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Estimation of Combining Ability and Hetrosis Via Half Diallel Cross in Faba Bean (*Vicia fab*a L.) for Yield, its Components and Seed Quality.

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ABSTRACT

This investigation was carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh, Egypt. Seven faba bean (*Vicia faba* L) cultivars and/ or varieties were used as parents, sown and crossed with each of half diallel set giving a total of 21 crosses under insect free cages. The resulted F_1,^{s} along with their parental genotypes were sown in a complete randomized block design with three replications during 2016 /17 season. Griffing approach (1956) was used to estimate general and specific combining ability effects. The results pointed out that additive and non-additive nature of gene action were involved in controlling the inheritance of all studied traits. The ratio of GCA/SCA mean squares was higher than unity for flowering date, number of branches/plant , 100-seed weight and EC of seeds, while the same ratio was less than unity for plant height, number of pods/plant , number of seeds/plant, seed yield /plant and protein percentage. The parental varieties; Giza40 and Line1 considered as good source for yield improvement, while the parental varieties; Giza 429 and Maghreby1 considered as good combiners for improvement of earliness and yielding ability. The crosses; Ohishima-Zaira x Giza40, Ohishima-Zaira x Line1, T.W x Line1, Line 1x Sakha1 and Sakha1x Maghreby1 expressed highly significant inter and intra-allilic interactions in desirable direction for the traits in view. The crosses; Ohishima-Zaira x Giza40, Giza429 x Giza40, T.W x Ohishima - Zairai, T.W x L1 and T.W x Maghreby1 exposed significant better parent heterosis for most studied traits. Progenies of these crosses could be used in the segregating generations with application of bulk method to regenerate pure line(s) characterized by high yielding potentiality and high protein content.

Keywords: Faba bean, Heterosis, General combining ability, Specific Combining ability

INTRODUCTION

Faba bean (*Vicia fab*a L.) is one of the most important winter legume crops grown in the Mediterranean region, Not only because of its high protein content that ranged from 22% -38% and carbohydrates (Griffiths and Lawes, 1978), but also because of its use in preparing several local dishes, the green pods of many grain legumes are consumed as vegetables, while the green stocks and dry straw are used in animal feed. Through symbiotic nitrogen fixation, can contribute to sustain or enhance total soil nitrogen fertility through biological N_2-fixation (Lindemann and Glover, 2003). Legumes play a significant role in low input agriculture by reducing the dependence on mineral nitrogen fertilizers. In addition, faba bean is a self-pollinating plant with significant levels of outcross and inter - cross, ranging from 10% to 60% depending on presence or absence of honey bees in the area. The improvement of crop desired traits depends on the nature and magnitude of genetic variability and interactions involved in the inheritance of these traits, which can be estimated using diallel cross technique. This technique may also result in the production of new genetic combinations whose performance may exceed that of the parents, a phenomenon known as heterosis. Exploitation of heterosis could play an important role in improving yield potential and its components in faba bean. Heterotic effects for important yield components, *i.e*., number of branches per plant, number of pods per plant and seed index may range from significantly positive to significantly negative for different traits depending on the genetic makeup of parents (Darwish *et al*., 2005 and El-Hady *et al*., 2006). While, an inference can be made from diallel crosses about GCA of parents and SCA of hybrids. Such information may help breeders to identify the best combiners which may be hybridized to build up favorable fixable genes. Several researchers have reported of significance of both GCA and SCA effects for seed yield and other important traits of faba bean (Attia and Salem, 2006).

Moreover, The breeder should know the type of gene action of controlling the genetic behavior of the quantitative traits because this is the main determinate in the choice of the most efficient breeding procedures. Nevertheless, for obtaining a clear picture of genetic mechanism of faba bean populations, the absolute value of variances must be partitioned into its genetic components. Hence, exploitation of the genetic components could encourage improvement of yield potential and other traits in faba bean plants. Whereas, the superiority of crosses over parents for seed yield is associated with manifestation of gene effects in important yield components, *i.e.* no. of branches / plant, no. of pods / plant and seed yield/plant.

However, the present study was carried out to investigate the nature of gene action influencing seed yield components, the magnitude of both general and specific combining abilities and their interactions of seven local and foreign faba bean genotypes and heterotic effects in their F_1 generation using diallel cross mating system, of the present genetic materials.

Seed technology, a segment of agricultural production systems, aims to improving seed germination and vigor tests to obtain good expression for seed lot performance potential, under a broad range of field conditions. (EC) electric conductivity is a fast and practical procedure, allowing obtaining objective information; it is also easily used in most seed analysis laboratories, not requiring expensive equipment or skilled personnel. EC test is an index of grain subsistence leakage. When low vigor seeds are soaked in distilled water, excrete their substance, but excretion is lower in high vigor seeds, so there is a negative correlation between electrical conductivity and seed emergence ability (Levitt 1980)

MATERIALS AND METHODS

The investigations of the present studies were carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh, Egypt during the season of 2014/15. Seven faba bean (*Vicia faba*.L.) cultivars and /or varieties were used as parents namely; Giza 429, T.W, Ohihima-Zairai, L1(Nubaria1 x Ruoza-isson), Sakha 1,Giza 40 and Maghreby1 were sown and crossed in a half diallel set giving a total of 21 crosses under insect free cages. In 2015/16 season the parental genotypes were sown again and re-hybridized in order to obtain more hybrid seeds .The resulted F_1's along with their parental genotypes were sown in a randomized complete block design with three replications during 2016 /17 season. Seeds were sown in single seeded hills, 20 cm apart, each entry was represented by one row for parents and their F_1's. The row was 3 meters long and 60 cm in between. The choice of parents was based on: a) genetic diversity. b) differences in growth habit disease reactions and c) differences in yielding ability. The pedigree, disease reactions, agronomic characters and yielding level are presented in Table 1.

Table 1. Names, Origin', botanical group, disease reactions and agronomic characters of the parental faba bean genotypes used in this investigation.

Genotypes	Origin	Botanical group	Agronomic characters		
			Disease reactions	Flowering date	Yielding level
Giza 429	Sudan	Equina	S	Early	High
T.W	Egypt	Equina	S	Early	Medium
Ohishima - Zairai	Japan	Equina	S	Early maturity	High
L1 (Nubaria x Ruoza- isson)	Egypt	Major	H. R	Medium	Medium
Sakha 1	Egypt	Equina	H.R	Early	High
Giza 40	Egypt	Equina	S	Early	High
Maghreby1	Moracco	Major	M.R	Medium	High

HR=High resistance to foliar diseases S= Susceptibility to foliar diseases M.R = Moderate to foliar diseases

Measurements were taken on the basis of individual plant as follows:

Flowering date, plant height, number of branches/ plant, number of pods/plant, number of seeds / plant, 100-seed weight, seed yield / plant , protein curdle percentage and Electric conductively of seed.

Mean squares and expected mean square of RCBD analysis of variance are presented in Table 2.

Table 2. The analysis of variance and the expected mean of square (EMS)

S.O.V	d f	MS	EMS
Replication	r-1	M r	
Entries	(E-1)	ME	$\sigma^2 e + r\sigma^2 g$
Parents (P)	(P-1)	Mp	$\sigma^2 e + rc\sigma^2 p$
P vs C (Heterosis)	1		
Crosses	(c-1)	Mc	$\sigma^2 e + rc\sigma^2 p$
Error	(r-1)(E-1)	MS e	$\sigma^2 e$
G.C.A	P-1	Mg	$\sigma^2 e + (p+1)(1/p-1)\Sigma^2_{gi}$
S.C.A	P(P-1)/2	Ms	$\sigma^2 e + 2/p(p-1)\Sigma_i \Sigma_j s^2_{ij}$
Error terrm	(r-1) (E-1)	Me	$\sigma^2 e / r$

Where: r is the number of replication; E is the number of entries ; σ^2_E and $\sigma^2 e$ refer to genotypic and error variance, respectively . The difference between any two means was tested according to the least significant difference (L.S.D) at both 5% and 1% levels of significance as follows: LSD : $P\leq 0.05$= t 0.05 (d.f) x S d
$P\leq 0.01$= t 0.01 (d.f) x S d
Where: r is the number of replications and Ms_e : is the mean squares of error

Estimation of combining ability analysis:

The sum of squares among entries (genotypes) is in turn partitioned into parents and crosses and the latest is partitioned into general combining ability (GCA) and specific combining ability (SCA) and t is the tableted t at the degrees of freedom of error. The combining ability analysis of variance wascalculated according to model 1 method 2 of Griffing approach (1956). The effects of parental varieties and crosses were considered as fixed effects.

The mathematical model for the combining ability analysis is assumed to be:

$$X_{ijk} = u + \hat{g}_i + \hat{g}_j + \hat{S}_{ij} + r_k + e_{ijk}$$

where: **xij, is the performance of the i th parent mated to the j th parent in block k. u is the population mean, ĝi is the gca effect of the i th parental variety, Ŝ ij is the interaction of the i th and j th parents or sca effect of the crosses between them r k is the block effect and eijk is the random efect of the indvidual observation.**

The restrictions: $\Sigma i\,(\hat{g}) = 0$ and $\Sigma j(\hat{S}_{ij}+\hat{S}_{ii}) = 0$ (for each i) are imposed on the combining ability effects. The gca and sca effects were calculated as suggested by Griffing,1956

Heterosis:

The amount of heterosis was expressed as the percentage deviation of F_1 mean performance from the mid –parent and better parent as follows:

$$\text{Heterosis over mid – parent \% (M.P)} = (\overline{F}_1 - \overline{MP}) / \overline{MP} \times 100$$

$$\text{Heterosis over better – parent \% (B.P)} = (\overline{F}_1 - \overline{BP}) / \overline{BP} \times 100$$

$$\text{LSD for mid-parent } (\overline{F}_1 - \overline{M.P}) = t\,(3MSE/2r)^{1/2}$$

$$\text{LSD for better -parent } (\overline{F}_1 - \overline{B.P}) = t\,(2MSE/r)^{1/2}$$

Potence ratio:

This parameter was calculated according to Wigan(1944) and Mather and Jinks (1971) as follows:

$$\mathbf{P.R} = \overline{F}_1 - \overline{MP} / 1/2(HP - LP)$$

Where: F_1=Mean of the F_1 performance.
M.P = Mid-Parent value = P1+P2/2.
H.p = The hiegher parent value.
L. P = The lower parent value.

Absence of dominance is consider when (p) is zero, and partial dominanance is assumed when (p) is between +1 and -1 but not equal zero, complete dominance is considered when (P) is equal +1 or -1 and over–dominance is considered when (P) is > +1 or < -1.

Seed Quality : All seed properties were carried out at Sakha Seed Technology Research section as Follow.

1-Viability: Electrical conductivity (EC)

Electrical conductivity (EC) of leached from four replicates of 50 seeds was weighed and soaked in 250 ml of dustilled water for 24 h to measured in u-mhos using conductivity meter were carried out under optimum conditions according to the international rules(ISTA,1999).

The electrical conductivity (E.C) per gram of seed weight for each sub sample and calculated as fllows :

E.C = Conductivity for each flask / Weight of seed sample (g)

2-Crude Protein (%)

Tested seeds were ground to a fine powder to pass through 2 mm mesh and used to determine the crude protien percentage according to methods of A.O.A.C (1990).

RESULTS And DISCUSSION

The analysis of variance

The preliminary statistical analysis revealed highly significant differences among the parents and their possible hybrids for all studied traits (Table 3). These findings provide evidence for the presence of high considerable amount of genetic variability among the parental faba bean genotypes and their respective hybrids, which may facilitate genetic improvement using such genetic pools of faba bean. These results were in harmony with those reported by Awaad *et al*.,(2005), Bayoumi and El-Bramawy (2010), Ghareeb and Helal (2014)and Abdalla *et al*.,(2017).

ANOVA of the diallel set with respect to flowering date, seed yield and its components, protein percentage and EC of seeds revealed highly significant general and specific combining ability mean squares (Table 3). Hence, the significant estimates of both GCA and SCA variances might suggest that each of additive and non – additive nature of gene actions were involved in controlling the inheritance of these traits .These results confirmed those findings reported by Darwish *et al*.(2005), Attia and Salem(2006), El-Hady *et al*.(2007), Ibrahim(2012), El-Bramawy and Osman (2012),Ghareeb and Helal(2014) and Abdalla *et al*.(2017).

The ratio of GCA/SCA mean squares was higher than unity for flowering date, number of branches/plant, 100-seed weight and EC of seeds. This means that greater considerable contribution of additive and additive x additive gene effects existed in the genetic expressions controlling these traits. In contrast, non-additive (dominance and their epistatic interactions) was found to have more contribution in the genetic variance for plant height, number of pods/plant, number of seeds/plant, and seed yield/plant and protein percentage due to less than unity of the same ratio. Therefore, selection can be effective in the early segregating generation in the first case, while selection in the delayed generations selection would be more effective in the second one. However, it could be emphasized that GCA/SCA ratio of mean squares may not always project the true picture of the gene action for a particular trait. This state is due to the deferential parental ability to combine well with each other. On the other hand, such combination depends upon complex interaction between genes and genotype x environment ((Mulusew *et al*., 2008, El-Bramawy and Osman, 2012).

Table 3. Analysis of variance for yield and its components of faba bean in the F_1 generation.

S.O.V	d.F	Flowering date	Plant height	No .of branches/ Plant	No .of pods / plant	No .of seed/ Plant	Seed Yield/ plant	100- seed weight	Crude Protein (%)	Electric Conductivity (μ mhos/gm)
Replication	2	8.46	6.033	1.158	11.151	57.247	32.886	14.943	1.327	1.155
Genotypes	27	198.312**	196.981**	6.560**	251.43**	1402.456**	1482.003**	1618.996**	56.084**	2.807**
Parents	6	304.428**	281.689**	2.084**	136.935**	910.405**	541.372**	2885.30**	5.0933**	2.766**
P. Vs. C	1	294.33**	197.05**	3.01**	3.47ns	413.12**	203.43**	2581.41 **	7.78**	2.94**
Crosses	20	188.22**	112.355**	7.487**	117.967**	905.174**	1144.07**	1315.113**	58.768**	2.987**
GCA	6	177.92**	22.491ns	2.702**	30.969**	365.422**	351.986**	1235.48**	12.205**	2.280**
SCA	21	34.157**	77.994**	2.040**	98.909**	496.646**	534.577**	340.861**	20.549**	0.552**
Error	54	4.641	11.831	0.200	4.397	34.814	19.961	7.885	0.903	0.212
Error	54	1.547	3.944	0.066	1.465	11.604	6.653	2.628	0.301	0.071
GCA/SCA		5.20	0.28	1.32	0.31	0.73	0.65	3.62	0.60	4.13

and significant at0.05 and 0.01 levels of probability, respectively.**

Mean performance

Mean performance of parental varieties and their F1, s for the studied traits are presented in Table 4. Highly significant difference between genotype was found for flowering date revealed that the means of the parental varieties showed that the varieties; Giza 429, T.W and Sakha1 were the earliest varieties. On the other hand, the parental varieties; L1 (nubaria1 x Ruoza- isson) and Ohishima- Zairai were the latest varieties, While. The mean performance of the crosses for earliness characters are shown in Table 4.The crosses; Giza 429x T.W, Giza 429x Ohishima- Zairai, Giza 429 x Sakha1, Giza 429xMaghraby1, T.W x Maghraby1 and Ohishima- Zairai x Sakha1were considered as the earliest crosses. On the other side, the crosses; L1 x Sakha1, L1 x Giza 40 and L1 x Maghraby1 behaved as the latest crosses. Mean performance of parental varieties and their crosses for yield and its components are presented in Table 4. The data revealed that highly significant difference between genotypes were found for yield and its components. The varieties; Giza 429, Giza 40 and sakha1 were the highest parental variety for seed yield while the parental line (Nubaria1 x Rouza-issun) and Maghraby1 were lowest yielded while observed high 100-seed weight. On the other hand, the crosses; Giza429x T.W, Giza 429x Ohishima- Zairai, Giza429x Sakha1, Giza429x Giza40, Giza429xMaghraby1, T.W x Giza40, T.W xMaghraby1, Ohishima- Zairai x L 1 and Ohishima- Zairai x Giza 40 were the highest yielding crosses, while the crosses; Giza429x L 1 and T.W x Ohishima- Zairai performed as low yielding crosses . On the other hand, for electric Conductivity ranged from (2.25 - 4.45 μ mhos/gm) in the parental Maghraby1 and Giza40 ranged from (2.18 - 5.78 μ mhos/gm), in the crosses; Ohishima- Zairai x Giza40 and L1 x Giza40, respectively. On the other side, The means of the parental variety showed that; Sakha1was highly protein% (25.50), while, the variety; Ohishima- Zairai was low protein percentage (22.50) .On the other side, the crosses; Giza 429 x T.W, Giza 429 x L 1, T.W x L 1, T.W x Sakha1, T.W x Maghraby1, Ohishima- Zairai x Sakha1 and L 1x Sakha1were the highest values ranged from (31.25%-32.67%).

Table 4. Mean performance of parents and their crosses of faba bean genotypes for studied traits .

Genotypes	Flowering date	Plant height	No. of branches /plant	No of .pods /plant	No of seeds /plant	Seed yield / plant	100-Seed weight	Electrical Conductivity (μ mhos/gm)	Crude Protein (%)
Parents									
Giza429	39.90	131.88	3.63	31.69	90.06	67.18	74.79	3.12	25.08
T.W	40.00	112.50	3.90	25.97	66.00	40.72	60.85	2.85	23.92
Ohishima- Zairai	65.00	132.14	5.02	23.14	55.79	34.80	63.35	2.33	22.50
Ll (Nubaria xRouza-issun)	58.57	141.43	5.52	18.14	53.29	66.60	126.16	4.14	22.53
Sakha1	52.07	130.09	4.24	26.76	83.09	67.95	83.19	2.77	25.50
Giza40	47.78	133.15	3.22	25.22	75.78	59.92	78.03	4.45	22.50
Maghraby1	46.25	141.46	4.92	10.88	41.71	58.49	139.84	2.25	22.75
Crosses									
Giza429 xT.W	39.00	152.33	4.30	44.73	119.07	97.10	82.32	2.93	32.18
Giza429x Ohishima- Zairai	42.41	136.67	5.70	38.44	87.93	64.41	77.52	3.90	23.46
Giza429 x(L1)	43.15	142.78	4.48	20.59	58.26	92.95	159.88	5.75	32.67
Giza429 x Sakha1	35.83	139.31	4.69	39.28	99.11	83.94	86.61	3.11	25.67
Giza429 x Giza40	49.23	142.18	4.67	35.28	109.38	89.78	82.39	4.99	31.08
Giza429 xMaghraby1	40.67	135.50	3.83	37.77	100.10	93.86	93.29	3.53	20.42
T.W x Ohishima- Zairai	57.00	150.33	3.84	29.20	79.76	59.58	76.74	3.88	30.33
T.Wx (Nubaria xRouza-issun))	53.33	148.89	4.94	40.00	87.67	82.08	97.15	4.07	32.33
T.Wx Sakha1	49.31	140.20	4.61	39.35	88.06	64.93	73.50	2.48	31.58
T.W x Giza40	47.33	142.50	4.57	43.90	101.13	66.46	66.86	2.67	23.46
T.W xMaghraby1	40.00	148.17	4.60	*46.15*	117.45	91.05	78.08	2.78	31.25
Ohishima- Zairai x (L1)	53.33	145.00	5.00	37.45	89.49	78.44	87.63	4.03	29.70
Ohishima- Zairai x Sakha1	40.00	131.85	6.19	33.19	86.37	73.75	84.56	2.78	32.04
Ohishima- Zairai x Giza40	50.00	144.67	8.20	46.87	136.60	116.99	94.64	2.18	29.75
Ohishima- Zairai x Maghraby1	57.50	127.26	8.07	37.71	87.95	91.31	105.89	3.03	26.83
(L1)x Sakha1	65.00	136.67	6.94	33.44	103.78	115.83	111.68	4.33	31.67
(L1) x Giza40	60.00	142.67	9.40	42.07	111.20	104.20	95.52	5.78	21.58
(L1) x Maghraby1	59.05	138.33	4.14	43.62	75.33	55.35	77.90	2.91	21.00
Sakha1x Giza40	50.00	139.87	3.95	36.05	84.05	64.85	77.35	2.98	21.00
Sakha1 x Maghraby1	45.00	143.33	4.00	33.22	96.27	122.06	126.78	3.23	31.83
Giza40 x Maghraby1	48.70	136.11	5.59	44.93	110.96	101.58	94.97	3.44	27.42
F-test	**	**	**	**	**	**	**	**	**
L.S.D (0.05)	3.51	5.61	0.72	3.42	9.63	7.29	4.58	0.65	1.31

L1= Nubaria xRouza-issun

For the estimates of (ĝi) shown in Table 5, it must be taken in consideration that, the negative sign would be of more interest from the breeder point of view for flowering date and electric conductivity while for the other traits , the positive sign is more favourable.

The estimates of general combining ability effects (ĝi) showed that, the parental variety Giza429 had highly significant (ĝi) in desirable direction for flowering date, number of seeds /plant and seed yield /plant. While the parental variety Giza40 had highly significant (ĝi) in desirable direction for number of branches /plant, number of pods/plant, number of seeds /plant, seed yield/plant and electric conductivity. On the other hand, the parental variety; (L1) showed highly significant (ĝi) in desirable direction for plant height, No of branches/plant, seed yield /plant and100-seed weight. The parental variety; T.W showed highly significant (ĝi) in desirable direction for flowering date, No of pods/plant, electric conductivity and protein percentage, and the parental variety; Maghraby1 expressed highly significant (ĝi) in desirable direction for flowering date, seed yield /plant, 100-seed weight and electric conductivity. However, the parental varieties; Giza 40 and L1 could be considered as good source for yield improvement, while the parental varieties; Giza 429 and Maghraby1 could be considered as good combiner varieties for improving earliness and yield potentiality. Moreover, the varieties; T.W considered as good combiner for improving earliness and protein percentage due its low value of electric current.

Therefore, the faba bean parents which showed superior (ĝi) indicated that, these parents are favorable for inclusion in the production of synthetic varieties and choosing the proper breeding scheme. Similar trend of these findings was earlier reported by Drwish *et al*., (2005) , El-Hady *et al* (2007and 2008) and El-Bramawy and Osman (2012).

Estimates of specific combining ability effects (Ŝij) for the studied traits are listed in Table 6. The data revealed that eight crosses; expressed highly significant (Ŝij) in desirable direction for all studied traits. The cross;, Giza 429 x T.W had highly significant desirable (Ŝij) for all studied traits except flowering date. The crosses; T.W x Maghraby1and Ohishima- Zairai x L1 exposed highly significant(Ŝij) in desirable direction for flowering date, plant height, number of pods/plant, No of seeds/plant seed yield /plant and protein percentage. The crosses; T.W x L1, L1 x Sakha1 and Sakha1 x Maghraby1 had highly significant inter and intra-allelic interactions in desirable direction for number of seeds/plant, seed yield /plant, 100-seed weight and protein percentage. These cross combinations are considered as good specific combiners (crosses), their progenies in segregating generations could be used with suitable breeding program according the nature of genes controlling the trait(s) looking forward to improve the crop. However, the most traits of the present genetic material seem to be controlled by non-additive gene effects in their inheritance –as previously mentioned. So the progenies of the above crosses might be of interest to use the bulk method in breeding program toward obtaining pure lines characterized by high yield and high protein content.

Generally, GCA effects provide appropriate criterion for detecting the validity of a genotype in hybrid combination, while SCA effects may be related to heterosis. The results revealed that GCA effects for some traits were related to several SCA values of their corresponding crosses. Thus the three parents; Line1, Giza 40 and Maghraby1, which exhibited significant and positive (ĝi) for No. of branches/plant, No of pods/plant ,seed yield /plant, and 100-seed weight, produced some crosses as Ohishima Zairai x Giza40 , line1 x Giza 40 and Sakha1 x Maghraby1 showing positive and highly significant (Ŝij) for these traits. This may indicate that additive and non –additive genetic effects in the crosses are acting in the same direction to maximize the traits in view. These finding are in agreement with Darwish *et al.*(2005), Attia and Salem(2006), El-Hady *et al.*(2007), Ibrahim (2012), Ghareeb and Helal(2014) and Abdalla *et al.*(2017).

Table 5. Estimates of parental general combining ability effects for yield and its components, electrical conductivity and Crude Protein (%) in the F_1 generation.

Parents	Flowering date	Plant height (cm)	No .of branches /plant	No .of pods /plant	No .of seeds/ Plant	Seed Yield/ plant	100- seed weight	Electrical Conductivity (μ mhos/gm)	Crude Protein (%)
Giza429	-6.988**	0.207ns	-0.633**	0.416ns	4.549**	2.895**	0.097ns	0.314**	0.086ns
T.W	-2.999**	-0.359ns	-0.662**	2.171**	1.344ns	-9.741**	-14.928**	-0.346**	1.567**
Ohishima- Zairai	4.141**	-1.175*	0.713**	-0.732*	-3.708**	-8.472**	-8.558**	-0.352**	0.249ns
L(nubaraia x japany)	6.448**	2.949**	0.593**	-2.474**	-8.971**	3.523**	16.820**	0.836**	-0.095ns
Sakha1	-0.410ns	-2.137**	-0.195**	-0.853*	1.198ns	3.437**	-0.427ns	-0.354**	1.103**
Giza40	0.872ns	0.405ns	0.244**	2.645**	10.205**	3.706**	-6.990**	0.368**	-1.731**
Maghraby 1	-1.063**	0.109ns	-0.060ns	-1.175**	-4.617**	4.653**	13.986**	-0.467**	-1.179**
L.S.D(gca)									
(0.05)	0.64	1.02	0.13	0.62	1.72	1.33	0.83	0.14	0.29
(0.01)	0.91	1.46	0.19	0.89	2.51	1.90	1.19	0.20	0.41
L.S.D(gi-gj)									
(0.05)	0.97	1.56	0.20	0.95	2.68	2.03	1.27	0.21	044
(0.01)	1.40	2.23	0.29	1.36	3.83	2.90	1.82	0.30	0.62

Heterosis

Heterosis percentage relative to mid parent (M.P), potence ratio and better parent (B.P) are given in Table 7. Results revealed highly significant negative heterosis (%)relative to mid parent (M.P) for the flowering date in eight crosses ; Giza429x Ohishima –Zairai, Giza429x L1, Giza429xSakha1, T.W x Maghraby1, Ohishima –Zairai x L1, Ohishima–Zairai x Sakha1, Ohishima –Zairai x Giza40 and x Sakha1 x Maghraby1 where the values ranged from (-7.25% to -31.66 %). The heterotic effects were due to over dominance towards the lower (earlier) parent in all cases.

For yield and related traits, the significant positive heterotic values are important from the breeder point of view. The data shown in Table 7, revealed that significant and/or highly significant heterotic effects relative to mid-parent (M.P) for plant height, in fourteen crosses with arrange of (3.92% -24.67%) for mid parent where over-dominance was the main cause of such heterosis, except in three crosses where hetertic effects ere resulted from partial dominance . Significant and/or highly significant mid parental heterosis for number of branches/plant due to partial–dominance was found in ten crosses out of twenty-one crosses, ranged from 28.25% to 114.97%.

Twenty crosses out of twenty-one ones showed highly significant mid parental heterosis for number of pods/plant where over- dominance was the main cause of such heterosis. The range of heterotic effects was between 18.92% and 200.64% for the trait in view. Ninteen crosses expressed highly significant mid parental heterosis for number of seeds/plant due to over–dominance, where the range of heterotic effects was laid between 14.48% and 118.09%. Ninteen crosses showed significant and/or highly significant mid- parental heterosis, for seed yield/plant due to over–dominance in most cases ranged from 19.5% and 147.03%. Eleven crosses disclosed significant and /or highly significant mid parental heterosis for 100-seed weight/plant a result of over–dominance in all cases, ranged from 4.23% to 59.13%. On the other hand, three crosses showed significant and/or highly significant mid-parental heterosis for electric conductively a result of over-dominance in two crosses i.e., T.W x Giza 40 and Ohishima–Zairai x Giza 40 as partial dominance in the cross; Sakha1 x Giza 40 the heterotic effects ranged from 17.54% to 35.69%. Fifteen crosses showed highly significant mid parental heterosis for protein percentage as a result of over-dominance in all crosses. The range of heterotic effects was between 18.61% and 39.23%.

Heterosis over better parent is more important than heterosis over mid-parent from the breeder point of view, especially if the heterotic effects are due to over-dominance (P>+1or <-1), the case which allow the breeder to searched out the transgressive segregating recombinations in the segregating generations. The data listed in Table 7 revealed that, the cross; Ohishima –Zairai x Giza 40, expressed significant better-parent heterosis for the plant height, number of branches/plant , number of pods/plant, number of seeds/plant, seed yield /plant, 100-seed weight and protein percentage. The cross; Giza429 x T.W had significant better-parent heterosis for the plant height, number of pods/plant, number of seeds/plant, seed yield /plant, 100 - seed weight and protein percentage. The crosses; Giza 429 x Giza 40, T.W x Ohishima –Zairai, T.W x L1 and T.W x Maghraby1 disclosed significant better-parent heterosis for plant height, number of seeds/plant, seed yield /plant and protein percentage. The crosses; Giza 429 x Giza 40, Ohishima – Zairai x Maghraby1 and L1x Sakha1 expressed significant better-parent heterosis for number of branches/plant, number of pods/plant, number of seeds/plant, seed yield /plant and protein percentage and the crosses; Ohishima–Zairai x L1, Sakha 1 x Maghraby1 and Giza40 x Maghraby1 expressed significant better-parent heterosis for number of pods /plant, number of seeds/plant, seed yield /plant and protein percentage. Therefore, the progenies of these crosses could be used in the segregating generations with application of bulk method to regenerate pure line(s) characterized by high yielding potentiality and high protein content. These results are in good agreement with those reported by Darwish *et al.* (2005) , Attia and Salem(2006), Farag(2007) , El-Hady *et al.* (2008) Farag and Afrah(2012), Ahmed (2013) and Abdalla *et al*.,(2017).

However, it could be noticed that , these is an approximately accordance between better parent heterosis in the present study and specific combining ability effects, which pointed out the important role of non-additive gene effects in controlling the inheritance of the traits in question , and this may confirm the obtained results mentioned before.

Table 6. Estimates of specific combining ability effects for yield and its components, electrical conductivity and Crude Protein (%)in the F_1 generation.

Crosses	Flowering date	Plant height	No .of branches /plant	No .of pods /plant	No .of seeds /plant	Seed Yield/ plant	100-seed weight	Electrical Conductivity (μ mhos/gm)	Crude Protein (%)
Giza429 x T.W	-0.13ns	13.65**	0.518*	7.68**	24.04**	25.15**	5.82**	-0.49*	3.67**
Giza429 x Ohishima- Zairai	-3.87**	-1.20ns	0.545**	4.30**	-2.04ns	-8.81**	-5.36**	0.48*	-3.74**
Giza429 x L1	-5.43**	0.79ns	-0.558**	-11.82**	-26.45**	7.74**	51.63**	1.15**	5.82**
Giza429 x Sakha1	-5.89**	2.41ns	0.444*	5.25**	4.24ns	-1.19ns	-4.40**	-0.31ns	-2.38**
Giza429 x Giza40	6.23**	2.73ns	-0.022ns	-2.25*	5.50*	4.39*	-2.06ns	0.86**	5.87**
Giza429 xMaghraby1	-0.40ns	-3.65*	-0.551**	4.06**	11.04**	7.52**	-12.13**	0.23ns	-5.35**
T.W x Ohishima- Zairai	6.74**	13.04**	-1.286**	-6.71**	-7.01*	-1.00ns	8.88**	1.125**	1.66**
T.W x L1	0.76ns	7.46**	-0.065ns	5.84**	6.16*	9.51**	3.92**	0.127ns	4.00**
T.W x Sakha1	3.60**	3.86*	0.389*	3.57**	-3.61ns	-7.55**	-2.48*	-0.276ns	2.06**
T.W X Giza40	0.34ns	3.62*	-0.093ns	4.62**	0.45ns	-6.29**	-2.56*	-0.805**	-3.24**
T.W X Maghraby1	-5.06**	9.59**	0.244ns	10.69**	31.59**	17.35**	-12.32**	0.140ns	4.00**
Ohishima- Zairai x L1	-6.38**	4.39**	-1.384**	6.19**	13.04**	4.60*	-11.97**	0.089ns	2.69**
Ohishima- Zairai X Sakha1	-12.85**	-3.67*	0.587**	0.30ns	-0.25ns	0.00ns	2.21ns	0.033ns	3.83**
Ohishima- Zairai X Giza40	-4.13**	6.61**	2.165**	10.49**	40.97**	42.96**	18.85**	-1.289**	4.37**
Ohishima- Zairai X Maghraby1	5.30**	-10.50**	2.342**	5.15**	7.15*	16.34**	9.13**	0.399ns	0.91*
L1X Sakha1	9.84**	-2.97*	1.471**	2.30*	22.42**	30.08**	3.94**	0.392ns	3.80**
L1 x Giza40	3.56**	0.48ns	3.485**	7.43**	20.84**	18.18**	-5.65**	1.123**	-3.45**
L1x Maghraby1	4.54**	-3.56*	-1.468**	12.80**	-0.21ns	-31.62**	-44.24**	-0.909**	-4.58**
Sakha1x Giza40	0.42ns	2.77ns	-1.177**	-0.21ns	-16.48**	-21.09**	-6.57**	-0.491*	-5.23**
Sakha1x Maghraby1	-2.65*	6.53**	-0.823**	0.78ns	10.56**	35.18**	21.88**	0.598**	5.05**
Giza40x Maghraby1	-0.23ns	-3.23*	0.332ns	8.99**	16.24**	14.43**	-3.37*	0.082ns	3.47**
L.S.D(sca)									
(0.05)	1.86	2.97	0.38	1.81	5.10	3.86	2.43	0.40	0.83
(0.01)	2.66	4.25	0.55	2.59	7.30	5.53	3.47	0.57	1.18
L.S.D(sij-skij)									
(0.05)	2.77	4.42	0.57	2.69	7.58	5.74	3.61	0.60	1.23
(0.01)	3.96	6.32	0.82	3.85	10.85	8.21	5.16	0.85	1.75

Table 7. Heterotic effects relative to mid, better parent and potence ratios (M.P, B.P and P) for disease reaction .

Crosses	Flowering date			Plant height			No of branches/plant		
	M.P	p	B.P	M.P	p	B.P	M.P	p	B.P
Giza429 x T.W	-2.37	-0.05	-2.25	24.67**	9.69	15.51**	14.29	0.14	10.26
Giza429 x Ohishima- Zairai	-19.14**	-12.6	6.30	3.53	0.13	3.42	31.90**	0.70	13.53
Giza429 x L1	-12.36***	-9.34	8.15	4.48*	4.78	0.95	-2.03	-0.95	-18.87**
Giza429 x Sakha1	-22.07**	-6.08	-10.18*	6.35**	0.89	5.63**	19.34*	0.31	10.65
Giza429 x Giza40	12.31**	3.94	23.40**	7.30**	0.64	6.78**	36.32**	0.20	28.74**
Giza429 xMaghraby1	-5.59	-3.18	1.93	-0.85	-4.79	-4.21*	-10.28	-0.65	-22.09**
T.W x Ohishima- Zairai	8.57**	12.50	42.50**	22.90**	9.82	13.77**	-13.84	-0.56	-23.48**
T.W x L1	8.21**	9.29	33.33**	17.27**	14.46	5.27**	4.94	0.81	-10.49
T.W x Sakha1	7.13*	6.03	23.28**	15.58**	8.80	7.77**	13.18	0.17	8.61
T.W X Giza40	7.85*	3.89	18.33**	16.02**	10.32	7.02**	28.25**	0.34	17.09
T.W X Maghraby1	-7.25*	-3.13	0.00	16.69**	14.48	4.74**	4.31	0.51	-6.50
Ohishima- Zairai x L1	-13.68**	-3.21	-8.94**	6.01**	4.64	2.53	-5.19	-0.25	-9.48
Ohishima- Zairai X Sakha1	-31.66**	-6.47	-23.17**	0.56	1.03	-0.22	33.50**	0.39	23.12**
Ohishima- Zairai X Giza40	-11.33**	-8.61	4.65	9.06**	0.50	8.65**	98.90**	0.90	63.22**
Ohishima- Zairai X Maghraby1	3.37	9.38	24.32**	-6.97**	-4.66	-10.04**	62.34**	0.05	60.66**
L1X Sakha1	17.50**	3.25	24.84**	0.67	5.67	-3.37	42.21**	0.64	25.72**
L1 x Giza40	12.84**	5.40	25.58**	3.92*	4.14	0.88	114.97**	1.15	70.17**
L1x Maghraby1	12.66**	6.16	27.67**	-2.20	-0.02	-2.21	-20.66**	-0.30	-25.00**
Sakha1x Giza40	0.16	2.14	4.65	6.27**	1.53	5.05*	5.81	0.51	-6.92
Sakha1x Maghraby1	-8.46**	-2.91	-2.70	5.57**	5.68	1.32	-12.69	-0.34	-18.70*
Giza40x Maghraby1	3.60	0.76	5.31	-0.87	-4.16	-3.78	37.39**	0.85	13.67
L.S.D									
(0.05)	3.04		3.51	4.86		5.61	0.63		0.72
(0.01)	4.05		4.53	6.27		7.24	0.81		0.93

Table 7. Cont.

Crosses	No of pods/plant			No of seeds/plant			Seed yield /plant		
	M.P	p	B.P	M.P	p	B.P	M.P	p	B.P
Giza429 x T.W	55.18**	2.86	41.17**	52.59**	12.03	32.20**	79.97**	13.23	44.53**
Giza429 x Ohishima- Zairai	40.23**	4.27	21.32**	20.57**	17.14	-2.37	26.31**	16.19	-4.13
Giza429 x L1	-17.35*	-6.77	-35.01**	-18.72**	-18.39	-35.31**	38.96**	0.29	38.35**
Giza429 x Sakha1	34.41**	2.46	23.95**	14.48**	3.49	10.05**	24.23**	0.39	23.53**
Giza429 x Giza40	23.99**	3.23	11.34	31.92**	7.14	21.45**	41.27**	3.63	33.64**
Giza429 xMaghraby1	77.46**	10.41	19.18**	51.93**	24.18	11.15**	49.37**	4.34	39.71**
T.W x Ohishima- Zairai	18.92**	1.41	12.45	30.98**	5.11	20.84**	57.78**	2.96	46.30**
T.W x L1	81.37**	3.91	54.04**	46.99**	6.36	32.83**	52.97**	12.94	23.26**
T.W x Sakha1	49.28**	0.40	47.07**	18.13**	8.55	5.98	19.50**	13.61	-4.44
T.W X Giza40	71.52**	0.37	69.06**	42.66**	4.89	33.46**	32.08**	9.60	10.93
T.W X Maghraby1	150.53**	7.55	77.73**	118.09**	12.15	77.95**	83.54**	8.89	55.66**
Ohishima- Zairai x L1	81.43**	2.50	61.84**	64.09**	1.25	60.42**	54.72**	15.90	17.78**
Ohishima- Zairai X Sakha1	33.01**	1.81	24.02**	24.38**	13.65	3.95	43.56**	16.58	8.54
Ohishima- Zairai X Giza40	93.80**	1.04	85.81**	107.66**	10.00	80.26**	147.03**	12.56	95.25**
Ohishima- Zairai X Maghraby1	121.73**	6.13	62.96**	80.43**	7.04	57.66**	95.76**	11.85	56.11**
L1X Sakha1	48.97**	4.31	24.99**	52.19**	14.90	24.90**	72.17**	0.68	70.45**
L1 x Giza40	94.01**	3.54	66.78**	72.32**	11.25	46.74**	64.72**	3.34	56.46**
L1x Maghraby1	200.64**	3.63	140.42**	58.61**	5.79	41.38**	-11.50	-4.05	-16.89**
Sakha1x Giza40	38.71**	0.77	34.73**	5.81	3.66	1.16	1.43	4.02	-4.57
Sakha1x Maghraby1	76.57**	7.94	24.16**	54.28**	20.69	15.86**	93.06**	4.73	79.62**
Giza40x Maghraby1	148.92**	7.17	78.12**	88.90**	17.03	46.43**	71.56**	0.71	69.53**
L.S.D									
(0.05)	2.95		3.42	8.34		9.63	6.31		7.29
(0.01)	3.81		4.41	10.76		12.42	8.15		9.40

Crosses	100-Seed weight			Electrical conductivity (µ mhos/gm)			Crude Protein (%)		
	M.P	p	B.P	M.P	p	B.P	M.P	p	B.P
Giza429 x T.W	21.39**	6.97	10.08**	-1.84	-0.41	2.81	31.33**	13.16	28.28**
Giza429 x Ohishima- Zairai	12.24**	5.72	3.66	43.00**	2.97	67.24***	-1.40	-0.26	-6.49*
Giza429 x L1	59.13**	25.69	26.73**	58.40**	4.16	84.29**	37.22**	6.94	30.23**
Giza429 x Sakha1	9.65**	4.20	4.11	5.49	0.92	12.15	1.48	1.80	0.65
Giza429 x Giza40	7.82**	1.62	5.58	31.92**	1.82	60.04**	30.66**	5.64	23.94**
Giza429 xMaghraby1	-13.07**	-32.5	-33.29**	31.35**	1.93	56.74**	-14.63**	-3.00	-18.60**
T.W x Ohishima- Zairai	23.57**	1.25	21.13**	49.81**	4.96	66.52**	30.71**	10.04	26.81**
T.W x L1	3.90	32.66	-22.99**	16.45*	0.89	42.81**	39.23**	13.14	35.19**
T.W x Sakha1	2.06	11.17	-11.64**	-11.86	-8.33	-10.59	27.82**	8.68	23.86**
T.W X Giza40	-3.71	-8.59	-14.31**	-26.9**	-1.23	-6.32 **	1.08	0.35	-1.92
T.W X Maghraby1	-22.19**	-39.5	-44.16**	9.02	0.77	23.56	33.93**	13.57	30.66**
Ohishima- Zairai x L1	-7.52**	-31.4	-30.54**	24.47*	0.87	72.82**	31.91**	431.00	31.81**
Ohishima- Zairai X Sakha1	15.41**	9.92	1.65	9.02	1.05	19.31	33.50**	5.35	42.39**
Ohishima- Zairai X Giza40	33.88**	7.34	21.29**	-35.69**	-1.14	-6.44	32.24**	∞	32.22**
Ohishima- Zairai X Maghraby1	4.23*	38.24	-24.28**	32.46*	18.58	34.81*	18.61**	33.24	17.95**
L1X Sakha1	6.69**	21.49	-11.48**	25.23**	1.27	56.20**	31.86**	5.15	24.18**
L1 x Giza40	-6.44**	-24.1	-24.29**	34.58**	9.58	39.61**	-4.13	-55.80	-4.20
L1x Maghraby1	-41.43**	-6.84	-44.29**	-8.82	-0.30	29.48*	-7.24**	-14.91	-7.69*
Sakha1x Giza40	-4.04	-2.58	-7.01*	-17.54*	-0.75	7.46	-12.49**	-2.00	-17.65**
Sakha1x Maghraby1	13.69**	28.32	-9.34**	28.69*	2.77	43.56**	31.94**	5.60	24.82**
Giza40x Maghraby1	-12.82**	-30.9	-32.09**	2.59	0.08	52.74**	21.19**	37.84	20.51**
L.S.D									
(0.05)	3.96		4.58	0.56		0.65	1.14		1.31
(0.01)	5.12		5.91	0.80		0.93	1.62		1.87

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تقدير القدرة على التآلف و قوة الهجين من خلال التحليل النصف دائرى فى الفول البلدى لصفات المحصول ومكوناته وجودة البذور.

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أجريت هذه الدراسه بمحطة البحوث الزراعيه بسخا- كفر الشيخ –مصر. تم تقيم الأباء مع هجنها احدى وعشرون هجين في تجربه مصممه في القطاعات كاملة العشوائيه ذات الثلاث مكررات في الموسم ٢٠١٧/٢٠١٦ .أستخدم تحليل half diallel بناء على اقتراح Griffing,1957 لتقدير القدره العامه والخاصه على التآلف أشارت النتائج أن الفعل الجينى المضيف والغير مضيف كانا المتحكمين في توريث كل الصفات المدروسه. * كانت النسبه بين تباين القدرة العامه على التآلف منسوبا الى تباين القدرة الخاصة على التآلف σ^2gca/σ^2sca أكبر من الواحد الصحيح لصفات عدد الأيام حتى التزهير , عدد الفروع/ النبات , وزن ال١٠٠ بذرة وحيوية البذور مما يدل على أن الفعل الجيني المضيف كان الأكثر أهميه في توارث هذه الصفات. بينما كانت أقل من الواحد الصحيح لصفات طول النبات ,عدد القرون/النبات ,عدد البذور /النبات ,محصول الذور بالنبات و النسبه المئوية للبروتين مما يدل على الفعل الجينى الغير المضيف كان الأكثر أهميه في توارث هذه الصفات. * كان الصنف جيزة ٤٠و سلاله١ عالي التآلف في تحسين المحصول بينما كان الصنفان جيزة٤٢٩و مغربى١ ذا قيم عاليه المعنويه للقدره العامه علي التآلف لصفات التبكير في التزهير والقدرة المحصولية العالية. أظهرت الهجن Ohishima-Zairai x Giza40, Ohishima-Zairai x سلاله١ , T.W x سلاله١, مغربي ١ x سخا١ و سلاله١ x سخا١قدرة ائتلافية خاصه مما يدل علي أن التفاعل بين الجينات الآليلية والغيرآليليه المسئول عن توريث هذه الصفات. أظهرت الهجن جيزة ٤٠ Ohishima-Zairai x,جيزه٤٢٩ x جيزة ٤٠ , Ohishima-Zaira x T.W , T.W x سلالة ١ و مغربى١ x T.W قيما معنويه لقوة الهجين مقارنة با لأب الأفضل لمعظم الصفات تحت الدراسه . من هذة النتائج يتضح لنا أن هذه الهجن يمكن زراعتها فى الأجيال الأنعزالية المبكرة باستخدام طريقة الأنتخاب التجميعي لانتاج سلالات عالية في المحصول والبروتين.