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Estimation of Genetic Parameters and Heterosis in Half-Crosses of Bread Wheat (Triticum Aestivum L.)

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Annotation: The study was conducted in one of the farmers' fields affiliated to Kirkuk Governorate. The study included (10) genetic compositions of wheat introduced from the International Center for Agricultural Research in the Dry Areas (ICARDA) that were introduced in half-crosses and the parents and heterosiss were planted in a randomized complete block design (RCBD) with three replicates. Data were recorded for the traits (number of spikelets, number of grains per spike, number of spikelets per plant, weight of 100 grains, individual plant yield, biological yield, harvest index and yield efficiency). The analysis of variance showed that the mean squares of (parents), (heterosiss), (parents and heterosiss), (genotypes and parents, and parents against heterosiss and heterosiss) were significant at the probability level (1%) for all the studied traits under study except for the trait of number of spikelets, harvest index and yield efficiency, and parents against heterosiss for the trait of weight of 1000 grains and individual plant yield, in estimating the degree of dominance and heritability in the broad and narrow sense and the expected genetic improvement for all traits. The studied, as the values for all the traits showed no dominance in them except for the number of grains/spike, the harvest index and the efficiency of the crop. It is also noted that all the traits had a high degree of heritability in both the broad and narrow senses. The reason for the high heritability values for the above-mentioned traits is due to the high values of genetic variance compared to the environmental variance. Also, the values of the expected genetic improvement for the studied traits were low in all the traits except for the number of spikelets, the individual plant yield and the biological yield, which were average. The expected genetic improvement in the grain yield is the result of increasing one or more of the main components of the yield because it is the result of multiplying these components that form it. The presence of significant heterosis strength compared to the average of the parents as a percentage for most heterosiss and in all the traits indicates that the ability to combine was highly significant in the parents, which is passed on to their offspring. These results give the opportunity to predict the possibility of benefiting from these heterosiss directly because they possess the genes of the desired traits or introducing them into repeated selection programs to increase the frequency of certain desired genes to obtain a new variety with desirable traits.

Keywords: Genetic parameters, heterosis vigor, bread wheat.

Introduction

Wheat cultivation in Iraq is concentrated depending on rainfall in the northern region, where rainfall is characterized by fluctuations in the amount of rainfall and irregular distribution during the growing season. Several varieties are grown in this region, characterized by low production rates. Statistics from the Central Bureau of Statistics and Science Technology 2003 indicated that the average yield in this region was about 752.4 kg/ha for the years 1993-2003. Wheat cultivation is concentrated in the region of Iraq with guaranteed rainfall. This is due to the large number of residents of these regions relying on it for food after undergoing various manufacturing processes. Its grain is characterized by flexibility and lack of elasticity due to the absence of the D chromosome group responsible for elasticity (Al-Jubouri, 2002). To ensure the availability of breeding material that plant breeders use continuously, the introduction method is one of the main sources for the continued renewal of breeding material, as this method has been adopted in all countries of the world to create new genetic structures containing high-yield genes and important qualitative traits, and the first main steps in the introduction program It is the evaluation of new genetic compositions to estimate their performance compared to local varieties. It is known that in order for the genetic composition to be acceptable to the farmer, it must be superior or its average yield should not be less than the yield of the local variety (Amiruzzam et al., 2011). The correct scientific method followed in all developed countries in agriculture, especially grain crops, is to continue the flow of new genetic compositions and to keep these compositions with the aim of any of them being an alternative to the local variety that may deteriorate due to continued cultivation for several years and the presence of genetic isolation in the resulting offspring. Also, non-superior genetic compositions can be kept to benefit from their stock of genes for other good traits other than the high yield trait, as in such cases they can be entered into a heterosisization program with local varieties to transfer the traits of resistance to diseases and insects as well as good qualitative traits. Heterosisization is one of the main sources for creating new genetic variations that can then be selected from their isolated communities in order to derive new varieties that are suitable for environmental conditions and have important economic characteristics. The first basic step in a heterosisization program is to evaluate the characteristics of the genetic structures that are used as parents in such a program. In this field, reciprocal heterosisization and factor heterosisization are important methods used in breeding, especially in the breeding of grain crops. What we really need is to develop genetic structures resulting from new unions and select heterosiss that are superior in their characteristics, by taking advantage of the phenomenon of heterosis strength that has been widely exploited in other crops. To reach an integrated program for breeding and deriving new varieties, it is necessary to estimate basic genetic parameters related to the expected genetic improvement, as well as the rate of dominance and correlation between traits and heritability, as these parameters are guides for plant breeders in using the appropriate technology to derive the new variety. This study aims to study the genetic features and heterosis strength for different traits and to identify the best heterosiss based on the deviation of the first generation heterosiss from the average of the parents and the best parents.

Materials and methods

The study was conducted in one of the farmers' fields affiliated with Kirkuk Governorate. The study included (10) genetic compositions of wheat introduced from the International Center for Agricultural Research in the Dry Areas (ICARDA) Table (1). The land was prepared by the process of smoothing and amending as needed. The experiment was irrigated with flooding according to the crop's need, and weeds were controlled manually in all seasons. As for the method of implementing the heterosisization and comparison program, in order to implement the system of half-reciprocal heterosisizations and in the second method explained by (Griffing, 1956) and to obtain the first generation heterosiss, the seeds of the ten genetic compositions (parents) were planted in the season (2022-2023) on two dates, the first on December 2 and the second on December 5, in order to ensure the largest possible number of heterosisizations. The heterosisization process was carried out in the manner explained by Poehlman (1983), as individual heterosiss were obtained between them according to the design of half-reciprocal heterosisization Diallell Mating Design (AA) Where (55) genetic combinations were obtained, consisting of the first generation heterosiss, numbering (45), in addition to the ten genetic combinations, and the seeds of the ten genetic combinations and their individual heterosiss were planted on December 2 of the season (2023 - 2024) in separate panels with four lines for each genetic combination, where the length of the line was 2.5 m and the distance between the lines was 30 cm, and the randomized complete block design (R.C.B.D.) was used with three replicates. Urea fertilizer was added at a concentration of 45% at a rate of 20 kg nitrogen per acre in two batches, the first - at planting, and the second - before the expulsion of the spikes, and the studies were conducted on the two middle lines for each parent. The following traits were studied: number of spikelets, number of grains per spike, number of spikes per plant, weight of 100 grains, individual plant yield, biological yield, harvest index, and yield efficiency.

Genetic Statistical Analysis:

The statistical analysis of all studied traits was conducted according to the Random Complete Block Design (R.C.B.D.) with three replicates to determine the differences between the genotypes and in the manner explained by (Al-Rawi and Khalaf Allah, 1980).

The average degree of dominance (a) for each trait was estimated according to the following equation:

$$\bar{a} = \sqrt{\frac{2\sigma^2 D}{\sigma^2 A}}$$

$\bar{a}$ = zero = no dominance, 1> $\bar{a}$ >0 = partial dominance, $\bar{a}$ =1 = complete dominance, 1< $\bar{a}$ = super dominance

The inheritance rate was estimated in the broad and narrow sense based on the following equations:

$$H^2(b.s) = \frac{\sigma^2 G}{\sigma^2 p}$$

$$H^2(n.s) = \frac{\sigma^2 A}{\sigma^2 p}$$

Whereas:

h^2_{bs} = Broad sense heritability

h^2_{ns} = Narrow sense heritability

Broad sense heritability was estimated according to the method of Hanson et al. (1956) and based on the ranges explained by Ali (1999), less than 40% is low, 40-60% is medium, and more than 60% is high. The limits of narrow sense heritability values provided by Al-Adhari (1987) were adopted as follows: less than 20% is low, 20-50% is medium, and more than 50% is high.

According to the expected genetic improvement of traits from the following equation: -

$$\Delta G = h^2.n.si\sigma p$$

Where:

$h^2.n.s$ = Narrow sense heritability

i = Selection intensity 10% with a value of 1.76

$\sigma 2p$ = Phenotypic variance.

ΔG =Genetic improvement

The ranges indicated by Robinson et al. (1951) and Agrwal and Ahmad (1982) were adopted for the limits of expected genetic improvement, where less than 10% was considered low, 10% - 30% was considered medium, and more than 30% was considered high.

Heterosis:

The heterosis for the studied traits was estimated in two ways:

1- Based on the deviation of the mean of the first generation from the mean of the parents using the following equation:

Heterosis = mean of the first generation - mean of the parents

Where:

$$\text{Heterosis(H)} = \bar{F}1 - \frac{\bar{p}i + \bar{p}j}{2}$$

$\overline{F_1}$ = Mean of the first generation.

$\overline{pi}$ = Mean of the first sire.

$\overline{pj}$ = Mean of the second sire.

The significance of the Heterosis was tested by calculating the t value for each heterosis, as follows:

$$t = \frac{H}{\sqrt{V(H)}}$$

$$\text{V(H)} = (3/2)\frac{\sigma_e^2}{\text{r}}$$

Environmental variation $\sigma_e^2 = \text{mse}$

2- Based on the deviation of the average of the first generation from the best parents, as follows:

$$H = \bar{F}1 - \bar{P}$$

The significance of heterosis vigor was tested by calculating the t-value for each heterosis, as follows:

$$\text{V(H)} = 2\frac{\sigma_e^2}{\text{r}} \quad t = \frac{H}{\sqrt{V(H)}}$$

The ready-made computer programs Microsoft Excel, SAS and Minitab were used to conduct statistical and genetic analyses.

Results and Discussion

The results of the analysis of variance shown in Table (2) show that the mean squares of (parents) and (heterosiss) and (parents and heterosiss) and (genotypes and parents and parents against heterosiss and heterosiss) were significant at the probability level (1%) for all the studied traits under study except for the number of spikelets, harvest index and yield efficiency, and parents against heterosiss for the weight of 1000 grains and individual plant yield, that there are clear differences between the genetic structures under study by having different genes for the traits that were studied, and this allows us to have these data to conduct genetic analysis of these traits to know the genes that control them, and to estimate the components of genetic variance and choose the best parents and heterosiss for breeding and improvement programs. Other researchers have obtained significant differences between the genetic structures that were tested by them, such as Hasan and Abdullah, (2020) and Hasan et al., (2022) and Muhammad et al., (2021) and Younis et al., (2022). Genetic parameters: Table (3) shows estimates of the degree of dominance and heritability in the broad and narrow sense and the expected genetic improvement for all the studied traits, as the values for all traits showed no dominance except for the number of grains/spike, harvest index and yield efficiency. It is also noted that all traits had a high degree of heritability in the broad and narrow senses. The reason for the high heritability values for the above-mentioned traits is due to the high values of genetic variance compared to environmental variance. It was also found that the values of the expected genetic improvement for the studied traits were low in all traits except for the number of spikelets, individual plant yield and biological yield, which were average. The expected genetic improvement in grain yield results from increasing one or more of the main components of the yield because it results from the product of these components that form it (Baktash et al., 2000). These results are consistent with what many researchers have found, including Al-Karkhi (2015), Hasan and Abdullah, (2020), Hasan et al., (2022), and Muhammad et al. (2021) and Younis et al., (2022).

Heterosis

heterosis from the average of the parents as a percentage

Table (4) shows the estimate of the heterosis of the first generation heterosiss for the studied traits from the average of the parents. It is noted that the trait of the number of spikelets, the heterosis ranged as a percentage from (10.61%) in the heterosis (3×10) to (1.99%) in the heterosis (2×8) in the desired direction at a probability level of (1%), and from (-15.29%) in the heterosis (5×6) to (-2.79%) in the heterosis (2×6) in the undesired direction at a probability level of (1%), and reached (1.96%) in the heterosis (1×7) at a probability level of (5%) in the desired direction, and the other positive and negative values did not reach the level of significance in the rest of the heterosiss.

In the trait of number of grains/spike, the heterosis strength ranged as a percentage from (19.43%) in the heterosis (3×4) to (2.68%) in the heterosis (4×10) in the desired direction at a probability level of (1%), and from (-25.65%) in the heterosis (8×10) to (-2.08%) in the heterosis (2×9) in the undesirable direction at a probability level of (1%), and reached (-2.42%) in the heterosis (1×4) at a probability level of (5%) in the undesirable direction, and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. For the number of spikes trait, the heterosis strength ranged as a percentage from (55.37%) in the heterosis (4×7) to (5.27%) in the heterosis (1×4) in the desired direction at a probability level of (1%), and from (-41.7%) in the heterosis (3×8) to) -9.39%) in the heterosis (2×8) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. As for the 1000-grain weight trait, the heterosis strength as a percentage was from (23.49%) in the heterosis (3×5) to (2.44%) in the heterosis (4×9) in the desired direction at a probability level of (1%), and from (-25.92%) in the heterosis (4×8) to) -2.74%) in the heterosis (8×10) in the undesirable direction at a probability level of (1%), and reached (2.40%) in the heterosis (3×6) at a probability level of (5%) in the desired direction, and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. While in the trait of individual plant yield, the heterosis strength as a percentage ranged from (36.79%) in the heterosis (7×8) to (2.47%) in the heterosis (5×7) in the desired direction at a probability level of (1%), and from (-23.8%) in the heterosis (4×7) to) -2.81%) in the heterosis (7×10) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. As for the biological yield, the heterosis strength as a percentage was from (29.34%) in the heterosis (2×6) to (3.44%) in the heterosis (3×7) in the desired direction at a probability level of (1%), and from (-32.22%) in the heterosis (4×8) to -4.6%) in the heterosis (5×8) in the undesirable direction at a probability level of (1%), and reached (2.51%) in the heterosis (6×10) at a probability level of (5%) in the desired direction, and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. In the harvest index trait, the heterosis strength ranged as a percentage from (36.08%) in the heterosis (3×10) to (2.83%) in the heterosis (3×9) in the desired direction at a probability level of (1%), and from (-21.81%) in the heterosis (2×10) to) -2.85%) in the heterosis (1×9) in the undesirable direction at a probability level of (1%), and reached (-2.43%) in the heterosis (3×4) and (-2.10%) in the heterosis (6×8) at a probability level of (5%) in the undesirable direction and reached (2.12%) in the heterosis (8×9) at a probability level of (5%) in the desired direction, and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. As for the efficiency of the product, the heterosis strength as a percentage was from (98.72%) in the heterosis (2×7) to (4.32%) in the heterosis (3×6) in the desired direction at a probability level of (1%), and from (-46.15%) in the heterosis (2×5) to (-2.90%) in the heterosis (4×6) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the heterosiss. In light of the above results, the following is clear: The presence of a significant heterosis strength compared to the average of the parents as a percentage for most heterosiss and in all traits indicates that the ability to combine was highly significant in the parents, which is passed on to their offspring. The heterosis strength of some heterosiss was obtained based on the deviation of the average of the first generation from the average of the parents for many researchers, including Al-Fahadi (2009), Hasan and Abdullah, (2020), Hasan and others, (2022), Muhammad and others, (2021), and Younis and others, (2022).

Heterosis based on the average deviation of the first generation hybrids of the half-crosses from the best parents as a percentage: -

Table (5) shows estimates of the heterosis of the first generation hybrids from the best parents as a percentage. It is noted that the trait of the number of spikelets, the heterosis ranged as a percentage from (9.45%) in the heterosis(1×10) to (3.43%) in the heterosis (7×8) in the desired direction at a probability level of (1%), and from (-20.30%) in the heterosis(5×9) to (-2.58%) in the heterosis(2×4) in the undesirable direction at a probability level of (1%), and reached (-2.01%) in the heterosis(1×4) and (-2.00%) in the heterosis(6×8) at a probability level of (5%) in the desired direction, and the other positive and negative values did not reach the level of significance in the rest of the hybrids.

In the trait of number of grains/spike, the heterosis ranged as a percentage from (16.15%) in the heterosis(3×4) to (2.80%) in the heterosis(3×5) in the desired direction at a probability level of (1%), and from (-25.65%) in the heterosis(8×10) to (-3.09%) in the heterosis (1×9) in the undesirable direction at a probability level of (1%), and reached (-2.07%) in the heterosis(3×10) at a probability level of (5%) in the undesirable direction, and the other positive and negative values did not reach the level of significance in the rest of the hybrids. For the number of spikes trait, the heterosis ranged as a percentage from (45.26%) in the heterosis(4×7) to (19.79%) in the heterosis(1×5) in the desired direction at a probability level of (1%), and from (-53.5%) in the heterosis(2×9) to) -2.62%) in the heterosis(5×8) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the hybrids. As for the 1000-grain weight trait, the heterosis as a percentage was from (21.98%) in the heterosis(3×5) to (4.77%) in the heterosis(1×5) in the desired direction at a probability level of (1%), and from (-30.34%) in the heterosis(1×4) to) -3.62%) in the heterosis(8×10) in the undesirable direction at a probability level of (1%), and reached (2.10%) in the heterosis(2×7) and (2.18%) in the heterosis(2×8) and (2.09%) in the heterosis(3×8) at a probability level of (5%) in the desired direction and reached (-2.45%) in the heterosis(2×3) at a probability level of (5%) in the desired direction, and the other positive and negative values did not reach the level of significance in the rest of the hybrids. While in the trait of individual plant yield, the heterosis as a percentage ranged from (24.68%) in the heterosis (7×8) to (2.95%) in the heterosis (1×4) in the desired direction at a probability level of (1%), and from (-33.1%) in the heterosis (4×7) to) -2.47%) in the heterosis (1×2) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the hybrids. As for the biological yield, the heterosis as a percentage was from (28.03%) in the heterosis(2×6) to (5.59%) in the heterosis (8×9) in the desired direction at a probability level of (1%), and from (-46.46%) in the heterosis (4×7) to) -2.46%) in the heterosis(6×10) in the undesirable direction at a probability level of (1%), and reached (2.33%) in the heterosis (3×9) at a probability level of (5%) in the desired direction and reached (-2.10%) in the heterosis (2×9) at a probability level of (5%) in the undesirable direction, and the other positive and negative values did not reach the level of significance in the rest of the hybrids. In the harvest index trait, the heterosis ranged as a percentage from (66.76%) in the heterosis (3×7) to (3.80%) in the heterosis (1×3) in the desired direction at a probability level of (1%), and from (-28.90%) in the heterosis (8×10) to (-3.12%) in the heterosis (1×8) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the hybrids.

As for the yield efficiency trait, the heterosis as a percentage ranged from (98.72%) in the heterosis (2×7) to (5.59%) in the heterosis (2×3) in the desired direction at a probability level of (1%), and from (-56.15%) in the heterosis (1×2) to (-3.21%) in the heterosis (3×6) in the undesirable direction at a probability level of (1%), and the other positive and negative values did not reach the level of significance in the rest of the hybrids. It is clear from the above: These results give the opportunity to predict the possibility of benefiting from these hybrids directly because they possess the genes for the desired traits or introducing them into repeated selection programs to increase the frequency of certain desired genes to obtain a new variety with desired traits. (Hayman, 1957), and similar results were obtained by Hasan and Abdullah, (2020) and Hasan et al., (2022) and Muhammad et al., (2021) and Younis et al., (2022).

Table (1): Strains used in the study and their source

Strains name	Genetic ratios
Site Mall	Research Center / Sulaymaniyah
Kawz	Kauz 2 \ yaco \\ Kauz \ 3 \ Ousis
Abu Ghraib	Ajeeba* Lian 12 * Mexico 24
Florica	Research Center / Sulaymaniyah
Oasis	Ousis\ Kauz \\ 4 BUC
Clack	Research Center / Sulaymaniyah
Milan	Research Center / Sulaymaniyah
Sham 6	Plo - Ruft GTOS - RHel (M12904) – IM – SM – 14 – OSK – GAP
Abaa 99	Ures \ Rows \ 3 \ Jup \ B \ S \ Ures
Hadaab	Research Center / Sulaymaniyah

Table (2) Analysis of variance for (genotypes and parents and parents against hybrids and hybrids) for the studied traits

S.O.V	d.f	Mean square M.S							
		Number of spikelets	Number of grains per spike	Number of spikes per plant	Weight of 100 grains	Individual plant yield	Biological yield	Harvest index	Yield efficiency
Replications	2	233.66	3874.42	6486.13	489.49	6021.30	48395.84	0.1958	0.00789
Genetic Structures	54	ns 5.81	**53.33	**102.43	**42.25	**75.21	**856.90	ns0.0042	ns0.00023
Parents	9	ns 7.60	**44.71	**94.58	*25.66	**68.65	**853.28	ns0.0056	ns0.00016
Parents vs. Hybrids	1	ns12.67	*42.12	**199.82	ns10.32	ns10.16	**4118.78	ns0.0009	ns0.0000011
Hybrids	44	ns 5.29	**55.34	**101.83	**46.37	**78.03	**783.50	ns0.0040	ns0.00025
Experimental error	108	2.01	28.57	43.45	4.02	59.57	407.94	0.0013	0.00011

Table (3) Genetic parameters of the studied traits

Prosperities Parents	Number of spikelets	Number of grains per spike	Number of spikes per plant	Weight of 100 grains	Individual plant yield	Biological yield	Harvest index	Yield efficiency
Â	0.242	138.664	0.168	0.177	0.103	0.082	26.979	84.158
$_{n.s}H^2$	0.764	0.445	0.498	0.660	0.604	0.403	0.508	0.557
$_{B.s}H^2$	0.930	0.811	0.856	0.970	0.818	0.819	0.884	0.852
GA	12.934	0.01	8.81	7.80	11.14	19.48	0.06	0.016

Table (4) heterosis based on the deviation of the average of the first generation hybrids of the half-crosses from the average of the parents as a percentage.

Prosperities Hybrid	Number of spikelets	Number of grains per spike	Number of spikes per plant	Weight of 100 grains	Individual plant yield	Biological yield	Harvest index	Yield efficiency
2×1	**-4.44	**-8.30	**21	**-6.44	**5.27	**-11.14	**-3.41	**-52.22
3×1	0.88	**-10.58	**-36.2	**3.06	**-21.1	**-29.88	**4.80	**-22.97
4×1	**-4.73	*-2.42	**5.27	**-23.96	**8.32	**-21.06	**14.28	**73.42
5×1	0.90	**-2.79	**19.79	**5.24	**-20.4	**-14.86	**-18.01	**-25.64
6×1	**-3.88	**17.41	**25.8	**10.04	0.23	**-10.23	0.94	**-20.57
7×1	*1.96	**-5.49	**-27.3	**-11.05	**-5.01	**-16.13	**-7.31	**-18.09
8×1	**-3.39	0.48	**-4.32	**5.51	**14.91	**-5.92	**7.35	**20.24
9×1	**-11.63	1.00	**-13.5	**-5.93	-14.1	**-7.75	**-2.85	**-25.89
10×1	**10.63	1.06	**-12.3	**-5.03	**-2.97	**-8.19	**11.45	**15.18
3×2	**-11.69	**-12.70	**27.15	0.45	**-4.97	**12.26	**-16.10	**15.12
4×2	**4.30	**-7.43	**26.92	-0.12	**11.52	**-19.96	**12.55	**19.56
5×2	**3.75	**-7.74	**26.09	**15.13	**-17.9	**-29.58	**-12	**-46.15
6×2	**-2.79	**-12.66	**31.36	**20.81	**12.46	**29.34	**-7.5	**23.9
7×2	**3.62	**-8.24	**-10	**7.52	**21.52	1.17	**-5.57	**98.72
8×2	**1.99	**-12.43	**-9.39	**4.46	**4.04	**-8.89	**-16.60	**-24.23
9×2	**-4.88	**-2.08	**-39.7	**3.06	**19.59	0.30	0.84	**-25.09
10×2	**-13.48	-1.09	**-14	-1.69	-1.1	**4.95	**-21.81	**-33.52
4×3	0.57	**19.43	**25.27	**-22.46	**-13.1	**-21.42	*-2.43	**56.08
5×3	**-7.87	**2.80	**37.74	**23.49	**-15.1	**-6.26	**-20.53	**-7.66
6×3	1.44	**-10.62	**-7.19	*2.40	**5.28	**-8.52	**3.73	**4.32
7×3	-0.44	**-2.95	**-25.8	**11.2	**15.08	**3.44	**25.60	**98.41
8×3	**-8.75	**-17.84	**-41.7	**7.41	**16.51	**21.64	**-21.03	**70.84
9×3	**-9.16	**8.17	**-11.4	**-8.36	**13.75	**7.98	**2.83	**27.16
10×3	**10.61	-0.35	**-9.42	**17.4	1.28	**-27.84	**36.08	**7.5
5×4	0.87	**5.11	**-45.8	**-11	**-6.86	**-29.93	1.36	**-38.25
6×4	-1.73	1.42	**-29.8	**-9.69	**-13.1	**-23.99	**-11.00	**-2.90
7×4	**-5.43	**-4.06	**55.37	**-17.29	**-23.8	**-36.65	0	**-22.75
8×4	**3.58	**12.60	**-18.8	**-25.92	**-23	**-32.22	**-17.54	**-43.5
9×4	**-12.66	**11.79	**-11.2	**2.44	**7.63	**-22.30	**13.04	**-19.93
10×4	**-4.93	**2.68	**-33	**-11.57	**-10.2	**-28.67	**5.82	**-31.19
6×5	**-15.29	**-4.43	**-28.2	**9.08	-0.23	-0.61	**-14.03	**22.09
7×5	-0.74	**9.57	1.07	**-12.7	**2.47	**-24.35	**-9.50	**-14.78
8×5	**-9.75	**-19.62	**-2.62	-0.39	**5.60	**-4.6	**-13.36	**-19.94
9×5	**-14.20	-0.98	**-35.4	**8.93	**-11.2	**-18.64	0	**-10.4
10×5	**-4.09	**-3.07	**-6.11	**4.10	**3.68	**-18.36	**10.57	**16.16
7×6	**2.51	**5.59	**-18.4	**11.49	-0.24	**-22.15	**4.26	**12.17
8×6	-1.01	-1.49	**-28.7	**-5.17	**17.65	**-7.74	*-2.10	**9.34
9×6	**-7.88	**-2.17	**13.89	**-13.74	**27.87	**13.36	**-2.77	**-18.83
10×6	**-2.86	**-11.40	**-30.6	**-17.1	**20.72	*2.51	**6.06	**-16.8
8×7	**5.86	-1.58	**-40.5	**-11.5	**36.79	**10.12	**-8.69	**33.62
9×7	**-5.36	**10.28	**-15.8	**12.24	**24.37	**13.21	**11.00	**61.37
10×7	**-4.89	**-11.92	**-24.6	**-14.43	**-2.81	**-28.37	**21.46	**5.72
9×8	**-7.40	**-14.00	**-44.5	**-4.72	**5.12	**8.01	*2.12	**-18.59
10×8	-1.19	**-25.65	**-29.9	**-2.74	**-9.25	**-10.44	**-16.12	**-38.29
10×9	**-4.61	**5.97	**-13.9	**-6.91	**7.81	**21.02	**3.06	**-22.14
S.E(H)	**1.00**	**3.77**	**4.66**	**1.41**	**5.45**	**14.28**	**0.026**	**0.0077**

(**) and (*) are significant at 1% and 5% probability levels, respectively.

Table (5) heterosis based on the average deviation of the first generation hybrids of the half-crosses from the best parents as a percentage.

Prosperities Hybrid	Number of spikelets	Number of grains per spike	Number of spikes per plant	Weight of 100 grains	Individual plant yield	Biological yield	Harvest index	Yield efficiency
2×1	**-8.23	**-19.05	**19.03	**-7.63	**-2.47	**-15.45	**-13.74	**-56.15
3×1	*-2.01	**-16.44	**-46.1	1.35	**-23.4	**-31.27	**3.80	**-22.92
4×1	**-7.47	**-6.361	**-4.97	**-30.34	**2.95	**-28.91	**12.62	**57.42
5×1	-0.59	**-10.77	**10.42	**4.77	**-22.7	**-19.44	**-23.52	**-40.39
6×1	**-5.84	**15.08	**11.79	**9.00	**-8.92	**-15.40	-1.83	**-13.92
7×1	1.20	**-12.01	**-38.2	**-14.49	**-20.1	**-21.94	**-6.86	**-31.19
8×1	**-6.30	**-7.74	**-22.2	1.93	**5.11	**-10.62	**-3.12	**10.41
9×1	**-19.03	**-3.09	**-34.1	**-6.09	**-17.9	**-14.22	**-4.67	**-40.66
10×1	**9.45	**-7.07	**-29.2	**-9.06	**-9.92	**-9.10	**3.88	**7.96
3×2	**-17.52	**-17.89	**8.90	*-2.45	**-9.44	**8.92	**-24.42	**5.593
4×2	**-2.58	**-15.17	**16.29	**-7.41	**8.54	**-31.02	-0.76	**18.12
5×2	-1.77	**-11.63	**18.02	**13.16	**-26	**-36.42	**-16.03	**-53.63
6×2	**-8.47	**-21.51	**18.45	**18.16	**10.13	**28.03	**-15.26	**22.37
7×2	-1.20	**-13.38	**-22.4	*2.10	**9.39	**-1.16	**-16.03	**55.82
8×2	**-4.87	**-16.14	**-25.3	*2.18	**2.62	-9.05	**-17.55	**-24.27
9×2	**-15.98	**-10.25	**-53.5	1.93	**15.77	*-2.10	**-8.39	**-35.59
10×2	**-16.04	**-5.41	**-29.7	**-4.69	-1.32	0.82	**-34.35	**-35.01
4×3	0.574	**16.15	**16.28	**-30.04	**-15	**-30.48	**-4.76	**41.59
5×3	**-9.19	0.86	**25.19	**21.98	**-19.9	**-12.97	**-15.23	**-26.01
6×3	0.57	**-14.87	**-12.4	1.65	-1.65	**-12.10	**5.71	**-3.211
7×3	**-2.58	**-3.32	**-25.2	**13.85	-0.74	-1.87	**23.81	**66.76
8×3	**-8.62	**-19.38	**-44.4	*2.09	**9.58	**17.83	**-28.12	**56.77
9×3	**-14.46	**5.22	**-22.1	**-10.04	**11.91	*2.33	**3.80	1.77
10×3	**6.32	*-2.07	**-14.4	**10.63	**-3.28	**-28.58	**25.71	0.70
5×4	-0.57	0.34	**-47.1	**-18.8	**-13.9	**-33.51	**-6.72	**-46.28
6×4	**-2.58	-0.73	**-31	**-17.98	**-17.2	**-35.05	**-14.67	**-5.24
7×4	**-7.47	**-7.04	**45.26	**-26.89	**-33.1	**-46.46	-0.98	**-39.96
8×4	**3.73	**7.52	**-27.8	**-29.89	**-26	**-41.67	**-26.56	**-44.21
9×4	**-6.89	**11.76	**-26.8	**-5.99	**7.03	**-34.4	**9.34	**-30.43
10×4	**-19.28	-1.81	**-41	**-15.58	**-12.4	**-36.32	0	**-33.52
6×5	**-15.78	**-10.61	**-31	**8.53	**-11.7	**-11.06	**-17.64	**4.039
7×5	-1.47	**7.91	**-7.49	**-15.71	**-15.8	**-33.10	**-15.96	**-39.9
8×5	**-11.17	**-19.64	**-15.1	**-4.19	**-5.95	**-13.98	**-16.40	**-31.1
9×5	**-20.30	**-5.45	**-47.7	**8.25	**-17.5	**-28.11	**-5.04	**-10.26
10×5	**-6.50	**-3.24	**-18.9	-0.74	**-6.34	**-23.48	**-3.36	-1.85
7×6	1.16	0.19	**-22.4	**8.16	**-8.46	**-23.18	0.91	**-11.24
8×6	*-2.00	**-7.85	**-35.6	**-9.22	**16.78	**-8.52	**-9.37	**8.063
9×6	**-13.95	**-4.27	**-4.7	**-14.71	**21.3	**15.02	**-3.66	**-30.92
10×6	**-5.84	**-17	**-37.8	**-21.33	**17.95	**-2.46	**-3.66	**-17.66
8×7	**3.43	**-3.05	**-43.7	**-17.7	**24.68	**7.76	**-17.9	**4.81
9×7	**-12.69	**6.87	**-26.5	**7.71	**8.79	**13.33	**8.41	**13.69
10×7	**-6.60	**-13.11	**-29.2	**-21.09	**-12.7	**-32.71	**13.72	**-15.69
9×8	**-12.69	**-17.87	**-49.1	**-7.80	0.42	**5.59	**-6.25	**-30.03
10×8	**-5.15	**-25.76	**-30.6	**-3.62	**-10.7	**-14.10	**-28.90	**-39.64
10×9	**-13.45	1.35	**-20.3	**-10.71	**4.60	**13.58	**-5.60	**-34.3
S.E(H)	**1.15**	**4.36**	**5.38**	**1.63**	**6.30**	**16.49**	**0.030**	**0.0089**

References

1. Al-Jubouri, Ahmed Hawas Abdullah (2002). Reciprocal hybridization of some bread varieties (Triticum aestivum L.) and its effect on grain yield and its components and the incidence of

wheat wart nematode (Anguina tritici). Master's thesis, Department of Field Crops, College of Agriculture, Tikrit University.

2. Al-Rawi, Khashe' Mahmoud and Abdul Aziz Khalaf Allah (1980). Design and analysis of agricultural experiments. Ministry of Higher Education and Scientific Research. University of Mosul.
3. Al-Athari, Adnan Hassan Mohammed (1987). Fundamentals of Genetics. Second edition. Directorate of Dar Al-Kutub for Printing and Publishing. University of Mosul.
4. Ali, Abdo Al-Kamil Abdullah (1999). Hybrid vigor and gene action in yellow corn. PhD thesis. Department of Crops. College of Agriculture and Forestry. University of Mosul.
5. Al-Fahadi, Muhammad Yousef Hamid (2009) Inheritance of some traits in broad beans (Vicia faba L.). Jordanian Journal of Agricultural Research. 5(4): 507-518.
6. Abdullah, R.M., Hasan, S.A. (2021) . Estimation of components of genetic variance using Jinks-Hayman method analysis on the crop of faba bean (Vicia faba L.) . Int. J. Agricult. Stat. Sci. 16(1); pp. 1897-1903 .
7. Agarwal , V. and Z. Ahmad, . (1982) . Heritability and genetic advance in triticale . Indian J. Agric. Res. 16: 19-23.
8. Amiruzzam , M. ; M. A .Islam; K.V. Pixley and M. M. Rohman (2011). Heteroises and combining ability of cimmyt tropical × subtropical quality protein maize germplasm. International of Sustainable Agric, 3(3):76-81.
9. Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. of Bio. Sci. 9: 463-493.
10. Hasan, S.A., Abdullah, R.M.. (2020) Estimating the performance and gene action of a number of individual genotypes and hybrids on the crop of faba bean (Vicia faba L.) . Plant Archives Volume 20 No. 2, pp. 8981-8988.
11. Hasan, SA Abdullah, RM Hanoon, MB. (2022)Effect of foliar application with proline on growth, yield, and quality of faba bean (Vicia Faba L.) (A review) . European Journal of Agricultural a nd Rural Education (EJARE). Vol. 3 No. 3, March 2022 ISSN: 2660-5643.
12. Muhammad, NI. Humada, YH. Abdullah, RM (2021). Using phenotypic and molecular indicators RAPD-PCR to evaluate the performance and genetic dimension of a number of genotypes and their individual hybrids in the chickpea plant Cicer arietinum L. . NVEO-NATURAL VOLATILES & ESSENTIAL OILS Journal| NVEO . Nat. Volatiles & Essent. Oils, 2021; 8(4): 11786-11810.
13. Poehlman , J. M. (1983) . Breeding field crops . A.V.I. Publishing Company inc. 2nd , pp:486 . Robinson , H . F . R .E comstock and P . H Harvey . (1951) . Genotypic and Phenotypic correlations in Corn and their implications in Selection Agron . J , 43 , 282-289.
14. Younis, H. S. Abdul Sattar, A. A. and Amer K. Z. Abdullah, R.M. Hassan, A. S. (2022) Effect of biological and cultivar control to Ear- Cockle Nematode disease caused by the nematode (Anguina tritici) on different genotypes of bread wheat (Triticum aestivum L.) Annals of Forest Research .65(1): 916-930, 2022.