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Estimation of Some Genetic Parameters of Maize Genotypes Affected by Irrigation Intervals

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ABSTRACT

A field experiment was conducted during the spring and autumn seasons of 2024 on agricultural land located in the Abu Loka area, Al-Musayyib District, Babil Governorate, Iraq. The land is situated at a latitude of 32◦ north and a longitude of 44◦ east, and is approximately 40 km north of the city of Babilon Governorate. The aim was to determine the response of selected maize genotypes to Irrigation intervals for growth traits, yield, and some genetic parameters. The experiment was carried out according to a completely randomized block design with three replicates, using two factors: Irrigation intervals (irrigation every 5 and 10 days), while the second factor included 14 selected genotypes. These were obtained from the spring season and for six genotypes, selection was based on ear length and ear height, which were used as selection indicators. The genotypes used in the spring season were (Fajr, Maha, Baghdad, 5018, American hybrid, Euphrates and HS synthetic variety). The statistical analysis results indicated the following: the 5 day irrigation treatment was superior for the cultivar in all studied traits except for the oil percentage, where the plant yield reached 145.20 g plant^{-1}, the biological yield 463.64 g plant^{-1}, the total yield 7.74 ton ha^{-1}, and the protein percentage 12.05 %. As for the genetic compositions, the genotype (5018), selected using the ear length method, outperformed in most of the studied traits, except for oil content, where it yielded a plant yield of 145.20 g plant^{-1}, a biological yield of 463.64 g plant^{-1}, a total yield of 7.74 ton ha^{-1}, and a protein content of 12.05%.

Keywords: *Zea mays L., genotype, selection indicators*

1. INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop in the world, including Iraq. It ranks third after wheat and rice in terms of cultivated area and productivity. Its importance stems from its multiple uses in human nutrition, as its grains are included in concentrated feed or as animal and poultry feed due to its high carbohydrate, protein, and oil content. Its importance is also attributed to its high production capacity and its adaptability to different environmental conditions. Furthermore, due to the possibility of growing it in more than one season per year, there remains a continuing need to develop its cultivation and increase its productivity (Cheyed and Elsahookie, 2018). Therefore, this crop has received significant attention from breeders. The plant is bred for improvement because it is a cross-pollinated crop. It is considered one of the most extensively studied crops by plant breeders, and extensive genetic and cytological research has been conducted on it. Furthermore, self-pollination and hybridization facilitate the production of large numbers of seeds. Producing food to meet population growth will be a major challenge over the next fifty years, with drought being one of the major factors negatively impacting productivity (Elsahookie et al., 2019). Drought causes significant losses in maize yields, and the likelihood of these losses has increased with global climate change, such as rising temperatures and uneven rainfall distribution. The successes achieved over the past fifty years in improving drought tolerance have formed an important basis for studies aimed at producing drought-resistant varieties (Comps et al., 2004). maize is grown in Iraq in most of the Iraqi governorates (Baghdad, Wasit, Babylon, Kirkuk). However, the average production per unit area is still low, as the cultivated area for the year 2019 recorded a total of 83 thousand hectares with an average production of 4.15 ton ha^{-1} (Directorate of Agricultural Statistics 2020), compared to the average yield of agriculturally developed countries such as the United States of America 11.08 ton ha^{-1}, Egypt 8.00 ton ha^{-1} (2018, USDA). The importance of this crop globally in general and Iraq in particular, and its low productivity in Iraq, requires us to seriously search for all possible ways and means that achieve an increase in the yield, both quantitatively and qualitatively. Irrigation is a determining factor for agricultural production in many regions of the world that suffer from a scarcity of water resources, as Arid and semi-arid regions suffer from water scarcity, so efforts must be made to make the best use of water to maintain and increase agricultural production.

2. MATERIALS AND METHODS

A field experiment was conducted during the spring and autumn seasons of 2024 in the Abu Luka area - Al-Musayyab District - at latitude 44◦ and longitude 32◦, which is about 40 km north of Babil Governorate, with the aim of evaluating the performance of selected genetic combinations of maize for growth and yield traits under the influence of irrigation intervals and estimating some of their genetic parameters. Six genetic combinations of maize were used in the study, obtained from the General Authority for Agricultural Research / Ministry of Agriculture (Table 1).

Table (1) Varieties used in the study and their source

Varieties	Origin and Source
Fajr	Locally bred from an American hybrid
Maha	Locally bred from a Yugoslavian hybrid
Baghdad	Strain derived from a Spanish hybrid
Euphrates	Strain derived from a Spanish hybrid
American hybrid	American strain
HS	Local composite variety
5018	Strain derived from an American hybrid

Soil Analysis

Random samples were taken from different locations in the experimental soil layer (0.30 cm) and from different sites. All samples were then mixed, and a composite sample was extracted and analyzed in the Soil Department Laboratory at Al-Musayyab Technical Institute.

Table (2) Some chemical and physical properties of the field soil before planting.

Characteristic		Value	Unit
pH		7.15	--
EC		4.0	ds m^{-1}
N		98.0	mg kg^{-1} soil
P		7.95	mg kg^{-1} soil
K		231.0	mg kg^{-1} soil
Soil separators	Clay	2.8	g kg^{-1} soil
	Silt	38.8	
	Sand	58.4	
Soil texture		Sandy Loam Soil	

Spring Season(2024)

The genotypes were planted in the spring season on April 1, 2024, on all rows, alternating at a ratio of 1:1. The experimental unit included a row with a length of 6 m, with a distance of 0.75 m between rows and 25 cm between holes. The experimental service was carried out from the beginning until harvest according to the experimental requirements, including fertilization, weeding, and pest control. The experiment was fertilized with urea fertilizer (46% nitrogen) at a rate of 400 kg ha^{-1} in two batches, and triple superphosphate at a rate of 200 kg ha^{-1}. When the plants reached physiological maturity, two plants were selected from each genotype using selection indicators (ear length and shortest ear height). Thus, (12) genotypes were obtained, and the seeds were saved for planting in the autumn season (2024) to evaluate their performance. The following table shows the symbols used for the selections planted in the following season:

Table (3) Symbols used for selective genotypes

Varieties	Selection tool	Symbol
Fajr	Ear length	G1S1
	Ear height	G1S2
Maha	Ear length	G2S1
	Ear height	G2S2
Baghdad	Ear length	G3S1
	Ear height	G3S2
Euphrates	Ear length	G4S1
	Ear height	G4S2
American hybrid	Ear length	G5S1
	Ear height	G5S2
HS	Ear length	G6S1
	Ear height	G6S2
5018	Ear length	G7S1
	Ear height	G7S2

Autumn Season(2024)

Fourteen 14 genotypes were planted to evaluate the performance of the selected genotypes for growth, yield, and some genetic traits on July 1, 2024. Two irrigation intervals were used: every 5 and 10 days. The genotypes were planted on rows, and the experimental unit included a row 6 m long, with a distance of 0.75 m between rows and 0.25 m between holes. All soil and crop maintenance operations were carried out as in the first season. The experiment was designed using a Random Complete Block Design (RCBD) with three replicates, with 28 treatments (14 × 2) in each replicate, totaling 84 experimental units. Traits were studied on an individual plant basis, and all traits were measured on ten plants, with the exception of protein percentage.

Traits studied

1. Grain yield (g plant^{-1}): Calculated by weighing the yield of five selected plants and dividing by five.
2. Biological yield: Calculated by taking the total weight of 5 complete plants (stem, leaves, and ear) and dividing by 5, including the ear.
3. Total yield (g plant^{-1}): The total is calculated by multiplying (grain yield (g plant^{-1}) × plant density), after adjusting the weight based on 15.5% moisture content (Elsahookie and Cheyed 2023).
4. Oil content in grain (%): 5 samples were taken for each genotype to estimate the percentage of oil in the seeds using a Soxhlet device.
5. Protein content in grain (%): Calculated by taking 5 samples from each genotype as a function of the modified nitrogen content by multiplying the nitrogen content by 6.25.

3. RESULTS AND DISCUSSION

Plant yield (g plant^{-1})

Table (3) shows the superiority of the (G7S1) genotype over the other studied genotypes for the plant yield trait, yielding the highest average of 145.20 g plant^{-1}, while the (G1S1) genotype yielded the lowest average of 103.99 g plant^{-1}. This can be attributed to the differences in genetic compositions and their response to environmental conditions, as well as the interaction between the environment and genetic compositions. As for irrigation intervals, the 5 day level outperformed, recording the highest mean for the trait, reaching 126.47 g plant^{-1}, while the 10 day level yielded the lowest mean, reaching 118.26 g plant^{-1}. It can be concluded that the superiority of the first level is due to the provision of all water and nutrient requirements. This, in turn, increases plant height, leaf area, and yield components, according to the previous tables for vegetative growth traits, resulting in an increase in the yield per plant. Regarding the two-way interaction between genetic compositions and irrigation intervals, the combination (G7S1 × 5 days) outperformed the other combinations, recording the highest mean for the trait, 150.20 g plant^{-1}, while the combination (G1S1 × 10 days) yielded the lowest mean for the trait, reaching 100.66 g plant^{-1}.

Table 3. Arithmetic means of selected maize genotypes for the yield trait, influenced by the two irrigation intervals.

Genotype (G)	**Irrigation intervals (day) (I)**		**Mean (G)**
	5	**10**	
G1S1	107.33	100.66	103.99
G1S2	111.45	102.87	107.16
G2S1	122.77	114.29	118.53
G2S2	116.62	111.20	113.91
G3S1	135.87	129.40	132.63
G3S2	128.66	123.28	125.97
G4S1	130.17	120.37	125.27
G4S2	122.87	112.35	117.61
G5S1	145.19	136.18	140.68
G5S2	140.62	127.49	134.05
G6S1	118.45	115.97	117.21
G6S2	115.32	101.26	108.29
G7S1	150.20	140.20	145.20
G7S2	125.12	120.17	122.64
Mean (I)	126.47	118.26	
LSD 0.05	**G = 7.24**	**I = 1.80**	**G×I = 10.09**

Biological yield (g plant^{-1})

Table (4) shows the superiority of the genotype (G7S1) over the other studied compositions, giving it the highest average for the trait, reaching 463.64 g plant^{-1}, while the genotype (G1S2) gave the lowest average for the trait, reaching 201.35 g plant^{-1}. The superiority of the genotypes over their counterparts may be due to the characteristics of each composition and the extent of response to irrigation intervals in terms of the genetic composition and the extent of adaptation to the environment in which it is grown. The interaction of the genotype, whether variety or hybrid, with various environmental factors also applies. Regarding irrigation intervals, the 5 day treatment outperformed the 5day treatment for the biological yield trait, giving it the highest average for the trait, reaching 337.07 g plant^{-1}, while the 10 day treatment recorded the lowest average for the trait,

Table 4. Arithmetic means of maize genetic selections for the biological yield trait, influenced by the two irrigation intervals.

Genotype (G)	Irrigation intervals (day) (I)		Mean (G)
	5	**10**	
G1S1	237.40	211.40	224.40
G1S2	219.78	182.92	201.35
G2S1	276.52	240.47	258.50
G2S2	255.66	235.25	245.45
G3S1	347.78	281.86	314.82
G3S2	318.69	266.84	292.76
G4S1	376.84	348.65	362.74
G4S2	351.27	324.81	338.04
G5S1	463.43	429.71	446.57
G5S2	420.62	389.44	405.03
G6S1	320.14	284.17	302.15
G6S2	290.22	243.11	266.66
G7S1	480.56	446.72	463.64
G7S2	359.92	331.89	345.90
Mean (I)	337.07	301.23	
LSD 0.05	**G = 81.51**	**I =21.78**	**G×I =57.63**

reaching 301.23 g plant^{-1}. This can be explained by the fact that irrigation intervals to the first treatment provided the required water and nutrient requirements, compared to the second treatment, which did not. As a result, water and nutrients play a fundamental role in increasing leaf area and, consequently, increasing the amount of sugar ($C_6H_{12}O_6$). They also increase the number of proteins and carbohydrates, thus increasing the biological yield. Regarding the interaction between the two experimental factors (variety × irrigation intervals), the combination (G7S1 × 5 days) outperformed, recording the highest average for the trait, reaching 480.56 g/plant, while the combination (G1S2) produced the lowest average for the trait, reaching 182.92 g plant^{-1}.

Total yield (ton ha^{-1})

Table (5) indicates that the (G7S1) genotype outperformed the other genotypes, giving it the highest average for the trait, reaching 7.743 ton ha^{-1}, while the (G1S1) genotype gave the lowest average for the trait, reaching 5.546 ton ha^{-1}. Thus, an increase in the trait of 27.53% was achieved. This can be analyzed by saying that the varieties that excelled in per-plant yield are the same as those that excelled in total yield, since the total yield is the result of the per-plant yield multiplied by the plant density 53.333. As for irrigation intervals, the 5 day irrigation intervals outperformed the 10-day irrigation intervals, as the former achieved an average of 6.745 ton ha^{-1}, while the latter gave the lowest average of 6.307 ton ha^{-1}. Thus, we obtained an increase in the total yield trait of 6.49%. This can be explained by the fact that the first level outperformed the second level in the yield per plant, in addition to other traits. Therefore, it is natural for it to outperform in the total yield trait. As for the two-way interaction between the two experimental factors (genotypes × irrigation intervals), the combination (G7S1 × 5 days) outperformed the other combinations, giving the highest average for the trait of 8.010 tons ha^{-1}, while the combination (G1S1 × 10 days) gave the lowest average for the trait of 5.368 ton ha^{-1}. Thus, we obtained an increase in the trait of 25.91%.

Table 5. Arithmetic means of genetic selections of yellow maize for the total yield trait, affected by two irrigation intervals.

Genotype (G)	Irrigation intervals (day) (I)		Mean (G)
	5	10	
G1S1	5.724	5.368	5.546
G1S2	5.943	5.486	5.715
G2S1	6.547	6.095	6.321
G2S2	6.219	5.930	6.075
G3S1	7.246	6.901	7.073
G3S2	6.861	6.574	6.718
G4S1	6.942	6.419	6.680
G4S2	6.553	5.991	6.272
G5S1	7.743	7.262	7.502
G5S2	7.499	6.799	7.149
G6S1	6.317	6.185	6.251
G6S2	6.150	5.400	5.775
G7S1	8.010	7.477	7.743
G7S2	6.673	6.409	6.541
Mean (I)	6.745	6.307	6.526
LSD 0.05	**G = 0.08**	**I =0.04**	**G×I = 0.310**

Protein content in grain (%)

Table (6) shows the superiority of the genetic composition (G7S1) over the other studied genetic compositions, giving the highest average for the trait, reaching 12.05%, while the genetic composition (G1S1) gave the lowest average for the trait, reaching 10.25%. This can be explained by its superiority in the vegetative and fruiting traits (Table 3, 4, 5) respectively) and as a result its superiority in the protein percentage. As for the irrigation intervals, the 5day level was superior by giving it the highest average for the trait, which reached 11.11%, while the 10 day level gave the lowest average for the trait, which reached 10.78%, with a difference of 2.97 %. This can be explained by the plants in the first level obtaining their full needs of water and nutrients, and thus the vegetative and fruiting traits increased, such as (plant height, leaf area, ear length, number of rows per ear), respectively. Thus, the protein percentage in the 5day treatment was superior to the 10 day treatment. As for the interaction between the experimental factors, the combination (G7S1 × 5 days) was superior, giving it the highest average for the trait, which reached 12.43%, while the average of the combination (G1S1 × 10 days) was the lowest average. For the trait, it reached 10.11%.

Table 6. Arithmetic means of selected maize genetic lines for protein percentage, influenced by two irrigation intervals

Genotype (G)	Irrigation intervals (day) (I)		Mean (G)
	5	10	
G1S1	10.39	10.11	10.25

G1S2	10.57	10.27	10.42
G2S1	10.89	10.66	10.77
G2S2	10.78	10.59	10.68
G3S1	11.24	10.88	11.06
G3S2	11.09	10.73	10.91
G4S1	10.97	10.70	10.83
G4S2	10.89	10.71	10.80
G5S1	11.72	11.57	11.64
G5S2	11.82	11.17	11.49
G6S1	10.69	10.49	10.59
G6S2	10.82	10.60	10.71
G7S1	12.43	11.67	12.05
G7S2	11.27	10.88	11.07
Mean (I)	11.11	10.78	
LSD 0.05	**G = 0.06**	**I =0.30**	**G×I = 0.50**

Oil content in grain (%)

Table 7 indicates that the G6S2 genotype outperformed the other studied genotypes for the oil percentage trait, giving the highest average for the trait, reaching 5.07%, while the G3S1 genotype gave the lowest average for the trait, reaching 4.00%. This can be explained by the fact that the G6S2 genotype gave the lowest averages for the vegetative and fruit traits, and thus achieved a higher increase than the other varieties in oil percentage and the lowest protein percentage, as well as its superiority in protein percentage, as the proportion is inversely proportional. As for irrigation intervals, the 5day level outperformed, recording the highest average for the trait, reaching 0.704, while the 10day level gave the lowest average for the trait, reaching 4.54%. This is because the 5day level stimulates the plant to absorb water and nutrients, which increases most vegetative traits. The fruiting and dry matter components, thus increasing protein. However, the second level 10 days did not fully meet the plant's water, nutrients, and requirements, so the oil percentage increased over the protein percentage. As for the two-way interaction between genetic compositions and irrigation intervals, the combination (G6S1 ×5 days) outperformed the other combinations, recording the highest average for the trait, reaching 5.27%, while the combination (G3S1 × 10 days) gave the lowest average for the trait, reaching (3.90%).

Table 7. Arithmetic means of selected maizegenetic lines for the oil percentage trait, influenced by the two irrigation intervals.

Genotype (G)	**Irrigation intervals (day) (I)**		**Mean (G)**
	5	**10**	
G1S1	4.79	4.65	4.72
G1S2	4.69	4.60	4.64
G2S1	4.50	4.31	4.40
G2S2	4.73	4.59	4.66
G3S1	4.10	3.90	4.00

G3S2	4.37	4.12	4.24
G4S1	4.80	4.69	4.88
G4S2	4.82	4.70	4.76
G5S1	4.78	4.66	4.72
G5S2	4.70	4.65	4.68
G6S1	5.02	4.80	4.91
G6S2	5.27	4.87	5.07
G7S1	4.45	4.40	4.42
G7S2	4.76	4.66	4.71
Mean (I)	4.70	4.54	
LSD 0.05	**G = 0.216**	**I = N.S***	**G×I = 0.331**

***N.S = Nan significant**

4. CONCLUSIONS

This study concludes that maize genotypes differ in their performance and grain yield. This is due to differences in their genetic makeup, which is reflected in the variation. genotype 5018 was the most distinguished in most grain yield indicators. The Maha genotype showed superiority in seed oil content. It also appears that increasing the irrigation interval from 5 to 10 days negatively affected plant performance and grain yield, given that planting and the early stages of plant growth occurred during July and August. It is noted that ear length under a 5 day irrigation interval provides the best selection index for genotype 5018.

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