Estimation of Genetic Parameter by Using Full Diallel Cross in Maize under Different Irrigation Interval

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Abstract. The research was carried out with the aim of estimating the general and specific capabilities of the coalition and the genetic action of inbred lines of maize The field experiment was carried out in one of the agricultural fields of Al-Khalidiya District - Anbar Governorate - Iraq for the spring season 2019, five inbred lines AG116, AG-M20, MH17, MH121 and ZM4 were used for this study and entered into a full diallel-cross breeding program, and evaluate the behavior of these inbred lines and their diallel and reciprocal crosses according to the first Griffing method and the fixed model. A comparison experiment was carried out between parental inbred lines and diallel and reciprocal hybrids using the RCBD design in split-plot arrangement with three replications. Where the irrigation intervals 6 and 12 days allocated to the main plots, and genotypes (inbred lines and hybrids) allocated to the sub plots in order to estimate the general and specific combining ability of the studied traits. The results of the study indicated that there were significant differences between the parental inbred lines and their diallel and reciprocal hybrids in the general and specific combining abilities and their effects for most of the studied traits. The inbred ZM4 gave the highest negative combining ability to female flowering, which was -0.77 and -1.06 for 6 and 12-day irrigation intervals, respectively. While the MH121 inbred line with 6-day irrigation interval and ZM4 inbred line with 12-day irrigation interval were distinguished by giving it the highest positive and significant combining ability of grain yield, which amounted to 4.78 and 9.45, respectively. The specific combining ability of the hybrids was characterized by negative and positive values, the cross-hybrid AG116 x AGM20 with the irrigation interval of 6 days gave the highest positive and significant combining ability of 34.05. While the hybrid MH17 x ZM4 with an irrigation interval of 12 days was distinguished by giving it a positive combining ability of 7.12. As for the reciprocal hybrids, the reciprocal hybrid MH121 x AG116 with irrigation intervals of 6 and 12 days gave the highest positive and significant values of 48.74 and 25.76, respectively. The percentage of heritability in the broad sense was 99.8% in the leaf area of the 6-day irrigation interval, while with the 12-day irrigation interval it was 98.76% in the female flowering trait. Whereas, the percentages of heritability in the narrow sense reached 78% in the number of rows in ear with the irrigation interval of 6 days for the reciprocal hybrids, while it reached 78.91 in the reciprocal hybrids at the 12-day irrigation interval for female flowering.

1. Introduction
Maize (Zea mays L.) is one of the most important strategic and economic crops in the world. It is considered the third crop in terms of economic importance after wheat and rice. Maize is used in human and animal nutrition, as well as various other uses such as treatment, dye production, and use as biofuel, it is promised as an alternative to traditional car fuel or other and called the King of crops. [1]and [2,3,15].
The importance of the crop increased rapidly due to the increase in the world population and the expansion of livestock projects, and despite this importance, it still suffers from a decrease in the rate of productivity per unit area in Iraq compared to global production, as the cultivated area for the year 2019 is about 128,800 hectares, with a production rate of approximately 3,673 tons ha\(^{-1}\). Improving drought-resistant genotypes is one of the most important means that can be used in response to contemporary climatic changes, and the development of the root system of these genotypes is at the forefront of mechanisms that will improve their resistance to water stress conditions. UNESCO asserts that about 1.8 billion people will suffer from water shortage and two thirds of humanity will be affected by the consequences of water shortage by 2025, which will negatively affect the production of agricultural crops. Increasing the general and specific combining ability in maize (Zea mays L) leads to obtaining hybrids vigor, so plant breeders seek to find the best hybrids by diagnosing the best parents, in order to achieve the highest hybrid vigor. Large numbers of pure lines can be used to produce better and superior hybrids in yield and its components. Also, good field management contributes to increasing the yield by 30-50%, while the genetic improvement contributes to the remaining percentage in the yield of the crop [33]. This phenomenon has attracted plant breeders for the purpose of studying and applying it in many field crops, with the aim of raising their production efficiency per unit area and improving their qualitative characteristics. The system of mating between different genotypes is called diallel-crossing and this type of diallel-crossing can obtain all possible combinations between the genotypes included in the program [20]. In order to promote an increase in the yield of maize, it is necessary to use single cross hybrids due to their good characteristics in productivity [6]; [14].

The method of diallel-crossing is one of the best methods of hybridization, because it is possible to determine the performance of the different genotypes in the resulting offspring by calculating the average of the studied traits and calculating the hybrid vigor with an estimate of the general and specific combining ability of the combination and their effects, as well as the estimation of some genetic parameters. Also, the diallel analysis gives an indirect estimate of the nature and type of gene action affecting the inheritance of the trait, and this enables the plant breeder to choose the appropriate breeding method [10]; [34].

Therefore, based on the foregoing, the research aims to estimate some genetic parameters of the yield and its components in maize, in addition to calculating the effect of the general and specific combining ability to combination and the variance of their effect.

2. Materials and Methods

Five inbred lines AG116, AG-M20, MH17, MH121 and ZM4 were used in this study. (The inbred lines were numbered from 1 - 5) The research was carried out in farmer field in Al-Khalidiya, Anbar Governorate, Iraq, for the spring season 2020.

The experimental land was prepared by plowing, smoothing, leveling and dividing according to the recommended scientific recommendations. The field was fertilized in all cultivation seasons. The field was fertilized with 320 kg ha\(^{-1}\) of DAP fertilizer added to the soil during the preparation of the land, and 100 kg ha\(^{-1}\) urea was added in two batches, half the amount when the plant reaches an average height of 25 cm and the other half at the beginning of flowering, after germination, weeding and hoeing were done as needed. Corn stem borer insect was controlled using granulated diazinon (10% active substance) added in two batches, the first when the plant reached 20 cm and the second two weeks after the first addition. Diallel crossing was carried out according to the first Griffing method, fixed model.
The planting was at the beginning of March for the spring season, where the first season was a cross between inbreed lines to obtain single cross hybrids, while the second season was to compare the hybrids among themselves with irrigation intervals of 6 and 12 days. When the maturity is complete, the hybrid ears are harvested. The comparison experiment was carried out in the spring season 2020 using a randomized complete block design (RCBD) in split plot arrangement with three replications. The analysis of general and specific combining ability and variances was carried out according to the method of [20]. The expected mean square variance (EMS) was calculated, which included the variance of general and specific combining ability and the variance of the reciprocal effect.

The ratio was calculated between the variance of the general and specific combining ability of the diallel hybrids and reciprocal hybrids. As for the effect of the general combining ability (g^ii) and the effect of the specific combining ability of diallel hybrids (S^ij), and the effect of the specific combining ability of reciprocal hybrid (r^ij), it was estimated according to the following equations:

\[ g^{\text{ii}} = \frac{1}{2P} \left( X_{i.} + X_{.j} \right) - \frac{1}{P^2} X \ldots \]

\[ S^{\text{ij}} = \frac{1}{2} \left( X_{ij} + X_{ji} \right) - \frac{1}{2P} \left( X_{i.} + X_{.i} + X_{j.} + X_{.j} \right) + \frac{1}{P^2} X \ldots \]

\[ r^{\text{ij}} = \frac{1}{2} \left( X_{ij} - X_{ji} \right) \]

Estimate the standard error of the difference between the effect of the general combining ability (g^ii) of two parents as follows:

\[ \text{Standard Error (S.E)} = (g_i - g_j) = \left( \frac{m_{se}}{P} \right)^{1/2} \]

\[ g_i = \left[ (P-1) \left( \frac{m_{se}}{P^2} \right) \right]^{1/2} \]

The standard error between the effect of the specific combining ability between two diallel hybrids is as follows:

\[ S.E(S^{ij} - S^{ik}) = \sqrt{\left( (P - 1)/2 \cdot M_{se} \right)} \]

\[ S.E.S^{ij} = [(P - 1/P) \cdot M_{se}]^{1/2} \]

Whereas, the standard error between the effect of the specific combining ability between two reciprocal hybrids is as follows:

\[ S.E.(r^{ij} - r^{ik}) = \sqrt{M_{se}} \]
2.1 Components of phenotypic and genetic variance

The components of phenotypic variance representing additive genetic variance ($\sigma^2_A$), dominant genetic variance ($\sigma^2_D$) as well as environmental variance ($\sigma^2_E$) were estimated using the expected mean variance EMS (Griffing, b 1956) on the basis of the following equations:

$$
\sigma^2_A = 2\sigma^2 gca \\
\sigma^2_D = \sigma^2 Sca \\
\sigma^2_E = MSE = MSE/r
$$

Thus, the phenotypic variance is:

$$
\sigma^2 P = \sigma^2 G + \sigma^2 E = \sigma^2 A + \sigma^2 D + \sigma^2 E
$$

3. Results and Discussion

3.1 Number of days from planting to 50% female flowering. The results of the statistical analysis and the partitioning of the genotype variance values into its components indicate that there are significant differences for all components of this trait (Table 1). Which indicates the role of both the additive and non-additive effects of genes in the inheritance of the trait, all inbred lines showed a significant negative effect of the general combining ability (-0.160, -0.010, -0.005 and -0.770) for inbred lines 1, 3, 4 and 5 respectively, except for inbred line 2 which showed a positive effect of treatment Irrigation 6 days. As for the irrigation 12-day treatment, all inbred lines except for inbred line 1 showed a negative effect of the general combining ability, reaching as low as -1.060 for inbred line 5. Negative values of the general combining ability indicate that the progeny's ability to inherit the early flowering hybrids, while the positive values for the general combining ability indicate the extent to which the progeny is capable of inheriting the delay of hybrids in female flowering. As for the effect of the specific combining ability to the diallel and reciprocal hybrids, we find that 7 diallel and 6 reciprocal hybrids for the 6-day irrigation treatment, 8 diallel hybrids and 4 reciprocal hybrids for the 12-day irrigation treatment were the best hybrids in the ability towards early female flowering, and the diallel hybrids 3×1, 3×2, and the reciprocal 1×2 for the 6-day irrigation treatment, and the diallel hybrids 4×1, 5×3 and 5×4, and the reciprocal 3×4 and 4×5 for the 12-day irrigation treatment the best hybrids ability towards early flowering. These hybrids may be the result of different parents in their general combining ability, and therefore the possibility of benefiting from their parents, regardless of the degree of general combining ability in the breeding programs to produce early hybrids at the time of their flowering. As for the variance of effects, the parent 2 for the 6-day irrigation treatment and the parent 1 for the 12-day irrigation treatment showed a high variance of the effect of the general combining ability, which indicates their great contribution to transferring their traits towards the early date of female flowering to their offspring. As for the variance of the specific combining ability of diallel hybrids, the parent 1 for the irrigation treatment 6-days and the parent 1 for the irrigation treatment 12-days gave the highest value of variance for the specific effect. Whereas, for the reciprocal hybrids, the parent 3 for the 6-day irrigation treatment and the parent 5 for the 12-day irrigation treatment showed the highest value for the variation of the effect. It is clear from this
that parent with high variance of specific and reciprocal effects can pass on their traits to some of their hybrids towards reducing the number of days for female flowering, while low values indicate that the parent can pass on his characteristics to most of his hybrids in a close manner. These results agree with [8]and[10,31]. It was found from the results of the same table that the ratio between the general combining ability to the specific combining ability to diallel-crossing was less than one, and this was reflected on the average degree of dominance (\(\bar{\alpha}\) , if they were greater than one, which indicates that the non-additive effect of genes is dominant on the expression of these traits. As for the variance of the specific combining ability in reciprocal hybrids was less than the variance of the general combining ability, this was reflected on the average degree of dominance (\(\bar{\alpha}=\bar{\gamma}\)) as they were less than one, which indicates that the trait is subject to the act of partial dominance of genes and to the importance of the additive gene action in the inheritance of this trait.

The percentage of heritability in the broad sense was (99.21% and 98.67%) for the diallel hybrids for the 6 and 12-day irrigation treatments, respectively, and (87.62% and 88.61%) for the reciprocal hybrids for the 6 and 12-day irrigation treatments, respectively. The high values of the degree of heritability in the broad sense are due to the high value of genetic variance and low environmental variance in their effect on this trait. Whereas for the degree of heritability in the narrow sense, it was (3.79% and 9.27%) for the diallel hybrids for the 6 and 12-day irrigation treatments, respectively, and (59.69% and 78.91%) for the reciprocal hybrids for the 6 and 12-day irrigation treatments, respectively. The low percentage of heritability in the narrow sense indicates the importance of non-additive genes in the inheritance of the trait. These results are in agreement with what was reported [5]and[11,12]

Table 1. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper-diagonal values) and reciprocal hybrids (sub-diagonal values) to female flowering in maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.

| Parents | 1    | 2    | 3    | 4    | 5    | g\(\hat{i}\)j \(\sigma^2\)ij | g\(\hat{s}\)ij \(\sigma^2\)sij | g\(\hat{r}\)ij \(\sigma^2\)rij |
|---------|------|------|------|------|------|-----------------|-----------------|-----------------|
| 1       | -0.160 | -1.67 | -3.63 | -0.98 | -1.20 | 0.019           | 6.10            | 1.14            |
| 2       | -1.68  | 0.945 | -2.59 | 0.30  | 0.84  | 0.887           | 3.43            | 1.35            |
| 3       | -0.22  | -0.167 | -2.09 | -0.83  | -1.06 | 0.013           | 2.04            | 1.93            |
| 4       | -0.52  | -0.50  | -0.010 | 2.02  | -0.98  | -0.010          | 1.80            | 11.3            |
| 5       | 0.00   | 0.50   | -0.516 | 0.03  | -2.21  | 0.252           | 1.58            | 7.26            |
| S.E     | 0.030  | 0.074  | 0.544 | 0.035 | 3.15  | 6.88            | 3.29            | 4.72            |

Table 1. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper-diagonal values) and reciprocal hybrids (sub-diagonal values) to female flowering in maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.
3.2. Leaf area (cm²) It is noticed from (Table 2) that the parents 2 and 4 showed a positive significant effect of the general combining ability (0.025 and 0.001) for the 6-day irrigation treatment respectively. Whereas, parents 2 and 5 for the 12-day irrigation interval showed the highest overall positive and significant general combining ability effect, which 0.015 and 0.014 respectively. This indicates his good ability to combine with other parents in inheriting this trait in his offspring, while parent 4 scored for the same irrigation interval the highest negative combining ability effect, which indicates the weakness of his combining ability towards increasing the leaf area. It is noted that parent 2 and parent 4 scored the highest value for the variance of the effect of the general combining ability and for the irrigation treatments 6 and 12 days, respectively. It is noted from the same table in estimating the variance of the effect of the specific combining ability of the diallel hybrids, as it was found that the parent 4 and the parent 2 gave the highest value for the variance of the effect of the specific combining ability of the diallel hybrids for the 6 and 12-day irrigation treatments. Whereas, the Reciprocal hybrids, the parent 5 for the 6-day irrigation treatment and the parent 1 for the 12-day irrigation treatment had the highest values for the specific combining ability variance. These results are in agreement with [4]; [28].

The results of the same table showed that the ratio of \( \frac{\sigma^2_{gca}}{\sigma^2_{sca}} \) was less than one (0.06 and 0.03) for irrigation treatments 6 and 12-days respectively, as well as the ratio of \( \frac{\sigma^2_{gca}}{\sigma^2_{rca}} \) was less than one (0.28 and 0.34) for irrigation treatments 6 and 12-days respectively, which indicates the importance of non-additive gene action that control the inheritance of leaf area trait in first generation plants. It is noted that the dominance genetic variance of the diallel-crosses \( \sigma^2 D \) was greater than the components of the additive genetic variance \( \sigma^2 A \) and this was reflected on the average degree of dominance \( \bar{a} \) as it was greater than one (4.04 and 5.26) for the irrigation treatments 6 and 12-days respectively, which indicates that this trait is subject to the act of over-dominance of genes, this result was confirmed for the ratio \( \frac{\sigma^2_{gca}}{\sigma^2_{sca}} \), as they were less than one, and the value of the dominance genetic variance for Reciprocal hybrids, \( \sigma^2 D \), was greater than the additive genetic variance, and this was reflected on the average degree of dominance \( \bar{a} \) as it was greater than one and reached 1.87 and 1.71 for the 6 and 12-day irrigation treatments, respectively. Which indicates that the trait is subject to the act of over-dominance of genes and to the importance of the additive gene action in the inheritance of this trait. This is confirmed by the ratio \( \frac{\sigma^2_{gca}}{\sigma^2_{rca}} \), as they were less than one.

The percentage of heritability in the broad sense was high in the diallel hybrids, which amounted to (99.88 and 92.86%) for the 6 and 12-day irrigation treatments, respectively, and the reciprocal hybrids reached (99.61 and 68.30%) for the 6 and 12-day irrigation treatments, respectively. The reason is due to the high value of genetic variance and low value of environmental variance in controlling the expression of leaf area trait. The percentage of heritability in the narrow sense was (10.88 and 6.32%) for diallel-hybrids for irrigation treatments 6 and 12-days, respectively, and (36.12 and 27.74%) for Reciprocal-
crosses for irrigation treatments 6 and 12-days, respectively. These results are in agreement with [9] and [25,26].

Table 2. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper-diagonal values) and reciprocal hybrids (sub-diagonal values) to leaf area in maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.

| Parents | 1   | 2     | 3     | 4     | 5  | σ²g²i | σ²r²i | σ²r²ij |
|---------|-----|-------|-------|-------|----|-------|-------|--------|
| 1       | -0.015 | 0.007 | 0.022 | 0.027 | -0.044 | 0.0002 | 0.0011 | 0.0040 |
| 2       | -0.003 | 0.010 | 0.008 | -0.021 | 0.031 | 0.0001 | 0.0005 | 0.0059 |
| 3       | -0.016 | 0.025 | 0.028 | 0.005 | 0.044 | 0.0006 | 0.0010 | 0.0037 |
| 4       | -0.013 | 0.015 | 0.012 | 0.018 | 0.060 | 0.0002 | 0.0014 | 0.0001 |
| 5       | -0.023 | -0.044 | -0.007 | 0.015 | 0.006 | 0.0002 | 0.0009 | 0.0012 |

S.E | 6 days | 12 days |
--- |-------|--------|
G6 | 0.0001 | 0.007  |
sij | 0.0020 | 0.017  |
rj | 0.0022 | 0.019  |

| Genetic parameters | GCA | SCA | RCA | σ²g²ca | σ²sca | σ²rca | σ²A | σ²D | a | h²b.s | h²n.s | %h²b.s | %h²n.s | %h²n.sr | 6-days | 12-days |
|-------------------|-----|-----|-----|--------|--------|--------|-----|-----|---|------|-------|--------|--------|----------|--------|--------|
| 6-days            | 0.00 | 0.00 | 0.00 | 0.00   | 0.00   | 0.00   | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00   | 0.00   | 0.00     | 36.12  | 27.74  |
| 12-days           | 0.00 | 0.00 | 0.00 | 0.00   | 0.00   | 0.00   | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00   | 0.00   | 0.00     | 68.3   | 1.00   |

3.3 Number of rows per ear. The results of the genetic analysis of the number of rows in the ear (Table 3) indicated that there were significant differences between the genotypes, as the mean squares were divided into their components in the general and specific combining ability for the diallel and reciprocal crosses and it was significant and for irrigation treatments 6 and 12-days except for the non-additive effect of genes (RCA) for irrigation treatment 12-days, this indicates the role of additive and non-additive genes in the manifestation of this trait. The results presented in (Table 6) shows that parents 2, 3 and 4 showed a general positive and significant general combining ability irrigation for the treatment of 6-days, i.e. in the
direction of increasing the number of rows in the ear. On the other hand, parents 3 and 4 showed a positive and significant general combining ability, whereas the effect of the specific combining ability for the diallel and reciprocal hybrids, we note that 5 diallel-hybrids and 4 reciprocal hybrids for the irrigation treatment 6-days gave a positive and significant combining ability, and the diallel hybrid 4×2 and the reciprocal hybrid 2×4 for the irrigation treatment 6-days and the diallel hybrid 2×4 for the irrigation treatment 12- days it achieved the highest impact of the specific combining ability. The variance of effects, parent 1 gave high values for the effect of the general combining ability for irrigation treatment 6 and 12-days, which indicates their great contribution to transferring their traits to their offspring. parent 2 gave the highest variance of the effects of the specific combining ability to the diallel-hybrids for irrigation treatments 6 and 12-days, and parent 3 gave the highest variance of the effects of the specific combining ability to the reciprocal hybrid. These results are in agreement with [29]; [30]

The results showed that the variance of the specific combining ability for the diallel hybrids is greater than the general combining ability, and this was reflected in the degree of dominance $\hat{a}$, as it was greater than one, which indicates that the trait is subject to the action of the over-dominance of genes and to the importance of the non-additive gene action in the inheritance of the trait (Table 3). The ratio $\frac{\sigma^2_{gca}}{\sigma^2_{sca}}$ confirms this were it was less than one. Whereas, the variance of the specific combining ability in reciprocal hybrids was less than the variance of the general combining ability, this was reflected on the average degree of dominance ($\bar{a} - \bar{r}$) as they were less than one, which indicates that the trait is subject to the act of partial dominance of genes and to the importance of the additive gene action in the inheritance of this trait, The ratio $\frac{\sigma^2_{gca}}{\sigma^2_{sca}}$ confirms this were it was greater than one. The percentage of heritability in the broad sense was (98.48 and 78.86%) for the diallel hybrids for the 6 and 12-day irrigation treatments, respectively, and (91.45 and 51.77%) for the reciprocal hybrids for the 6 and 12-day irrigation treatments, respectively. While the percentage of heritability in the narrow sense, it reached (13.84 and 13.81%) for the diallel hybrids for irrigation treatment 6 and 12-days respectively, and (78.00 and 38.06%) for the reciprocal hybrids for irrigation treatments 6 and 12-days respectively. These results indicate that the dominant genetic action on this trait is the additive and non-additive gene action. These results are in line with [4]and[7,8]

Table 3. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper- diagonal values) and reciprocal hybrids (sub- diagonal values) to number of rows in ear of maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.

| Parents | 1   | 2   | 3   | 4   | 5   | $\sigma^2_{g}ii$ | $\sigma^2_{s}ij$ | $\sigma^2_{r}ij$ |
|---------|-----|-----|-----|-----|-----|-----------------|-----------------|-----------------|
| 1       | -0.84 | -0.25 | 0.72 | -0.87 | -0.07 | 0.704           | 0.442           | 0.527           |
|         | -0.45 | 0.17 | 0.92 | -0.80 | 0.04  | 0.196           | 0.483           | 0.419           |
| 2       | 0.10  | 0.28 | 1.30 | 1.61  | -2.09 | 0.075           | 2.890           | 0.104           |
|         | -0.45 | -0.21 | -0.36 | 0.95  | -1.04 | 0.036           | 0.751           | 0.226           |
| 3       | -0.50 | 0.10 | 0.50 | -1.16 | 1.36  | 0.253           | 1.136           | 2.323           |
|         | -0.45 | -0.30 | 0.23 | -0.39 | 0.75  | 0.045           | 0.255           | 0.657           |
| 4       | -0.55 | 0.25 | -0.10 | 0.15  | 0.53  | 0.020           | 0.200           | 4.216           |
|         | -0.50 | -0.40 | -0.40 | 0.31  | 0.32  | 0.089           | 0.141           | 1.170           |
| 5       | 0.00  | 0.20 | -0.68 | -0.20 | -0.10 | 0.006           | 0.162           | 6.503           |
|         | -0.15 | 0.30 | 0.45 | -0.10 | 0.11  | 0.003           | 0.024           | 1.645           |

| S.E   | 6 days | 12 days |
|-------|--------|---------|
| gii   | 0.011  | 0.050   |
| sij   | 0.214  | 0.444   |
| rij   | 0.239  | N.S     |
3.4 Number of grains per ear. The results of the genetic analysis showed that there were significant differences for the mean squares of the general and specific combining ability of the diallel and reciprocal crosses and for irrigation treatments 6 and 12-days (Table 4), and this indicates the role of both the additive and non-additive gene action in showing this trait. The result of the presence of significant differences between the genotypes, the mean squares were divided into their components in the general and specific combining ability of the diallel and reciprocal crosses and it was significant and for the 6 and 12-day irrigation treatments except for the effect of the general combining ability (GCA) for the 6-day irrigation treatment and the effect of the specific combining ability of diallel-crossing (SCA) for irrigation treatment 12-days. The results show the superiority of the parents 2, 3 and 4 for the 12-day irrigation treatment by giving it a significant positive effect of the general combining ability amounting to 2.74, 1.48 and 9.54 for the inbred lines, respectively (Table 4), while parent 1 showed the highest negative general combining ability, which indicates its weak combining ability towards increasing the number of grains per ear. The effect of the specific combining ability of diallel and reciprocal hybrids, we notice that 4 diallel-hybrids and two reciprocal hybrids for the 6-day irrigation treatment and 3 reciprocal hybrids for the 12-day irrigation treatment achieved a positive and significant specific combining ability. As the diallel-hybrids 2×1 and 4×2 and the reciprocal hybrids 1×4 and 3×4 for the irrigation treatment 6-days, and the reciprocal hybrids 1×3 and 1×5 for the irrigation treatment were 12-days the best of the hybrids combined towards increasing the number of grains per ear. Whereas, the variance of effects, parents 4 and 1 for irrigation treatments 6 and 12-days respectively gave high values for the general combining ability due to the high additive variance in it.

Parent 4 for irrigation treatment 6-years gave the highest variance of the effect of specific combining ability for diallel-crosses, and parents 5 and 2 for irrigation treatments 6 and 12-days, respectively, gave the highest variance of effect of specific combining ability for reciprocal crosses. This results agrees with [27]and [32,34]

The results of the genetic parameters analysis showed that the ratio of the variance of the general combining ability to the variance of the specific combining ability of the diallel-crossing was greater than one, and this was reflected in the degree of dominance $\bar{a}$ they were less than one, this indicates that the additive gene action was greater and more important than the non-additive gene action in the inheritance of the number of grains per ear for diallel-hybrids. As for the ratio of the variance of the general combining ability to the variance of the specific combining ability of the reciprocal crosses, it was less than one, and this was reflected in the degree of dominance $(\bar{a} - r)$, it was greater than one. This indicates that the non-additive gene action was greater and more important than the additive gene action in the inheritance of the number of grains per ear for reciprocal crosses of the trait.

| Genetic parameters | Diallel hybrids | Reciprocal hybrids |
|--------------------|-----------------|--------------------|
| MS                 | GCA             | SCA               |
|                    | $\sigma^2_{gca}$ | $\sigma^2_{sca}$ | $\sigma^2_{rca}$ | $\sigma^2_{D}$ | $\bar{a}$ | $h^b_s$ | $h^n_s$ | $\sigma^2_{D-r}$ | $\bar{a}$ | $h^b_s$ | $h^n_s$ |
| 6-days             | 2.6             | 3.2               | 0.23              | 0.0             | 0.26        | 0.08    | 2.89     | 0.5               | 3.2         | 3.4       | 98.4     | 13.8    | 0.0     | 0.5     | 91.4    | 78.0    |
| 12-days            | 1.0             | 1.0               | 0.27              | 0.2             | 0.08        | 0.10    | 5.12     | 0.1               | 0.7         | 3.0       | 78.8     | 13.8    | 0.0     | 0.4     | 51.7    | 38.0    |

|                | $h^b_s$ | $h^n_s$ | $\sigma^2_{D-r}$ | $\bar{a}$ | $h^b_s$ | $h^n_s$ |
|----------------|---------|---------|-------------------|-----------|---------|---------|
| 6-days         |         |         |                   |           |         |         |
|                | 2.6      | 3.2      | 0.23               | 0.0       | 0.26    | 0.08    |
| 12-days        | 1.0      | 1.0      | 0.27               | 0.2       | 0.08    | 0.10    |

|                | $h^b_s$ | $h^n_s$ | $\sigma^2_{D-r}$ | $\bar{a}$ | $h^b_s$ | $h^n_s$ |
|----------------|---------|---------|-------------------|-----------|---------|---------|
| 6-days         |         |         |                   |           |         |         |
|                | 2.6      | 3.2      | 0.23               | 0.0       | 0.26    | 0.08    |
| 12-days        | 1.0      | 1.0      | 0.27               | 0.2       | 0.08    | 0.10    |
The percentage of heritability in the broad sense was (79.28 and 71.33%) for the diallel hybrids for irrigation treatments 6 and 12-days respectively, and (48.84 and 86.16%) for the reciprocal hybrids for irrigation treatments 6 and 12-days respectively.

The percentage of heritability in the narrow sense was (4.29 and 47.81%) for the diallel hybrids for irrigation treatment 6 and 12-days respectively, and (11.01 and 23.04%) for the reciprocal hybrids for irrigation treatments 6 and 12-days respectively. These results are in agreement with [32].

### Table 4. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper-diagonal values) and reciprocal hybrids (sub-diagonal values) to number of grains per ear of maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.

| Parents | 1    | 2    | 3    | 4    | 5    | σ^2g^ii | σ^2s^ij | σ^2r^ij |
|---------|------|------|------|------|------|---------|---------|---------|
| 1       | -19.69 | 74.26 | 48.03 | -26.84 | -34.54 | 326.27   | 3069.5  | 7153.4  |
| 2       | -36.65 | -5.58 | 12.52 | -2.54  | 1.96  | 925.43   | 25.83   | 6153.3  |
| 3       | 8.83   | -5.09 | -75.84 | 49.89  | 45.52 | -35.61   | 3286.2  | 2485.7  |
| 4       | -64.17 | 2.74  | -21.88 | -17.45 | 16.05 | -6.64    | 1677.50 | 8151.0  |
| 5       | 23.00  | 0.00  | -12.09 | -0.10  | 29.69 | 84.69    | -53.44  | 11393   |

|       | σ^2gca | σ^2sca | σ^2rca | σ^2A | σ^2D | h^2b.s | h^2n.s | h^2b.sr | h^2n.sr | α | α-r | 6 days | 12 days |
|-------|--------|--------|--------|------|------|-------|-------|--------|--------|----|-----|--------|---------|
|        | GCA    | SCA    | RCA    | ē    | σ^2gca| σ^2sca| σ^2rca| σ^2A   | σ^2D   | h^2b.s| h^2n.s| h^2b.sr | h^2n.sr |
| 6-days | 3133.  | 7111.  | 151    | 354. | 251. | 251.  | 251.  | 251.  | 251.  | 251. | 251. | 251.  | 251.    |
|        | 15     | 08     | 02     | 03   | 02   | 02    | 02    | 02    | 02    | 02   | 02   | 02     | 02       |
| 12-days| 3313.  | 645.8  | 359.6  | 354. | 295.8| 295.8 | 295.8 | 295.8 | 295.8 | 295.8| 295.8| 295.8  | 295.8   |
|        | 58     | 1      | 0.91   | 9     | 1     | 1     | 1     | 1     | 1     | 1    | 1    | 1       | 1        |

3.3 Weight of 300 grains. The results of the genetic analysis showed that there were significant differences for the mean squares of the general and specific combining ability of the diallel and reciprocal crosses and for irrigation treatments 6 and 12-days (Table 5), and this indicates the role of both the additive and non-additive gene action in showing this trait except the non-additive gene action (RCA) of the 12-day irrigation treatment.
It is clear from (Table 5) that parent 5 for the 6-day irrigation treatment achieved a positive significant effect of the general combining ability (2.61), while the 12-day irrigation treatment achieved the highest positive and significant effect of the general combining ability (3.00), while the parent 1 recorded the least negative significant effect for general combining ability for irrigation treatments 6 and 12-days.

It is noted from the same table that the value of the effect of the specific combining ability was positive and significant in 2 diallel-hybrids and 2 reciprocal hybrids for the 6-day irrigation treatment, and the highest value was 6.52 in the 3×1 diallel-hybrid, while the reciprocal hybrid 1 × 4 gave a positive and significant value of the effect of the specific combining ability in the reciprocal hybrid, which was 7.8. Whereas, for the 12-day irrigation treatment, 2 diallel-hybrids and 2 reciprocal hybrids had a positive and significant effect on the specific combining ability, as the highest value reached 10.13 in the 1×2 diallel hybrid and 15.68 in the 1×4 reciprocal hybrid.

As for the variance of effects, parent 6 for the 6-day irrigation treatment and parent 1 for the 12-day irrigation treatment were given the highest variance value for the effect of the general combining ability, and this indicates the extent of variation shown by the additive gene action of this inbred line in determining the average trait in its cross. Whereas, inbred line 3 and inbred line 4 gave the highest variance in the effect of the specific combining ability of diallel-crosses for irrigation treatments 6 and 12-days, respectively. Whereas the variance in the effect of the specific combining ability the reciprocal hybrids, inbred line 2 and inbred line 1 had the highest value of the effect variance for the 6 and 12-day irrigation treatments respectively.

The results indicate that the dominance variance \( \sigma^2 D \) was greater than the additive variance \( \sigma^2 A \), which was reflected in the average degree of dominance \( \bar{a} \), which was greater than one, which indicates that the trait is subject to the action of the over-dominance of genes and the importance of the non-additive genetic action in the inheritance of this trait (Table 5). Also, the dominance variance \( \sigma^2 D-r \) in reciprocal hybrids was greater than the additive variance \( \sigma^2 A \), and this was reflected in the degree of dominance \( (\bar{a} \text{-} \bar{r}) \) as it was greater than one, which indicates that the trait is subject to the action of the over-dominance of genes and to the importance of the non-additive gene action in the inheritance of this trait.

The percentage of heritability in the broad sense, was in the reciprocal hybrids (74.92 and 83.96%) for the 6 and 12-day irrigation treatments, respectively, and for the reciprocal hybrids (66.36 and 84.30%) for the 6 and 12-day irrigation treatments, respectively. The high percentage of heritability in the broad sense is due to the high value of genetic variance and the low value of environmental variance. The percentage of heritability in the narrow sense of the diallel crosses was (9.73 and 26.56%) for the 6 and 12-day irrigation treatments, respectively, and for the reciprocal hybrid (18.06 and 25.99%) for the 6 and 12-day irrigation treatments, respectively. It agrees with [7]and [13,19,21]

| Parents | 1    | 2    | 3    | 4    | 5    | \( \sigma^2 g \text{'ii} \) | \( \sigma^2 s \text{'ij} \) | \( \sigma^2 r \text{'ij} \) |
|---------|------|------|------|------|------|------------------------|------------------------|------------------------|
| 1       | -1.69| 2.98 | 6.52 | -6.68| -6.35| 2.34                   | 44.08                  | 84.99                  |
|         | -5.52| 10.13| 1.71 | -2.81| -4.28| 30.04                  | 42.49                  | 408.2                  |

Table 5. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper- diagonal values) and reciprocal hybrids (sub- diagonal values) to weight of 300 grain of maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.
2.2. Plant grain yield. The results of the genetic analysis showed that there were significant differences in the mean squares of the genotypes for the plant grain yield, and for the irrigation intervals (Table 6). Therefore, the mean of the squares of the genotypes were divided into their components that were significant in the mean squares of the general and specific combining ability to diallel and reciprocal hybrids, in the irrigation intervals, which confirms the importance of additive and non-additive gene action for the grain yield of the plant. The results of the genetic analysis of grain yield for the spring season of 2020 indicate that there are significant differences between the genotypes, as the mean squares were divided into their components in the general and specific combining ability of the diallel and reciprocal crosses and it was significant and for irrigation treatments 6 and 12-days except for the additive effect of genes (GCA) for irrigation treatment 6-days and non-additive gene action (SCA) of 12-day irrigation treatment.

It is evident from (Table 6) that the inbred lines 5 and 4 showed a significant effect of the general combining ability, which reached 9.45 and 3.02 respectively for the 12-day irrigation treatment. Whereas, for the effect of the specific combining ability of the diallel and reciprocal hybrids, we find that 4 diallel and 2 reciprocal hybrids for the 6-day irrigation treatment were characterized by a positive and significant combining ability, i.e. in the direction of increasing the yield. The diallel hybrids 2×1, 4×2, and the reciprocal 1×4 and 3×4 for irrigation 6 and the reciprocal hybrids 1×3 and 1×4 for the 12-day irrigation treatment, the best hybrids were combined towards increasing the grain yield, and that these hybrids may be the result of crosses between two different parents in their general combining ability, which indicates the possibility of benefiting from their parents, regardless of the combining ability between them in breeding programs to produce crosses that lead to an increase in grain yield.

The variance of effects, parents 1 and 5 of the 12-day irrigation treatment showed a high variance of the effect of the general combining ability, which indicates their great contribution to the transfer of their...
traits towards increasing the grain yield to their offspring. Whereas the variance of the effect of the specific combining ability for the diallel hybrids, the parent 2 and 4 for the irrigation treatment 6-days gave the highest variance effect for the specific combining ability. Whereas for the reciprocal hybrids, the parent 3 for the irrigation treatment 6-days and the parent 2 for the 12-day irrigation treatment gave the highest values of the effect variance. The high value of the specific combining ability for diallel and reciprocal of a particular parent means their great contribution to the transfer of the trait to one of his crosses or to a few of them due to the high value of the non-additive genetic variance in it, while the low value of the variance for a particular parent means its little contribution to the transmission of the trait in most of his crosses due to the weakness of the non-additive genetic variance in it. These results are in agreement with [9]; [17]

It is clear from the same table that the variance of the specific combining ability of diallel hybrids was greater than the variance of the general combining ability, and this was reflected in the average degree of dominance $\bar{a}$ as they were greater than one, which indicates that the trait is subject to the action of the over-dominance of genes and to the importance of the non-additive gene action in inheritance of this trait. This is confirmed by the ratios $\frac{\sigma^2 gca}{\sigma^2 scg}$, as they were less than one for the spring season. While the variance of the specific combining ability of reciprocal hybrids was greater than the variance of the general combining ability, this was reflected on the average degree of dominance $\bar{a}$ if they were greater than one, Which indicates that the trait is subject to the act of over-dominance of genes and the importance of the non-additive gene action in the inheritance of this trait, This is confirmed by the ratios $\frac{\sigma^2 gca}{\sigma^2 scg}$, as they were less than one.

The percentage of heritability in the broad sense was (79.17% and 61.34%) for the diallel hybrids for irrigation treatments 6 and 12-days respectively, and (44.27% and 86.50%) for the reciprocal hybrids for irrigation treatments 6 and 12-days respectively. The percentage of heritability in the narrow sense was (2.37% and 59.60%) for the diallel hybrids for irrigation treatments 6 and 12 respectively, and (6.35% and 20.81%) for the reciprocal hybrids for irrigation treatments 6 and 12-days respectively. These results are in agreement with [18]and [23,24].

Table 6. Effect of general combining ability (diagonal values) and specific diallel-hybrids (upper-diagonal values) and reciprocal hybrids (sub-diagonal values) to plant grain yield of maize and its variance with genetic parameters for the 6-day irrigation interval (Upper values) and for the 12-day irrigation interval (lower values) for the spring season 2020.

| Parents | 1     | 2     | 3     | 4     | 5     | $\sigma^2 g^ii$ | $\sigma^2 s^ij$ | $\sigma^2 r^ij$ |
|---------|-------|-------|-------|-------|-------|----------------|----------------|----------------|
| 1       | -5.00 | 34.05 | 17.74 | -10.71| -22.06| 12.40          | 655.44         | 1915.04        |
|         | -12.65| 5.09  | 5.50  | 1.75  | -4.82 | 157.28         | 18.47          | 1964.50        |
| 2       | 10.03 | 0.51  | -46.60| 34.15 | 11.23 | -12.39         | 1151.34        | 381.71         |
|         | -24.48| 0.39  | -9.36 | -4.83 | 3.17  | -2.81          | 231.55         | 1344.60        |
| 3       | -2.18 | -9.20 | -1.75 | 7.73  | 28.55 | -9.59          | 211.73         | 3692.05        |
| 4       | 20.98 | -29.73| -0.21 | 5.80  | 7.12  | -2.92          | 443.87         | 260.79         |
|         | 48.74 | 2.08  | 36.16 | 4.78  | -22.25| 11.11          | 1147.33        | 1904.59        |
|         | 25.76 | -22.07| 14.03 | 3.02  | -0.99 | 6.17           | 423.88         | 33.39          |
| 5       | 5.23  | -3.01 | -16.30| -28.35| 1.36  | -10.79         | 194.35         | 1440.64        |
|         | -26.42| 1.43  | -1.78 | -3.53 | 9.45  | 86.34          | 213.02         | 31.79          |

S.E 6 days 12 days
| Gii     | N.S   | 14.86 |
| Sij     | 15.94 | N.S   |
| Rij     | 17.82 | 8.62  |
4. Conclusion

It was found that there is an effect on the general and specific combining ability to unite between the two irrigation intervals, as some breed lines excelled, as well as some hybrids under the two irrigation intervals. It is possible to supplement the breeding program by selection for the superior breed lines and hybrids.

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