Estimation of Combining Ability and Gene Action for Yield and Yield Components in Maize (Zea mays L.)

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Abstract. A field experiment was carried out in one of the farms in the AL- Sufi area of Anbar Governorate. Six Inbred lines of corn (Zea mays L.) (Pio-36, Sy-52, Am-63, Zm-69, ART-B17, NAdh-26) were used in this study. These lines were introduced into program Half dillael in the spring season 2019 15 hybrids were obtained. These crosses and their parents were in the full season using a randomized complete block design with three replications in the autumn season, to analyze the general and specific combining ability and estimate their effects, hybridization and some genetic parameters. The results of the statistical analysis showed that there were high significant differences between the genotypes (parents + hybrids) for all the studied traits, and the (Pio-36) was the best in plant height and leaf area as it reached 163.67 cm and 536.3 cm² respectively. In the ear diameter, the (ART-B17) was the highest and it reached 5.49 cm, and in the Weight 300 grains (NAdh-26) was the highest, and it reached 78.33 g, while the yield plant high value with line (Pio-36) was 203 g. In hybrids, the hybrid 3x5 gave the highest average for the number of grains per row, and it was 36.4 grains per row, and at 300 grains, the Add this word (hybrid 4x5) gave the highest hybrids and it reached 84.67 g, and the 4x5 hybrid gave the highest individual plant yield, as it reached 285.2 g. plant⁻¹. The of heritability in the narrow sense was low in all the studied traits, and the value of the average degree of dominance was greater than one in all the studied traits, which indicates the importance of the effect of the over dominance of genes. It is concluded from the study the possibility of using some superior Inbred lines in their speculations to derive individual hybrids.

1.Introduction

Zea mays L. corn is one of the important grain crops, which is adapted to different environmental conditions and third placed after wheat and rice in of cultivated area and production. Its grains were used as human food [1] and as a concentrated feed for poultry and animals because its carbohydrates and starch content [2,3]. The corn crop is considered one of the mixed pollination crops that are characterized by the ease of hybridization and breeding, and that the Monoecious plant contains male and female flowers Isolated from each other in the same plant [4,5,6]. which easy to conduct the hybridization process and the production of hybrids, and that the studies conducted on the yield of corn on the effect of hybridization show that the outcome the first generation had an increase of 40% [7]. Regarding cross-pollinating species, the general combining ability (GCA) effect is an indicator of the relative value of the population in terms of frequency of favorable genes and of its divergence, as compared to the other parents in the diallel. Thus, the analysis of GCA effects allows identification of superior parents, to be used in intra-population breeding programs [8]. The specific combining ability (SCA) effect of two populations expresses the differences of gene
frequencies between them and their divergence, as compared to the diallel parents [8,9]. Therefore, the GCA and SCA effects should be considered in the selection of populations for hybrid production and for reciprocal recurrent selection programs. In addition to being indicators of the divergence of each population compared to the diallel parents, the SCA effects of a population with itself allow assessment of the predominant direction of the deviations due to dominance [10, 11].

2. Materials and methods

2.1. Plant materials
Most studies indicate that the grain yield of individual hybrids suitable for the environment of the region is higher than the other of the genotypes of maize, and the development of Inbred lines became easier with the progress of genetics, breeding and improvement [12]. For this purpose, six pure lines of corn were used in this study to produce 15 hybrids. The lines are (Pio-36, Sy-52, Am-63, Zm-69, ART-B17, NAAdh-26). The research was carried out in the fields of a farmer in Al-Sufi area of Ramadi in the Government Anbar for the spring and fall seasons of the year (2019).

2.2. Field experiment
After carrying out all the agricultural operations such as plowing, smoothing and leveling, then the land was fertilized with urea fertilizer at a rate of 400 Kg ha.⁻¹ (N46%) added in two doses, the first when preparing the land for cultivation and the second before the emergence of tasseling inflorescences and P₂O₅ fertilizer at 200 kg.ha.⁻¹ at one time before planting [10, 13]. This was followed by the operations of opening the lines with a distance of (0.75 m) between one line and another and a distance of (0.25 m) between the plants [14].

2.3. Phenotypic data were collected
The following characteristics were studied: - Plant height cm, Leaf area cm², Diameter ear cm², number of rows in ear, number of grains per row, Weight of 300 grain, Plant yield (g). Plant⁻¹ Statistical analysis and estimation of genetic parameters:

2.4. Equations used
Genetic parameters estimated as follow [13]

Heritability in broad sense since

\[ (h^2)_{b.s} = \frac{\sum_{i} \delta^2 A_i}{\sum_{i} \delta^2 A_i + \sum_{i} \delta^2 D_i + \sum_{i} \delta^2 E_i} \times 100 \]

Heritability in narrow sense

\[ (h^2)_{n.s} = \frac{\sum_{i} \delta^2 A_i}{\sum_{i} \delta^2 P_i} \times 100 \]

Where: \( \delta^2 A \) = additive genetic variance
\( \delta^2 D \) = dominance variance
\( \delta^2 E \) = environmental variance, \( \delta^2 P \) = phenotypic variance \( \delta^2 E_{mse} \) = the average degree of dominance

The effect of general combining ability for each parent (\( \hat{g}_i \)) and the effect of specific combining ability for each hybrid (\( \hat{S}_{ij} \)) was calculated according to the equation [15, 16].

\[ \hat{g}_i = \frac{1}{P + 2} \left[ \sum \left( Y_i + Y_i \right) - \frac{2}{P} Y_i \right] \]

\[ \hat{S}_{ij} = Y_{ij} - \left[ \frac{1}{P + 2} \left( Y_i + Y_i + Y_j + Y_{ij} \right) \right] + \frac{2}{(P + 1)(P + 2)} Y_i \]

Statistical analysis for each characteristic was performed using RCBD for three replicates [17] and used [25], according to the following mathematical model

\[ Y_{ij} = M + T_i + R_i + e_{ij} \]

The arithmetic means of the traits were tested using the last significant difference of 5% and 1%.
3. Results and Discussion

The results of the analysis of variance in Table (1) show general and specific combining ability there is a high significant difference in all the characteristics, while the ratio between the components of the general and specific ability variance was less than one in all the characteristics, and this indicates the importance of the non-additive effects. in Table (2) The line 1 was the highest parent in the characteristic of plant height as it reached 163.67 cm, and the same line gave the highest parent in the characteristic of leaf area, as it reached 536.3 cm², while in the diameter of ear, the line 5 gave the highest average, reaching 5.49 cm, and in the number of rows in ear, the line1 was the highest and reached 1.66 number of rows per ear. In hybrids, the hybrid 3x5 gave the highest average for the number of grains per row, and it was 36.4 number of grain per ear, and with 300 grains, the hybrid 4x5 gave highest reached 84.67 g, and the hybrid 4x6 gave the highest individual plant yield, as it reached 285.2 g plant⁻¹. Table (3) shows the estimation of the effects of general combining ability for the lines, as it was observed Line 2 gave the highest positive effect of for trait plant high, while the Line1 gave the highest positive effect for general coalition viability, as it reached 21,716 in trait leaf area. In the diameter ear the 2 line gave the highest average of 0.05 and in the number of rows in ear, The line 6 (NADH-26) gave the height value 0.154, and in the number of grains per row, Line5 gave the highest average of 0.63. In individual plant yield the line the line 4 superior and gave and gave 14,808 [5, 19, 20, 21]. Table (3) indicates the estimation of the effects of specific combining ability of diallel hybrids for the studied traits, where hybrid (3 x 5) showed the highest effect of in the plant height, which reached 10.318 and in the leaf area characteristic the hybrid record hybrid (2 x 5) and gave 55.489 as for the ear diameter the hybrid (2 x 4) superior the highest effect, reaching 0.201. and in the number of rows in ear, the hybrid (1 x 4) superior the highest average, which was 0.864, while in the number of grains in a row, the hybrid (3 x 5) gave the highest average of 3.47 and at 300 grains, the hybrid (4x5) gave the highest average of 6.76 while the hybrid in the individual plant yield superior the (2 x 5) gave 49.35 These results are consistent of with (7, 12, 13, 14, 16). Table (4) shows the estimation of some of the genetic parameters of the studied traits, where the percentage of heritability in the broad sense was high in plant height, leaf area, diameter of ear, number of rows in ear, number of grains per row and weight of 300 grains, and the Grain yield per plant was respectively [10, 17, 18, 23]. The reason is due to the high value of the Genetic variance and the decrease in the environmental variance in all of the study traits. As for the heritability in the narrow sense, it was low in all the above mentioned traits and the reason is due to the high values of the phenotypic variance and the decrease in the additive variance. The degree of dominance was greater than one in all the studied traits, which indicated the dominance of the genes of superior in the inheritance of these traits, and this is consistent with what found [21, 22, 24].

Table 1. Analysis of variance of the general combining ability to parents and specific combining ability to hybrids for the studied traits in maize

| SOV          | DF | Plant high | Leaf area | Ear diameter | No. of rows per ear | No. of grains per row | Weight 300 grains | Plant yield |
|--------------|----|------------|-----------|--------------|---------------------|-----------------------|--------------------|-------------|
| Replicates   | 2  | 6.09       | 218.65    | 0.1645       | 1.2975              | 1.68                  | 3.0635             | 5197.25     |
| Genotypes    | 20 | 215.69*    | 4417.785* | 71.272*      | 0.8375*             | 12.375*               | 67.98*             | 5420.01*    |
| GCA          | 5  | 46.7464*   | 2105.37*  | 0.007313*    | 0.236573*           | 1.435828*            | *9.747308*        | *1192.54*   |
| SCA          | 15 | 80.2759*   | 1260.362* | 0.022534*    | 0.293429*           | 5.019003*            | *26.96574*        | *2011.091*  |
| Error        | 40 | 5.587      | 205.06    | 0.0164       | 0.1785              | 1.725                | 2.130              | 832.11      |

(*) Significance at 5% level
Table 2. Mean performance of parents for all studied traits of corn

| Traits       | Genotypes | Plant high (cm) | Leaf area (cm²) | Ear diameter (cm²) | No. of rows per ear | No. of grains per row | Weight 300 grains (g) | Plant yield (g) |
|--------------|-----------|----------------|-----------------|--------------------|---------------------|----------------------|-----------------------|----------------|
| Plant yield  | 1 (Pio-36) | 163.67         | 536.3           | 4.21               | 1.66                | 32.73                | 77.67                 | 203            |
|              | 2 (Sy-52)  | 162.46         | 488.2           | 4.55               | 1.4                 | 29.67                | 71.67                 | 156.7          |
|              | 3 (Am-63)  | 158.46         | 474.1           | 4.23               | 1.46                | 29.2                 | 74                    | 163.3          |
|              | 4 (Zm-69)  | 158.47         | 497.2           | 4.44               | 1.6                 | 32.14                | 71.33                 | 192.3          |
|              | 5 (ARTB17) | 154.14         | 469.3           | 5.49               | 1.66                | 30.12                | 66                    | 177.2          |
|              | 6 (NAdh-26)| 163.14         | 475.2           | 4.66               | 1.4                 | 28.67                | 78.33                 | 165.4          |

Table 3. Estimates of the effects of general and specific combining ability for half diallel method cross of corn

| Traits       | Genotypes | Plant high | Leaf area | Ear diameter | No. of rows per ear | No. of grains per row | Weight 300 grains (g) | Plant yield |
|--------------|-----------|------------|-----------|--------------|---------------------|----------------------|-----------------------|-------------|
| Plant yield  | 1 (Pio-36)| 0.683      | 21.716    | -0.0171      | -0.295              | -0.5004              | 0.6809                | -14.266     |
|              | 2 (Sy-52) | 3.533      | -11.083   | 0.0566       | -0.048              | -0.382               | -0.817                | -12.629     |
|              | 3 (Am-63) | -2.879     | -11.795   | -0.0121      | -0.055              | 0.032                | -0.569                | -4.191      |
|              | 4 (Zm-69) | -0.412     | -17.658   | 0.0104       | 0.102               | 0.2995               | -0.319                | 14.808      |
|              | 5 (ARTB17)| 1.458      | 16.241    | -0.0121      | 0.144               | 0.6345               | -0.902                | 10.683      |
|              | 6 (NAdh-26)| -2.382   | 2.579     | -0.0258      | 0.154               | -0.0829              | 1.928                 | 5.595       |

| Traits       | Genotypes | SE(gi) | 1x2 | 4.0114 | -48.285 | 0.0095 | 0.214 | -0.704 | -1.320 | -21.194 |

L.S.D. 0.05 3.900 23.629 0.211 0.696 2.167 2.13 47.600
| Traits              | Genetic parameters | Plant high | Leaf area | Ear diameter | No. rows per ear | No. of grains per row | Weight 300 grains | Plant yield |
|---------------------|--------------------|------------|-----------|--------------|------------------|-----------------------|-------------------|-------------|
|                     | h²b.s%             | 97.964     | 96.137    | 76.152       | 82.380           | 89.014                | 97.570            | 87.616      |
|                     | h²n.s%             | 12.263     | 28.777    | 1.989        | 13.108           | 4.111                 | 7.730             | 10.214      |
|                     | σ²A                | 11.221     | 509.254   | 0.0004       | 0.044            | 0.215                 | 2.259             | 228.792     |
|                     | σ²D                | 78.413     | 1192.008  | 0.017        | 0.233            | 4.444                 | 26.255            | 1733.721    |
|                     | E^A                | 1.862      | 68.353    | 0.005        | 0.059            | 0.575                 | 0.710             | 277.37      |
|                     | Ā                  | 3.738      | 2.163     | 8.633        | 3.250            | 6.426                 | 4.821             | 3.892       |

4. Conclusion
The results of this study showed that the best Line recorded the highest average seed yield (Pio-36) which was 203 g. plant followed by (Zm-69) which recorded average seed yield of 192.3 g. plant. As the results of the averages of the hybrids indicated that the hybrids produced by the parents had outperformed the others of the hybrids, as the (Zm-69 × NAdh-26) hybrid recorded the highest average seed yield of 285.2 g. plant, and this indicates the role of additive genes in the inheritance of this trait to the resulting generation. Through the above results, it was found that the dominant genes (σ²D) were superior in all traits to the additive genes (σ²A) and that the heritability in the narrow sense was low for all the traits from the inheritance ratio in the broad sense. This confirms that the studied traits are dominated by the dominant genetic action in heritability on the resulting generation.
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