A study of heritability, genetic advance and some genetic parameters of maize genotypes at different plant densities

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ABSTRACT

Estimation of genetic variance, heritability and genetic advance of traits is an essential task in any plant advance programme. Genetic performance and some genetic parameters were evaluated for ten genotypes of different origins of maize in a randomized complete block design, (RCBD) in a Factorial Experiment arrangementwith three replications during the spring growing season / 2022, in the field of (Bashiqa site) in one of the private agricultural fields of Bashiqa district, which is about 40 km away. from Mosul city center.

The results of the analysis of variance showed that the mean squares of the genotypes were significant for all the traits under study at the probability level of 1%, and the presence of such significant differences between the genotypes under study is necessary to study their genetic behavior in order to select the best and improve them. SAGUNTO genotype plants were characterized by the highest values, with an average of 479.400 g and 25.345 ton. ha^{-1}, respectively, for individual plant grain yield and total grain yield. The plants cultivated at the plant density of 44444 plant.ha^{-1} were characterized by the highest yield per single plant of grain amounted to 371.810 g, and the plants grown at the plant density 66667 plant.ha^{-1} had the highest total grain yield of 17.173 ton. ha^{-1}. The heritability values in the broad sense were high forall the traits except it was medium for number of ears per plant , while the values of expected genetic advance as a percentage of the average trait were high for total ear weight , no. of grains/ear, individual plant grain yield and total grain yield and oil ratio.

Key words: Heritability - Genetic advance - Maize.

INTRODUCTION

Yellow corn *Zea mays* L., is one of the most important cultivated grain crops in the world after wheat and barley wheat, barley and rice which belongs to the Poaceae family, due to the adaptability of its cultivation to the different environmental conditions and the possibility of growing it in more than one season per year compared to the rest of the Poaceae family [24]. The cultivated area of this crop in the world amounted to 197.2 million hectares, with an average productivity of 5.823 tons.ha^{-1}, and a total production of 1148.49 million tons [11], while the cultivated area in Iraq amounted to about 81 thousand hectares with an average productivity of 0.228 tons. hectares. And a total production of 374.4 thousand tons [9].

The economic importance of the yellow corn crop lies in the fact that its grains contain a high percentage of nutrients, in addition to the grains containing a high percentage of vitamins [5], and an oil percentage ranging between 4-10%. They are used as feed for poultry and livestock, moreover, they are used for various industrial purposes [28].

One of the most important reasons that indicate the decrease in the cultivated area and then the total production of the yellow corn crop in Iraq recently is the instability of the prices of this crop from one season to another as a result of the unplanned import, which made the majority of farmers not interested in

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cultivating this crop, and reducing the area cultivated with it. In addition to the decrease in the productivity rates per unit area as a result of the deterioration of the genetically cultivated varieties and genotypes due to the lack of genetic advance processes for them, and the adoption of modern scientific methods in their cultivation, which led to the loss of many of their productive advantages in quantity and quality. Hence, for the purpose of advancing the crop and increasing its productivity per unit area, it was necessary to constantly find and provide new genotypes characterized by good specifications in terms of quantity and quality, which depends on the introduction of genetic materials from different sources and testing them under different environmental conditions to elect the superior ones that respond and adapt to local environmental conditions [3].

The estimation of the heritability of quantitative traits is one of the most important estimations that plant breeders cared about, as it became clear that by estimating heritability in a broad sense, it is possible to determine the contribution of both genetic and environmental influences to the appearance of the trait, and then the value of heritability can be a criterion for determining the relationship between parents and progeny. The important thing to know for any quantitative trait depends on its evaluation to determine the best way to breed a trait to improve it, and its evaluation is important to determine the amount of expected genetic advance, which is the largest application of quantitative inheritance theory in plant breeding and advance programs [4]**.**

Accordingly, the current study aims to plant density and estimate the components of phenotypic variance (genetic and environmental) for the traits under study and to estimate the percentage of heritability and the expected genetic advance of the crop and its components in order to infer from its results in the development of future breeding programs.

MATERIALS AND METHODS

The experiment was carried out during the spring growing season / 2022, in the (Bashiqa site) in one of the private agricultural fields of Bashiqa district, which is about 40 km away. from Mosul city center , within the Randomized Complete Block Design (R.C.B.D.), with three replications, with 30 experimental units per replicate, and 90 experimental units in the experiment.

To evaluate the genetic performance of ten different genotypes of yellow corn genotypes , whose source and country of origin are indicated in the table (1).

It was planted with three plant densities:

1- Plant density at a rate of 66667 ($plant.ha^{-1}$) at a planting distance of 20 x 75 cm.

2- Plant density at a rate of 53333 ($plant.ha^{-1}$) at a planting distance of 25 x 75 cm.

3- Plant density at a rate of 44444 ($plant.ha^{-1}$) at a planting distance of 30 x 75 cm.

Table 1: Pure genotypes used in the study and their country.

No.	**GENOTYPES**	**COUNTRY**
1	AGN720	AMERRICAN
2	DKC6664	AMERRICAN
3	CADIZ	AMERRICAN
4	JAMESON	AMERRICAN
5	JOXLIN	AMERRICAN
6	SIMON	HOLLAND
7	TORRO	HOLLAND
8	CONS	GERMANY
9	SAGUNTO	SPANISH
10	ZP GLORYA	YUGOSLAVIA

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grains/ear , 500 grains weight and oil percentage.

The existence of such significant differences between the genotypes under study is necessary to study their genetic behavior with the aim of selecting and improving the best of them, and this is in line with the findings of [25] , [18] , [7] and [6] Significant differences between the genotypes of growth and yield traits in maize.

The results of table (3) show the mean genotypes of the traits under study, and from it ,it is clear that there are significant differences for all the studied traits according to the Duncan multiple border test at the probability level of 0.05, as the results of the table indicate that the JOXLIN genotype was the earliest in the male and female flowering date and needed 61.444 and 62.155 days for flowering, respectively, and it differed significantly with most of the other genotypes under study, except DKC6664 where the differences between them did not reach the significant limit of the female flowering date , other than the SAGUNTO genotype, which was the most late and needed 65.400 and 67.444 days for flowering, respectively, compared with the rest of the other genotypes.

As for plant height, the plants of the genotype CONS were the highest plant height of 241.233cm, and it differed significantly with most existence, while the lowest plant height was 197.900cm and was found among the plants of the genotype ZP GLORYA. As for the number of ears per plant, the plants of genotype ZP GLORYA gave the lowest number of ears per plant, which amounted to 1.644ears.plant^{-1}, compared to the highest number of ears per plant, which amounted to 2.300 ears.plant^{-1}, which was characterized by the plants of the genotype AGN720 and with a significant difference with some plants of the other genotypes. The highest total ear weight was recorded in SAGUNTO genotype plants with an mean of 269.837 g, and it differed significantly with all plants of other genotypes, compared with the lowest total ear weight with an average of 152.673 g recorded in DKC6664

On 1/4/2022, inside the panels, represented by the experimental unit, with an area of (x 2 m), with three planting lines of 3 meters long for each line and 75 cm between one line and another. Agricultural management operations during the experimental period were carried out equally and as recommended in the cultivation of this crop.

The components of the phenotypic variance σ^2p (genetic σ^2g and environmental σ^2e) were estimated from the analysis of variance table (Table 2) and the significance of the genetic variance σ2g and environmental σ2e and the Interaction between them was tested for zero according to the method of [14], and some genetic parameters were estimated Following equations: -

$$\sigma^2_p = \sigma^2_g + \sigma^2_e$$

$$\sigma^2_g = (MS_g - MS_e) / R$$

$$\sigma^2_e = MS_e$$

$$GCV\ \% = (\sqrt{\sigma^2_g} / \bar{y}) \times 100$$

$$PCV\ \% = (\sqrt{\sigma^2_p} / \bar{y}) \times 100$$

$$H^2_{b.s}\ \% = \sigma^2_g / \sigma^2_p$$

$$E.G.A. = (K\ H^2_{b.s.} \sqrt{\sigma^2 P})$$

$$E.G.A.\ \% = [(K\ H^2_{b.s.} \sqrt{\sigma^2 P}) / \bar{y}] \times 100 .$$

RESULTS AND DISCUSSION

The results of the analysis of variance for the site of Mosul for the traits of maize under study, which represent the values of the mean squares are shown in Table (2), and from it is clear that the mean squares of the genotypes were significant for all the traits under study at the probability level of 1%. While the plant density was significant at the level of probability 5% for the characteristics of no. of days to tasseling and total grain yield , And at the level of probability 1% for plant height , number of ears per plant , total ear weight , no. of grains/ear , 500 grains weight and individual plant's grain yield. As for the interaction of genotypes × plant density, it was significant at the level of probability 5% for the characteristic of individual plant's grain yield and total grain yield , and at a probability level of 1% for the characteristic of the total ear weight , no. of

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genotype plants.

Table (2): Analysis of variance for the studied traits in maize.

Sources of difference	Degrees of freedom	Mean Squares				
		No. of days to male flowering	No. of days to female flowering	Plant height (cm)	No. of ear / plant	Total ear weight (gm)
Replications	**2**	1.477	0.857	264.282	0.355	192.484
Genotypes	**9**	12.558 **	23.765 **	1304.118 **	0.489 **	13077.347 **
Plant density	**2**	3.073 *	1.961	1826.443 **	1.420 **	9497.734 **
Genotypes× Plant density	**18**	0.801	1.195	231.021	0.148	1531.841 **
Experimental error	**58**	0.981	1.404	235.153	0.142	382.452

Sources of difference	Degrees of freedom	Mean Squares				
		No. of grains/ear	500 Grains weight (gm)	Grain yield /plant^{-1}(gm)	Total grain yield (t/h)	Oil ratio (%)
Replications	**2**	663.648	89.677	9849.995	24.387	0.408
Genotypes	**9**	96573.923 **	1376.276 **	42158.320 **	114.364 **	5.469 **
Plant density	**2**	37234.744 **	883.511 **	97829.240 **	3.160 *	0.325
Genotypes× Plant density	**18**	8705.162 **	823.795 **	7247.168 *	14.381 *	4.602 **
Experimental error	**58**	2285.797	199.493	3482.703	9.179	0.925

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

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Table (3): Mean values of genotypes for the studied traits in maize.

No.	Genotypes	Traits				
		No. of days to male flowering	No. of days to female flowering	Plant height (cm)	No. of Ear / plant	Total ear weight (gm)
1	**AGN720**	64.933 ab	66.844 ab	228.067	2.300 a	182.499 e
2	**DKC6664**	62.466 d	63.177 e	231.289 ab	2.155 ab	152.673 f
3	**CADIZ**	62.844 d	64.688 d	222.878 b	2.044 abc	191.889 de
4	**JAMESON**	64.088 bc	66.088 bc	229.311 ab	1.722 cd	209.002 cd
5	**JOXLIN**	61.444 e	62.155 e	222.667 b	2.266 a	153.503 f
6	**SIMON**	62.911 d	65.422 cd	239.533 a	2.077 abc	178.492 e
7	**TORRO**	63.288 cd	65.466 cd	228.911 ab	1.933abc d	247.387 b
8	**CONS**	64.155 bc	66.422 abc	241.233 a	1.777bcd	225.056 c
9	**SAGUNTO**	65.400 a	67.444 a	232.967 ab	2.200 a	269.837 a
10	**ZP GLORYA**	63.444 cd	65.622 cd	197.900 c	1.644 d	206.017 cd

No.	Genotypes	Traits				
		No. of grains/ear	500 Grains weight (gm)	Grain yield /plant^{-1}(gm)	Total grain yield (t/h)	Oil ratio (%)
1	**AGN720**	327.500 de	210.444 a	313.980 bcd	16.976 bcd	5.833 ab
2	**DKC6664**	305.940 ef	198.111 ab	260.510 de	13.990 de	5.833 ab
3	**CADIZ**	404.280 c	194.667 b	310.750 bcd	16.388 bcde	4.500 cd
4	**JAMESON**	459.500 b	174.556 c	273.820 de	14.675 de	5.000 bc
5	**JOXLIN**	278.720 f	202.333 ab	245.790 e	13.224 e	5.333 bc
6	**SIMON**	361.780 cd	196.778 ab	290.140 cde	15.844 cde	6.666 a
7	**TORRO**	484.280 b	196.444 ab	364.990 b	19.367 b	5.333 bc
8	**CONS**	489.280 b	196.333 ab	340.250 bc	18.340 bc	3.833 d
9	**SAGUNTO**	617.330 a	174.556 c	479.400 a	25.345 a	5.166 bc
10	**ZP GLORYA**	464.560 b	177.333 c	271.390 de	14.331 de	5.666 b

** Treatments that share the same letters within a single column do not differ significantly with each other according to Duncan's multiple-polynomial test with a 5% probability level.*

The SAGUNTO genotype was the best for the number of grains per ear, with an mean of 617.330 grains. per ear $^{-1}$, with a significant difference with all other genotypes on the contrary the JOXLIN genotype, whose ears were characterized by the lowest number of **grains**, with an mean of 278.720 grains per ear $^{-1}$. The values of the weight of 500 grains varied between the lowest weight of 174.556 g in plants of genotype JAMESON and SAGUNTO respectively, and the highest weight of 210.444g in plants of genotype AGN720, which differed significantly with some other genotypes. As for the individual plant yield of grains and the total grain yield, plants of genotype SAGUNTO were characterized by the highest values, with an mean of 479.400 g and 25.345 t.ha^{-1},

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respectively, and differed significantly with all genotypes of these two traits on the contrary plants of genotype JOXLIN, which recorded the lowest values for these two traits with an mean of 245.790 g and 13.224 tons.ha^{-1}, respectively.

And when comparing the genotypes cultivated plants for the characteristic of the percentage of oil, it is noted that the plants of the genotype SIMON excelled in this percentage, which amounted to 6.666%, with a significant difference from most other genotypes, compared with the lowest percentages in the plants of the genotype CONS, which amounted to 3.833%. It is concluded from the results of table (3) that the existence of significant differences between the ten genotypes under study and for all the studied traits is necessary to continue studying the genetic behavior of these traits in order to improve them, and the presence of these discrepancies and differences between the genotypes is the basic material for plant breeders in order to exploit them by devising the best ones in one or more traits [3], and this difference is explained by the different genetic factors carried by these genotypes, which in turn were reflected in their effect on the characteristics of vegetative growth and yield. This agrees with what was obtained by [25]. For ear weight and 1000 grain weight , [12] for individual plant grain yield and [6] for total grain yield.

The mean values of plant density for the traits under study are shown in table (4), and from it, it turns out that plants grown plant densities 44444 plants.ha-^{1} were the earliest in the dates of male flowering 63.146 days, and differed only significantly from plants grown at plant density 53333 plants.ha-^{1}, which were the most late for this trait 63.773 days. The differences between the three plant densities did not reach a significant level for the dates female flowering.

In terms of plant height, the plants cultivated with a plant density of 66667 plants.ha^{-1} were the highest with a height of 235.773cm, and they differed significantly on the other two densities of 53333 and 44444 plants.ha^{-1}, and the differences between them did not reach the limit of significance. Plants cultivated with low vegetation density showed 44444 plants. ha^{-1} had a significant superiority in the number of ears per plant 2.263 ears. plant^{-1} over the other two densities, while plant density of 66667 plants.ha^{-1}, which the lowest values were 1.880 ears. plant^{-1}.

When comparing the plants grown under the conditions of the three plant density for the characteristic of the total ear weight, it is noted that the lowest weight of the ear reached 181.169 g, which was recorded in the plants grown at the high plant density 66667 plants.ha^{-1}, and with a significant decrease from the plants of the two density 53333 and 44444 plant.ha-^{1}, where the latter gave the highest weight of the ear reached 213.429 g. The plants grown at the high plant density of 66667 plants.ha-^{1} showed a significant decrease in the number of grains per ear, amounting to 378.910 grains.ear-^{1}, compared to the other two density of 53333 and 44444 plants.ha-^{1}, and the latter recorded the highest number of grains per ear, amounting to 443.570 grains.ear-^{1}.

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Table (4): Mean plant density values for the studied traits in maize.

Plant density	Traits				
	No. of days to male flowering	No. of days to female flowering	Plant height (cm)	No. of ear/ plant	Total ear weight (gm)
66667 plant.ha^{-1}	63.573 ab	65.373 a	235.773 a	1.880 b	181.169 b
53333 plant.ha^{-1}	63.773 a	65.566 a	226.367 b	1.893 b	210.308 a
44444 plant.ha^{-1}	63.146 b	65.060 a	220.287 b	2.263 a	213.429 a

Plant density	Traits				
	No. of grains/ ear	500 Grains weight (gm)	Grain yield /plant^{-1} (gm)	Total grain yield (t/h)	Oil Ratio (%)
66667 plant.ha^{-1}	378.910 b	187.067 b	257.600 c	17.173 a	5.350 a
53333 plant.ha^{-1}	435.480 a	197.867 a	315.890 b	16.846 ab	5.200 a
44444 plant.ha^{-1}	443.570 a	191.533 ab	371.810 a	16.524 b	5.400 a

** Treatments that share the same letters within a single column do not differ significantly with each other according to Duncan's multiple-polynomial test with a 5% probability level.*

The values of the weight of 500 grains varied between the lowest weight of 187.067 g. in the plants grown at the high plant density 66667 plants.ha-^{1}, and significantly lower than the plants grown at the plant density 53333 plants.ha-^{1}, which gave the highest weight of 197.867g. As for the grain yield of an individual plant, the plants grown at a plant density of 44444 plants.ha^{-1} were distinguished with the highest yield amounting to 371.810 g. , with a significantly different from the plants of the other two density on the contrary plants grown at a high plant density of 66667 plants.ha $^{-1}$, which gave the lowest yield for the individual plant, which amounted to 257.600g, with a significant decrease from the plants of the other two densities. The increase in the number of plants per unit area was reflected in the increase in the total grain yield, as the cultivated plants excelled at the plant density of 66667 plants. ha $^{-1}$ with the highest total grain yield amounted to 17.173 tons.ha^{-1} and with a significant superiority over the yield of plants grown with low plant density 44444 plants.ha-^{1} amounted to 16.524 tons.ha^{-1}.The differences did not reach the level of significant among all the three densities plants for the characteristic of the percentage of oil.

The results of the superiority of plants grown at high plant density 66667 plants.ha^{-1} can be explained by the characteristic of plant height significantly over plants grown at densities 53333 and 44444 plants.ha^{-1} that the increase in plant density led to a significant increase in plant height and this results from the effect of competition between plants on growth requirements, including light, which encourages the action of auxin with gibberellins, which leads to increase the growth and then to an

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increase in plant height. It is also attributed to the fact that in high plant density the amount of light penetrating into the lower part of the plant decreases, so the concentration of the hormone indole acetic acid (IAA) increases, which encourages elongation of cells, and then this leads to an increase in plant height in high density, and it also explains that in low plant densities The penetration of light into the vegetative canopy increases, which causes auxin oxidation, and thus decreases the growth and height of the plant [30]. This agrees with what [26] and [10] indicated for the characteristic of plant height.

The results of table (4) also show that the cultivated plants at plant density of 53333 and 44444 plants.ha^{-1} were significantly superior to the individual plant yield of grain compared to plants grown at a high plant density of 66667 plants.ha^{-1}. This may be due to competition and crowding between plants at high densities affect the different growth requirements (water, nutrients, and light) as a result of the increase in the number of plants per unit area, which leads to a decrease in the amount of these requirements per plant, and then this affects the growth of the plant and the total leaf area, and thus the yield of one plant. As for the significant increase in the total grain yield of plants grown at a high plant density of 66667 plants.ha^{-1}. This is attributed to the increase in the number of plants per unit area despite the decrease in the individual plant's grain yield. This is consistent with what was obtained by [7] for the yield individual plant of grains and [22] , [1] and [23] for total grain yield.

The values of phenotypic variances and their total genetic and environmental components and the genetic parameters of the traits under study in maize are shown in table (5). It is clear from the table that the values of genetic and environmental variance were significant from zero for all the traits under study, and these results are consistent with the findings of [8] , [20] and [18]. The results indicate that the values of genetic variance were higher than the values of environmental variance for all studied traits except for no.of ear/plant .

The values of the coefficient of genetic variance, **(GCV)** were high for the traits of total ear weight , no. of grains/ear , individual plant's grain yield , total grain yield and oil percentage they were 32.261, 42.279, 36.033, 35.145, and 23.153, respectively. As for the values of the coefficient of phenotypic difference, (**PCV)**they were high for the characteristics of the number of ears per plant **,** total ear weight , no. of grains/ear , individual plant's grain yield , total grain yield and oil percentage they were 25.245, 33.688, 43.789, 40.610, 39.478 and 29.383 respectively, while they were medium for the rest of the other traits under study. This is agree with with what was indicated by [2] , [15] , [18] and [29] values of coefficient of genetic and phenotypic variance.

It turns out that the values of the coefficient of phenotypic variance were much higher than the values of the coefficient of genetic variance for all traits. This can be explained by the fact that most of these traits are quantitative traits that are greatly affected by the environment, and accordingly, as indicated by [19] that selection for these traits on the basis of their external appearance is effective. This difference and phenotypic and environmental variation between the ten genotypes under study for the studied traits leads us to obtain a high heritability efficiency for these traits.

The heritability values in the broad sense were medium for the characteristics of the number of ears per plant 0.449 , while the heritability values were high for the rest of the other traits. From previous studies, some researchers obtained heritability values It ranged between low, medium, and high for different traits, including [8] , [12] and [16]. This increase in heritability values may ultimately be due, as indicated by [27] , to a decrease in the values of phenotypic variance to genetic variance, and what was mentioned by [17] to the role of additional and non-additional effects of genes in controlling the inheritance of these traits, high heritability values, as mentioned [4] considered evidence

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for the possibility of direct advances to these ten genotypes grown at different plant densities for the studied traits in the following seasons.

Table (5):The general mean, components of phenotypic variance (genetic and environmental) , and genetic parameters for the studied traits in maize.

Genetic Parameters	Traits				
	No. of days to male flowering	No. of days to female flowering	Plant height (cm)	No. of ear /plant	Total ear weight (gm)
δ^2G.	3.859 1.788±	7.454 3.381±	356.322 187.009±	0.116 0.071±	4231.632 1859.170±
δ^2E.	0.981 0.310±	1.404 0.444±	235.153 74.362±	0.142 0.045±	382.452 120.942±
δ^2P.	4.840	8.858	591.475	0.258	4614.084
GCV	3.093	4.178	8.298	16.928	32.261
PCV	3.464	4.555	10.691	25.245	33.688
$H^2_{(b.s.)}$	0.797	0.841	0.602	0.449	0.917
EGA	3.612	5.156	30.160	0.469	128.315
EGA%	5.688	7.891	13.258	23.310	63.637
General Mean	**63.497**	**65.333**	**227.475**	**2.012**	**201.635**

Genetic Parameters	Traits				
	No. of grains/ear	500 Grains weight (gm)	Grain yield /plant^{-1}(gm)	Total grain yield (t/h)	Oil ratio (%)
δ^2G.	31429.375 13728.534±	392.261 196.742±	12891.872 6003.358±	35.062 16.284±	1.515 0.783±
δ^2E.	2285.797 722.832±	199.493 63.085±	3482.703 1101.327±	9.179 2.903±	0.925 0.293±
δ^2P.	33715.172	591.754	16374.575	44.241	2.440
GCV	42.279	10.307	36.033	35.145	23.153
PCV	43.789	12.659	40.610	39.478	29.383
$H^2_{(b.s.)}$	0.932	0.663	0.787	0.793	0.621
EGA	352.529	33.223	207.456	10.865	1.998
EGA%	84.072	17.289	65.838	64.488	37.584
General Mean	**419.316**	**192.155**	**315.100**	**16.848**	**5.316**

δ^2G., δ^2E.= Genotypic , Environment , δ^2P.Phenotypic variance / GCV, PCV = Genotypic, Phenotypic Coefficients of variance , $H^2_{(b.s.)}$= Heritability broad sense / EGA= Expected Genetic Advance /EGA%= Expected Genetic Advance as a percentage of the average /G.M.= General Mean .

The results of Table (5) also indicate that the values of expected genetic advance as

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a percentage of the mean trait were high for the total ear weight , no.of grains/ear , individual plant's grain yield , total grain yield and oil percentage 63.637, 84.072, 65.838, 64.488 and 37.584, respectively, and low for the male and female flowering dates 5.688 and 7.891 respectively while they were medium for the rest of the other traits. [13], [21] and [16] indicated that the genetic advance values varied between low, medium and high for the studied traits. [27] indicated that the high percentage of heritability that corresponds to the high values of genetic advance gives an indication to predict the selection that we will obtain, and therefore it can be asserted that the total selection method achieves the required success in breeding this crop.

CONCLUSION

1- SAGUNTO genotype plants were characterized by the highest values, with an mean of 479.400 g and 25.345 tons. ha-1, respectively, for individual plant grain yield and total grain yield.

2- The plants cultivated at the plant density of 44444 plants.ha-1 were characterized by the highest yield per single plant of grain amounted to 371.810 g , and the plants grown at the plant density 66667 plants.ha^{-1} had the highest total grain yield of 17.173 tons. ha^{-1}.

3- The heritability values in the broad sense were high for all the traits except it was medium for number of ears per plant .

4- The values of expected genetic advance as a percentage of the mean rait were high for total ear weight , no. of grains/ear, individual plant grain yield and total grain yield and oil ratio.

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