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Genetic Performance of Inbred and Hybrids of Maize Under Irrigation Interval

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Abstract. A field experiment was carried out using four inbred lines of maize BK112, Inb17, ZP607 and Zm6, as they were entered into half-diallel cross-breeding program in the fall season 2019, and 10 genotypes (6 crosses + 4 parents) were obtained according to the second Griffing method, the first model, in the spring season of 2020, the behavior of these inbreds and their hybrids were evaluated with three irrigation intervals with the aim of obtaining one or more distinct hybrids of pure strains derived from maize *Zea mays* L. under the irrigation interval and the study of hybrid vigor. The experiment was carried out in the fields of a farmer in Anbar Governorate, using the RCBD randomized complete block design (split –plot) with three replications. The irrigation interval (4, 8 and 12) days occupied the main plots, while the inbred and hybrids occupied the sub-plots. The results of the statistical analysis showed a significant effect of genotypes on the studied traits. The studied hybrids Zm6 × ZP607 were distinguished by their weight of 300 grains and the grain yield (85.83 g and 186.70 g) respectively. The plants grown under the irrigation interval 4 days outperformed the grain yield of the plant by giving it the highest yield of 156.03 g. It did not differ significantly with the 8-day irrigation interval, while the yield decreased significantly at the 12-day irrigation interval with a decrease of 120.8% and 120.5% than the 4 and 8 irrigation treatments, respectively. It was also found that the interaction was significant and reached the highest grain yield with an irrigation interval of 8 days, 224.0 g. The hybrid Zm6 × ZP607 gave the highest positive hybrid vigor for individual plant yield, which was 119.24%, 126.72% and 166.05% for the irrigation interval of 4, 8 and 12 days, respectively. Therefore, the plant breeder can use the characteristics of the yield components as selection guides with the superior hybrids in yield and the strength of the hybrid.

1. Introduction

Maize represents corn *Zea mays* L. a direct food for humans and fodder for animals and constitutes an important source of income for millions of people in the countries of the world because its grain contains starchy, protein, oil, vitamins and minerals, in addition to its use as a source of biofuels such as the production of ethanol gas [2,8]. Describing the production of hybrids as the agricultural revolution and the greatest event in plant breeding, and the strength of the hybrid depends mainly on the genetic difference between the parents, so many statistical analysis tools were proposed that can be used to verify the nature of the genetic material and the genetic action controlling the transmission of traits across generations, and perhaps the most famous of which is the half diallel cross system, which includes performing all cross crosses between a number of breeds only. The second Griffing method



(1956 b) Method 2[14], so plant breeders seek to find the best hybrids by diagnosing the best parents to achieve the highest hybrid vigor (Heterosis), using inbred line to evaluate and produce the best hybrids that are superior in grain yield and its components. The discovery of the phenomenon of hybrid vigor in maize played a major role in the development of the science of plant breeding, especially in the production of hybrids on a large scale, which depends mainly on the genetic distance between the parents. The amount of this distance increases the strength of the hybrid due to the increase in the general ability. Therefore, plant breeders request to identify the best hybrids by diagnosing the best parents in order to achieve the best hybrid vigor. This can be done by using inbred line to produce the best hybrids that are superior in yield and its components. Good field management also contributes to increasing the yield from 30-50%, while genetic collection contributes to the remaining percentage in the yield of the crop [4 , 21]. Improving drought-resistant genetic structures 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 structures 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 [24].

The maize crop is considered one of the crops sensitive to water stress, especially if it coincides with the flowering period, as it will lead to a loss in the yield that may reach 45-60% [17]. The distribution of water in the soil is affected by the duration of irrigation and the method of cultivation, and the nature of the water distribution in the soil affects the distribution of the root system in its size, and then the growth of the stem, leaves and other plant organs are affected. The moisture tension varies around the root total of the plant according to the growth of the plant in proportion to the degree of difference in the moisture tension that it is exposed to, for him, the moisture content of the soil is one of the most important factors that determine and regulate the vital processes inside the plant, and water plays a crucial role in the life of the plant by playing the role of solvent and carrier medium. As well as supplying the energy needed for the photosynthesis process in which organic food is made, as well as the lowering of the plant's temperature. [5].

The study aims to obtain hybrids of high productivity with hybrid vigor and to know the extent of the response of and hybrids to irrigation periods. And choose the good ones.

2. Materials and Methods

The first paragraph after a heading is not indented (Bodytext style) In this research, four pure strains of maize were used (Table 1). These inbred lines were entered into the half dialle program to derive single cross from them.

Table 1. Codes and numbers of maize inbreds used in the research

Inbred number	Inbred code	Inbred origin
1	BK112	locally derived
2	Inb17	locally derived
3	ZP607	locally derived
4	Zm6	locally derived

Fall season 2019

The experiment field was divided into two parts, the first part was planted with the seeds of the four strains of the pollination process on 28/7/2019, and the second part planted the seeds of the strains on lines with 7 lines for each strain. The length of the line is 3 m, the distance between one line and another is 0.80 m, and between the indentation is 0.30 m. 2-3 seeds per hole, thinned after the plant reaches a height of 20 cm to one plant in the hole and when the plants reached the stage of flowering and the appearance of the female inflorescence, and before the appearance of the silk, they were covered with paper bags to avoid open pollination and to ensure obtaining the required crosses. As for the male inflorescences, they were also bagged with large paper bags a day before the start of the

pollination process, and after releasing the pollen grains, the pollen grain was collected the next day to be vaccinated ready from the silks to receive the pollen, and by continuing the process of bagging and pollination it was possible to conduct all possible crossing between the inbred lines. In addition, the parents of these camels were self-pollinated. All half-cross crosses were carried out between the parental breeds to produce individual hybrids according to the second method of Griffing (b 1956), so the number of crosses according to the following equation: $2/P(P-1)$,

Spring season 2020

In this season, cultivation was carried out in the season of the comparison experiment on (3/3/2020) by planting the seeds of individual hybrids (6 single crosses) and their 4 parents, so that the total number of genotypes was 10 genotypes with the irrigation interval treatments of 4, 8 and 12 days. The design of split-plot sectors was used. Randomized RCBD with three replications. The irrigation interval (4, 8 and 12) days occupied the main plots, while the inbred and hybrids occupied the sub-plots. The experimental unit consists of five lines with a line length of 2 m for each genetic material and for each experimental unit. The distance between one line and another is 0.75 m and between the hole 0.25 m and at a rate of 2-3 seeds per hole, it eased after the plant reached a height of 20 cm to one plant in the hole, taking into account all agricultural operations from soil and crop service, starting from plowing, softening, leveling, fertilizing and irrigation as needed. The data for each trait were taken on ten guarded plants in each experimental unit.

Studied traits:

- 1- Number of days from planting to 50% tasseling
- 2- Average plant height (cm)
- 3- The average number of rows in the ear (row).
- 4- Weight of 300 grains (gm)
- 5- Average yield per plant (gm)

Hybrid Vigor

The single hybrids not reciprocal crosses were estimated for all traits and based on the deviation of the first generation's reciprocal mean from the mean of the best parents according to the following equation:

$$\text{Heterobeltiosis (H\%)} = \frac{F1 - BP}{BP} \times 100$$

$$\text{Heterobeltiosis (H\%)} =$$

Since: Heterobeltiosis = the strength of the hybrid attributable to the best parent (BP)⁻

F1 = average first generation hybrid, [12].

Then, the significance of the hybridization strength was tested using Standard Error (S.E) for cross-hybrids.

3. Results and Discussion

3.1. Number of days from planting to 50% tasseling

Table (2) shows that the plants of inbred 2 needed the least number of days to reach the stage of 50% male flowering, which amounted to 73.10 days, while the plants of inbred 1 needed the longest period to reach this stage, which amounted to 77.07 days for the spring season, that these differences between the parents were reflected in the hybrids resulted from cross-crossing the hybrid 3×4 took the least male flowering period of 65.15 days and did not differ significantly with four crosses, while the hybrid 1×2 gave the longest flowering period of 68.67 days. Both [22, 28, 29] reached similar results when

they indicated significant differences between the genotypes in the character of the number of days from planting to 50% of male flowering.

It is noted from the results of the same table that the plants grown under the 12-day irrigation interval were superior to male flowering by giving them a lower number of days, which amounted to 64.06 days, while the number of days for male flowering for the irrigation intervals 4 and 8 days did not differ significantly, and perhaps the reduction in the number of days from planting to 50% flowering females in the 12-day irrigation interval led to a decrease in the water content of the soil with high temperatures and low relative humidity, which led to accelerating the growth stages that take place inside the plant and then stimulating it to speed up towards early entry into the flowering phase [13,31]. This result is consistent with what was found by [1, 23], who indicated that plants exposed to water stress, early access to male flowering. As for the interaction between irrigation treatments and genotypes, the same table showed that the 1×3 hybrid plants grown under the 12-day irrigation treatment took the least male flowering period of 57.87 days and did not differ significantly with 3 crosses.

Table 2. Average 50% of male flowering (day) for inbred and their hybrids for maize for an interval of spring season 2020

genotypes	4 days	8 days	12 days	Mean
1	80.00	79.11	72.11	77.07
2	75.03	74.14	70.12	73.10
3	78.12	77.93	69.21	75.09
4	74.89	76.33	69.32	73.51
1 x 2	75.03	69.99	60.99	68.67
1 x 3	70.00	69.22	57.87	65.70
1 x 4	70.11	68.67	57.96	65.58
2 x 3	69.78	68.41	61.22	66.47
2 x 4	68.44	68.01	62.95	66.47
3 x 4	68.04	68.54	58.86	65.15
Mean	72.94	72.04	64.06	
L.S.D	Irrigation interval	5.63		
	Genotypes	1.95		
	Interaction	4.21		

3.2. Average plant height (cm)

Table (3) shows that inbred 4 outperformed by giving it the highest plant height of 169.9 cm, while inbred 3 gave the lowest plant height of 155.36 cm. These differences between the parents were reflected in the hybrids resulting from cross-bringing. The superiority of the hybrid 2×4 by giving it the highest plant height of 192.77 cm did not differ significantly. With two hybrids, while the hybrid 3×4 gave the lowest plant height of 174.74 cm. [4, 9, 22] reached similar results when they indicated significant differences between the genotypes in the plant height characteristic. It is noted from the results of the same table that the plants grown under the irrigation interval were superior 4 days with plant height by giving it the highest plant height of 188.30 cm and it did not differ significantly with the irrigation interval of 8 days, while the irrigation interval 12 days gave the lowest height for the plant [21].

The reason for the decrease in plant height in 12 days of irrigation coefficients may be attributed to the short period from planting to 50% of male flowering (Table 2), which falls within the stage in which the stem is elongated. It is expected that the length of the irrigation period that led to the decrease in water in the plant, which determines the division and expansion of cells, and thus the decrease in the

density of the vegetation cover in this treatment as a result of the reduction in the number of leaves and their area, which allowed the penetration of light into the vegetative covering, which led to not giving the growth hormone (Auxins) the opportunity to work on the elongation of the internodes due to its destruction by oxidation photovoltaic negatively affecting plant height [18]. This result is in agreement with what was found by, [1, 15, 16, 26], who reported a decrease in the mean height of maize plants under stress watery conditions.

The results in (Table 3) showed that there was a significant interaction for the two study factors, which indicates a difference in the behavior of the genotypes towards the irrigation interval treatments. The type of interaction was a difference in the amount of response and not in the direction of the answer, meaning that all the genotypes had a significant decrease in the plant height rate for the irrigation treatments 12 days compared to 4 and 8 days. With irrigation treatments 4 and 8 days, where the hybrid 1×2 with Ari interval 4 days gave the highest plant height of 213.36 cm and did not differ significantly with 6 hybrids and also with an increase rate of 60.76 % than the strain 3 with the interval of irrigation 12 days.

Table 3. Average plant height (cm) inbred and their hybrids for maize for an interval of spring season 2020.

genotypes	4 days	8 days	12 days	Mean
1	169.51	166.18	141.71	159.13
2	175.07	168.74	132.72	158.84
3	164.75	160.82	140.52	155.36
4	168.26	179.37	162.08	169.90
1 x 2	213.36	202.76	162.47	192.86
1 x 3	188.05	191.55	164.67	181.42
1 x 4	206.03	194.41	152.41	184.28
2 x 3	206.12	181.25	146.09	177.82
2 x 4	208.03	199.04	171.24	192.77
3 x 4	183.78	184.82	155.61	174.74
Mean	188.30	182.89	152.95	
L.S.D	Irrigation interval	22.44		
	genotypes	12.66		
	Interaction	21.92		

3.3. *The average number of rows in the ear (row)*. It appears in (Table 4) that inbred 4 excelled by giving the highest number of rows per ear, which amounted to 14.77 rows, and it did not differ significantly with the two inbred 2 and 3, while inbred 1 gave the lowest number of rows per ear, which amounted to 13.40 rows. These differences between the parents were reflected in the crosses resulting from cross-bred superiority of the hybrid 1×2 by giving the highest number of rows with the ear reached 17.57 rows and it did not differ significantly with the 2×4 hybrid, while the 1×4 hybrid gave the lowest number of rows with the cob reaching 14.50 rows. Both [27, 33] reached similar results when they indicated the difference in the number of rows in the eardrum among the genotypes.

It is noted from the results of the same table that the water tension caused the reduction in the number of rows in the ear, as the plants of the irrigation interval 12 days recorded the lowest average number of rows in the ear reached 13.8 rows, while the irrigation interval treatment of 8 and 4 days recorded the highest average for this trait amounting to 15.81 and 15.79 rows, respectively. The reason may be due to the insufficiency of the products of photosynthesis to form the largest number of rows as it is the first part determined in the ear after determining the size of the ear. This result is in agreement with the findings of [1, 15, 20] that water tension caused the reduction of the number of rows in maize plants.

The results in the table showed that there was a significant interaction for the study workers, which indicates a difference in the behavior of the genotypes towards the irrigation interval treatments.

Compared with irrigation treatments 4 and 8 days, the highest percentage decrease in the average number of rows in the ear was 27.5% in the 1×2 hybrid, while strain 4 gave the lowest percentage decrease in the average number of grains by 5.6% for the 12 day irrigation treatment compared to the 4 and 8 day irrigation treatments.

Table 4. The average number of rows in the ear of inbred and their hybridization of maize for an interval for the spring season 2020

Genotypes	4 days	8 days	12 days	Mean
1	14.1	14.0	12.1	13.40
2	15.2	15.4	13.5	14.70
3	14.4	14.2	13.0	13.87
4	15.0	15.1	14.2	14.77
1 x 2	19.0	18.8	14.9	17.57
1 x 3	16.3	16.7	14.6	15.87
1 x 4	15.2	15.2	13.1	14.50
2 x 3	14.9	14.9	14.0	14.60
2 x 4	17.6	17.5	14.1	16.40
3 x 4	16.2	16.3	14.5	15.67
Mean	15.79	15.81	13.8	
L.S.D	Irrigation interval	2.09		
	Genotypes	1.33		
	Interaction	1.94		

3.4. Weight of 300 grains (gm)

Table (5) shows that inbred 2 gave the highest weight of 300 grains, which amounted to 78.70 g, while inbred 4 gave the lowest average weight of 300 grains. These differences between the parents were reflected in the crosses resulting from cross-bringing. The superiority of the hybrid 3×4 by giving the highest weight of 300 grains reached 85.83 gm and it did not differ significantly with 3 crosses, while the 2×3 hybrid gave the lowest weight of 300 grains, which was 77.20 g. Both [4, 6, 7] reached similar results when they indicated the difference among the genotypes.

It is noted from the results of the same table that the 8 day irrigation treatment recorded the highest weight of 300 grains which amounted to 83.08 gm and it did not differ significantly with the 4 day irrigation treatment which gave 82.98 gm, while the 12 day irrigation treatment produced the lowest average for this trait amounted to 70.99 gm, and the reason may be due to the grain Cereals in the treatment of irrigation 12 days to increase the water stress, which affected in reducing the period of male flowering and the height of the plant, which reduced its interception of light and thus decreased the amount of manufactured and temporarily stored materials in the stem. This result is in agreement with the findings.

Table 5. Average weight of 300 grains (gm) inbred and their hybrids of maize for an interval for the spring season 2020.

genotypes	4 days	8 days	12 days	Mean
1	76.0	78.0	67.5	73.83
2	82.1	84.1	69.9	78.70
3	82.2	81.2	71.0	78.13
4	71.1	70.1	59.1	66.77
1 x 2	80.6	80.6	75.6	78.93
1 x 3	87.2	87.2	77.2	83.87
1 x 4	90.3	91.3	71.3	84.30
2 x 3	88.2	87.2	56.2	77.20
2 x 4	84.6	82.6	80.6	82.60

3 x 4	87.5	88.5	81.5	85.83
Mean	82.98	83.08	70.99	
L.S.D	Irrigation interval	5.52		
	Genotypes	6.48		
	Interaction	9.58		

3.5. Average yield per plant (gm)

Table (6) shows that inbred 2 outperformed by giving the highest individual plant yield, which amounted to 89.53 g, while inbred 4 gave the lowest grain yield, which amounted to 72.47 g. These differences between the parents were reflected in the crosses resulting from cross-bringing. Two hybrids, while the hybrid 1 × 3 gave the lowest grain yield per plant, which was 123.20 g. Perhaps the superiority of the hybrid 1×3 is due to the superiority of the weight of 300 grains delivered by [3, 27, 11]. To similar results when they indicated significant differences between the genotypes in the character of the grain yield of the plant. It is noticed from the results of the same table that the plants grown under the irrigation interval 4 days outperformed the grain yield of the plant by giving it the highest yield of 156.03 g. Irrigation 4 and 8 sequentially. The reason for the decrease in grain yield under conditions of soil moisture deficiency is attributed to the effect on the growth and development of the crop and its reflection on the reduction of leaf area, number of rows per ear, and weight of 300 grains (Table 3, 4 and 5). These results were reinforced by what was found by [1, 19, 15, 25, 32], who indicated that the grain yield of maize plants Bile subjected to water stress decreased significantly and attributed this to the decrease in the number of rows in the ear and the weight of the grains. The stress also led to the formation of small, wrinkled and wrinkled seeds due to acceleration of ripening and shortening the length of the grain filling period. The grain yield decreased for the 12-day irrigation interval, compared to the 8 and 4 day irrigation intervals. The highest decrease in grain yield was 187.5% and 182% for the 1×3 hybrid, while the 1×4 hybrid gave the lowest percentage decrease in the grain yield rate by 77.9% and 80.6% for the 12-day irrigation treatment compared to the 4 and 8 day irrigation treatments, respectively.

Table 6. Average grain yield (gm) for inbred and their hybrids for maize for an interval for the spring season 2020.

genotypes	4 days	8 days	12 days	Mean
1	104.6	105.4	42.8	84.27
2	111.3	110.5	46.8	89.53
3	100.8	98.8	43.3	80.97
4	90.3	92.3	34.8	72.47
1 x 2	188.7	185.7	74.9	149.80
1 x 3	155.7	158.7	55.2	123.20
1 x 4	198.2	201.2	111.4	170.26
2 x 3	214.2	210.2	86.8	170.40
2 x 4	175.5	171.5	95.4	147.46
3 x 4	221.0	224.0	115.2	186.70
Mean	156.03	155.83	70.66	
L.S.D	Irrigation interval	21.42		
	genotypes	17.22		
	Interaction	26.83		

The genetic divergence between heterosis was reflected in their hybrids for female flowering, and the strength of the hybrid attributed to the earliest parents (Table 7) was different. It was found in the treatment of irrigation 4 days that the crosses gave a negative and moral heterosis, the lowest of which was -10.39 for the 1×3 hybrid and the 1×2 hybrid gave heterosis. Hybrid zero in order to equal the

male flowering days of the hybrid with the earliest parents. All the hybrids in the irrigation treatment of 8 days gave negative and significant hybrid strength, the lowest of which was -11.17 in the 1×3 hybrid, while in the treatment of irrigation 12 days the performance of the genotypes was greatly affected by their genetic divergence when they showed that all hybrids had negative hybrid vigor, the lowest value of which was -16.78 in the 1×4 hybrid. These results indicate the presence of an over-dominance of genes in the direction of early emergence of female inflorescences in the hybrids that gave negative hybrid vigor. These results agreed with the findings of [9, 33] in that they obtained negative hybrid vigor for most of the crosses, that is, it resulted in early male flowering of maize.

Table 7. Heterosis (%) of male flowering of cross-hybrids of maize for 4, 6 and 12 day irrigation intervals for the spring season 2020

Hybrid	4 days	8 days	12 days
1×2	00.00	-5.59	-13.02
1×3	-10.39	-11.17	-16.38
1×4	-6.38	-10.03	-16.78
2×3	-6.66	-7.72	-11.54
2×4	-8.61	-8.26	-9.19
3×4	-9.14	-10.20	-14.95
S.E	1.50	0.33	1.20

According to the genetic differences in the plant height trait, the over-dominance genes varied in controlling the inheritance of the trait, based on giving the hybrids positive values for the hybrid vigor as shown in (Table 8). The hybrid (1x2) in the treatment of irrigation 4 and 8 days gave the highest positive and moral hybrid vigor 21.87% and 20.16% respectively, while in the 12-day irrigation treatment the performance of the genotypes was greatly affected by their genetic divergence when four of the crosses showed a positive hybrid vigor (heterosis), the highest value was 16.20% in the 1×3 hybrid, while two hybrids gave a negative hybrid vigor as below a value of 5.97 - % in the hybrid 1×4 and these results are consistent with the findings of [4 , 10 , 34] .

Table 8. Heterosis (%) for plant height of cross-hybrids of maize for irrigation interval of 4, 8 and 12 days for spring season 2020

Hybrids	4 days	8 days	12 days
1×2	21.87	20.16	14.68
1×3	10.93	15.26	16.20
1×4	21.54	8.40	-5.97
2×3	17.73	7.41	3.09
2×4	18.82	10.96	5.65
3×4	9.22	3.03	-3.99
S.E	3.09	2.80	8.49

According to the genetic differences, the over dominance and partial dominance genes varied in controlling the inheritance of the number of rows in the ear, based on the hybrids giving positive and negative values for the heterosis of the hybrid as shown in Table (9). The hybrid 1x2 in irrigation treatment 4, 8 and 12 days gave the hybrid vigor (heterosis) positive and significant hybrid: 25.00%, 22.07%, and 10.37%, respectively, and these results agree with [3, 6].

Table 9. Heterosis (%) for the number of rows in the ear of the alternating hybrids of maize for the irrigation interval of 4, 8 and 12 days for the spring season 2020

Hybrids	4 days	8 days	12 days
1×2	25.00	22.07	10.37
1×3	13.10	10.59	12.30
1×4	1.33	0.66	-7.74
2×3	-1.97	-3.24	3.70
2×4	15.79	13.63	-0.70
3×4	8.00	7.94	2.11
S.E	4.03	5.14	2.31

The difference between the two hybrids in the trait of 300 grains was reflected on their hybrids and on the heterosis of the hybrid, which in turn differed significantly (Table 10), where 5 of the crosses appeared, as the percentage of heterosis exceeded the in its direction towards positive in the irrigation coefficients 4 days, in which the 1x4 hybrid was distinguished in giving it the heterosis a hybrid reached 18.81%. As for the 8-day irrigation treatment, 4 hybrids appeared. The percentage of heterosis exceeded the moral threshold in its direction towards positive, and the 1×4 hybrid was distinguished by giving it the highest heterosis amounted to 17.05%, while the 12-day irrigation treatment in which two hybrids 2×4 and 3×4 were distinguished by giving them high and moral heterosis amounted to 15.30% and 14.79%. These results are confirmed by previous studies conducted by [9, 11, 22] and those who obtained negative and positive results of the hybrid vigor and indicated the effect of the partial and over-dominance of genes in the inheritance of the trait.

Table 10. Heterosis (%) for weight of 300 kernels of alternating hybrids of maize for 4, 8 and 12 day irrigation intervals for the spring season 2020

Hybrids	4 days	8 days	12 days
1×2	-1.82	-4.16	8.15
1×3	6.08	7.39	8.73
1×4	18.81	17.05	5.63
2×3	7.30	3.68	-20.84
2×4	3.04	-1.78	15.30
3×4	6.44	8.99	14.79
S.E	2.47	2.24	2.33

The genetic differences between the genotypes (inbreds and the resulting hybrids) were reflected in the heterosis of the yield (Table 11), as the 3x4 hybrid in the irrigation treatment of 4, 8 and 12 days gave the highest positive and moral hybrid strength 119.24%, 126.72% and 166.05%, respectively. In this field [28, 30] indicated similar results in obtaining positive and negative significant values for the heterosis of the hybrid.

Table 11. Heterosis (%) of the individual plant yield of cross-hybrids of maize for 4, 8 and 12 day irrigation intervals for the spring season 2020

Hybrid	4 days	8 days	12 days
1×2	69.54	68.05	60.04
1×3	48.85	50.57	27.48
1×4	89.48	90.89	160.28
2×3	92.45	90.22	85.47
2×4	57.68	55.20	103.84

3×4	119.24	126.72	166.05
S.E	10.59	11.60	22.42

4. Conclusion

Irrigation treatments 4 and 8 days gave the highest average grain yield with an insignificant difference between them, and irrigation every 8 days contributed to improving the efficiency of water use in the spring season, and this is an indication of the ability of maize hybrids to adapt to conditions of water scarcity, and the 12-day irrigation treatment had a similar effect. Negative behavior of maize strains and hybrids, and this was reflected negatively on grain yield and its components, although some crosses gave a very acceptable yield under drought conditions with high hybrid vigor (Heterosis).

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