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Modified model for assessment of maternal effects in first generation of faba bean

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KEYWORDS

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Reciprocal effect;
Maternal effect

Abstract This study was carried out during two successive growing seasons, 2013/14 and 2014/15 at Giza Research Station, ARC, Giza, Egypt, in order to assess proposed modified model when the general and specific combining ability (GCA and SCA) effects were portioned to female and male effects and to assess the maternal and reciprocal effects in 5 × 5 diallel crosses of faba bean. The results of statistical analysis for parental genotypes and their F_1 hybrids, revealed highly significant differences among them for all studied traits except number of branches per plant. The cytoplasmic components were significant for number of seeds/plant, weight of 100 seeds and seed yield/plant. Results also revealed that estimated GCA effects according to Griffing's method were equal to the average of GCA effects of each parent, after partitioning in the proposed model. In addition, the average of the difference between female and male GCA effects would provide valid and precise estimation of the maternal effect (favorable alleles, which are mainly additive) as previously confirmed by Hayman analysis for number of seeds/plant, weight of 100 seeds and seed yield/plant. The SCA effects calculated according to Griffing's method equaled the average of SCA effects of each cross and its reciprocal. Meanwhile, in the proposed model, the average of the difference between SCA effects of each cross and its reciprocal equaled the reciprocal effects. This would prove that reciprocal effect provides precise estimation to the interaction effect between nuclear and cytoplasmic genes of the cross and its reciprocal hybrid.

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 estimated using diallel cross technique, which provides early information on the

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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), maybe 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 considers 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 the improvement of 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 total value of variances must be portioned into its genetic components. Hence, exploitation of the genetic components could encourage 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 importance of gene action and heritability was previously discussed by Awaad et al. (2005), Darwish et al. (2005), Attia and Salem (2006), El-Hady et al. (2007, 2009), Bayoumi and El-Bramawy (2010), El-Bramawy and Osman (2010, 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 to: (1) compare the GCA and SCA effects before and after partitioning, (2) evaluate the relative contribution of each parent to its cross combination when it is used as a male or a female parent, (3) detect the significant of maternal effects and (4) estimate the relationship between SCA effect and reciprocal effect.

Materials and methods

Genetic materials and cross model

The current investigation was carried out at Giza Research Station, ARC, Giza, Egypt, during two successive growing seasons, 2013/14 and 2014/15. Five faba bean varieties were chosen on the basis of the presence of wide differences among them as shown in Table 1. In 2013/14 season, full diallel crosses (all cross combinations including reciprocals) were made between the five parents. The parents and their 20 F_1's (25 genotypes) were grown in 2014/15 season at the 26th November. Each genotype was planted in 4 rows 3 m long, 30 cm apart from one seed spaced at 20 cm. Randomized Complete Block Design with three replications was used under free insect cages. The soil texture of the experimental site was clay loam with pH value of 7.4 and EC of 2.46 dS/m. Cultural practices were applied as recommended for faba bean production in the area to raise a good crop. At harvest, data were recorded on ten individual guarded plants aiming the following

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	Cross (Giza 1 × Dutch Intr. 29)	Equina	Resistant to foliar disease, high yield
Giza 461 (P_2)	* FCRI, ARC, Egypt	Cross (Giza 3 × ILB938)	Equina	Resistant to foliar disease, high yield
Nubaria 1 (P_3)		Single plant selection from the Spanish cultivar Reina 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.