The 9th Plant Breeding international Conference September 2015 *Egypt. J. Plant Breed. 19 (5):* **425 - 442** *. 2015 Special Issue*

MODIFIED MODEL FOR ASSESSMENT OF MATERNAL EFFECTS IN FIRST GENERATION OF FABA BEAN

Zeinab E. Ghareeb and W. M. Fares
Center Laboratory for Design and Statistical Analysis Research, ARC, Giza. Egypt.

ABSTRACT

The statistical analysis for five parental faba bean genotypes and their hybrids, revealed highly significant differences among the five parents and their possible hybrids (F_1) for all the studied traits except number of branches per plant. Preliminary information about the presence of significant variation is obtained from Hayman diallel analysis to divide total sum of square into various differences, e.i. additive, non-additive components, maternal or cytoplasmic and other reciprocal differences. The cytoplasmic components were significant for number of seeds/plant, the weight of 100 seeds and seed yield/plant. General and specific combining ability effects were partitioned according to a proposed model to estimate them for each parent when it is used as a female or a male in its hybrid combinations. Results revealed that estimated GCA effects according to Griffing's method is equal to the average of GCA effects of each parent, after partitioning, when it is used as a male and a female in its hybrid combinations. In addition, the average of the difference between female and male GCA effects would provide valid and precise estimation of the maternal effect as previously confirmed by Hayman analysis for number of seeds/plant, the weight of 100 seeds and seed yield/plant. This would prove that maternal effect provides precise estimation to the favorable alleles, which are mainly additive ones. The SCA effects calculated according to Griffing's method is the average of SCA effects of each cross and its reciprocal. Meanwhile, the average of the difference between SCA effects of each cross and its reciprocal, according to the proposed model, is equal to the reciprocal effects. This would prove that reciprocal effect provides precise estimation to the interaction effect between nuclear and cytoplasmic genes inside the nucleus of the cross and its reciprocal hybrid.

Keywords: Griffing's method, Partitioning, Full-diallel, GCA, SCA, Maternal effect, Reciprocal effect.

INTRODUCTION

Faba bean (*Vicia faba* L.) is a valuable food legume crop in Egypt and many other Mediterranean countries. Furthermore, this crop can play a key role in sustainable production and management of agriculture and in enhancement total soil nitrogen fertility of nutrient poor soil through biological atmospheric nitrogen fixation (**Lindemann and Glover, 2003**).

On the other hand, faba bean is a self-pollinating plant with significant levels of outcross and inter-cross, ranging from 20 to 80% (**Suso and Moreno,**

1999) depending on tested genotype and surrounding environmental effects. The genetic improvement of crop desired traits depends on the nature and magnitude of genetic variability and interactions involved in the inheritance of these traits. It can be estimate using diallel cross technique, which provide early information on the genetic behavior of these traits in the first (F_1) generation (**Chowdhry *et al.*, 1992**). This technique may also result in the production of new genetic combinations performance (negatively or positively), may be exceeding over the parents. However, the parental superiority may not depend so much on their actual performance as on their ability to combine well and through transgressive segregates (**Zhang and Kang, 1997**).

The combining ability consider as an important criteria for plant breeders, where it is useful in connection with testing procedures to study and compare the performance of lines in hybrid combinations and the nature of gene action. So, the plant breeders are interesting with the gene effect estimates to apply the most effective breeding procedure for improvement the desired attributes. Moreover, the choice of the most efficient breeding methodology mainly depends upon the type of gene action controlling the genetic behavior of most agronomic and economic characters. 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 the improving yield potential and its components in faba bean plants. Whereas, the superiority of crosses/hybrids over parents for seed yield is associated with manifestation of gene effects in important yield components. These effects may differ from significantly positive to significantly negative for different traits depending on genetic makeup of faba bean parents. The important of gene action and heritability were previously discussed by **Awaad *et al.* (2005); Darwish *et al.* (2005); Attia and Salem (2006); El-Hady *et al.* (2007); El-Harty *et al.* (2009), Bayoumi and El-Bramawy (2010); El-Bramawy and Osman (2010 and 2012) and Ghareeb and Helal (2014).**

Griffing (1956) defined diallel crosses, which have been used extensively in plant breeding. However, general and specific combining ability effects are commonly based on the average effect of the parent when it is used as a female or a male in its hybrid combinations assuming that they are likely to be similar as proposed by **Yates, (1947**). When crosses and their reciprocals are included, the fixed models, only one GCA effect value for each parent and one SCA effect value for each cross combination is estimated. Accordingly, these estimated effects were not separated, showing the contribution of each parent to the cross combination when this particular parent is used as a male or, alternatively, female. The difference between the interaction effect of the cross and its reciprocal is due mainly to the interaction between the nuclear and the cytoplasmic genes as indicated above. Cytoplasm of the female parent may represent different environment that differs from one parent to another (**Ghareeb *et. al.* 2014**) and therefore, interacts with nuclear genes differently. Interaction between the nuclear and the cytoplasmic genes was reported by **Singh and Brown (1991); Ekiz and Konzak (1991); Maan (1992); and Voluevich and Buloichik (1992)**.

Partitioning of the general and specific combining ability effects would provide additional information about each parent when it is used as a female or a male in its hybrid combinations (**Mahgoub, 2004**). Improving the precision of the statistical model used for estimating GCA and SCA effects may provide an effective tool for selecting the breeding method as well as the paired populations to be used in a reciprocal recurrent selection program. In Egypt, on faba bean, no references have been found about the abovementioned research topic.

Therefore, the objectives of the present study were: (1) to compare the GCA and SCA effects before and after partitioning, (2) to evaluate the relative contribution of each parent to its cross combination when it is used as a male or a female parent, (3) to detect the significant of maternal effects, (4) to estimate the relationship between SCA effect and reciprocal effect.

MATERIALS AND METHODS

Faba bean materials and cross model

The current investigation was carried out at Giza Research Station, ARC, Giza, Egypt during two successive growing seasons of faba bean, 2013/14 and 2014/15. Five faba bean genotypes were selected on the basis of the presence of wide differences among them as shown in (**Table 1**). In 2013/2014 season, a complete diallel cross (all crosses combinations including reciprocals) were made between these five parents. The parents and derived 20 F_1's (25 genotypes) were grown in 2014/2015 season under free insect cages in rows 3m long, 30 cm apart with one seed spaced at 20cm. Randomized Complete Block Design with three replications was used. At harvest, data were recorded on ten individual guarded plants aiming the following traits: Plant height (cm), number of branches per plant, number of pods per plant, number of seeds per plant, 100-seed weight (g) and seed yield per plant (g).

Table 1. Pedigree and special traits of five faba bean parental genotypes.

Genotype	Source	Pedigree	Seed type	Characteristics
Giza 3 (P_1)	**Food Legumes Research Department * FCRI, ARC, Egypt**	Cross (Giza 1 x Dutch Intr.).	Equina	Resistant to foliar disease, high yield.
Giza 461 (P_2)		Cross (Giza3 x Colombia Intr.)	Equina	Resistant to foliar disease, high yield.
Nubaria 1 (P_3)		Single plant selection from Rina Blanca	Major	Recommended for planting in newly reclaimed lands and resistant to foliar diseases**.**
Triple white (P_4)		Sudan	Equina	High autofertility, white flower with light seed coat color and colorless hilum, and susceptible to insects' storage.
Giza 716(P_5)		461/843/83 × 503/453/84	Equina	Resistant to foliar diseases and early maturing.

*** FCRI (Field Crop Research Institute), ARC (Agriculture Research Center), Egypt**

Statistical analysis

Analysis of variance was carried out to determine the significance of genotypic differences. When the significant differences among the genotypes were established, the total variance was portioned due to genetic factors using two partitioning methods as follows: 1- The diallel analysis model proposed by **Hayman (1954**) to separate total sum of square into various components, namely, a (additive), b (non-additive, which is further subdivided into b_1,b_2 and b_3), c (maternal) and d (reciprocal differences other than c). 2- The model suggested by **Griffing (1956) method 1 model I** was also applied in a modification type, where GCA and SCA effects were partitioned to study the contribution of each parent when it is used as a male or a female in its hybrid combinations, but not on the average performance of male and female parents (**Mahgoub, 2011**).

Proposed model formula

Griffing's method 1 model I (all crosses, their reciprocals and parents are included = n) was applied where, n = p^2 (p = parent number) Various effects are estimated according to **Griffing (1956**) as follows:

$$\hat{g}_i = \left(\frac{1}{2p}\right)\left(x_{i.} + x_{.i}\right) - \left(\frac{1}{p2}\right) x_{..},$$

$\hat{s}_{ij} = (\frac{1}{2})(x_{ij} + x_{.ji}) - (\frac{1}{2p})(x_{i.} + x_{.i} + x_{j.} + x_{.j}) + (\frac{1}{p2})\, x..,$

$\hat{r}_{ij} = (\frac{1}{2})(x_{ij} + x_{.ji}).$

Maternal effect is estimated according to **Cockerham (1963**) using Griffing's notations as follows: $\hat{m} = (\frac{Xi.+X.j}{2p})$

A proposed model where GCA effect $\hat{g}_i$ is partitioned to estimate GCA effect for the parent when it is used as a female in its hybrid combination $\hat{g}_{fi}$; and GCA effect for the parent when it is used as a male in its hybrid combination $\hat{g}_{mi}$ as follows:

$\hat{g}_{fi} = (\frac{1}{p})(x_{i.}) - (\frac{1}{p2})\, x_{..},$

$\hat{g}_{mi} = (\frac{1}{p})(x_{.i}) - (\frac{1}{p2})\, x_{..}$, where $\hat{g}_{fi}$ is the deviation of the mean performance of the i th parent when it is used as a female, averaged over a set of P males, from the grand mean and $\hat{g}_{mi}$ is the deviation of the mean performance of the i th parent when it is used as a male, averaged over a set of P females, from the grand mean where:

$\hat{g}_i = (\frac{1}{2})(\hat{g}_{fi} + \hat{g}_{mi})$ and, $\hat{m} = (\frac{1}{2})(\hat{g}_{fi} - \hat{g}_{mi})$

This proves that the average of the difference between $\hat{g}_{fi}$ and $\hat{g}_{mi}$ is exactly equal to maternal effect ($\hat{m}$). In other words, estimation of ($\hat{g}_{fi}$ - $\hat{g}_{mi}$) would provide precise estimation for the maternal effect. General combining ability effect provides estimation for the additive effect. Therefore, maternal effect is mainly additive and expresses how much additive effect is involved.

***Check of computaions:** $\sum \hat{g}_i = 0, \sum \hat{g}_f = 0, \sum \hat{g}_{mi} = 0$ **and** $\sum \hat{m} = 0$

Specific combining ability effect is partitioned to estimate SCA effect for the cross $\hat{s}_{ij}$ and for its reciprocal $\hat{s}_{ji}$ as follows:

$\hat{s}_{ij} = x_{ij} - (\frac{1}{2p})(x_{i.} + x_{.i} + x_{j.} + x_{.j}) + (\frac{1}{p2})\, x..,$

$\hat{s}_{ji} = x_{.ji} - (\frac{1}{2p})(x_{i.} + x_{.i} + x_{j.} + x_{.j}) + (\frac{1}{p2})\, x..$, where the average of the partitioned components ($\hat{s}_{ij}$ and $\hat{s}_{ji}$) is equal to calculated $\hat{s}_{ij}$ according to **Griffing'**s method.

*** Check of computaions:** $\sum \hat{s}_{ij} + \sum \hat{s}_{ij} = 2$ *Griffing's* $\sum \hat{s}_{ij}$

Reciprocal effect (r) = $(\frac{1}{2})(\hat{s}_{ij} - \hat{s}_{ji})$ and Reciprocal effect $r_{ij} = -r_{ji}$

This proves that the average of the difference between SCA effect of the cross and its reciprocal is exactly equal to the estimated reciprocal effect. Accordingly, this difference provides precise estimation for the reciprocal effect. Testing the significance differences was estimated according to Griffing's method.

RESULTS AND DISCUSSION

The progress in the breeding program of a certain crop characters depends on the variability in populations and the extent to which the desirable characters are heritable in this respect. However, the knowledge of the genetic architecture of yield and other characters help to formulate a meaningful breeding strategy for developing improved genotypes. Before conducting a complete diallel analysis for all the studied traits, a formal analysis of variance procedure following **Steel and Torrie (1980)** was carried out to see significant genotypic differences among the studied genotypes because only significant genotypic differences allows further analysis of the data. Therefore, the obtained results and their discussion will presented in the following,

Diallel analysis

The statistical analysis for faba bean parental and their hybrids, revealed highly significant differences among the parents and their possible hybrids (F_1) for all the studied traits except number of branches (**Table 2**). These findings were providing evidence for the presence of high considerable amount of genetic variability (genotypes) and additive effect (item a) among the parental faba bean and their respective hybrids (F_1) for all the studied traits except number of branches. Consequently, complete diallel analysis for all the studied traits except number of branches was done. These results were in harmony with those reported by **El-Hosary *et al.* (1998), Awaad *et al.* (2005), Attia and Salem (2006), Bayoumi and El-Bramawy (2010), El-Bramawy and Osman (2012) and Ghareeb and Helal (2014).** Complete diallel analysis for all the studied traits except number of branches was done.

Genotypic variance was partitioned into various components additive (a), non additive (b), maternal effects (c) and d items (**Mather and Jinks 1971 and Aksel and Johnson 1963**). Diallel analysis showed that both additive (a) and non additive (b) components of variance were significant and they have equally important in genetic control of all traits in F_1's. However, the additive component accounted for greater proportion than the non additive component. Significant (b_1) values were obtained for all the studied traits except number of pods, revealing that the dominance deviation of the genes is predominantly in one direction. But

(b_2) was highly significant for all the studied traits, pointing to presence of asymmetrical gene distribution of dominant and recessive alleles, and thus some parents considerably have more number of dominant alleles than others. However, (b_3) was highly significant for 100-seed weight, indicating to significance of the part of dominance deviation which was not attributable to (b_1) and (b_2). Number of seeds, 100-seed weight and seed yield/plant recorded significant item (c) meaning the presence of maternal effects, meanwhile plant height, number of seeds and seed yield/plant revealed significant values for item (d), pointing to the presence reciprocal differences (**Singh and Chaudhary 1985**).

Significant reciprocal effects in the expression of yield and other important traits have been reported by **Chowdhary *et al.* (2007**) in bread wheat and, **Topal *et al.* (2004)** in durum wheat. This indicates maternal influence or role of maternal parent in determining the phenotype of F_1 and thus importance of selecting the parents while making crosses, also there exist evidence for expression of heterosis in yield and almost of agronomic traits. **Radawan *et al* (2010)** pointed out the importance of cytoplasmic effects on faba bean; the presence effects in the reciprocal crosses indicate extra nuclear factors influencing some traits. This suggests that the reciprocal effects may be widely spread in faba bean and that trait expression in F_1 hybrid maybe due to the function of both genetic and cytoplasmic factors.

Table 2. Significance of mean squares due to different sources of variations for the all studied characters according to Hayman's model.

S.O.V	d.f	Plant height	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100- seed weight	Seed yield/ plant
Genotypes	**24**	487.31**	2.64^{ns}	310.79**	1376.51**	920.83**	1351.34**
a	**4**	1314.87**	-	1080.74**	4222.79**	3939.93**	2875.58**
b	**10**	383.06**	-	169.00*	798.64**	367.21**	945.81**
b_1	**1**	938.35**	-	201.57	1238.18*	976.55**	3774.15**
b_2	**4**	521.15**	-	273.25**	1300.62**	124.38**	1260.63**
b_3	**5**	161.53	-	79.09	309.14	439.61**	128.30
c	**4**	151.37	-	197.59	818.01*	573.73**	1582.86**
d	**6**	333.30**	-	109.28	814.44*	62.18	856.71**
Pooled Error	**48**	82.109	1.95	67.91	262.38	32.82	295.50

a: additive variance component, b: non-additive, which is further subdivided into (b1,b2 and b3), c: maternal or cytoplasmic and d: reciprocal differences other than c variance component.
***, ** and ns indicates significant, highly significant and insignificant at the 0.05 and 0.01 level of probability.**

Performance of parents and their hybrids

There is no doubt genetically, that the offspring which produced from different hybrids may be displays a higher yielding potential compared to the mean yield of its parents. Mean values of the five faba bean parental and their respective hybrids for the significant traits are obtainable in **Table (3).** The behavior of plant height character was significantly differed from one genotype to another over all faba bean genotypes (parents and their hybrids). The faba bean parents plants ranged from 135.00 (P1, Giza **3**) to 100.00 (P4, Triple white) cm, while, the average of plant length in the different hybrids ranged from 141.67 (Nubaria 1x Giza 461) to 91.11 (Giza 3 x Giza 716) cm. Therefore, it can note that the crosses P2 x P1 (Giza 461 x Giza 3), P1 x P3 (Giza 3 x Nubaria 1) and P1 x P2 (Giza 3 x Giza 461) had the tallest plants.

The parent P4 (Triple white) possessed the lowest values for number of branches per plant (2.33), 100-seed weight (51.13g) and seed yield per plant (32.33g). Moreover, the parent P3 (Nubaria 1) gave the highest values (5.31, 111.70g and 64.78g, respectively) for the same traits. The hybrid P3 x P2 (Nubaria 1 x Giza 461) revealed the highest values for branches number per plant (6.67) and seed yield per plant (119.33). While, P4 x P3 (Triple white x Nubaria 1), P1 x P3 (Giza 3 x Nubaria 1) and P2 x P3 (Giza 461 x Nubaria 1) revealed the highest values of 100-seed weight (115.06, 114.68 and 113.83g, respectively).

The parent P1 (Giza 3) gave the highest values for number of pods per plant (33.00) and number of seed per plant (91.00). Moreover, P5 (Giza 716) showed the lowest values (16.50 pods and 47.92 seeds per plant). On the other side, the hybrid, P1x P2 (Giza 3 x Giza 461) recorded the highest values for number of pods per plant (51.00 pods) and number of seeds per plant (133.33 seeds).

Regarding to the mean performance of the parents and their hybrids, it could conclude that these hybrids had highly promising characters for breeding faba bean genotypes. Thus, it should possess the genetic factors for high yield potential. These results could be confirmed the possibility of selection for these characters through the hybrids and their respective parents. Moreover it allowed the gate open in the front of plant breeders to build future breeding program for high potential yield in faba bean crop. These findings were in agreement with whose reported by **El-Hosary *et al.* (1998); Awaad *et al.* (2005); Darwish *et al.* (2005); El-Hady *et al.* (2007); EL-Harty *et al.* (2009), Bayoumi and El-Bramawy (2010), Ibrahim (2010), El-Bramawy and Osman (2012) and Ghareeb and Helal (2014)**.

Table 3. The mean performance of parents, F_1´s and their reciprocals for the significant traits.

Genotypes	Plant height	No. of pods/ plant	No. of seeds/ plant	100- seed weight	Seed yield/ Plant
Giza3 (P_1)	135.00	33.00	91.00	69.31	63.17
Giza461 (P_2)	116.67	25.00	63.00	70.38	44.30
Nubaria 1 (P_3)	102.64	16.83	58.95	111.70	64.78
Triple white (P_4)	100.00	29.00	81.00	51.13	32.33
Giza 716(P_5)	105.00	16.50	47.92	85.04	41.47
P_1 x P_2	131.67	51.00	133.33	67.79	90.00
P_1 x P_3	131.67	28.33	78.67	114.68	90.77
P_1 x P_4	115.00	46.67	103.00	72.89	75.10
P_1 x P_5	91.11	11.11	36.89	80.49	29.89
P_2 x P_3	126.67	27.33	81.00	113.83	57.97
P_2 x P_4	130.00	37.00	103.00	63.52	65.53
P_2 x P_5	124.17	22.92	71.83	91.20	67.33
P_3 x P_4	116.67	39.67	98.33	89.16	93.07
P_3 x P_5	117.78	16.00	62.44	89.21	56.89
P_4 x P_5	113.61	17.11	53.53	88.33	47.33
P_2 x P_1	140.00	29.67	75.33	72.75	54.40
P_3 x P_1	123.33	25.00	76.67	93.00	72.20
P_4 x P_1	123.33	31.67	81.00	65.10	53.83
P_5 x P_1	120.83	19.97	65.08	75.18	49.00
P_3 x P_2	141.67	37.67	98.00	100.33	119.33
P_4 x P_2	128.33	36.00	96.33	72.52	90.73
P_5 x P_2	106.25	19.92	67.50	91.46	61.17
P_4 x P_3	111.67	31.00	77.67	115.06	67.23
P_5 x P_3	110.00	17.33	60.50	98.83	59.92
P_5 x P_4	110.33	17.94	50.50	75.36	37.19
LSD	**25.76**	**23.42**	**46.04**	**16.28**	**48.86**

Combining ability

In diallel hybrids, such information about general and specific combining ability for parents and their hybrids may be helpful breeders to identify the best combiners which may be hybridized to build up favorable fixable genes. The estimates of GCA effects “**gi**” listed in **Table (4),** where differed from one individual parent to another and from character to other. Partitioning of the GCA effects to estimate male and female effects revealed that the average of $\hat{g}_{fi}$ and $\hat{g}_{mi}$ effects calculated according to Griffing's method might underestimate the breeding value of the parent if it showed better performance when it is used as a female or a male in its hybrid combinations. Data in **Table 4** show that the average of the difference between $\hat{g}_{fi}$ and $\hat{g}_{mi}$ is exactly equal to maternal effect, which is based on the average of the females over all associated males.

The parental genotype Giza 461 (P2) had significant and highly significant positive GCA effects “**gi**” for all studied characters except to 100-seed weight. Therefore, this parent could be good combiner for improving these studied characters, since the significant values positive according to the desirable trend of these characters (**Table 4**). Also, the parent Triple white (P4) showed positive and highly significant values for number of pods per plant (4.16) and number of seeds per plant (6.04). However, the parental genotype Nubaria 1 (P3) was good combiner for 100-seed weight (19.02) and seed yield per plant (11.30). Therefore, the parent Nubaria 1 (P3) could be good source for improving 100-seed weight and seed yield per plant in faba bean crop. Consequently, it could be concluded that previously mentioned parental genotypes and their hybrids would prospect in faba bean breeding and therefore may be valuable for improving seed yield and its components. The detection of the combining ability of the parental genotype provides better information not only for selecting the parent for hybridization (or building synthetic cultivars) but also in choosing the proper breeding scheme. Similar findings were earlier reported by **El-Hosary *et al.* (1998); Darwish *et al.* (2005); El-Hady *et al.* (2007), Ibrahim (2010) and El-Bramawy and Osman (2012)**.

Partitioning of the GCA effects to estimate male and female effects ($\hat{g}_{fi}$ and $\hat{g}_{mi}$) showed better performance when it is used as a female or a male in its hybrid combinations. Data in **Table 4** show that the average of $\hat{g}_{fi}$ and $\hat{g}_{mi}$ effects for 100-seed weight calculated according to Griffing's method (19.02) overestimated the breeding value of the parent 3 (Nubaria 1) compared with its breeding value when it was used as a female parent (11.95), while it underestimated when it was used as a male parent (26.09). Parent 3 (Nubaria 1) revealed much higher $\hat{g}_{mi}$ than $\hat{g}_{fi}$ parent 3 (Nubaria 1). Likewise in seed yield per plant trait had higher GCA effects when it was used as a female $\hat{g}_{fi}$, rather

Table 4. The GCA effects ($\hat{g}_{i}$) and the adjusted partitioning of the GCA effects to estimate female ($\hat{g}_{fi}$) and male effects ($\hat{g}_{mi}$) of the five parent populations.

Genotype	GCA	Plant height	No. of pods/ plant	No. of seeds/ plant	100- seed weight	Seed yield/ plant
Giza3 (P_1)	$\hat{g}_i$	*5.76***	*3.60**	*6.70***	*-6.68***	*0.75*
	$\hat{g}_{fi}$	**1.95**	**6.68****	**12.08****	**-3.70****	**6.39****
	$\hat{g}_{mi}$	**9.56****	**0.52**	**1.32**	**-9.66****	**-4.88***
Giza461 (P_2)	$\hat{g}_i$	*7.27***	*3.80**	*8.73***	*-3.31***	*6.11***
	$\hat{g}_{fi}$	**8.56****	**1.04**	**2.33**	**-2.39**	**-5.49***
	$\hat{g}_{mi}$	**5.98****	**6.57****	**15.13****	**-4.23****	**17.71****
Nubaria 1 (P_3)	$\hat{g}_i$	*-0.46*	*-1.75*	*-1.38*	*19.02***	*11.30***
	$\hat{g}_{fi}$	**1.48**	**-0.31**	**2.38**	**11.95****	**17.86****
	$\hat{g}_{mi}$	**-2.41**	**-3.18***	**-5.14***	**26.09****	**4.73***
Triple white (P_4)	$\hat{g}_i$	*-4.04**	*4.16***	*6.04***	*-10.31***	*-3.93*
	$\hat{g}_{fi}$	**-3.55***	**1.61**	**1.41**	**-6.30****	**-5.10***
	$\hat{g}_{mi}$	**-4.54****	**6.71****	**10.67****	**-14.32****	**-2.75**
Giza 716(P_5)	$\hat{g}_i$	*-8.53***	*-9.82***	*-20.09***	*1.28*	*-14.23***
	$\hat{g}_{fi}$	**-8.45****	**-9.01****	**-18.20****	**0.44**	**-13.65****
	$\hat{g}_{mi}$	**-8.60****	**-10.62****	**-21.98****	**2.12**	**-14.81****
SE GCA_i	$\hat{g}_i$	2.563	2.33	4.58	1.62	4.86

***, ** and ns indicates significant, highly significant and insignificant at the 0.05 and 0.01 level of probability.**

than a male $\hat{g}_{mi}$ ($\hat{g}_{fi}$, 17.86 higher than $\hat{g}_{mi}$, 4.73), with an average 11.30 for both according to Griffing's method overestimated the breeding value of the parent 3 (Nubaria 1). This indicated that more favorable alleles were provided by the female plants of parent 3 to the offspring than the male ones of the same parent and GCA effects calculated according to Griffing's method do not show the magnitude of the difference between parents 3 when it used as male or female parents. Therefore, a breeding method, where the progeny test is based mainly on the performance of the offspring of the female plants (e. g. half sib family selection), may be more effective in detecting the high $\hat{g}_{fi}$ and consequently more effective in improving of population 3 in seed yield per plant. The significance of $\hat{g}_{fi}$ of parent 3 (Nubaria 1) may indicate that some gain from selection is expected if the progeny test was based on the performance of the offspring of the female plants as family selection (**Genter and Eberhart, 1974**).

Adjusted maternal effects:

Table (5) showed the adjusted maternal (m) effects of the tested five parents. Results revealed significant values for number of seeds, 100-seed weight and seed yield/plant. Nubaria 1 (P_3) recorded the highest maternal effects values for 100-seed weight and seed yield per plant (-7.07** and 6.56*, respectively). Meanwhile, Giza 461 (P_2) had significant maternal effect value for number of seeds per plant (-6.40*), whereas Giza3 (P_1) had significant maternal effect value for seed yield per plant (5.63*). Also Triple white (P_4) recorded (4.01*) for 100-seed weight. The average of the difference between $\hat{g}_{fi}$ and $\hat{g}_{mi}$ effects are exactly equal to the maternal effect calculated according to **Cockerham (1963**), which is based on the average of the females over all associated males. Therefore, partitioning of the GCA effects provided additional information to plant breeders about estimating maternal effect. Estimation of maternal effects, which is based on the average of the females over all associated males, would underestimate maternal effect of some specific cross combinations, which may be more important. Therefore, partitioning of the maternal effects leads to estimation of the reciprocal effects, this provides estimation of the maternal effects on a hybrid combination basis rather than on the average of all associated male parents **(Mahgoub, 2011 and Fan *et al*., 2014)**.

Table 5. The adjusted maternal (m) effects of the five parent populations.

Genotypes	Plant height	No. of pods/ plant	No. of seeds/ plant	100- seed weight	Seed yield/ plant
Giza3 (P_1)	-3.81	3.08	5.38	2.98	5.63*
Giza461 (P_2)	1.29	-2.77	-6.40*	0.92	-11.60**
Nubaria 1 (P_3)	1.94	1.43	3.76	-7.07**	6.56*
Triple white (P_4)	0.49	-2.55	-4.63	4.01*	-1.18
Giza 716(P_5)	0.07	0.80	1.89	-0.84	0.58
SE (GCAi-GCAj)	**4.052**	**3.68**	**7.14**	**2.56**	**7.68**

***, ** and ns indicates significant, highly significant and insignificant at the 0.05 and 0.01 level of probability ns**

Specific combining ability:

The SCA effects calculated according to Griffing's method and the partitioned SCA effects are presented in **Table (6).** Plant height and seed yield per plant traits revealed that, cross (3 x 2) had significant and much higher values for SCA effects (15.92** and 38.53**, respectively) after partitioning, compared with its reciprocal (2 x 3) values (0.92 and -22.84**, respectively). But SCA effects calculated according to Griffing's method assumed that SCA effects are the same (8.42** and 7.85*, respectively) for each cross and its reciprocal (equal the average of cross and its reciprocal SCA effects) and do not show this additional information. Likewise, cross (1 x 2) had SCA effects with more significant and much higher values after partitioning (16.25** and 41.40**), compared with their reciprocals (2 x 1) for number of pods and seeds per plant (-5.08* and -16.60**), respectively. Also, cross (4 x 3) had significant with much higher SCA effects values after partitioning (21.62**), compared with their reciprocal (3 x 4) for 100-seed weight (-4.28).

Adjusted reciprocal effects:

The SCA effects were different (after partitioning) when a genotype was used as female from those when the same genotype was used as male (**Mahgoub, 2011 and Fan, et. al. 2014**). Reciprocal effects (r) calculated according to Griffing's method and the partitioned SCA effects are presented in **Table (7).** Crosses between P2 and P3 recorded the highest and significant reciprocal effect (r) values for yield per plant (±30.68**). Meanwhile, number of seeds and seed yield per plant showed the greatest and significant reciprocal effects (±29.00** and ±17.80**) by the progeny of crosses P1 and P2, respectively. The highest and significant reciprocal effects (±14.86** and ±14.10**) were obtained in crosses between P1 and P5 for plant height and number of seeds. Then, reciprocal effect values between P1 x P2 (r_{ij}) and between P2 x P1 (r_{ji}) had the same values with different sign ($r_{ij} = - r_{ji}$) **(Fan, et. al. 2014)**.

Table 6. The SCA effects according to Griffing's method (upper) and SCA effects according to the proposed method (bold, lower) of F_1´s and their reciprocals.

Genotypes	SCA	Plant height	No. of pods/ plant	No. of seeds/ plant	100- seed weight	Seed yield/ plant
P1, P2	Griffing's	3.87	5.59*	12.40**	-4.47	1.94
P1 x P2	**Cross**	**-0.30**	**16.25****	**41.40****	**-6.95***	**19.74****
P2 x P1	**Reciprocal**	**8.03****	**-5.08***	**-16.60****	**-1.99**	**-15.86****
P1, P3	Griffing's	3.27	-2.53	-4.15	6.77	6.04
P1 x P3	**Cross**	**7.44****	**-0.86**	**-3.15**	**17.61****	**15.32****
P3 x P1	**Reciprocal**	**-0.90**	**-4.20**	**-5.15**	**-4.07**	**-3.25**
P1, P4	Griffing's	-1.49	4.06	2.77	1.25	4.24
P1 x P4	**Cross**	**-5.65***	**11.56****	**13.77****	**5.15**	**14.88****
P4 x P1	**Reciprocal**	**2.68**	**-3.44**	**-8.23***	**-2.64**	**-6.39**
P1, P5	Griffing's	-10.20**	-5.58*	-12.12**	-1.50	-10.48**
P1 x P5	**Cross**	**-25.06****	**-10.01****	**-26.22****	**1.16**	**-20.03****
P5 x P1	**Reciprocal**	**4.67**	**-1.16**	**1.97**	**-4.16**	**-0.92**
P2, P3	Griffing's	8.42**	3.10	5.65	6.64	7.85*
P2 x P3	**Cross**	**0.92**	**-2.07**	**-2.85**	**13.39****	**-22.84****
P3 x P2	**Reciprocal**	**15.92****	**8.26****	**14.15****	**-0.11**	**38.53****
P2, P4	Griffing's	7.00**	1.19	8.40*	-3.09	12.55**
P2 x P4	**Cross**	**7.83****	**1.69**	**11.73****	**-7.59***	**-0.05**
P4 x P2	**Reciprocal**	**6.17***	**0.69**	**5.06**	**1.41**	**25.15****
P2, P5	Griffing's	-2.47	0.08	4.52	8.63*	8.97**
P2 x P5	**Cross**	**6.49****	**1.58**	**6.69***	**8.50***	**12.06****
P5 x P2	**Reciprocal**	**-11.43****	**-1.42**	**2.35**	**8.76***	**5.89**
P3, P4	Griffing's	-0.26	5.57*	6.85*	8.67*	9.39**
P3 x P4	**Cross**	**2.24**	**9.91****	**17.18****	**-4.28**	**22.30****
P4 x P3	**Reciprocal**	**-2.76**	**1.24**	**-3.49**	**21.62****	**-3.53**
P3, P5	Griffing's	3.94	0.88	6.44*	-11.02	-2.06
P3 x P5	**Cross**	**7.83****	**0.21**	**7.41***	**-15.83**	**-3.57**
P5 x P3	**Reciprocal**	**0.05**	**1.55**	**5.47**	**-6.02**	**-0.55**
P4, P5	Griffing's	5.60*	-4.16	-10.43**	6.14	-2.98
P4 x P5	**Cross**	**7.24****	**-4.58***	**-8.92****	**12.63****	**2.09**
P5 x P4	**Reciprocal**	**3.97**	**-3.75**	**-11.95****	**-0.35**	**-8.05***
SE SCA_{ij}		**5.284**	**4.80**	**9.44**	**3.34**	**10.02**

***, ** and ns indicates significant, highly significant and insignificant at the 0.05 and 0.01 level of probability.**

Table 7. Reciprocal (r) effects calculated according to Griffing's and adjusted method (as the same values, but in two directions).

Genotypes	Plant height	No. of pods/ plant	No. of seeds/ plant	100- seed weight	Seed yield/ plant
P_1 , P_2	-4.17**	10.67**	29.00**	-2.48	17.80**
P_1 , P_3	4.17**	1.67	1.00	10.84**	9.28*
P_1 , P_4	-4.17**	7.50**	11.00**	3.90	10.63*
P_1 , P_5	-14.86**	-4.43	-14.10**	2.66	-9.56*
P_2 , P_3	-7.50**	-5.17	-8.50*	6.75**	-30.68**
P_2 , P_4	0.83	0.50	3.33	-4.50*	-12.60**
P_2 , P_5	8.96**	1.50	2.17	-0.13	3.08
P_3 , P_4	2.50*	4.33	10.33*	-12.95**	12.92**
P_3 , P_5	3.89**	-0.67	0.97	-4.81*	-1.51
P_4 , P_5	1.64	-0.41	1.51	6.49**	5.07
SE R_{ij}	**6.407**	**5.82**	**11.45**	**4.05**	**12.15**

There are r_{ij} values, whereas r_{ji} had the same values with different sign (r_{ij} = - r_{ji}).

In diallel, the occurrence of reciprocal differences for all components, indicated that the cytoplasm of maternally inherited factors interact with nuclear genes to control the response of faba bean genotypes. The reciprocal effects were strongly influenced estimates of SCA effects.

REFERENCES

Aksel, R. and L. P. V. Johnson (1963). Analysis of a diallel cross: A worked example. Advancing Frontiers Plant Science 2: 37-53.

Attia Sabah M. and Manal M. Salem (2006). Analysis of yield and its components using diallel mating among five parents of faba bean. Egyptian Journal of Plant Breeding 10(1): 1-12.

Awaad H. A., A. H. Salem, A. M. A. Mohsen, M. M. M. Atia, E. E. Hassan, M. I. Amer and A. M. Moursi (2005). Assessment of some genetic parameters for resistance to leaf miner, chocolate spot, rust and yield of faba bean in F2 and F4 generations. Egyptian Journal of Plant Breeding 9(1):1-15.

Bayoumi T. Y. and M. A. S. El-Bramawy (2010). Genetic behavior of seed yield components and resistance of some foliar diseases with its relation to yield in faba bean (*Vicia faba* L.). The International Conference of Agronomy, 20-22 September, ELArish, 290-315.

Chowdhary M. A., M. Sajad and M. I. Ashraf (2007). Analysis on combining ability of metric trait in bread wheat (*Triticum aestivum*). Journal of Agriculture Research 45(1): 11-17.

Chowdhry M. A., M. S. Akhtar and M. T. Ahmad (1992). Combining ability analysis for flag leaf area, yield and its components in spring wheat. Pakistan Journal of Agricultural Research 30**:**17-23.

Cockerham, C. C. (1963). Estimation of genetic variances *In* Hanson, W D and H F Robinson (ed) Statistical genetics and plant breeding. Natl Acad of Sci- Natl Res Counc. Washington, DC.

Darwish D. S., M. M. F. Abdalla, M. M. El-Hady and E. A. A. El-Emam (2005). Investigations on faba bean (*Vicia faba* L.) 19-Diallel and triallel mating using five parents. Proceed. Fourth Plant Breeding Conference March 5 (Ismailia) Egyptian Journal of Plant Breeding 9(1): 197-208.

Ekiz, H. B., and C. F. Konzak (1991). Nuclear and cytoplasmic control of anther culture response in wheat III Common wheat crosses. Crop Science 31:1432-1436.

El-Bramawy M. A. S. and M. A. M. Osman (2010). Influence of potassium fertilization on yield components and resistance to leaf miner and aphid infestations of *Vicia faba* L. Agriculture Research Journal, Suez Canal University, 9(3): 93-104.

El-Bramawy M. A. S. and M. A. M. Osman (2012). Diallel crosses of genetic enhancement for seed yield components and resistance to leaf miner and aphid infestations of *Vicia faba* L.. International Journal of Agronomy and Agricultural Research (IJAAR), 2(2):8-21.

El-Hady M. M., A. M. A. Rizk, M. M. Omran and S. B. Ragheb (2007). Genetic behavior of some faba bean (*Vicia faba* L.) genotypes and its crosses. Annals of Agriculture Science, Moshtoher 45(1): 49-60.

EL-Harty E. H., M. Shaaban, M. M. Omran and S. B. Ragheb (2009). Heterosis and genetic analysis of yield and some characters in faba bean (*Vicia faba* L.). Minia Journal of Agriculture Research and Development 27(5): 897-913.

El-Hosary A. A., S. A. Sedhom, M. H. Bastawisy and M. H. El-Mahdy (1998). Diallel analysis of some quantitative characters in faba bean (*Vicia fabea* L.). Proceeding of the 8th Conference on Agronomy, Suez Canal University, Ismailia, Egypt, 28-29, November: 256- 267.

Fan X. M., Y. Z. Zhang, W. H. Yao, Y. Q. Bi, L. Liu, H. M. Chen and M. S. Kang (2014). Reciprocal diallel crosses impact combining ability, variance estimation, and heterotic group classification. Crop Science 54:89-97.

Genter, C. F., and S. A. Eberhart (1974). Performance of original and advanced maize populations and their diallel crosses. Crop Science 14:881-885.

Ghareeb Zeinab, E. and A. G. Helal (2014). Diallel analysis and separation of genetic variance components in eight faba bean genotypes. Annals of Agricultural Science, 59(1): 147–154.

Ghareeb Zeinab, E., Hoda E. A. Ibrahim and M. A. M. Ibrahim (2014). Probability of maternal effects on faba bean seed quality and yield components. Egyptian Journal of Plant Breeding, 18(3):483 – 494.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biology and Science 9:463-493.

Hayman B. I. (1954). The theory and analysis of diallel crosses. Genetics 39: 789-809.

Ibrahim H. M. (2010). Heterosis, combining ability and components of genetic variance in faba bean (*Vicia faba* L.). Journal of King Abdulaziz University, Faculty of Meteorology, Environment and Arid Land Agriculture Sciences 21: 35-50.

Lindemann C. and R. Glover (2003). Nitrogen Fixation by Legumes, New Mexico State University, Mexico. Available at: www.cahe.nmus.edu/pubs/- a/a-129.pdf.

Maan, S. S. (1992). A gene for embryo-endosperm compatibility and seed viability in alloplasmic *Triticum turgidum* Genome, Ottawa: National Research Council of Canada, 35:772-779.

Mahgoub, G. M. A. (2004). Modification of Griffing's methods 1 and 3 of diallel analysis for estimating general and specific combining ability effects for male and female parents. Egyptian Journal of Plant Breeding, 8:1-20.

Mahgoub Galal M. A. (2011). Partitioning of general and specific combining ability Effects for estimating maternal and reciprocal effects. Journal of Agricultural Science. 3 (2): 213-222.

Mather K. and J. L. Jinks (1971). Biometrical Genetics, 2nd ed. Chapman & Hall Ltd., London. 382.

Radwan, F. I., M. A. A. Nassar, M. M. EL-Hady and A. A. Abou-Zied (2010). Evaluation of some hybrids faba bean (*Vicia faba* L.) to chocolate spot disease (*Botrytis fabea sard*.). Journal of Advanced Agriculture Research Saba Basha, Alexandria University.15 (1):123-139.

Singh, M. and G. G. Brown (1991). Suppression of cytoplasmic male sterility by nuclear genes alters expression of a novel mitochondrial gene region. Plant Cell, 3:1349-1362.

Singh, R. K., and B. D. Chaudhary (1985). Biometrical methods in Quantitative genetic analysis *Kalyani puplishers* New Delhi-Ludhiana.

Steel, R. G. D. and J. H. Torrie (1980). Principals and procedures of statistics. McGraw Hill Book Co. Inc., New York, USA.

Suso M.J. and M.T. Moreno (1999). Variation in outcrossing rate and genetic structure on six cultivars of *Vicia faba* L. as affected by geographic location and year, Plant Breeding **118,** 347-350.

Topal A. , C. Aydin, N. Akgun and M. Babaoglu (2004). Diallel cross analysis in durum wheat: Identification of best parents for some kernel physical features. Field crops research 87:1-12.

Voluevich, E. A., and A. A. Buloichik (1992). Nuclear-cytoplasmic interactions in the resistance of wheat to fungal pathogens II Effect of cultivated and wild cereal cytoplasms on the expression of the genome of the Leningradka variety during interaction with the floury mildew pathogen. Sov Genet, New York Consultants Bureau 27:1501-1505.

Yates, F. (1947). The analysis of data from all possible reciprocal crosses between a set of parental lines. Heredity 1:287-301.

Zhang Y. and M.S. Kang (1997). DIALLEL-SAS: a SAS program for Griffing's diallel analyses. Agronomy Journal 89: 176–182.

نموذج معدل لتقييم التأثيرات الامية فى الجيل الأول للفول البلدى

زينب السيد غريب – وليد محمد فارس

المعمل المركزي لبحوث التصميم والتحليل الاحصائى – مركز البحوث الزراعية – الجيزة – مصر

اظهر التحليل الإحصائي لخمسة تراكيب ابوية من الفول البلدى وكل هجن الجيل الاول (F1) الممكنة الناتجة فيما بينها وجود فروق عالية المعنوية لجميع الصفات المدروسة باستثناء عدد الأفرع على النبات. حيث استخدم تحليل diallel لهايمان للحصول على معلومات أولية عن وجود تباين معنوى للتراكيب الوراثية وتوزيع مجموع المربعات الكلية الى مصادرها المختلفة مثل التباين المضيف ، والتباين الغير مضيف ، والتباين السيتوبلازمى أو الراجع للأم ، وتباين التاثيرات العكسية الأخرى. وقد اظهر المكون السيتوبلازمى تاثيرا معنويا لصفات عدد البذورعلى النبات ، ووزن ١٠٠ بذرة ، ومحصول البذور على النبات. تم تقسيم تأثيرات القدرة العامة والخاصة على الائتلاف وفقا لنموذج مقترح لتقسيم كل تأثير لكل تركيب أبوى عندما يستخدم بوصفه أم أو أب في تركيبات الهجين.

وقد اوضحت النتائج ان تاثيرات القدرة العامة على التآلف GCA وفقا لطريقة جريفنج مساوية لمتوسط تاثيرات القدرة العامة على التآلف GCA من كلا الأبوين (بعد التقسيم، عندما يتم استخدامها كأم أو كأب في تركيبات الهجين). بالإضافة إلى ذلك، فإن متوسط الفرق بين تاثيرات القدرة العامة على التآلف GCA للأم و للأب تعطى تقديرا دقيقا للتأثيرات الأمية أو السيتوبلازمية تأكيدا على نتائج هايمان لنفس صفات عدد البذورعلى النبات ، ووزن ١٠٠ بذرة ، ومحصول البذور على النبات. هذا من شأنه أن يثبت أن التأثيرات الأمية او السيتوبلازمية تبرز الأليلات المتاحة، والتي تعتبر ذات تأثيراً مضيفاً. تأثيرات القدرة الخاصة على الائتلاف SCA وفقا لطريقة جريفنج كان مساويا لمتوسط تأثيرات القدرة الخاصة على الائتلاف SCA لكل هجين وعكسه (وفقا للنموذج المقترح). بينما متوسط الفرق بين تأثيرات القدرة الخاصة على الائتلاف SCA بين كل هجين عكسه (وفقا للنموذج المقترح) كان مساويا للتأثيرات العكسية. وذلك يؤكد أن التأثيرات العكسية تقدم تقديرا دقيقا لتأثيرات التفاعل بين الجينات النووية والسيتوبلازمية داخل نواة الهجين والهجين العكسى.

المؤتمر الدولى التاسع لتربية النبات - عدد خاص من *المجلة المصرية لتربية النبات ١٩(٥): ٤٢٥ - ٤٤٢ (٢٠١٥)*