

## Estimation of Certain Genetic Parameters and Foliar Application of the Growth Biostimulant Biozyme on (*Zea mays* L.) Genotypes

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### Abstract

A field experiment was conducted during the autumn growing season of 2025 at the experimental field of the Agricultural Extension Farm located in the Al-Mahnawiya area which is located 8 km north of Babylon Governorate, located at latitude <sup>0</sup>32 degrees north and longitude <sup>0</sup>44 degrees east. Six maize genotypes namely Buhouth 5018, Fajr1, Baghdad3, Sara, Al-Maha, and ZP707, were evaluated to assess the performance of selected maize genotypes and to estimate some of their genetic parameters under the influence of foliar application of the biostimulant Biozyme at four concentrations (0, 1.5, 2.5, and 3.5ml L<sup>-1</sup>). The experiment was arranged in a randomized complete block design (R.C.B.D.) using a split-plot design with three replications. The analyzed characteristics were plant height, number of leaves, leaf area, chlorophyll content, number of rows per ear, number of grains per row, number of grains per ear, 500, grain weight, grain yield, biological yield, and harvest index. Significant differences were detected between the tested genotypes for all the studied traits. Genetic variance components exceeded the environmental variance ones for all traits measured, thereby indicating genetic effects dominance. The very close extent of genotypic and phenotypic variation indicated only a small role of environmental factors. Broad, sense heritability estimates were quite high for most of the traits, and the highest values were for leaf area (95.31%), plant height (95.12%), and grain yield (95.07%). In addition, high expected genetic advance was obtained for several traits, particularly leaf area (411.37), grain yield (406.81), and biological yield (748.21).

**Keywords:** Genotypes, Genetic Variability, Heritability, Biostimulant Biozyme.

### Introduction

Maize (*Zea mays* L.) as one of the cereals in the family Poaceae, is among the staple food crops in the world. Maize in fact, accounts for the most extensively grown cereal crop worldwide and its total annual production is roughly estimated to be 1.2 billion tons [1]. Locally in Iraq, cultivated area has been expanded to nearly 360,000 dunums while total production has reached roughly 538,000 tons [2]. However, the productivity of maize, despite its prominence in the economy and nutrition, in Iraq is still rather low. The poor yield of maize is mostly due to the rapid growth of population and thus

an increasing demand of food in addition to various environmental factors that limit the production of the crops. The large discrepancy between the average maize yield in Iraq and the world average is primarily due to the fact that few high-yielding genotypes with good adaptability to the local conditions are used thus only a few production inputs are properly managed. Hence, higher productivity per unit area can be attained by testing a wide range of maize genotypes for their compatibility with local environmental conditions and thus their potential in enhancing both grain yield and quality [3].

Maize is a highly genetically malleable and therefore a broadly adaptable species to diverse environmental conditions which naturally let it have high yield potential and good grain quality traits, among which protein, oil, and starch contents. All these have somehow promoted better sales of maize all over the world. On the other hand, the decrease of maize-growing area and the drop in yield per unit area are generally blamed on the genetic deterioration of the present cultivars due to the small number of breeding efforts and the lack of implementation of modern scientific practices in maize production. As a result, the identification of new maize genotypes with better quantitative and qualitative characteristics has become a matter of urgency. Such genotypes may be discovered by the importation of genetic materials from diverse origins and their testing/ evaluation under different environmental conditions and biostimulant

### Materials and Methods

The trial was a split-plot experiment in a randomized complete block design (R.C.B.D.) with three replications. Six maize (*Zea mays* L.) genotypes were taken from Abu Ghraib Research Station; these were Buhouth 5018, Sara, Al-Maha, Fajr1, Baghdad 3 and ZP707. Biozyme biostimulant was sprayed at four different levels (0, 1.5, 2.5 and 3.5ml L<sup>-1</sup>). The field experimental layout was divided into 72 experimental units, each of 8 m<sup>2</sup> (4 × 2 m) after tillage and harrowing, and leveling. Each experimental was made of three rows, while the spaces were as follows: 60 cm between rows and 25 cm between plants; hence, a plant density of 66,666 plants ha<sup>-1</sup> was achieved.

Maize was planted on the 28th of July 2025 with a seed rate of two seeds per hill. The soil of the experiment was supplemented with diammonium phosphate (DAP) fertilizer as a phosphorus source at 200 kg P<sub>2</sub> O<sub>5</sub> ha<sup>-1</sup> the entire amount being a basal dose applied before

concentrations, e.g., Biozyme, so as to identify the most adaptable and productive genotypes [4].

Genotyping of these materials is a prerequisite in breeding plans aimed at genetic improvement especially if the genotypes under test have little or no known genetic information. Plant breeders consider figuring out the heritability of quantitative traits as one of their most important aspects. For instance, broad-sense heritability reveals the extent to which trait expression is influenced by genetic as compared to environmental factors. This type of information is crucial in deciding the best breeding approaches for improving economically important traits [5]. The objective of this research was to assess the responsiveness of various maize genotypes to Biozyme application and to identify those best adapted to local conditions based on their productivity and quality characteristics.

planting during land preparation, DAP fertilizer (46% P<sub>2</sub> O<sub>5</sub> and 18% N) was used. Urea (46% N) was the source [6]., of nitrogen, and it was applied at the rate of 320 kg N ha<sup>-1</sup> [7]., two stage: one after seedling emergence and the second at the tasseling stage. Irrigation was done immediately after planting and was regularly provided throughout the growing season as per the crop water requirements. Plants were thinned to maintain one plant/hill and hand weeding was done twice during the whole period. Also, a granular diazinon insecticide was used for the control of maize stem borer, which was applied into the plant whorl in two doses. Granular diazinon applications at the plant whorl in two doses were used to control the maize stem borer. Harvesting was done at the end of the season when the maize plants had fully matured. This was indicated by the yellowing of the leaves and stems, by the grains becoming hard and black scar formation, which is the last

stage of grain filling and the cessation of nutrient translocation.

**Table (1) Some chemical and physical properties of field soil before planting.**

Trait	Value	Unit
Electrical conductivity (EC)	2.38	d S m <sup>-1</sup>
Soil reaction (pH)	7.24	—
Organic matter	1.43	%
Available nitrogen	32.11	mg kg <sup>-1</sup> soil
Available phosphorus	11.9	mg kg <sup>-1</sup> soil
Available potassium	74.27	mg kg <sup>-1</sup> soil
Clay	380	g kg <sup>-1</sup> soil
Sand	300	g kg <sup>-1</sup> soil
Silt	320	g kg <sup>-1</sup> soil
Soil texture		Clay loam

**Table (2) Proportions of the compositions used**

Genetic Types	Pedigree and Breeding Method	Source
<b>Research 5018</b>	A local synthetic variety developed through polycross of superior inbred lines derived from American, Yugoslavian, Bulgarian, and Hungarian origins.	Agricultural Research Office, Abu Ghraib / Ministry of Agriculture
<b>Al-Maha</b>	A local synthetic variety developed via polycross of superior local inbred lines selected by the Agricultural Research Office.	Agricultural Research Office, Abu Ghraib / Ministry of Agriculture
<b>Fajr 1</b>	A synthetic variety developed through inbreeding of foreign genotypes to produce local inbred lines of European and American origins.	Agricultural Research Office, Abu Ghraib / Ministry of Agriculture
<b>Sarah</b>	A local synthetic variety developed through polycross of several superior hybrids using locally inbred lines (via self-pollination) of	Agricultural Research Office, Abu Ghraib / Ministry of Agriculture

	American, Yugoslavian, Bulgarian, and Spanish origins.	
<b>Baghdad 3</b>	A local synthetic variety developed through polycross of superior inbred lines derived from Yugoslavian, Bulgarian, Hungarian, and Spanish origins.	Agricultural Research Office, Abu Ghraib / Ministry of Agriculture
<b>Hybrid ZP707</b>	An imported hybrid from the Zemun Polje Agricultural Institute - Serbia.	Zemun Polje Agricultural Institute, Serbia

### Data recorded

#### Vegetative Growth traits

Five plants were randomly selected from each experimental unit and labeled with

#### Plant height (cm):

#### Number of leaves (leaves plant<sup>-1</sup>):

**Leaf area (cm<sup>2</sup>):** The area of a single leaf was calculated using the following equation: Leaf area (cm<sup>2</sup>) = Leaf length × Maximum leaf width × 0.75.[8]

#### Yield and Its Components

#### Number of rows (row ear<sup>-1</sup>):

#### Number of grains (grain row<sup>-1</sup>):

#### Number of grains (grain ear<sup>-1</sup>):

**500- grain weight (g):** The five randomly selected ear samples from each experimental unit were dehulled, and a random sample of 500 grains was taken and weighed after adjusting the weight for moisture content (15.5%) using an electronic scale. [10]

**Grain yield (Mg ha<sup>-1</sup>):** Calculated after calculating the average grain weight for five plants per experimental unit and multiplying it by the plant density.

#### Biological yield (Mg ha<sup>-1</sup>):

#### Statistical and Genetic Parameters Analysis

**Phenotypic, genetic, and environmental variances:** After significant differences were found among the genotypes,

colored strips to record different growth traits.

**Chlorophyll content (SPAD):** The chlorophyll content in the leaves was estimated using a SPAD502 chlorophyll meter.[9]

#### Statistical Analysis

A statistical analysis was performed on the data and all studied traits according to the randomized complete block design (RCBD) with a split-plot The main factor consisted of different concentrations of the biostimulant Biozyme, while the secondary factor comprised six maize genotypes provided by the Abu Ghraib Research Station, Ministry of Agriculture. arrangement, using the statistical software GenStat. The means were compared according to Duncan's test at a probability level of 0.05 [13].

phenotypic, genetic, and environmental variances were estimated according to the method described by [11]. Walter (1975),

and then each of the following was calculated:

$$\sigma^2 G = \frac{M_{sg} - M_{se}}{r}$$

$$\sigma^2 E = M_{se}$$

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

Where:

$\sigma^2 G$  = Genetic variance

$\sigma^2 E$  = Environmental variance

**Broad-sense heritability:** The broad-sense heritability of all studied traits is estimated using the method described by [12] according to the following equation:

$$h^2_{b.s.} = \frac{\sigma^2 G}{\sigma^2 P} \times 100$$

Where:

$h^2$  (b.s.) = Broad-sense heritability

$\sigma^2 G$  = Genotypic variance of the trait

$\sigma^2 P$  = Phenotypic variance of the trait

Heritability estimates were classified according to [9] as follows:

**Low:** less than 40%

**Moderate:** 40–60%

**High:** greater than 60%

**Expected Genetic Advance (GA):** was estimated according to the method described by [14] according to the following equation:

$$G.A = K.H^2_{B.S.}.\sigma_p$$

## Results and Discussion

Table (4) shows the values of some genetic parameters of six maize genotypes under the effect of four concentrations of the biozyme. The results reveal that genetic variance accounted for a large part of the total phenotypic variance of most of the vegetative growth characters, thus varying from the environmental variance in that it was smaller for the leaf number only. The dominance of genetic variance means that the genetic composition of the individual has a predominant role in determining the expression of traits. Hence, a great response to selection for growth traits will be expected which will facilitate the plant breeders to identify the best genes and select them in the breeding programs in

$$E.G.A = \frac{G.A}{X^-} \times 100$$

Where:

**GA** = Expected genetic advance

**$h^2$  (b.s.)** = Broad-sense heritability

**$\sigma P$**  = Phenotypic standard deviation

**K** = Selection intensity, equal to 1.76 when selecting 10% of plants

**EGA** = Expected genetic advance expressed as a percentage of the grand mean of the trait

$\bar{x}$  = Grand mean of the trait

**Estimation of Phenotypic and Genotypic Coefficients of Variation:** The values of phenotypic variation coefficients were calculated from the sum of genetic and environmental variations according to the method described by [15] as follows:

$$P.C.V\% = \frac{\sigma_P}{X^-} \times 100$$

$$G.C.V\% = \frac{\sigma_G}{X^-} \times 100$$

Where:

According to the ranges proposed by [16] for the limits of expected genetic improvement, they are as follows: less than 10% is low, between 10%-30% is medium, and more than 30% is high.

order to have the most efficient genotypes with the least environmental influence. Numerous studies have agreed with the current findings, indicating that genetic variation contributes more to the emergence of the trait than environmental variation [17,18,19].

The growth traits recorded high broad-sense heritability ( $h^2_{bs}$ ) according to the estimations, which was manifested in the high values of expected genetic advance as a percentage of the mean. The genetic advance for leaf area was the highest one (411.37), while all other traits showed relatively low values of expected genetic advance mainly due to their lower genetic variance.

Therefore, selection should be directed mainly at traits with high genetic advance

values. These results agree with those of [20]. Salih et al. (2024), who found that broad-sense heritability and expected genetic advance as a percentage of the mean were very high for all the genotypes and traits in their study of ten maize genotypes. Besides, the almost identical values of the genotypic coefficient of

variation (G.C.V.) and the phenotypic coefficient of variation (P.C.V.) for the investigated traits suggest that the properties were minimally influenced by environmental factors. The present study's high genetic variance and heritability estimates are supported by the results of [21,22]

**Table (3)** Analysis of Variance (ANOVA) for Maize Growth Parameters

S.O.V	DF	Plant Height	Number of Leaves	Leaf Area	Chlorophyll Content
Replications (R)	2	21.85	0.12	65653.79	5.82
Bio stimulant (S)	3	**981.47	**0.98	**1204.17	**30.82
Error (a)	6	19.86	0.06	114696.5	2.70
Genotypes (V)	5	**286.61	**0.69	**126366	**106.35
Interaction (S×V)	15	**17.02	*0.25	*90652.28	*10.25
Error (b)	40	3.80	0.12	46137.45	4.64

**Table (4)** Analysis of Variance (ANOVA) for Yield and Yield Components of Maize

S.O. V	DF	No. of Rows per Ear	No. of Grains per Row	No. of Grains per Ear	500-Grain Weight	Grain Yield	Biological Yield	Harvest Index	No. of Rows per Ear	No. of Grains per Row
Replications (R)	2	0.21	0.38	204.48	5.45	24,229	24,982	2.53	0.21	0.38
Biostimulant (S)	3	**30.4	**21.34	**5412.61	**824.33	**4365.0077	**8788.0390	**184.28	**30.4	**21.34
Error (a)	6	0.07	1.29	375.29	1.29	41293	154075	2.07	0.07	1.29
Genotypes (V)	5	**1.38	*3.66	**3056.73	**101.96	**1131.290	**3022.209	**14.55	**1.38	*3.66
Interaction (S×V)	15	*70.2	NS 1.81	NS 601.96	**30.07	*17343.8	**6850.23	*85.91	*70.2	1.81 NS
Error (b)	40	0.15	1.32	568.32	0.82	106793	193322	1.69	0.15	1.32

**Table 5:** Values of genetic parameters under spraying with different concentrations of the biostimulant Biozyme.

Traits	$\sigma^2G$	$\sigma^2GE$	$\sigma^2E$	$\sigma^2P$	H <sup>2</sup> (%)	GA	GA (%)	PCV (%)	GCV (%)
Plant height (cm)	13.46	4.40	1.26	14.15	95.12	6.26	3.46	2.08	2.02
Number of leaves (leaves plant-1)	0.02	0.042	0.041	0.035	77.18	0.25	1.92	1.42	1.25
Leaf area (cm <sup>2</sup> )	57977.55	14838.27	15379.15	60829.65	95.31	411.37	7.16	4.29	4.19
Chlorophyll content (SPAD)	4.84	1.87	1.54	5.18	93.42	3.72	6.59	4.03	3.90

Where:  $\sigma^2G$  represents genotypic variance;  $\sigma^2GE$  genotype–environment interaction variance;  $\sigma^2E$  refers to environmental variance;  $\sigma^2P$  indicates phenotypic variance; H<sup>2</sup> represents broad-sense heritability; GA denotes expected genetic advance; refers to expected genetic advance expressed as a percentage of the mean; PCV represents the phenotypic coefficient of variation; and GCV denotes the genotypic coefficient of variation.

The values of several genetic parameters for six maize genotypes evaluated under the effect of four concentrations of the biostimulant are presented in Table (2). It can be observed from the results that genetic variance made up the majority of the total (phenotypic) variance in contrast to environmental variance for most yield traits and their components, especially number of grains per ear, grain yield, and biological yield. The significantly high level of genetic variance signifies that genetic factors are mostly responsible for the variation in these traits. Thus, selection based on yield traits and their components is likely to be effective, and breeders of plants would in this way be able to select the genetic materials that possess the desired genes in the breeding programs to produce efficient genotypes which are not sensitive to environmental changes. These results are similar to those of [23] who in confirming their study on number of grains per ear and grain yield, explained that the

contribution of genetic variance in maize is greater than that of environmental variance.

High values of broad-sense heritability were recorded for all the yield traits and their components studied which found expression in the increased levels of expected genetic advance as a percentage of the mean. Grain yield (406.81) and biological yield (748.21) showed the highest genetic advance values, while the number of grains per ear (17.66) showed moderate values. However, the rest of the traits showed low genetic advance, mainly due to their relatively low genetic variance. For this reason, mainly traits with high genetic advance values should be the focus of selection.

These authors' findings are in line with those of [24] for grain yield whereas they differ in relation to the number of grains per ear for which the authors reported genetic advance values ranging from moderate to low. Also, the very small difference between the genotypic

coefficient of variation (GCV) and the phenotypic coefficient of variation (PCV) for the traits studied suggests that the expression of these traits was less affected

by environmental factors. These results agree well with the findings of [25,26] who reported low differences between GCV and PCV for all traits evaluated.

**Table 2:** Values of genetic parameters under spraying with different concentrations of the biostimulant Biozyme.

Traits	$\sigma^2G$	$\sigma^2GE$	$\sigma^2E$	$\sigma^2P$	(%) $H^2$	GA	GA (%)	PCV (%)	GCV (%)
Number of rows (row. ear-1)	0.058	0.042	0.050	0.067	87.44	0.39	2.35	1.53	1.43
Number of grains (grain ear-1)	125.57	29.29	524.45	154.73	81.15	17.66	3.36	2.36	2.13
Number of grains (grain row-1)	0.11	0.16	0.44	0.15	71.50	0.49	1.58	1.26	1.06
500- grain weight (g)	4.81	9.75	0.27	6.22	77.40	3.37	2.50	1.85	1.62
Grain yield (Mg ha <sup>-1</sup> )	56839.98	20411.34	605.79	59784.73	95.07	406.81	5.88	3.53	3.44
Biological yield (Mg ha <sup>-1</sup> )	202625.2	152448.7	1383.457	224469.5	90.21	748.21	4.37	2.62	2.76
Harvest index	0.57	1.10	0.02	0.73	78.32	1.17	2.92	2.13	1.89

Where:  $\sigma^2G$  represents genotypic variance;  $\sigma^2GE$  genotype–environment interaction variance;  $\sigma^2E$  refers to environmental variance;  $\sigma^2P$  indicates phenotypic variance;  $H^2$  represents broad-sense heritability; GA denotes expected genetic advance; EGA refers to expected genetic advance expressed as a percentage of the mean; PCV represents the phenotypic coefficient of variation; and GCV denotes the genotypic coefficient of variation.

### Conclusions

**Genetic Diversity:** Significant genetic variation exists among the studied maize genotypes for growth and yield traits.

**Genetic Control:** Genetic variance dominated over environmental variance for leaf area and yield, showing high heritability and genetic gain. This confirms

the effectiveness of direct selection in breeding programs.

**Trait Stability:** The close alignment between PCV and GCV values indicates minimal environmental influence on the expressed traits.

**Biozyme Efficacy:** Foliar application of Biozyme significantly enhanced genotype

performance and clarified genetic differences.

Optimal Concentration: The 3.5 ml/L concentration was the most effective

treatment, significantly outperforming other levels in boosting maize productivity under field conditions.

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