Determining Genetic Parameters for Some yield traits for Sunflower (*Helianthus annuus* L.)

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ABSTRACT

In the spring season (2014), six inbreds of sunflower (C, Q, F, I, E and A) were introduced in full diallel cross to obtain 15 single hybrids and 15 reciprocal hybrids. The seeds of genotypes (parents and single and reciprocal hybrids) were cultivated in a control experiment using the Randomized Complete Block Design (RCBD), with three replicates in the fields of a farmer in Al-Kifl district, south of Babylon province during the autumn season (2014). The data were taken for the traits of a number of seeds in the disc, the weight of 100 seeds, the seed yield of the plant, the percentage of oil in the seeds and the oil yield in the plant in order to study the additive and dominance genetic variance and average degree of dominance and the percentage of heritability in the broad and narrow sense. The average of square genotypes (parents and diallel and reciprocal crosses) were significant at a probability of 1% for all studied traits. The $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios were less than one for all traits. The average degree of dominance for diallel hybrids (ā) and the reciprocal hybrids (ā-r) was greater than one in all studied traits. The values of broad-sense heritability were high for all traits, while its value in the narrow sense is high in reciprocal hybrids for the trait of the weight of 100 seeds and medium in their reciprocal hybrids, and low in diallel hybrids and medium in reciprocal hybrids for the number of seeds in the disc and the percentage of oil. As for the rest of the traits were low in its diallel and reciprocal hybrids.

تقدير المعلمات الوراثية لبعض صفات الحاصل لزهرة الشمس (*Helianthus annuus L.*)

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الخلاصة

في الموسم الربيعي (2014) تم إدخال ست سلالات من زهرة الشمس (C ، Q ، F ، I ، E و A) في تهجين تبادلي كامل للحصول على 15 هجين فردي و 15 هجين عكسي. زرعت بذور التراكيب الوراثية (الآباء والهجن الفردية والعكسية) في تجربة مقارنة باستخدام تصميم القطاعات العشوائية الكاملة (R.C.B.D) بثلاثة مكررات في حقول احد المزارعين في ناحية الكفل الواقع جنوب محافظة بابل خلال الموسم الخريفي (2014) وأخذت البيانات لصفات عدد لبذور في القرص، وزن 100 بذرة، حاصل البذور بالنبات، نسبة الزيت في البذور وحاصل الزيت في النبات وذلك لدراسة التباين الوراثي المضيف والسيادي ومعدل درجة السيادة ونسبة التوريث بالمعنى الواسع والضيق. كان متوسط مربعات التراكيب الوراثية (الآباء + التضريبات التبادلية والعكسية) معنويا عند

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احتمال 1% لجميع الصفات المدروسة. كانت نسبة σ^2gca /σ^2sca ونسبة σ^2gca /σ^2rca اقل من واحد لجميع الصفات. كان معدل درجة السيادة للهجن التبادلية ā وللهجن العكسية ā-r اكبر من واحد في جميع الصفات المدروسة. قيم التوريث بالمعنى الواسع كانت عالية لجميع الصفات. بينما قيمته بالمعنى الضيق عالية في الهجن العكسية لصفة وزن 100 بذرة ومتوسطة في هجنها العكسية، وواطئة في الهجن التبادلية ومتوسطة في الهجن العكسية لعدد البذور في القرص ونسبة الزيت، أما بقية الصفات فكانت واطئة في هجنها التبادلية والعكسية.

1. INTRODUCTION

Sunflower (*Helianthus annus* L.) is from the Asteraceae family plant. Its oil is known to contain a high percentage of linoleic acid up to 62%, oleic acid 2.25%, and palmitic acid up to 4.6%, but there are cultivars of sunflower contain a high percentage of oleic acid up to 80% and are known high oleic cultivars, and tocopherols in its oil reach to 533 mg.kg^{-1}) (Lampi and Kamal-Eldin, 1998). Sunflower oil is used in nutrition as well as in the industry where it comes after soybeans in terms of importance. The cultivated area of this crop has increased as a result of the significant increase in the hybrids derived from it in some countries and this crop remains the top priority in oil production in the world. The global cultivated area amounted to (26.21 ha), with an average production of (18067 tons.ha^{-1}) from seed yield for 2016, while the cultivated area amounted to (25256155 ha) with an average yield of (16861 tons.ha^{-1}) of seed yield for 2014 (FAO STAT Database, 2016, 2013). It is noted from these statistics that the increase in the vertical direction exceeded the increase in the horizontal direction, this indicates the role of plant improvement in the production of genotypes with high productivity, thus increasing the yield per unit area in addition to the development of machinery and inputs serving crops, The increase in sunflower yield came as the result of its introduction in breeding programs, where the production of one hectare amounted to (5.412 tons.ha^{-1}) (Mijic et al., 2011). In Iraq, the cultivated area of this crop amounted to (845 ha), with an average production of (2156.4 kg.ha^{-1}) from the seed yield for 2014, while the cultivated area amounted to (453.25 ha), with an average production of (1765.2 tons.ha^{-1}) from the seed yield for 2015 (Agricultural Statistics Directorate, 2014, 2015). The gradual decline in sunflower yield must be countered through producing high-yield hybrids using one methods of plant breeding and improvement, including crossing between inbreds or cultivars according to the first method of (Griffing, 1956) and studying the general combining ability for parents which is useful in evaluating inbreds and determining their viability and validity in producing superior economic hybrids obtained when crossing it with other

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genotypes. It is also evidence of additive genetic variance and when the presence of superiority, it will include genetic variances, positively correlate with the degree of heritability in the narrow sense, and useful in selecting new genotypes for producing hybrids, The specific combining ability is useful for better hybrids and it is considered evidence on dominance variance. This leads to producing hybrids suitable to the conditions of the region, with responsive to planting dates and inputs of crop service as well as the optimal use for water. Therefore, hybrids were derived from crossing several inbreds genetically diversity to obtain one or more hybrids with high productivity and then estimating some of the genetic parameters such as degree of heritability and the average degree of dominance to benefit from them in knowing the best breeding method in improving the various traits in sunflower. The $\frac{\sigma^2 gca}{\sigma^2 sca}$ ratio determines the additive and non-additive gene effects, which include dominance, overdominance, and epistasis. If the values of general and specific combining ability are insignificant, they indicate the effect of the genes of Epistasis (Fehr, 1993). Chandra et al., (2011); Dudhe et al., (2011); Ciric et al., (2013); Kang et al., (2013); Imran et al., (2014); Qamar, (2015) stated that the $\frac{\sigma^2 gca}{\sigma^2 sca}$ ratio is less than one for the traits of the diameter of the disc, and the trait is under the additive and non-additive gene effects. The percentage of heritability is the heritability degree of the quantitative trait from the selected parents to the resulted sons, the amount of the qualitative trait from generation to generation, the degree of similarity in the trait between the parents and the sons, or the percentage of heritability to the total variance for the trait (AL-Shahery, 1990). Miller et al., (1987) mentioned that studying the heritability in the quantitative traits is necessary to know how many variances in traits were inherited to the next generation. Estimating the percentage of heritability is important because it is considered from a characteristic of plant populations and gives an expression of gene frequency in the population, (Syed et al., 2004). The average degree of dominance is the ratio between the dominance genetic variance to the additive genetic variance, through which it is possible to know the type of genes that controlling traits, thus determine the most appropriate breeding method to improve them, this means determining the genetic action that controls the studied trait. The research aims to derive a hybrids from crossing several inbreds genetically diversity to obtain one or more hybrids with high productivity, estimating specific and general combining ability for hybrids, knowing the genetic action that controls the trait through segmenting the

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genetic variance into its components using full diallel cross (Griffing, 1956b), and estimating some of the genetic parameters such as degree of heritability and the average degree of dominance to benefit from them in knowing the best breeding method in improving the various traits in sunflower.

2. MATERIALS AND METHODS

In this research, six inbreds of sunflower were used in the seventh generation from the self-cross, which their source from genetic origins obtained from Abu Ghraib Research Station, the General Company for Oil Crops Research and the Directorate of Agriculture in Babylon, Agricultural Supplies, as shown in Table (1).

Table 1: Name of inbred, Genetic Origin and Country of Origin.

Symbol	Symbol of inbred	Genetic Origin	Country of Origin
C	CO3L7Q3	Coban	Turkish
Q	QU4K2G2	Quds	Iraqi
F	FL1H1G1	Flamme	Turkish
I	IR1K3G1	Zahrat AL-Iraq	Iraqi
E	EUF7L5G1	EuroFlore	French
A	ARG5L1Q1	Argensun	Argentine

The research was conducted in the Al-Jaziriya region belonging to Al-Kifl district, south of Babylon province, in the spring and autumn seasons (2014). The parents and diallel hybrids were cultivated on furrows with a length of (5 m), the distance between furrow and another is (0.20 m) to obtain a plant density of (66666 plants.ha^{-1}), cultivating was conducted in the two seasons according to this method. During the spring season, the seeds of the six inbreds were cultivated on 21/2/2014. All crop service operations (irrigation, weeding, and fertilization) were conducted according to the recommendations for sunflower cultivation (El-sahookie and El-taweel, 2001). The mother plant was sprayed with Gibberellic Acid (GA3) at a concentration of (100 PPM) at the beginning of the appearance of flower buds and arriving their diameters to (4-2 cm) and the process was repeated after 48 hours from the first spraying (Al-Jubouri et al., 1990). The flowers of the parents and mothers were wrapped before the flowers opened with a gauze cloth. Full diallel crosses were conducted between the inbreds understudy, self-cross for the inbreds were conducted according to the first Griffing method. At the end of the season, 36 genotypes, including parents, were obtained. The plant discs (hybrids and parents) were harvested individually and their seeds were manually separated and dried. In the autumn 2014 season, a control experiment was applied in this season, which included the

ISSN 2072-3875

cultivation of 15 seeds of single and reciprocal hybrids and the seeds of the parents which amounted to six inbreds. Cultivating was conducted on 20/7/2014 according to the Randomized Complete Block Design (RCBD), with three replicates, at the rate of three furrows for each genotype without a barrier, with the cultivating one line at the beginning and end of each replicate as guard plants and all crop service operations (irrigation, fertilization, and weeding) were conducted as recommended. Ten plants from each treatment (genotype) were randomly selected to take the data of traits under study. The discs are then encapsulated for these plants when pollination and fertilization are complete to protect them from birds. When the plants reached full maturity (the back of the discs turned yellow and the outer bracts began colored with brown color), The discs of the plants were harvested from which the measurements of the previous field traits were taken, their seeds were then separated by hand. The seeds of each disc were placed individually in a paper bag and conducted on it the study of the yield and its components and other measurements, which included:

a) The average number of seeds per disc.
b) Weight of 100 seed (g)
c) The average seed yield (g.plant^{-1})
d) The percentage of Oil in seeds (%).
e) Oil yield (g.plant^{-1}), it was estimated by the following formula:

$$\text{Oil yield (g.plant}^{-1}\text{)} = \frac{\text{The percentage of Oil in seeds (\%)} \times \text{Oil yield (g.plant}^{-1}\text{)}}{100}$$

Statistical analysis and estimating the genetic parameters:

Statistical analysis was conducted for each trait for the data of genotype (parents and single and reciprocal hybrids) using the RBCD design, with three replicates using the GenStat Statistical Analysis Program. The arithmetic averages of the traits were tested using the least significant difference at the probability level of 1 %. Special data were analyzed statistically according to the design method of the full diallel cross, which proposed by Griffing (1956b) according to the first method (Method1) fixed model. Singh and Chaudhary, (2007) explained it for each trait of studied traits according to the following mathematical model equation:

$$Yij = \mu + g_i + g_j + s_{ij} + r_{ij} + \sum\sum eijk$$

Yij = Genotype value. , μ = general average for the community.

g_i = effect of the general combining ability for parents i, g_j = effect of the general combining ability for parents j.

ISSN 2072-3875

s_{ij} = the effect of the specific combining ability single hybrids, r_{ij} = the effect of the specific combining ability reciprocal hybrids.

∑∑eijk = The average value of the experimental error.

The average variance of the experimental error was divided by the number of replicates to obtain the experimental error variance for axis, which is symbolized by $\bar{M}se$.

$$\bar{M}se = \frac{Mse}{r}$$

The variance of each general combining ability **(σ2gca)** and specific combining ability **(σ^2sca)** for single hybrids and the variance of specific combining ability reciprocal hybrids (***σ^2rca***) were conducted as explained by (Singh and Chaudhary, 2007) according to the first method (the first fixed model).

The variance of general combining ability **(σ2gca),** $\sigma^2 gca = (MSgca - \bar{M}se)/2n$

The variance of specific combining ability for single hybrids **(σ2gca),** $\sigma^2 sca = MSsca - \bar{M}se$

The variance of specific combining ability for reciprocal hybrids (***σ^2rca***), $\sigma^2 rca = (MSrca - \bar{M}se)/2$

The variance ratio $\sigma^2 gca/\sigma^2 sca$

The variance ratio $\sigma^2 gca/\sigma^2 rca$

The variance effect of general ($\sigma^2 \hat{g}_{ii}$) and specific ($\sigma^2 \hat{s}_{ij}$) combining ability and the reciprocal effect ($\sigma^2 \hat{r}_{ij}$)

The variance effect of general ($\sigma^2 \hat{g}_{ii}$) combining ability for each parents: $\boldsymbol{\sigma^2 \hat{g}_{ii}} = (\hat{g}_{ii})^2 - (1/n^2 \times \bar{M}Se)$

The variance effect of specific combining ability of diallel hybrids ($\sigma^2 \hat{s}_{ij}$) for each parents

$\boldsymbol{\sigma^2 \hat{S}_{ij}} = 1/ n\text{-}2\times [\sum \hat{S}_{ij}^2 - ((n^2 - 2n + 2) / 2n^2)\times \bar{M}se]$

The variance effect of specific combining ability of reciprocal hybrids ($\sigma^2 \hat{r}_{ij}$) for each parents

$\boldsymbol{\sigma^2 \hat{r}_{ij}} = (1/ n\text{-}2)\times \Sigma\, \hat{r}_{ij}^2 - (\bar{M}se/2)$

Estimating components of Phenotypic Variance:

The additive genetic variance (***σ^2***A), the dominance genetic variance (***σ^2***D) and the environmental variance (***σ^2***E) have been estimated according to the following equations (Griffing, 1956 b):

$\boldsymbol{\sigma^2 A} = 2\sigma^2 gca$, $\boldsymbol{\sigma^2 D} = \sigma^2 sca$, $\boldsymbol{\sigma^2 E} = \bar{M}se = Mse/r$

Therefore, the genetic variation ***σ^2***G (assuming no epistasis) can be estimated as follows:

$\boldsymbol{\sigma^2 G} = \sigma^2 A + \sigma^2 D = 2\sigma^2 gca + \sigma^2 sca$

Phenotypic Variance

$\boldsymbol{\sigma^2 P} = \sigma^2 G + \sigma^2 E$

ISSN 2072-3875

Estimating the percentage of heritability:

The percentage of heritability in the broad sense ($h^2_{b.s}$) and narrow ($h^2_{n.s}$) for diallel hybrids and reciprocal hybrids were estimated according to the following treatments (singh and Chaudhary, 2007):

$\boldsymbol{h^2_{b.s.}} = (\sigma^2A + \sigma^2D)/(\sigma^2A + \sigma^2D + \sigma^2E)$.

$\boldsymbol{h^2_{b.s.r}} = (\sigma^2A + \sigma^2Dr)/(\sigma^2A + \sigma^2Dr + \sigma^2E)$.

$\boldsymbol{h^2_{n.s}} = \sigma^2A/(\sigma^2A + \sigma^2D + \sigma^2E)$. $\boldsymbol{h^2_{n.s-r}} = \sigma^2A/(\sigma^2A + \sigma^2Dr + \sigma^2E)$.

where:

$\boldsymbol{h^2_{b.s.}}$ = The percentage of heritability in the broad sense, $\boldsymbol{h^2_{n.s}}$ = The percentage of heritability in the narrow sense.

σ^2P = phenotypic Variance (genetic + environmental Variance). , σ^2A = additive genetic Variance.

σ^2D = dominance genetic variance. , σ^2G = total genetic variance (additive + dominance).

The percentage of heritability in a broad sense is considered high if it is greater than 60, medium (60-40), and low when less than 40 (Al-Edhari, 1999). While the percentage of heritability in a narrow sense is considered high if it is greater than 50%, medium (20% - 50%) and low when less than 20% (Ali, 1999).

The average degree of dominance:

The average degree of dominance for diallel hybrids (ā) and the reciprocal hybrids (ā-r) was estimated according to the following equations (singh and Chaudhary, 2007):

$\boldsymbol{a^-} = (2\sigma^2D/\sigma^2A)^{0.5}$, $\boldsymbol{a^- - r} = (2\sigma^2D.r/\sigma^2A)^{0.5}$

where:

$\mathbf{a^-}$ or $\mathbf{a^- - r}$= 0 lack of dominance.

0 > $\mathbf{a^-}$ or $\mathbf{a^- - r}$ > 1 The existence of partial dominance.

$\mathbf{a^-}$ or $\mathbf{a^- - r}$ = 1 The existence of complete dominance.

$\mathbf{a^-}$ or $\mathbf{a^- - r}$ <1 The existence of over dominance.

3. RESULTS AND DISCUSSION

Table (2) shows that there are highly significant differences between the genotypes for the studied traits.

Table 2: Analysis of variance and coefficient of variation for the studied traits.

The studied traits		M.s Repl.	M.s. Gen.	M.s.e	
	d.f.	2	35	70	**C.V**
The number of seeds in the disc		9052.98	252813.30**	5454.586	6.82%
Weight of 100 seeds (g)		0.362	4.403**	0.140	6.20%
Seed yield in the plant ($g.plant^{-1}$)		3.268	1518.217**	20.232	7.31%
The percentage of Oil (%)		15.522	78.739**	1.679	3.14%
Oil yield in the plant (g)		2.418	325.155**	4.447	8.15%

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The number of seeds per disc:

Table (3) shows that the $\frac{\sigma^2 gca}{\sigma^2 sca}$ ratio was less than one in diallel hybrids which amounted to (0.01), which indicates the importance of the action of the non-additional gene in inheriting of this trait as well as the $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratio, which was less than one also (0.16). AL-Shahery and Mohammad Ali, (2014) mentioned similar conclusions. It was also found that the variance of specific combining ability for diallel σ^2D and reciprocal σ^2D-r hybrids was greater than the variance of general combining ability. This was reflected in the average degree of dominance, which was greater than one, indicating that the trait is subject to overdominance action for gene, to the importance and greater contribution of non-additive genetic effects in inheritance of the trait. The percentage of broad-sense heritability for the diallel hybrids amounted to (98.92%) and 89.06% for reciprocal hybrids, which indicates that the genetic value for the trait was largely due to genetic influences and their effect on the environment is little. The percentage of narrow-sense heritability for the diallel hybrids amounted to (2.12%) and 21.44% for reciprocal hybrids. These results enable plant breeders to follow crossing to increase the weight of the seed in sunflower. Memon et al., (2014) mentioned similar results to these results. Pourmohammad et al., (2016) indicated to different conclusions.

Table 3: Components of combining ability and Genetic parameters for single and reciprocal crosses for the trait of Number of Seeds Per Disc.

Components of combining ability				
σ^2rca	σ^2sca	σ^2gca	σ^2A	σ^2E
11241.51	162780.43	1781.67	3563.33	1818.20
Genetic parameters for single crosses				
h^2n.s	h^2b.s	ā	σ^2D	σ^2sca/σ^2gca
2.12%	98.92%	9.56	162780.43	0.01
Genetic parameters for reciprocal crosses				
h^2n.s-r	h^2b.s-r	ā-r	σ^2D-r	σ^2gca/σ^2rca
21.44%	89.06%	2.51	11241.51	0.16

Weight of 100 seed (g):

Table (4) shows that the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios were less than one, which confirms the dominance of the non-additive-gene action for diallel and reciprocal hybrids and its importance in inheriting this trait. Kholghi et al., (2014); Qamar et al., (2015) indicated the importance of additive and non-additive effects in inheriting seed weight in sunflower. It is also noted that the variance of specific combining ability for diallel σ^2D and reciprocal σ^2D-r

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inversions hybrids is greater than the variance of general combining ability, which led to that the average degree of heritability was greater than one in both diallel and reciprocal hybrids, indicating that this trait is under the influence of overdominance for genes and to the large impact of the non-additive action, This result was confirmed by the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios, which was less than one. It is clear that the value of dominance variance σ^2D was higher than the value of additive variance σ^2A as well as that the percentage of broad-sense heritability for the diallel and reciprocal hybrids was high and amounted to (98.22%, 91.87%) for the diallel and reciprocal hybrids, respectively. As for the percentage of narrow-sense heritability for the diallel and reciprocal hybrids, it has amounted to (12.14%, 55.57%) for the diallel and reciprocal hybrids, respectively. These results agree with (Aleem et al., 2015; Yankov and Norettin, 2015).

Table 4: Components of combining ability and Genetic parameters for single and reciprocal crosses for the trait of Weight of 100 seed (g).

Components of combining ability				
σ^2rca	σ^2sca	σ^2gca	σ^2A	σ^2E
0.21	2.26	0.16	0.32	0.05
Genetic parameters for single crosses				
h^2n.s	h^2b.s	ā	σ^2D	σ^2sca/σ^2gca
12.14%	98.22%	3.77	2.26	0.07
Genetic parameters for reciprocal crosses				
h^2n.s-r	h^2b.s-r	ā-r	σ^2D-r	σ^2gca/σ^2rca
55.57%	91.87%	1.14	0.21	0.77

Seed yield in the plant (g.plant^{-1}):

Table (5) shows that the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios were less than one, which indicates the significant contribution of the non-additive action for gene and its importance in inheriting the seed yield in diallel and reciprocal hybrids. This is confirmed by (Qamar et al., 2015) in the importance of non-additive influences in inheriting plant yield in sunflower. It is also clear from the results of the same table that non-additive variance for genes is greater than the additive variance for genes, which made the degree of dominance is greater than one, which indicates that the trait is under the influence of overdominance for genes, This is confirmed by the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios were less than one. The percentage of broad-sense heritability for the diallel and reciprocal hybrids amounted

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to (99.33%, 93.26%), respectively. As for the percentage of narrow-sense heritability for the diallel and reciprocal hybrids, it has amounted to (1.73 %, 17.39%). It is noted that the difference between the two percentages of heritability in the broad and narrow sense was significant, which confirms the importance of the non-additive action for genes in the inheriting this trait. This refers to the possibility of plant breeders follow the crossing method to improve the trait in the diallel and reciprocal hybrids. The results agree with (Aleem et al., 2015; Yankov and Norettin, 2015) that the degree of heritability in the broad sense was high and in the narrow sense was low and the non-additive action for the genes was more influential in increasing plant yield in sunflower. They did not agree with (AL-Shahery and Mohammad Ali, 2014) because they obtained medium percentage of heritability in the broad and narrow sense.

Table 5: Components of combining ability and Genetic parameters for single and reciprocal crosses for the trait of Seed yield in the plant (g.plant^{-1})

Components of combining ability				
σ^2rca	σ^2sca	σ^2gca	σ^2A	σ^2E
75.87	978.59	8.69	17.39	6.74
Genetic parameters for single crosses				
h^2n.s	h^2b.s	ā	σ^2D	σ^2sca/ σ^2gca
1.73%	99.33%	10.61	978.59	0.01
Genetic parameters for reciprocal crosses				
h^2n.s-r	h^2b.s-r	ā-r	σ^2D-r	σ^2gca/σ^2rca
17.39%	93.26%	2.95	75.87	0.11

The percentage of Oil% in seeds:

Table (6) shows that the of $\frac{\sigma^2 gca}{\sigma^2 sca}$ ratio was less than one (0.07), as well as the □2rca / □2gca ratio, which amounted to 0.15, From this it is clear that non-additive action for the genes was more important than the additive action for the genes in inheriting the percentage of oil in the seeds for diallel and reciprocal hybrids, this confirms the presence of a positive and highly significant Heterosis for most diallel and reciprocal hybrids for the trait. Table (6) shows that the variance values of dominance for diallel and reciprocal hybrids were higher than the additive variance values. It is also noted that the percentage of broad-sense heritability for the diallel and reciprocal hybrids was high and amounted to (98.21% and 96.71%), respectively. As for the percentage of broad-sense heritability for the diallel and reciprocal hybrids, it has amounted to (11.88% and 21.88%), respectively. The average degree of dominance was higher than one in both diallel and reciprocal hybrids which amounted to

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(3.81, 2.62), respectively. In other words, the overdominance for genes influences the percentage of oil content in sunflower seeds. We conclude from the above that the percentage of oil content in the seeds is subject to the non-additive effect for the genes, this confirmed by the positive Heterosis for most hybrids as well as the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios, which was less than one and the degree of dominance greater than one with the presence of a role for the influence of additive genes with the role of genetic factors found in the cytoplasm. These results agree with (Al-Ati, 2014; Yankov and Norettin, 2015, Aleem et al., 2015).

Table 6: Components of combining ability and Genetic parameters for single and reciprocal crosses for the trait of the percentage of Oil% in seeds

Components of combining ability				
σ^2rca	σ^2sca	σ^2gca	σ^2A	σ^2E
12.72	27.04	1.86	3.72	0.56
Genetic parameters for single crosses				
h^2n.s	h^2b.s	ā	σ^2D	σ^2sca/σ^2gca
11.88%	98.21%	3.81	27.04	0.07
Genetic parameters for reciprocal crosses				
h^2n.s-r	h^2b.s-r	ā-r	σ^2D-r	σ^2gca/σ^2rca
21.88%	96.71%	2.62	12.72	0.15

Oil yield in the plant (g):

Table (7) shows that the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios were less than one, which confirms the control of non-additive gene action for diallel and reciprocal hybrids and its importance in inheriting this trait. These results agree with (AL-Dulaimy, 2013). The results also show that the variance of specific combining ability of diallel σ^2D and reciprocal σ^2D-r hybrids was greater than the general combining ability σ^2gca, Thus, the degree of dominance was greater than one in both diallel ā and reciprocal ā-r hybrids, which indicates that this trait is subject to the influence of the overdominance for genes and to the great influence of the non-additive action for genes and its importance in the inheriting this trait. This result confirms the $\frac{\sigma^2 gca}{\sigma^2 sca}$ and $\frac{\sigma^2 gca}{\sigma^2 rca}$ ratios which were less than one. It is also clear from the results that the value of the dominant variance σ^2D was higher than the value of the additive variance σ^2A as well as the percentage of broad-sense heritability for the diallel and reciprocal hybrids was high and amounted to (99.28%, 94.52%), respectively. The percentage of narrow-sense heritability for the diallel and reciprocal hybrids was high and amounted to (2.57, 19.50%),

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respectively. This is further evidence that this trait is subject to the non-additive effect for genes, therefore the trait can be improved by crossing. These results agree with (Ghaffari et al., 2011; Ramesh et al., 2013). However, it disagrees with (Vanitha et al., 2014), about obtaining a medium percentage of heritability in the broad and narrow sense.

Table 7: Components of combining ability and Genetic parameters for single and reciprocal crosses for the trait of the Oil yield in the plant (g)

Components of combining ability				
σ^2rca	σ^2sca	σ^2gca	σ^2A	σ^2E
20.28	198.34	2.64	5.27	1.48
Genetic parameters for single crosses				
h^2n.s	h^2b.s	ā	σ^2D	σ^2sca/σ^2gca
2.57%	99.28%	8.67	198.34	0.01
Genetic parameters for reciprocal crosses				
h^2n.s-r	h^2b.s-r	ā-r	σ^2D-r	σ^2gca/σ^2rca
19.50%	94.52%	2.77	20.28	0.13

CONCLUSIONS AND RECOMMENDATIONS:

a) The results of positive hybrid abundance and genetic analysis indicated the importance of the non-additive action for the genes to a greater extent than the additive action in the inheriting the studied traits. This was evident from the degree average of dominance is greater than one as well as the percentage of heritability in the broad and narrow sense in most of the traits.

b) Selecting genotypes whose traits have shown a non-additive action in heritability in order to be included in breeding and improvement programs to obtaining cultivars with high yielding.

REFERENCES

Al-Jubouri, Abdul Jassim Mohsen Jassim, Wajih Mzaal al-Rawi, Dia Boutros Youssef. 1990. Induction of male infertility in sunflower crop using gibberellin acid. Journal of Iraqi Agricultural Sciences. 22: 30-23.

AL-Shahery, Daham Sabhan Adrees, Abdul Sattar Ahmed Mohammed Ali. 2014. Genetic analysis for some sunflower (Helianthus annuus L.) traits using a full diallel cross. Journal of Iraqi Agricultural Sciences. 5 (2): 84--94.

Al-Ati, Yasser Hassan Saleh. 2014. Genetic analysis for quantitative traits in sunflower (Helianthus annuus L.). PhD thesis. Field Crop Science Department. College of Agriculture and Forestry, University of Mosul.

AL-Dulaimy, Tamather Adel Ahmed, Wajeeh M.Hassan Al-Rawi. 2013. Combining ability, Gene action and heritability for yield and its components in sunflower (Helianthus annuus L.). Tikrit University Journal for Agricultural Sciences. 1 (3): 143-151.

Al-Adhari, Adnan Hassan Mohammed. 1999. Fundamentals of Genetics. Ministry of Higher Education and Scientific Research,

ISSN 2072-3875

University of Mosul. Third Edition. Dar Al-Kutub for Printing and Publishing Mosul. Iraq p. P. 868.

Al-Rawi, Wajih Mizal. 1983. Effect of nitrogen levels and plant density on the traits of field, qualitative, yield and its constituents for sunflower crop (H. annuns L.). Master Thesis. College of Agriculture. Baghdad University.

Ali, Abdul Kamel Abdullah. 1999. Heterosis and genetic action in yellow corn. Ph.D thesis. Department of Field Crops. College of Agriculture and Forestry. University of Al Mosul.

Directorate of Agricultural Statistics. 2014, 2015. Production of paddy and sunflower. Ministry of Planning - Central Statistical Organization - Iraq.

Aleem, M. U., H. A. Sadaqat, Saif-ul-Malook, M. Asif, S. A Qasrani, M. Z. Shabir and M. A. Hussain. 2015. Estimation of Gene Action for Achene Yield in Sunflower (*Helianthus annuus* L.). American-Eurasian J. Agric. & Environ., 15 (5): 727-732.

Chandra, B. S., S. S. Kumar, A.R.G. Rangandha, and M. Y. Dudhe. 2011. Combining Ability Studies for Development of New Hybrids over Environments in Sunflower (*Helianthus annuus* L.). J. of Agric. Sci. 3 (2): 230-237.

Ciric, M., S. Jocic, S. Cvejic, M. Jockovic, P. Canak, R. Marinkovic, and M. Ivanovic. 2013. Combining Ability of New Inbred Lines of Sunflower (*Helianthus annuus* L.). Genetika, 45 (2): 289-296.

Dudhe, M.Y., Moon, M.K. and Lande, S.S. 2011. Study of gene action for restorer lines in sunflower. Helia, 34, Nr. 54, p.p. 159-164.

FAO STAT DATABASE. 2014, 2016 .(htt://faostat.fao.org) .

Fehr, W. R.. 1993. Principles of cultivar development. Vol. 1. Mac Millan Publ. Co. New York, USA.

Ghaffari, M., I. Farokhi. and M. Mirzapour . 2011. Combining ability and gene action for agronomic traits and oil content in sunflower (*Helianthus annuus* L.) Using F1 hybrids. Crop Bree. J. 1(1) :73-84

Griffing, B. . 1956a. A generalized treatment of the use of diallel crosses in quantitative inheritance. Heredity. 10: 31-50.

Griffing, B. . 1956b. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. of Biol. Sci., 9: 463-493.

Imran, M., Saif-ul-malook, H. M. Ahamed, M. M. Abrar, S. Nazik. 2014. Combining Ability for Yield and Yield Components in Sunflower (*Helianthus annuus* L.). Int. Arch. App. Sci. Techno. 5 (3): 13-21.

Kang, S, F. A. Khan, M. Z. Ashan, W. S. Chatha, and F. Saeed. 2013. Estimation of combining ability for the development of hybrid genotypes in (*Helianthus annuus* L.). Journal of biology, Agric. and Healthcare. 3 (1): 68-74.

Kholghi, M., H. H. Maleki, R. Darvishzadeh. 2014. Diallel Analysis of yield and It's Related Traits in Sunflower (*Helianthus annuus* L.) under Well-watered and Water-Stressed Condition. 79(3): 175-181.

Lampi, A.-M, A. Kamal-Eldin. 1998. Effect of α- and γ-Tocopherols on Thermal Polymerization of Purified High-Oleic Sunflower Triacylglycerols, JAOCS, Vol. 75, no. 12, 1699-1703.

Memon, S., M. J. Baloch, G. M. Baloch and M. I. Keerio .2014. Heritability and Correlation Studies for Phenological, Seed Yield And Oil Traits in Sunflower (*Helianthus annuus* L.). Pak. J. Agri. Eng. Vet. Sci., 30 (2): 159-171.

Mijic, A, A. Sudaric, M. Krizmanic, T. Duvanjac, M. Bilandzic, Z. Zdunic, E. Ismic. (2011). Grain and oil yield of single and three-way crosses os sunflower hybrids. Poljoprivreda, (1): 3-8.

Pourmohammad, A., M. Toorchi, S. S Alavikiai, M. R Shakiba. 2016. ESTIMATION OF GENETIC PARAMETERS FOR YIELD AND YIELD COMPONENTS IN

ISSN 2072-3875

SUNFLOWER UNDER NORMAL AND STRESS WATER DEFICIT. Bulg. Jour. of Agri. Sci., 22 (No 3), 426–430.

Qamar, R., H. A. Sadaqat, A. Bibi, & M. H. N. Tahir. 2015. Estimation of Combining Ability for Early Maturity, Yield and Oil Related Traits in Sunflower (*Helianthus annuus* L.). I.J.S.N. 6(1): 110-114.

Ramesh, M., J. Arunakumar, Y. Prashanth, A. R. G. Ranganatha and M. Y. Dudhe. 2013. Population Improvement for Seed Yield and Oil content By Using Working Germplasm in sunflower (*Helianthus annuus* L.). Sabrao J. Breed Genet., 45 (2): 291-295.

Singh, R. K., and Chaudhary, B. D. 2007. Biometrical Methods in Quantitative Genetics. Kalyani publisher, New Delhi-Ludhiana, ISBN 81-7663: 307-318.

Sprague, G.F. and L.A. Tatum. 1942. General versus specific combining ability in single crosses of corn. J. Amer. Soc. Agron. 34:923-932.

Syed, W. H., S. M. Syed, and S. Hassan. 2004. Variability for Agronomic Traits in two Random-Mating Sunflower Population: Means, Variance Components and Heritability. Helia, 27 (41): 99-112.

Vanitha, J., N. Manivannan and R. Chandirakala. 2014. Qualitative Trait Loci Analysis for Seed Yield and Component Traits in Sunflower. Afr. J. Biotech., 13 (6): 754-761.

YANKOV, B., and Nurettin TAHSIN. 2015. Genetic variability and correlation studies in some drought-resistant sunflower (Helianthus annuus L.) genotypes. J. of Cen. Euro. Agric., 16 (2): 212-220.

ISSN 2072-3875