit area of 14.91 tons ha $^{-1}$ at high plant density (90000 plants ha $^{-1}$).

REFERENCES

1. Abd Al-krim, A.A., Abd Al-Rahman, W.F. & Al-Mahdi, N.S. (2018). Effect planting distances and foliar spray of chelated iron on some quantity characters of corn yield (*Zea mays* L.). *Journal of Agricultural, Environmental and Veterinary Sciences.* 2(2), 18-27.
2. Abd, N.Y. & Baktash, F. Y. (2016). Diallel crosses and some genetic parameters for corn agronomic characters. *Anbar Journal of Agricultural Sciences*. 14(1), 128-154.
3. Allak, M.K. (2001). *Response of Growth and Yield of Two Genotypes of Maize (Zea mays L.) for Different Spaces*. M.Sc. Thesis, Department of Field Crop, College of Agricultural Engineering Science, University of Baghdad. Pp: 129.
4. Al-Mowsawi, S.H.T. (2019). *Evaluating The Performance of Triple, Single Hybrids and Their Inbred Lines of Maize Under Two Plant Densities*. M.Sc. Thesis, Department of Field Crop, College of Agricultural Engineering Science, University of Baghdad. Pp: 21-128.

5. Amanah, A.J. (2021). *Genetic Analysis by Using Partial Diallel Crossing of Maize In High Plant Densities*. M.Sc. Thesis, Department of Field Crop, College of Agricultural Engineering Science, University of Baghdad. Pp: 34-139.
6. Amanah, A.J. & Hadi, B.H. (2021). Genetic analysis by using partial diallel crossing of maize in high plant densities (Estimation GCA, SCA and Some Genetic Parameters). In IOP Conference Series*: Earth and Environmental Science*, 9(10), 120-135.
7. Bender, R.R., Haegele, J.W., Ruffo, M.L. & Below, F.E. (2013). Nutrient uptake partitioning and remobilization in modern transgenic insect-protected maize hybrids. *Agronomy Journal*, 105(1), 161-170.
8. Elsahookie, M.M.M. & Daoud, A.A. (2021). *Genome and Plant Dreeding*. Ministry of Agriculture-Republic of Iraq. PP: 364.
9. Greveniotis, V., Zotis**,** S., Sioki, E. & Ipsilandis, C. (2019). *Field Population Density Effects on Field Yield and Morphological Characteristics of Maize*. Food and Agriculture Organization (FAO). The United Nations, 160.
10. Hadi, B.H., Hassan, W.A. & Abed-Alamir, A.N. (2018). Evaluation the performance of double, single hybrids and inbreeds of maize under different plant population and estimation heterosis and hybrid vigor. *International Journal of Environment and Global Climate Change*, 6(2),76-93.
11. Hamdan, M.I. & Bactash, F.Y. (2014). Crossing between different number of Maize inbreeds and evaluation synthetic variety under effect of level population. *Al-Anbar Journal of Agricultural Sciences*, 12(Special Issue), 251-263.
12. Hamdi, A.A. (2020). *Assessment of Genetic Behavior by Effect of Plant Density by Using Half Diallel Cross in Maize*. M.Sc. Thesis, Department of Field Crop, College of Agriculture, University of Al-Anbar. Pp: 105.
13. Hamdi, A.A. & Al-Rawi, O.H. (2021). Evaluating the performance of the lines and their half diallel cross in maize (*Zea mays* L.) under plant density. In IOP Conference Series: *Earth and Environmental Science*, 76(1), 62-73.
14. Hashim, A.N. (2021). *Evaluation the Performance of Maize Single Crosses and Their Inbred Lines Under Different Sowing Dates.* M.Sc. Thesis, Department of Field Crop, College of Agricultural Engineering Science, University of Baghdad. Pp: 104.
15. Kazem, K.A. (2020). *Evaluation of The Performance of Introduced Varieties of Maize Under Different Planting Dates and Locations*. M.Sc. Thesis, Department of Field Crop, College of Agricultural Engineering Science, University of Baghdad. Pp: 143.
16. Mahmood, J.N., Yousif, D.P., Majeed, A.H., Kassar, H.I. & Alawi, H,H. (2017). Comparison study of introduced du Pont hybrids with local corn varieties. *Al-Anbar Journal of Agricultural Sciences,* 15, 58-67.
17. Shenawa, M.H.A. (2018). *Molecular Effect of Plant Density in Methylation level and Gene Expression Inbred Lines and Hybrids of Maize (Zea mays L.).* M.Sc. Thesis, Department of Field Crop, College of Agriculture University of Anbar. 120.
18. Steel, R.G.B. & Torri. H. (1980). *Principles and Procedures of Statistics, A Biometric Approach.* 2nd ed., MCGraw-Hill Book Company. New York, USA, PP:20-90.
19. Terefe, W., Teklewold, A. & Tesfaye, K. (2019). Combining ability of selected maize (Zea mays L.) inbred lines adapted to highland Agro-Ecologies of Ethiopia. *International Journal of Agriculture and Biosciences*, 8(2), 99-105.