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Estimation genetic action of heritability percentage and inbreeding depression of four hybrids maize by generation mean analysis

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Abstract

The current study aims of to estimate genetic action, heritability percentage in its broad and narrow sense and inbreeding depression resulting from inbreeding. Five pure inbred lines of maize (ZA17WR, Zi17WZ, ZM74, ZM19 and ZM49W3E) were selected from fifteen different inbred lines with flowering dates and maturity in the spring season 2019 and were crosses according to the research target (late × late),(late ×early) ,(early ×late) and(early ×early). Genetic analysis was done for the components of genetic variance for the three criteria, for the traits of the Ear length, Ear diameter, number of rows per Ear, number of grains per row and number of grains per ear. Results showed the dominance gene action is dominant in the inheritance of the ear length trait in the four hybrids (All values of genetic variation are higher than Environmental variation. However, the heritability percentage in the broad and narrow sense differed among the four hybrids for the studied traits. It possible to conclude that second hybrid was superior in most studied traits. As the influence of the dominance Genetic action had a vital role in the inheritance of the studied quantitative traits, so we recommend following the hybridization method in the production of future hybrids with high yield.

Keywords: Maize, Generation Mean Analysis, Dominance, Inbreeding depression

Introduction

The importance given of the corn crop due to its nutritional and industrial value, as it contains a high level of carbohydrates (starch, oils). As well as using it in animal feed as a concentrated feed or green forage. This requires a lot of work to raise the low productivity and improve the yield of the corn crop (by producing superior hybrids with high quantitative traits, including the yield trait). This requires understanding the genetic variation and their allelic interactions that control their heredity. Early in flowering time and physiological maturity have many benefits, whether on the grain yield or subsequent agricultural operations in the cultivation of other crops [1].

The early lead to saving time and effort and the possibility of exploiting the land in cultivation with other crops, on the other hand, the relationship between early silking and late physiological maturity (The length of the period between silking and physiological maturity) leads in the end to the longest period of fullness of the grain, which represents the important and critical stage in the life of the corn crop, as it is responsible for producing long Ears with full and healthy grains, then to an increase in the yield [2]. The Generations Mean Analysis method to analyze the six generations average (P1, P2, F1, F2, BC1, BC2) was adopted as a biological method for estimating the genetic action of its types, Domaince, Additive and Epistasis, which in turn requires the use of several generations of backcrossing between pure inbreed lines of maize [3]. It was indicated [4] in a study of the six generations of two haploid maize hybrids to estimate the components of the genetic action of the trait of the individual plant yield, that the domaince genetic action dominated the inheritance of the studied trait, and at the same time the Epistasis genetic action of the double type (Duplicate Epistasis) contributed to its inheritance. The results of [5] study of single crosses and their six generations (P1, P2, F1, F2, BC1, BC2) for the characteristic the number of rows per ear of maize crop showed that the additive genetic action has a vital role in the inheritance of the studied trait. Also, the researchers themselves indicated that number of rows per ear is under the control of the additive genetic action. [6] Presented, when studying three individual crosses and their six generations for the trait of the individual yield, which the domaince genetic action and the Epistasis genetic action are of great importance compared to the additive genetic action (small importance) in the inheritance of studied trait. Also, the same researcher indicated that the heritability percentage in the broad sense ranged from 97.37 for the characteristic of the ear diameter for the first hybrid, while it was 50.94 for the trait of the number of grains per row for the second hybrid, while the heritability percentage in the narrow sense was 64.24 for the trait of grain weight for the second hybrid, while it reached 13.85 for the trait of the number of rows per ear for the third hybrid. The results of [7] of their study the six generations of individual hybrids showed the dominance of the dominance genetic action in the inheritance of the two traits of the number of grains per row and the individual plant yield, and the additive genetic action of the Double type (Duplicate Epistasis) played a lesser role in the inheritance of the two studied traits. It was showed [8] in their study the six generations of three individual crosses of maize that the domaince and Epistasis genetic action of the Complementary type were Domaince in the inheritance of yield traits, number of grains per row and grain weight, three individual crosses and their six generations of maize crop were studied. The heritability percentage for the traits of plant yield, number of grains per row and grain weight, the heritability percentage in the broad sense was high for all the hybrids and studied traits, while the heritability percentage in the narrow sense was 61.3 for the number of grains per row in the first hybrid [9] found when they studied the of the genetic action components for the number of ears of maize crop, the additive genetic action is domaince in the inheritance of the trait and

that the dominance degree is less than the correct one, evidence that the partial dominance of genes is domaince (that the action of the additive gene is domaince in inheritance of the studied trait). It was implemented through their study [7] of an individual hybrid and its six generations for the traits of individual plant yield, ear height, plant and number of grains per row, that the domaince genetic action has the greatest role in inheriting the trait of the total yield of maize crop, as well as the contribution of the Epistasis genetic action of the Double type (Duplicate Epistasis) in Transfer and inheritance of studied traits. [10] conducted a cross-breeding of the parents (KE72012 (P1) × K1263/1 (P2) and their six generations to assess the field characteristics of the crop and its components using the Generation Mean Analysis method, and the presence of significant differences between the six generations (P1.P2.F1.F2.BC1.BC2) of the studied traits and that the domaince, additive and Epistasis gene action are influential in the inheritance of the studied traits. It was showed [11], during their study of maize cross, that the genetic dominance is the largest contributor to the transmission and inheritance of the characteristics of the number of grains per row, grain weight and total yield and that the dominance average degree is greater than the correct one, indicating the control of the over -dominance of genes in the inheritance of studied traits. [12] Indicated that the dominance genetic action has the largest role in the inheritance of the trait of the total yield of maize crop, that the dominance degree is greater than the correct one (indicating the role of the over -dominance genes in the inheritance of this trait).

[13] studied some genotypes of maize crop to find out the genetic variance of the characteristics of grain weight, number of grains per row and grain yield in hectares, the heritability ratio was high to moderate and that the effect of the additive gene is domaince and thus selection is effective in early generations to improve the studied traits.

The [14] results showed during their study of hybrids and the six generations (P1, P2, F1, F2, BC1, BC2) to estimate the domaince genetic action in the inheritance of five traits (ear height, individual plant yield, grain yield, number of tasselling and silking and maturity days) The domaince genetic action has the greatest role in the transmission and inheritance of most of the studied traits, contributing to the additive and domaince genetic action in the transmission and inheritance of other different traits, Therefore, Therefore, the current study aims to improve maize varieties depending on the correlation between the studied traits and the inheritance method, it will have the greatest impact in choosing the appropriate breeding program with high effectiveness to improve the genetic structures of the parents and then obtain the resulting (promising) hybrids to increase the yield in the first place. The genetic action nature, the calculation of the heritability percentage in the narrow and the broad sense, and the inbreeding depression resulting from Selfing inbreeding using the Generation Mean Analysis method, for the field characteristics of four maize crosses, varying in flowering time and physiological maturity, and determining the appropriate breeding method.

Materials and Methods

First Season (Spring 2019)

The experimental soil was prepared from plowing, smoothing, leveling and tamping, and the seeds of the fifteen pure inbred lines mentioned were planted on the furrows, the length of the furrows is 6 meters, and the distance between them is 0.8 m, by planting six lines for one inbred line, and in a hole at a distance of 0.25 m between one hole and another on 19-3-2019. For crossing program in next season we are calculating days to tasseling, silking, physiological maturity and flowering compatibility, developing the inbred lines by making self-pollinating between inbred lines. For cultivation in the next season the aim of increasing genetic purity, as well as selecting the inbred lines with good growth characteristics and yield.

Second Season (Fall 2019)

The seeds of the fifteen inbred lines were sown in the fall season on July 16, 2019 and the crossing experiment was conducted. The field designated for the experiment was divided into two parts. The first part was planted with half of the grains of the fifteen inbred lines on furrows, the distance from one to another (0.8) m, and in a hole, one from the other (0.25 m) at a rate of (6) furrows and at a rate of 2 seeds per hole, it was thinned out to One plant in the hole. A week after planting, the second part of the field was planted with the same grains, to ensure that flowering was compatible between the inbred lines and to obtain pollen with effective vitality throughout the crossing period. When the plants reached the flowering stage, the female inflorescence was wrapped before the emergence of the silk with paper bags to obtain the required pollination and to avoid open pollination between inbred lines. The male inflorescence was wrapped in paper bags one day before the start of the inoculation process between the pure inbred lines. On the next day, pollen grains were collected and what was ready from the female inflorescences to receive pollen were pollinated with it. This process was continued until all the required crosses were made between the pure inbred lines used in the study. Inbred lines were multiplied among themselves, and the number of male and female flowering days and physiological maturity for each inbred line were recorded. This is because, to select the resulting hybrids, according to the research objective (late × late), (late×early), (early × late) and (early × early). The process of self-pollination of the inbred lines was also carried out for the purpose of multiplying their seeds, and the process continued until the required crosses were completed and an average of (8-10) ears was obtained for each cross as a minimum to ensure that sufficient numbers of seeds were obtained for the experiment of the next season. At the end of the spring season and at full maturity, the hybrid ears and the self-pollinated parents were harvested individually. Four hybrids were selected, which were characterized by the success of the required cross-

fertilization and obtaining the largest number of seeds sufficient for planting. The hybrids were as follows: the first hybrid (late × late) for the two inbred lines ((Zi17WZ x ZA17WR)), the second hybrid (early × late) for the two inbred lines ((ZM49W3E× ZM74)), and the third hybrid (late × early) for the two inbred lines (ZM19 x ZM74), and the fourth hybrid (early × early) for the two inbred lines (ZM19×ZM49W3E).

Third Season (Spring 2020)

The planting took place in this season on March 17, 2020, as the four hybrids and their parents were planted with 10 furrows for each parent and for each hybrid the length of the furrows was 4 m. The crossing of the first generation F1 was carried out with the first parent P1 and the second parent P2 to produce BC1 and BC2 seeds respectively, and plants were also pollinated The first generation F1 self to produce the seeds of the second generation F2. The process of self-pollination of the parents was carried out for the purpose of multiplying their seeds and using them in the comparison experiment and according to the recommendations, the process continued until the required crosses were completed and a rate of (10-15) ears was obtained for each cross and self-pollinated as a minimum to ensure that sufficient numbers of seeds were obtained from the six generations (P1, P2 , F1, F2, BC1 and BC2) for each of the four hybrids, and introduced into a comparative experiment in the next season.

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Fourth Season (Fall 2020)

The comparison experiment was conducted during the autumn season (2020), where the seeds of the six generations were sown for each hybrid, on July 22, using a randomized complete block design (RCBD) with three replications. 50 thousand plants per hectare. Three seeds were sown in each hole and thinned to one plant after 15 days of emergence, and all agricultural operations were carried out as in the previous seasons. When the plants reached the stage of harvest maturity, 20 plants were selected from the guarded middle lines for each (P1, P2, F1) and 40 plants for the second generation (F2) and 30 plants for each of (BC1, BC2) and the following traits were calculated for them.

Studied traits

1. Ear length (cm): The ears lengths were taken randomly for the plants taken for each generation and for each studied hybrid y from the guarded lines for each experimental unit by using a measure tape.

2. Ear diameter (mm): The ear diameter was measured randomly for plants taken for each generation and for each studied hybrid from each experimental unit by using Vernier.

3. Number of rows per Ear (row ear^{-1})

4. Number of grains per row (grain row^{-1})

5. Number of grains per Ear

The expected genetic advance was estimated as a percentage of the mean GA% according to the following equations.

$GA=K\times h^2_{.n.s}\times \sigma F2$

$GA\%=GA/(\overline{F2})$

Where K = the intensity of selection and its value is 1.76 based on the selection of 10%

Where σP = phenotypic standard deviation

The ranges were adopted for the expected genetic advance limits as follows: - Less than 10% low, 10%-30% medium, more than 30% high suggested by (15)

Inbreeding Depression: It was calculated according to the equation developed by (16)

Inbreeding Depression (ID) = $(\overline{F1}\text{-}\overline{F2}/\overline{F1}) \times 100$

ID= Inbreeding dispersion.

$\overline{F}$ 1 = First generation hybrid average

$\overline{F}$ 2 = Second-generation hybrid average

The environmental variance E, the additive variance D, the dominance variance H, and the dominance degree (H/D) 1/2 and F was estimated according to the following equations:

E=1/3(VP1+VP2+VF1)

D=2(VF2-VB1-VB2)

H=4(VF2-1/2VD-E)

$\bar{a}$= (H/D)1/2

F=BC1-BC2

The inheritances in the broad and narrow sense were estimating according to the following equations, according to (16)

$h^2_{.b.s}$ = (VG/VP) ×100

$h^2_{.n.s}$ = (VA/VP) ×100

Data were analyzed in Software Excel 2018, Genstate 2018, and Spar.2 out of the box.

Results and Discussion

First Hybrid (Late × Late) (Zi17WZ × ZA17WR)

1. Ear length (cm)

It is noticed from the results of table (1) analyzing the variance components for the characteristic of ear length for the same hybrid that the genetic variance values were greater than the environmental variance values, which amounted to 4.76 and 0.50, respectively. This confirms that genetic variance contributes more than environmental variance to the inheritance of this trait. The additive variance effect was greater than the domaince and this was reflected on the dominance degree as it was less than the correct one (0.64), and the inheritance percentage in the narrow sense amounted to 63.87 and in its broad sense 90.49. The high heritability value in the broad sense indicates the greater contribution of genetic variance compared to environmental var-

iance. As for the value of F, it indicates the extent of the association between D and H in all loci. The positive value (0.5) indicates the dominance of the domaince alleles in the inheritance of the trait, and this confirms the previous tables results, which were similar to what was obtained by [17, 18, 19]. It appears from the previous tables and from table (1) results that the expected genetic advance value was low as it reached 1.51 and the genetic advance percentage reached% 8.16 and it was low. The trait is under the control of the additive genes more than the non-additive (SCA effect) type of genes action, so the studied trait can be improved by following the selection method.

The characteristic of the ear length in Table (1) showed a low level of the inbreeding depression degree resulting from self-breeding by (%10.89.).

2. Ear diameter (mm)

It appears from Table (1) to analyze the variance components of the ear diameter for the same hybrid, that the the environmental variance values were less than the additive values and domaince variance, as they reached 21.88 and 24.56 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of this trait . That the domaince variance effect was greater than the additive, and this was reflected in the dominance degree as it was greater than the correct one (1.05), and the inheritance percentage in the narrow sense was 45.97 and in its broad sense 97.58.The low heritability value in the narrow sense indicates a decrease in the additive genetic action, while the high heritability in the broad sense indicates the greater contribution of genetic variance compared to environmental variance. The value of F indicates the extent of the correlation between D and H in all loci, and the negative value (-1.36) indicates the contribution of additive alleles to the inheritance of the trait, and this confirms the previous tables results that came close to what was obtained by [6], [20] , [21] and [22].

The table (1) results indicated that the expected genetic advance value was low, as it reached 1.54, and the genetic advance percentage was low, which amounted to %3.73. From the previous tables results, it was found that the first generation members were distinguished by giving them the highest average for the characteristic of the ear diameter, as well as the control of the over -dominance genes and the high heritability percentage in the broad sense, evidence of the possibility of improving the studied trait by selection followed by hybridization method.

The hybrid vigor recorded in the first generation of the ear diameter coincided with a significant positive inbreeding depression rate in Table (1) in the second generation, amounting to% 4.15. These results are close to the results of [23].

3. Number of rows per Ear

The Table (13) results shown analysis of the variance components for the number of rows per ear for the same hybrid, the data indicate that the environmental variance values were less than the additive and domaince variance values, as they reached

9.514 and 3.532 respectively, and this confirm that genetic variance contributes more than environmental variance in inheriting this trait. The additive variance effect was greater than the domaince and this was reflected on the dominance degree as it was less than the correct one (0.60), and the inheritance percentage in the narrow sense amounted to 71.34 and in its broad sense 97.82. The high heritability value in the broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H in all the positive value loci (1.34), indicating the contribution of the domaince alleles to the inheritance of the trait, and this confirms the previous tables results that came similar with the findings of [24] and [25]..The previous tables and from table (1) results confirmed the expected genetic advance value was low, reaching 3.04, while the genetic advance percentage averaged %19.99. The trait is under the control of the additive genes more than the non-additive genes, so the studied trait can be improved through selection method. The table (1) results confirmed that the occurrence of inbreeding depression in the second generation is positive and low (%8.57) for the characteristic of the number of rows per Ear, in agreement with the study results of [26].

4. Number of grains per row (grain row^{-1})

The table (1) results shown in analysis of the variance components for the trait of the number of row grains for the same hybrid, showed that the environmental variance values were less than the additive and dominance variance values, as they reached 1.58 and 4.76 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of these trait. The domaince variance effect was greater than the additive, and this was reflected in the domaince degree as it was greater than the correct one, and the inheritance percentage in the narrow sense amounted to 22.03 and in its broad sense 88.42.A low heritability percentage in narrow sense indicates a decrease in additive variance, and a high heritability value in a broad sense indicates the greater contribution of genetic variance compared to environmental variance. As for the F value, it indicates the extent of the association between D and H in all loci. The positive value (5.6) indicates the contribution of the domaince alleles to the inheritance of the trait. This confirms the previous tables' results that agreed with the other researchers' results, each of [8] and [13].The table (1) results confirmed that the expected genetic advance value was low, reaching 0.64, and the genetic advance percentage was low, amounting to %1.85. From the previous tables' results, the hybrid vigor is positive and that the trait is under the Epistasis control of the genes, as well as the additive and non-additive action genes effect. Accordingly, the trait can be improved by hybridization followed by the selection method for superior individuals.

The table (1) results showed the inbreeding depression value associated with Selfing breeding was positive and low for the number of grains per row, amounting to (%8.59%), in agreement with study of [27] results.

5. The number of grains per Ear

Table (1) analyzes the variance components for the number of grains per ear of the same hybrid, the data indicate that the environmental variance values were less than the additive and domaince variance values, as they reached 5243.96 and 538.24 respectively, and this confirms that genetic variance contributes more than environmental variance in heritability this trait. The domaince variance effect was greater than the additive and this was reflected in the domaince degree as it was greater than the correct one (1.013), and the inheritance percentage in the narrow sense amounted to 41.60 and in its broad sense 85.35. The high heritability value in the broad sense indicates the greater contribution of genetic variance compared to environmental variance. As for the F value, it indicates the extent of the association between D and H in all loci. Negative values (-94.92) indicate the dominance of the additive alleles in the inheritance of the trait, and this confirms the previous tables results from the participation of the additive alleles with the domaince in the inheritance of the number of grains per ear, consistent with the previous studies results each from [28], and [22].The previous tables and from Table (1)results indicated that the expected genetic advance value was high, amounting to 43.52, while the genetic advance percentage averaged 12.55%. The trait is under the control of the non-additive genes more than the additive genes, so studied trait can be improved by Hybridization method.

The table (1) results confirmed the occurrence of inbreeding depression in the second generation, positive and moral, which achieved a value of %42.53 for the characteristic of the number of grains per Ear. This confirms what was found by [23]

Table (1): Estimation of the variance components, dominance degree, heritability in its narrow and broad sense inbreeding depression and advance of the first hybrid (Zi17WZ× ZA17WR)) (late × late) Second Hybrid (ZM49W3E× ZM74) (Early x Late)

Traits	E	D	H	$(H/D)^{1/2}$	F	h^2.n.s	h^2.b.s	▲G	%▲G	%ID
	Environmental variance	Additive variance	Dominance variance	Dominance variance / additive variance	association between Dominance and Additive variance	heritability in narrow sense	heritability in broad sense	Expected genetic advance	Genetic advance percentage	inbreeding depression percentage
Ear length	**0.5**	**3.36**	**1.4**	**0.64**	**0.5**	**63.87**	**90.49**	**1.51**	**8.16**	**10.89**
Ear di-	**1.15**	**21.88**	**24.56**	**1.05**	**-1.36**	**45.97**	**97.58**	**1.54**	**3.73**	**4.15**

ameter										
Number of rows per ear	**0.29**	**9.514**	**3.532**	**0.60**	**1.34**	**71.34**	**97.82**	**3.04**	**19.99**	**8.57**
Number of grains per row	**0.83**	**1.58**	**4.76**	**1.72**	**5.6**	**22.03**	**88.42**	**0.64**	**1.85**	**8.59**
The number of grains per Ear	**1972.35**	**5243.96**	**5387.24**	**0.98**	**-94.92**	**41.60**	**84.35**	**43.52**	**12.55**	**42.53**

1. Ear length (cm)

The data of table (2) of the variance components indicates that the environmental variance values (0.098) were less than the additive and domaince variance values , as they reached 0.9152 and 1.470 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of this trait. The domaince variance effect It was greater than the additive, and this was reflected in the domaince degree as it was greater than the correct one (1.267), and the inheritance percentage in the narrow sense amounted to 59.20 and in broad sense 96.05.That the high heritability value in the broad sense indicates the greater contribution of genetic variance compared to environmental variance. The F value indicates the extent of the association between D and H in all loci. The negative value (-0.21) indicates the contribution of additive alleles to the inheritance of the trait, and this confirms the previous tables results that agree with [17], [18] and [19] . whose results showed the control of the non-additive genetic action for this trait. The table (2) results showed that the expected genetic advance value was low, amounting to 1.07, and the genetic advance percentage was low, which amounted to (%6.02).

From the previous tables' results, it was found that the inheritance of the trait is under the influence of the non-additive genetic action of the genes, so we recommend following the hybridization method to improve the trait and then select the superior hybrids from them. The table (2) results estimating inbreeding depression in the ear length trait showed that the positive and significant value was, amounting to% 10.68 in agreement with [29] result.

2. Ear diameter (mm)

From the data of table (2) to analyze the c variance components for the characteristic of the ear diameter of the same hybrid, it is clear from the data that the environmental variance values were (0.973) less than the additive and domaince variance values , as they reached 2.772 and 5.48 respectively, and this confirms that the genetic variance contributes more than the environmental variance In the inheritance of the ear diameter trait, the domaince variance effect was greater than the additive and this was reflected on the dominance degree as it was greater than the correct one (1.41), and the inheritance percentage in narrow sense was 28.91, which is low as a result of the decrease in the additive and wide variance amounted to 89.45.The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of association between D and H in all loci. A positive value (0.61) indicates the contribution of domaince alleles to the inheritance of the trait. This confirms the previous table's results that agree with what was found by [6, 20, 21, 25].

The table (2) results showed that the expected genetic advance value was low as it reached 1.80, while the genetic advance percentage was %5.07and it was low. The narrowness makes the possibility of improving the trait by conducting selection and then follows hybridization.

The table (2) results indicated in the inbreeding depression value associated with in-Selfing breeding was positive (%16.72) and significant for the ear diameter characteristic [29].

3. Number of rows per Ear

Table (2) to analyze the variance components for the number of rows per ear of the same hybrid shows that the environmental variance values were few, amounting to (0.166), less than the additive and domaince variance values , as they reached 0.616 and 0.84 respectively, and this confirms that the genetic variance contributes more than the environmental variance in inheritance of the number of rows per Ear. The domaince variance effect was greater than the additive, and this was reflected in the domaince degree, as it was greater than the correct one, which amounted to (1.16), and the inheritance percentage in narrow sense amounted to 37.97 and in broad sense it was 89.76.The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H at all sites and that the negative value (14.00) indicates the contribution of additive alleles to the inheritance of the trait, and this confirms the previous tables results that supported confirmed by [18] and [30] .It appears from the previous tables' results and table (2) that the expected genetic advance value is less than the correct one, amounting to (0.26), while the genetic advance percentage was also low, amounting to %2.09. The trait is under the control of the over-dominance of genes, positive hybrid vigor and high heritability in broad sense, so the trait can be improved by following hybridization followed by selection later. The table (2) results indicated that the inbreeding depression value associated with Selfing breeding was positive and significant for the characteristic of the number of rows per Ear, which amounted to% 22.38 [29].

4. Number of grains per row (grain row^{-1})

The table (2) results for analyzing the variance components for the trait of the number of grains per row for the same hybrid, indicate that the environmental variance values were less than the additive and domaince variance values , as they reached 2.24 and 8.752 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of this trait. The domaince variance effect was greater than the additive and this was reflected in the dominance degree as it was greater than the correct one (1.91), and the inheritance percentage in narrow sense amounted to 20.04 and in its broad sense 98.37. The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H in all sites. The positive value (1.17) indicates the role of the domaince alleles in the inheritance of the trait, and this confirms the previous tables' results as it is in agreement with the findings of [13] and [30] .It appears from the previous tables' results and from table 2 that the expected genetic advance value is less than the correct one, as it reached 0.65, while the genetic advance percentage was %2.39.it was low. In addition, hybridization can be done, followed by selection, to

improve the trait. The trait of the number of grains per row recorded the highest level of the inbreeding depression degree in table (2) resulting from self-breeding by %19.39 [31].

5. The number of grains per Ear

Table (2) analysis the variance components for the number of grains per ear of the same hybrid indicates that the environmental variance were values less than the additive and domaince variance values , as they reached 648.4 and 2763.66 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of this trait, The domaince variance effect was greater than the additive and this was reflected in the domaince degree as it was greater than the correct one (2.06), and the inheritance percentage in narrow sense amounted to 18.10 and in its broad sense 95.26. The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H in all loci, and that the negative value (-26.72) indicates the contribution of additive alleles to the inheritance of the trait, and this confirms the previous tables the results, which agree with the [22] and [28] results. The previous tables results and from table (2) indicated that the expected genetic advance value was high and significant, amounting to (50.57), while the genetic advance percentage averaged %14.42, that the trait is under the control of the non-additive genes more than the additive genes. Therefore, the studied trait can be improved by following the hybridization method followed by selection.

The table (2) results showed that the inbreeding depression deterioration value associated with Selfing breeding was high and significant for the characteristic of the number of grains per Ear, which amounted to %27.49 [32].

Table (2): Estimation of the variance components, dominance degree, heritability in its narrow and broad sense inbreeding depression and advance of the second hybrid (ZM49W3E× ZM74) (early × late) Third Hybrid (ZM74×ZM19) (late×early)

Traits	E	D	H	$(H/D)^{1/2}$	F	h^2.n.s	h^2.b.s	▲G	%▲G	%ID
	Environ mental variance	Additive variance	Dominance variance	Dominance variance/ad ditive variance	association between Dominance and Additive variance	herita-bility in narrow sense	heritability in broad sense	Expected genetic advance	Genetic advance percentage	inbreeding depression percentage
Ear length	0.098	0.9152	1.4704	1.26	-0.21	59.20	96.05	1.07	6.02	10.68
Ear diameter	0.973	2.772	5.48	1.41	0.61	28.91	89.45	1.80	5.07	16.72
Number of rows per ear	0.166	0.616	0.84	1.16	-1.4	51.78	89.76	0.26	2.09	22.38
Number of grains per row	0.182	2.24	8.752	1.91	1.17	20.04	98.37	0.65	2.39	19.39
. The number of grains per Ear	169.552	648.42	2763.66	2.06	-26.72	18.10	95.26	50.57	14.42	27.49

1. Ear length (cm)

It is noted from the data in table (3) that the analysis of the variance components for the characteristic of the ear length of the same hybrid, the results of the genetic analysis showed that the genetic variance values are greater than environmental variance, as they reached 10.94 and 0.676 respectively, and this confirms that genetic variance contributes more than environmental variance in the inheritance of this trait. The domaince variance effect was greater than the additive, and this was reflected on the domaince degree as it was greater than the correct one (1.05), and the inheritance percentage in narrow sense amounted to 7.78 and in broad sense 94.16. The low heritability percentage in narrow sense as a result of low additive variance and high heritability percentage in
broad sense shows the greater contribution of genetic variance compared to environmental variance. Trait inheritance and this confirms the previous tables' results (18, 19 and 20). [26, 18, 30, 33] .The table (3) results indicated the expected genetic advance value, which amounted to 3.54, while the genetic advance percentage was %19.08, and it was medium. From the previous tables' results, the additive variance value is low, which is responsible for the transmission and inheritance of the trait, so hybridization must be carried out in order to improve the trait under study. The inbreeding depression degree resulting from self-breeding, table (3), reflects the loss in the vitality in the second generation members, and a significant value of the ear length characteristic was %17.03 [31].

2. Ear diameter (mm)

Table (3) analysis of the variance components for the ear diameter of the same hybrid, shows that the environmental variance values were less than the additive and domaince variance values, as they reached 6.462 and 2.404 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of this trait. The additive variance effect was greater than the domaince and this was reflected on the dominance degree as it was less than the correct one (0.60), and the inheritance percentage in narrow sense amounted to 65.89 and in broad sense 90.41. The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H in all loci, the positive value (1.25) indicates the participation of the dominant alleles in the inheritance of the trait, and this confirms the previous tables results (18, 19 and 20), Which agreed with the findings of[20] and [33].The table (3) results confirmed the expected genetic advance value, which amounted to 2.17, while the genetic advance percentage of was %5.12 and it was low. From the previous tables' results, the non-additive genetic action is dominant in the inheritance of the trait, so the hybridization method is the most appropriate and effective chosen by the breeder the maize crop and for studied trait.
The hybrid vigor was associated with a significant degree of inbreeding depression in table (3), which indicates the small genetic stock of the studied individuals for the ear

diameter trait that reached (%6.08) to the presence of a sequence of undesirable recessive genes in these individuals in agreement with the study of [32] results .

3. Number of rows per Ear

It is noted from table (3) the analysis of the variance components for the number of rows per ear of the same hybrid. The data indicate that the environmental variance values were less than the additive and domaince variance values , as they reached 5.236 and 1.512 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance this trait. The additive variance effect was greater than the domaince and this was reflected in the dominance degree as it was less than the correct one (0.53), and the inheritance percentage in narrow sense amounted to 73.47 and in broad sense 94.69. that the high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the correlation between D and H in all sites, the positive value (0.87) indicates the dominance influence in the inheritance of the trait, and this confirms the previous tables results implicitly agreed with the results of what was reported by [34], [18] and [30].The table (3) results indicated that the expected genetic advance value amounted to 2.17, while the genetic advance percentage was %5.12 and it was medium. From the previous tables results it was found that the additive variance value decreased, so hybridization must be carried out several times to obtain hybrids (individuals of the first generation) characterized the height of the number of rows per Ear. The characteristic of the number of rows per Ear showed a significant level of the inbreeding depression degree of resulting from Self-breeding (Table 3), with an amount of (%6.08), confirmed by [32]

4. Number of grains per row (grain row^{-1})

It appears from Table (3) the analysis of the variance components for the number of grains per row for the same hybrid, the data indicate that the environmental variance values 2.263 were less than the additive and domaince variance values , as they reached 10.5 and 12.472 respectively, and this confirms that the genetic variance contributes more than the environmental variance In the inheritance of the number of grains per row. The domaince variance effect was greater than the additive, and this was reflected in the dominance degree as it was greater than the correct one (1.089), and the inheritance percentage in narrow sense amounted to 71.25 and in broad sense 84.64.

that the high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H at all sites and that the negative value (0.26-) indicates the contribution of additive alleles to the inheritance of this trait, and this confirms the previous tables results (18, 19, 20) agreed with [30] and [33] .The table (3) results showed the expected genetic advance value 3.30, while the genetic advance percentage was %10.36 and it was medium, and from the previous tables re-

sults it was shown a decrease in the additive variance value, so hybridization must be carried out several times to obtain hybrids (individuals of the first generation) characterized by high grains per row. The hybrid vigor recorded in the first generation for the number of grains per row with a positive inbreeding depression in the second generation was% 10.03 [23].

5. The number of grains per Ear

It is clear from the table (3) results shown in analyzing the variance components for the number of grains per ear of the same hybrid, that the environmental variance value 161.76 was less than the additive and domaince variance values , as they reached 449.76 and 1548.16 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of the number of grains per Ear. The domaince variance effect was greater than the additive, and this was reflected in the domaince degree as it was greater than the correct one (1.85), and the inheritance percentage in narrow sense amounted to 20.82 and in broad sense 92.51.The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H in all loci, the positive value (31.32) indicates the role of dominant alleles in the inheritance of the trait. This confirms the previous tables results (18, 19 and 20), which agreed with the study's results of [31] , [18] , and [30] .The table (3) results indicated the expected genetic advance value amounted to 40.79, while the genetic advance percentage was low by% 8.85, and from the previous tables results it was found that the additive variance value decreased. Therefore, hybridization must be carried out several times to obtain hybrids (individuals of the first generation) characterized by a high number of grains per Ear. The table (3) results confirmed that the inbreeding depression percentage in the second generation is positive, achieving a value (%16.34) for the number of grains per Ear [26].

Table (3): Estimation of the variance components, dominance degree, heritability in its narrow and broad sense inbreeding depression and advance of the third hybrid (ZM74×ZM19) (late × early)

Traits	E	D	H	$(H/D)^{1/2}$	F	h^2.n.s	h^2.b.s	▲G	% ▲G	%ID
	Environ mental variance	Additive variance	Dominance variance	Dominance variance/addi tive variance	association between Dominance and Additive variance	heritability in narrow sense	heritability in broad sense	Expected genetic advance	Genetic advance percenta ge	inbreeding depression percentage
Ear length	0.676	0.904	10.04	1.05	-0.83	86.40	94.16	3.54	19.08	17.03
Ear di-ameter	0.94	6.462	2.404	0.60	1.25	65.89	90.41	2.17	5.12	6.08
Number of rows per ear	0.378	5.236	1.512	0.53	0.87	7 .78	94.69	2.07	14.38	7.04
Number of grains per row	2.263	10.5	12.472	1.08	-0.26	71.25	84.64	3.30	10.36	10.03
. The number of grains per Ear	161.76	449.76	1548.16	1.85	31.32	20.82	92.51	40.79	8.85	16.34

Fourth Hybrid (Early x Early (ZM19 x ZM49W3E)

1. Ear length (cm)

The table (4) results for analyzing the variance components for the ear length characteristic of the same hybrid showed that the environmental variance values amounted to 0.736, which were less than the additive and domaince variance values , as they reached 2.79 and 3.38 respectively. This confirms the contribution of genetic variance more than environmental variance in the inheritance of this trait. The domaince variance effect was greater than the additive, and this was reflected in the domaince degree as it was greater than the correct one (1.11), and the inheritance percentage in narrow sense amounted to 39.82 and in broad sense 89.50. The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H at all sites. Which agree with the findings of [17, 19, 18].The table (4) results indicated that the expected genetic advance value was low, amounting to 1.01, while the genetic advance percentage was %5.99 and it was low. from the previous tables results, the trait falls to the control of the non-additive genetic action more than the additive genetic action through the hybrid vigor positive and the high variance Therefore, the trait can be improved by hybridization and the selection of surpassed hybrids from it. The table (4) results indicated that the inbreeding depression value associated with Selfing breeding was %25.16 significant for ear diameter trait [23].

2. Ear diameter (mm)

It appears from the Table (4) results analysis of the variance components for the ear diameter of the same hybrid, which the environmental variance values were less than the additive and domaince variance values as they reached 22.58 and 8.2 respectively, and this confirms that the genetic variance contributes more than the environmental variance in the inheritance of this trait. The additive variance effect was greater than the domaince and this was reflected in the dominance degree as it was less than the correct one (0.60), and the inheritance percentage in narrow sense was 65.37 and in broad sense 89.11.The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, that the F value indicates the extent of the association between D and H at all sites and that the negative value (6.02-) indicates the participation of additive alleles in the heritability of the ear diameter. This confirms the table (24) results, similar results obtained by [6], [20] and [33] .The previous tables results and from table (4) confirmed that the expected genetic advance value was low, amounting to 4.11, while the genetic improvement percentage was %10.58, and it was medium. The hybrid vigor recorded in the first generation of the ear diameter coincided with a positive and significant inbreeding depression from the table (4) results in the second generation, amounting to %20.03 [23].

3. Number of rows per Ear

Table (4) shows the analysis of the variance components for the characteristic of the number of rows per ear of the same hybrid. The data indicate that the environmental variance values were less than the additive and domaince variance values , as they reached 1.123 and 1.204 respectively. This confirms that genetic variance contributes more than environmental variance to heritability this trait. The additive variance effect was greater than the domaince and this was reflected in the dominance a degree it was less than the correct one, and the inheritance percentage in narrow sense amounted to 46.53 and in broad sense 96.43.The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H at all sites, the negative value (1.74-) indicates the contribution of additive alleles to the inheritance of the trait, and this confirms the table (4) results this is similar to [18], and [30].It appears from the previous tables results and from table (4) that the expected genetic advance value was low, amounting to 0.69, while the genetic advance percentage was low, which amounted to %5.10 by following the election method. The table (4) results confirmed the occurrence of a positive inbreeding depression in the second generation, achieving a value of %16.81 for the characteristic of the number of rows per Ear [26].

4. Number of grains per row (grain row^{-1})

The table (4) results indicate the analysis of the variance components for the number of grains per row for the same hybrid, the data indicate that the environmental variance values were less than the genetic variance values , as it reached 2.19 and 15.33 respectively, and this confirms that genetic variance contributes more than environmental variance in the heritability of this trait. The domaince variance effect was greater than the additive and this was reflected in the dominance degree as it was greater than the correct one (2.66), and the inheritance percentage in narrow sense amounted to 10.81 and in broad sense 87.47.The low heritability percentage in narrow sense is due to the contribution of additive variance to the heritability of the trait, while the high heritability percentage in broad sense indicates the greater contribution of genetic variance compared to environmental variance, and the F value indicates the extent of the correlation between D and H in all sites that the negative value (-3.66) indicates To the contribution of additive alleles to the heritability of the number of grains per row. This confirms the data of genetic analysis in table (4). These results came with what was obtained by [22] and [30] .It is evident from the previous tables' results and from table (4) that the expected genetic advance value was low, amounting to 4.09, while the genetic advance percentage was medium, amounting to% 15.37.The studied trait can be improved by Hybridization. The inbreeding depression resulting from self-breeding from table (4) reflects the loss in the vitality of the second generation members, and the positive value of the trait of the number of grains per row reached %27.48 [31].

5. The number of grains per Ear

The table (4) results shown analysis of the variance components for the number of grains per ear of the same hybrid showed that the environmental variance values were less than the additive and dominance variances values , as they reached 1030.04 and 5387.24 respectively, and this confirms that the genetic variance contributes more than the environmental variance in heritability this trait. The domaince variance effect was greater than the additive, and this was reflected in the domaince degree as it was greater than the correct one (2.28), and the inheritance percentage in narrow sense amounted to 1.63 and in broad sense 94.07. The high heritability value in broad sense indicates the greater contribution of genetic variance compared to environmental variance, while the F value indicates the extent of the association between D and H at all sites, the negative value (-92.92) indicates the role of additive alleles in the inheritance of the trait, and this confirms the results put in tables (22, 23, 24) that agree with what was obtained by [22]and [28].

It appears from the previous tables' results and from table (4) that the expected genetic advance value was high, amounting to 79.51, while the genetic advance percentage was %21.80 and it was medium, that the trait is under the control of the non-additive genes more than the additive genes. The studied trait can improve by following the Hybridization method. The hybrid vigor was associated with a negative and non-significant inbreeding depression degree of from table (4), which indicates the small genetic stock of the studied individuals for the number of grains per Ear (%39.54) to the presence of a sequence of undesirable recessive genes in these individuals [32].

Table (4): Estimation of the variance components, dominance degree, heritability in its narrow and broad sense inbreeding depression and advance of the fourth hybrid (ZM19× ZM49W3E) (early × early)

Traits	E	D	H	$(H/D)^{1/2}$	F	h^2.n.s	h^2.b.s	▲G	%▲G	%ID
	Environmental variance	Additive variance	Dominance variance	Dominance variance/ additive variance	association between Dominance and Additive variance	heritability in narrow sense	heritability in broad sense	Expected genetic advance	Genetic advance percentage	inbreeding depression percentage
Ear length	0.736	2.793	3.484	1.11	0.73	39.82	89.50	1.01	5.99	25.16
Ear diameter	3.76	22.58	8.2	0.60	-6.02	65.37	89.11	4.11	10.58	20.03
Number of rows per ear	0.086	1.123	1.204	1.03	-1.74	46.53	96.43	0.69	5.10	16.81
Number of grains per row	2.196	1.896	13.44	2.66	-3.66	10.81	87.47	4.09	15.37	27.48
. The number of grains per Ear	403.85	5387.24	1030.04	0.43	611.36	78.68	97.07	79.51	802.5	39.54

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