

Selection Advantages in Faba Bean (*Vicia Faba L.*) For Early Maturity and High Productivity

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Abstract: This work was conducted in the experimental farm of Mattana Agricultural Research Station, Agricultural Research Center, Egypt, during two successive winter seasons of 2007/2008 and 2008/2009 to study the response of phenotypic directional selection from the offspring of 4-parent diallel cross among local cultivars with variable levels of earliness and high yielding ability. Four cultivars of faba bean i.e. Giza-716, Giza-843, Sakha-1 and TripleWhite were crossed in a half diallel pattern to attain the goal of this study. In the first season of 2007/2008, mean performances of the four parents and their offspring of F2 generation for both weights of seeds per plant (yield) and number of days from sowing to maturity were measured in order to make the best choices of populations of both high yielding ability and earliness. The results showed that three of six populations attained the best results of the critical traits i.e. Sakha-1 × Giza-843, Sakha-1 × Giza-716 and Giza-843 × TripleWhite. In the second season of 2008/2009, the responses to selection were measured at the levels of six out of eight traits because there were no significant differences between the bulk and the selected populations in both numbers of days from sowing to flowering and maturity. Plant height of the selected F3 families insignificantly varied among the 3 populations that ranged from 109.1 to 119.1 cm. Number of branches per plant of the selected F3 families considerably varied among the 3 populations that ranged from 4.47 to 7.07 branches. Number of pods per plant of the selected F3 families varied insignificantly among the 3 populations that ranged from 36.7 to 53.9 pods. Number of seeds per plant of the selected F3 families varied insignificantly among the 3 populations that ranged from 95.7 to 100.8 seeds and although the analysis of variance indicated insignificant variations among the 3 populations selected of F3 for number of pods and seeds/plant, the responses to selection for both traits were very high. Weight of seeds (g) per plant of the selected F3 families varied considerably among the 3 populations that ranged from 59.16 to 105.13 grams of seed and also the response to selection was so high and reached a convenient level to continue for further cycles of selection. Weight of 100 seeds (g) [seed index] of the selected F3 families relatively varied among the 3 populations that ranged from 62.1 to 80.9 g. The results obtained encouraged the team work to continue the research on the three populations selected for advanced cycles of selection in order to improve the performance of faba bean plants.

Key words:

INTRODUCTION

Selection is considered to be the most important way to maximize crop productivity and it has long been successful attempts for improving faba bean productivity in Egypt. Egyptians are securing an adequate supply of protein in their diet through consumption of faba bean. The limited success of the breeding effects for selecting faba bean cultivars with enhanced yield and early maturity is due mainly to the difficulty of combining both earliness and high yield in one genotype. Segregating generations were variable and allow efficient selection (Abdalla, 1977; Khalil, 1977; Ali *et al.*, 1978; Khalil and Nassib, 1982; Khalil *et al.*, 1982; Abdalla and Metwally, 1983; El-Menoufy, 1983; El-Hosary, 1989; El-Hosary and Sedhom 1990; El-Gamal *et al.*, 1990). Abdalla and Darwish, 1974, 1996 a and b found that selection in naturally intercrossed populations offers valuable genotypes. Selection in early segregating populations gave higher results than wild type varieties (Abdalla and Metwally, 1983). Selection within local and exotic populations may result in improving faba bean performance (Abdalla, 1976). Bakheit and Mahdy (1988) found that the family selection for two generations in Giza-2 was effective in producing some families exceeding the base population.

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Omar (1989) noticed that both pod and seed sets had a great influence on improving seed yield. He found that bulk method attained higher genetic variation and the number of superior families relative to other breeding methods. Ibrahim *et al.* (1979); Nassib *et al.* (1979) and Nassib and Khalil (1982) recommended using mass selection for improving commercial varieties. The procedure of mass selection involves single plant selection of few hundred plants every year and bulking their progenies after screening for the uniformity and yield. No significant differences were observed between traits in both the original and the selected populations of Giza-4 (El-Hosary, 1981) who found that selection under conditions of natural and self pollination gave similar results of traits studied on faba bean variety Giza-4. Ahmed (1987) practiced selection within segregating generations of 8 crosses for shedding and leaf minor infestation and measured the reflected gain in yield components. He also reported that the procedure used attained good chance for actual gain in yield and its components. El-Refaey and El-Keredy (1992) found that the effectiveness of selection between and within segregating generations varied from case to another. Ragheb (1994) found that the selection with Aquadolse (a major stock) for two cycles of selection was effective. Breeding efforts have been employed for combining genes for adaptability and high yield from elite faba bean genotypes with those for earliness (Bekheit, 2007). However, information on the genetics of earliness and high yield is scant and the nature of the genetic system involved is far from clear which might account for the rather limited number of early maturing and high yield cultivars released through breeding. The objective of this study is to develop, through selection, faba bean genotypes with increased levels of yield and earliness.

MATERIALS AND METHODS

Four faba bean (*Vicia faba* L.) varieties i.e. Sakha-1, Giza-843, Giza-716 and TripleWhite which comprised local varieties were used. The four genotypes were so chosen as to represent a wide range of agronomic traits as well as different levels of high yield and earliness. The brief descriptions of their important characteristics are given in Table (1). In 2007/2008 growing season, a field experiment was conducted in order to select the highest yield and earlier matured populations of F₂ families. Three populations attained this goal i.e. Sakha-1 × Giza-843, Sakha-1 × Giza-716 and Giza-843 × Triple White. In 2008/2009 growing season, seeds of ten selected F₃ plants of each of the 3 crosses were sown on 1st November into a field compared to the F₃ bulk of each cross. A randomized complete block design with three replications was used. In each block, a plot of seven ridges was assigned to each of the 3 entries; five ridges for the five F₃ selected families; one ridge for the F₃ bulk. The four parents were also represented by a plot of one ridge for each parent in each block. Each ridge was two-meter long, 60-cm wide and contained 10 plants spaced 20 cm from each other. Seed yield per plant and other attributes were recorded. The characters of plant height, number of branches, number of days to 50% flowering, number of days to 95% maturity, seed yield per plant (g), number of pods and seeds per plant and weight of 100 seeds (g) [seed index] were measured on individual plant basis throughout the different experiments. Selection differential was measured for each population as the deviation of the mean of selected F₂ plants from the F₂ population mean. Response to selection was expressed as percentage of change in the mean of the selected families from that of bulked plants of each population.

Experimental Results:

The mean performances of the four parents and their offspring of F₂ generation for weight of seeds per plant (yield) are presented in Table 2. The results of weight of seeds per plant for F₂ show that the averages ranged from 53.94 grams of seeds for the hybrid (Sakha-1 × Triplewhite) to 69.62 grams of seeds for hybrid (Triplewhite × Giza-843) with an average of 56.45 grams of seeds that surpassed the average of parents indicating positive heterotic effect. Sakha-1 has the highest weight of seeds per plant of faba bean genotypes with 63.87 grams of seeds, while Giza-716 has the lowest weight of seeds per plant of faba bean genotypes with 43.27 grams of seeds. The mean performances of the four parents and their offspring in F₂ generations for number of days from sowing to maturity are presented in Table 3.

The results of F₂ show that the averages of number of days from sowing to maturity ranged from 144.67 days for the hybrid (Triplewhite × Sakha-1) to 152.33 days for hybrid (Giza-716 × Giza-843) with an average of 148.67 days surpassing the average of parents with 4.10 days indicating positive heterotic effect. Triplewhite was the earliest matured faba bean genotype with 136 days, while Giza-716 was the latest matured faba bean genotype with 144.67 days from sowing to 95% maturity. The results obtained are in accordance with the conclusions of Mahmoud (1968), El-Hosary (1981,1982,1983 and 1984), and Khalil *et al.* (1982).

The means of eight characters studied for four parents and three populations of F3 generations that were selected in 2008/2009 season are presented in table (4). These three populations attained the best results of the critical traits of seed yield and maturity. The differences between the three populations in both flowering and maturity were high as shown in table (5). The differences between the three populations selected and bulks were not significant in both flowering and maturity so the measures of the responses to selection were done on the levels of the other six traits of plant height, number of branches, pods and seeds per plant and both weights of seeds per plant and 100 seeds (seed index) which had a special attention in this study and the results obtained encourage the team work to continue the research on the three populations selected for advanced cycles of selection in order to improve the performance of faba bean plants. The results are in agreement with those of Mahmoud (1968), El-Hosary (1981,1982,1983 and 1984), and Khalil *et al.* (1982).

The Response to Selection:

Plant Height (Cm):

The means of plant height for the selected F3 families of each of the 3 populations are presented in Table 6.

Positive responses were obtained in all of the 3 populations which were not significant in 3 populations as revealed by the analysis of variance Table 7. The responses ranging from 4.1 to 8.2 % with an average of 6.5 % of the population mean. Plant height of the selected F3 families varied considerably among the 3 populations that ranged from 109.1 to 119.1 cm. The most outstanding F3 selections of two crosses involved the tallest parental cultivars Saka-1 and Giza-843, namely population 1 (Sakha-1 × Giza-843), with a mean plant height of 119.1 cm and population 2 (Sakha-1 × Giza-716), with a mean of 109.1 cm. Meanwhile, the analysis also indicated that there were insignificant variations among the F3 selected families in all populations for plant height.

Number of Branches per Plant:

The means of number of branches per plant for the selected F3 families of each of the 3 populations are presented in Table 8.

Positive responses were obtained in all of the 3 populations which were significant in 3 populations as revealed by the analysis of variance Table 9. The responses ranging from 27.7 to 38.6 % with an average of 33.17 % of the population mean. Number of branches per plant of the selected F3 families varied considerably among the 3 populations that ranged from 4.47 to 7.07 branches.

The most outstanding F3 selections of two crosses involved the most branched parental cultivar Giza-843, namely population 2 (Sakha-1 × Giza-716), with a mean of 7.07 branches. Meanwhile, the analysis also indicated that there were significant variations among the F3 selected families in all populations which permit for further response to another cycle of selection.

Number of Pods per Plant:

The means of number of pods per plant for the selected F3 families of each of the 3 populations are presented in Table 10.

Positive responses were obtained in all of the 3 populations which were significant in 3 populations as revealed by the analysis of variance Table 9. The responses ranging from 62.4 to 150 % with an average of 111.1 % of the population mean. Number of pods per plant of the selected F3 families varied considerably among the 3 populations that ranged from 36.7 to 53.9 pods.

The most outstanding F3 selections of two crosses involved the highest parental pod numbered cultivars Sakha-1 and Giza-843, namely populations 1 (Sakha-1 × Giza-843) with a mean of 53.3 pods and 2 (Sakha-1 × Giza-716), with a mean of 53.9 pods. Despite the analysis indicated insignificant variations among the F3 selected families in all populations for number of pods, the responses to selection for this trait were very high.

Number of Seeds per Plant:

The means of number of seeds per plant for the selected F3 families of each of the 3 populations are presented in Table 12.

Positive responses were obtained in all of the 3 populations which were significant in 3 populations as revealed by the analysis of variance Table 13. The responses ranging from 63.6 to 77.2 % with an average of 71.03 % of the population mean. Number of seeds per plant of the selected F3 families varied considerably among the 3 populations that ranged from 95.7 to 100.8 seeds.

The most outstanding F3 selections of two crosses involved the highest seed number parental cultivar Sakha-1, namely populations 1 (Sakha-1 × Giza-843) with a mean of 100.8 seeds and 2 (Sakha-1 × Giza-716), with a mean of 138.5 seeds. Although the analysis indicated insignificant variations among the F3 selected families in all populations for number of seeds, the responses to selection for this trait were very high.

Weight of Seeds per Plant (g):

The means of weight of seeds (g) per plant for the selected F3 families of each of the 3 populations are presented in Table 14.

Positive responses were obtained in all of the 3 populations which were significant in 3 populations as revealed by the analysis of variance Table 15. The responses ranging from 65.9 to 72.5 % with an average of 70.03 % of the population mean. Weight of seeds (g) per plant of the selected F3 families varied considerably among the 3 populations that ranged from 59.16 to 105.13 grams of seed.

The most outstanding F3 selections of two crosses involved the most seed weighed parental cultivar Sakha-1, namely populations 1 (Sakha-1 × Giza-843) with a mean of 80.78 grams of seeds and 2 (Sakha-1 × Giza-716), with a mean of 105.13 grams of seeds. Meanwhile, the analysis also indicated that there were significant variations among the F3 selected families in all populations and the responses to selection were also very which permit for further response to another cycle of selection.

Weight of 100 Seeds g [Seed Index]:

The means of seed index for the selected F3 families of each of the 3 populations are presented in Table 16.

Two positive responses versus to one negative response were obtained in all of the 3 populations which were significant in 3 populations as revealed by the analysis of variance Table 17. The responses ranging from -2.05 to 2.37 % with an average of 0.86 % of the population mean. Weight of 100 seeds (g) [seed index] of the selected F3 families varied considerably among the 3 populations that ranged from 62.1 to 80.9 g.

The most outstanding F3 selections of two crosses involved the heaviest seed index parental cultivar Sakha-1, namely populations 1 (Sakha-1 × Giza-843) with a mean of 80.9 grams and 2 (Sakha-1 × Giza-716), with a mean of 77.9 grams. Meanwhile, the analysis also indicated that there were significant variations among the F3 selected families in all populations which permit for further response to another cycle of selection. in accordance with the conclusions of El-Hosary (1981), Khalil *et al.* (1982), and Mahmoud (1968).

Table 1: The description of the four parental varieties of faba bean (*Vicia faba* L.)

Parent	Pedigree	Seed index	Plant height	Maturity
Giza-716	461/442/83 × 503/453/83	90 - 95 g	140-145 cm	moderate
Giza-843	561/2076/85 × 461/845/83	60-65 g	150-160 cm	moderate
Sakha-1	716/724/83 × 620/283/85	85-89 g	150-155 cm	moderate
Triplewhite	Mutant of individual Sudan plant	54-55 g	130-135 cm	Early

Table 2: The mean performances of the parents (diagonal) and their crosses in F2's for weight of Seeds per Plant (Yield) 2007/2008season..

Parent	Giza-716	Giza-843	Sakha-1	Triplewhite
Giza-716	43.27	55.71	56.70	58.29
Giza-843		58.41	61.39	69.62
Sakha-1			63.88	53.94
Triplewhite				47.47

P ± SE = 51.83 ± 0.486, F2 ± SE = 56.45 ± 0.927

Table 3: The mean performances of the parents (diagonal) and their crosses in F2's for number of days to Maturity 2007/2008 season..

Parent	Giza-716	Giza-843	Sakha-1	Triplewhite
Giza-716	144.67	152.33	148.33	150.33
Giza-843		142.33	147.00	147.33
Sakha-1			142.67	144.67
Triplewhite				136.00

P ± SE = 144.27 ± 0.285, F2 ± SE = 148.67 ± 0.569

Table 4: Means of the flowering, maturity, plant height, number of branches, pods, seeds/plant, weight of seeds/plant and weight of 100 seeds (seed index) for parents and 3 population means of F3 generation.

Populations	Characters studied								
	flowering	maturity	p.height	n.branch	n.pods	n.seeds	Seedw/p	S. index	
Giza-716	46.7	144.3	139.7	3.4	17.4	49.0	43.2	88.2	
Giza-843	44.7	143.0	146.3	3.6	30.9	69.7	59.0	77.9	
Sakha-1	44.0	142.3	147.7	3.6	28.5	73.7	65.7	89.3	
Triplewhite	39.3	131.7	127.3	1.9	36.3	89.2	47.2	52.9	
Sakha-1 × Giza-843	42.3	142.3	111.1	3.5	24.1	61.6	48.7	79.1	
Sakha-1 × Giza-716	43.0	144.0	100.8	5.1	33.3	80.4	61.2	76.1	
Giza-843 × TripleWhite	38.3	139.3	109.0	3.4	24.0	54.0	34.3	63.4	
LSD	0.05	NS	NS	2.673	0.065	1.123	3.714	2.548	4.385

Table 5: Analysis of variance for 50 flowering and 95% maturity in the three selected populations.

S. of variance	D.F.	variance		F-value		Prob.	
		flowering	maturity	flowering	maturity	flowering	maturity
Between	2	19.11	16.78	86.0	30.2	0.0000	0.0007
Within	6	0.22	0.56				

Coefficient of Variation = 1.14% for flowering and 0.53% for maturity

Table 6: Means of plant height (cm) of the parents, the F3 bulk and F3 selected families of the 3 crosses grown in Mattana with the response to selection.

Populations	Means of seed yield per plant (g)				
	P1	P2	F3 bulk	F3 selected	Response %
1. Sakha-1 × Giza-843	147.7	146.3	111.1	119.1	7.2
2. Sakha-1 × Giza-716	147.7	139.7	100.8	109.1	8.2
3. Giza-843 × TripleWhite	146.3	127.3	109.0	113.5	4.1

** Significant at 0.01 level of probability.

Table 7: Analysis of variance of plant height (cm) between and within the three populations selected.

S. of variance	D.F.	variance	F-value	Prob.
Between	2	75.4	1.603	0.2768
Within	6	47.1		

Coefficient of Variation = 6.02%

Table 8: Means of number of branches per plant of the parents, the F3 bulk and F3 selected families of the 3 crosses grown in Mattana with the response to selection.

Populations	Means of seed yield per plant (g)				
	P1	P2	F3 bulk	F3 selected	Response %
1. Sakha-1 × Giza-843	3.6	3.6	3.5	4.47	27.7**
2. Sakha-1 × Giza-716	3.6	3.4	5.1	7.07	38.6**
3. Giza-843 × TripleWhite	3.6	1.9	3.4	4.53	33.2**

** significant at 0.01 level of probability.

Table 9: Analysis of variance of number of branches between and within the three populations selected.

S. of variance	D.F.	variance	F-value	Prob.
Between	2	6.591	10.299	0.0115
Within	6	0.640		

Coefficient of Variation = 14.94%

Table 10: Means of number of pods per plant of the parents, the F3 bulk and F3 selected families of the 3 crosses grown in Mattana with the response to selection.

Populations	Means of seed yield per plant (g)				
	P1	P2	F3 bulk	F3 selected	Response %
1. Sakha-1 × Giza-843	28.5	30.9	24.1	53.3	121
2. Sakha-1 × Giza-716	28.5	17.4	33.3	53.9	62.4
3. Giza-843 × TripleWhite	30.9	36.3	24.0	36.7	150

** significant at 0.01 level of probability.

Table 11: Analysis of variance of number of branches between and within the three populations selected.

S. of variance	D.F.	variance	F-value	Prob.
Between	2	288.14	0.912	
Within	6	316.03		
Total	8			

Coefficient of Variation = 37.05%

Table 12: Means of number of seeds per plant of the parents, the F3 bulk and F3 selected families of the 3 crosses grown in Mattana with the response to selection.

Populations	Means of seed yield per plant (g)				
	P1	P2	F3 bulk	F3 selected	Response %
1. Sakha-1 × Giza-843	73.7	69.7	61.6	100.8	63.6
2. Sakha-1 × Giza-716	73.7	49.0	80.4	138.5	72.3
3. Giza-843 × TripleWhite	69.7	89.2	54.0	95.7	77.2

** significant at 0.01 level of probability.

Table 13: Analysis of variance of number of seeds between and within the three populations selected.

S. of variance	D.F.	variance	F-value	Prob.
Between	2	1635.3	4.44	0.0655
Within	6	368.0		
Total	8			

Coefficient of Variation = 17.18%

Table 14: Means of weight of seeds (g) per plant of the parents, the F3 bulk and F3 selected families of the 3 crosses grown in Mattana with the response to selection.

Populations	Means of seed yield per plant (g)				
	P1	P2	F3 bulk	F3 selected	Response %
1. Sakha-1 × Giza-843	65.7	59.0	48.7	80.78	65.9
2. Sakha-1 × Giza-716	65.7	43.2	61.2	105.13	71.7
3. Giza-843 × TripleWhite	59.0	47.2	34.3	59.16	72.5

** significant at 0.01 level of probability.

Table 15: Analysis of variance of weight of seeds/plant between and within the three populations selected.

S. of variance	D.F.	variance	F-value	Prob.
Between	2	1586.5	9.151	0.0150
Within	6	173.37		
Total	8			

Coefficient of Variation = 16.12%

Table 16: Means of weight of 100 seeds (g) [seed index] of the parents, the F3 bulk and F3 selected families of the 3 crosses grown in Mattana with the response to selection.

Populations	Means of seed yield per plant (g)				
	P1	P2	F3 bulk	F3 selected	Response %
1. Sakha-1 × Giza-843	89.3	77.9	79.1	80.9	2.27
2. Sakha-1 × Giza-716	89.3	88.2	76.1	77.9	2.37
3. Giza-843 × TripleWhite	77.9	52.9	63.4	62.1	-2.05

** significant at 0.01 level of probability.

Table 17: Analysis of variance of weight of 100 seeds g [seed index] between and within the three populations selected.

S. of variance	D.F.	variance	F-value	Prob.
Between	2	307.62	24.237	0.0013
Within	6	12.69		
Total	8			

Coefficient of Variation = 4.84%

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