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Selection for seed yield in segregating population (Misr 1 x Giza 3) of faba bean (*Vicia faba* L.)

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Abstract

The current study was executed at the Experimental Farm, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt, during the 2016/2017, 2018/2019 and 2019/2020 seasons. The acquired results exhibited that the prospective response to selection was less than the real response to the selection of the studied characters with respect to the two selection criteria *i.e*. number of pods /plant and seed yield /plant. The results exhibited that the mean plants registered lower values in the F_3 generation and progressively increased in the next generation for the studied characters except, mean for days to maturity which scored higher values in the third (F_3) generation and progressively decreased in the next generation of the two selection criteria. Plant height, seed index, number of pods /plant and seed yield /plant, the mean of the bulk populations was lower than those for the selected families in the F_3, F_4, and F_5 generations, except for the number of days to maturity where the bulk population was higher than that of the selected families in the F_3, F_4 and F_5 generations for the two selection criteria. The phenotypic and genetic coefficients of variance registered higher values in the F_3 generation and progressively decreased in the next generation of the studied characters. Significant and Positive phenotypic and genotypic correlation coefficients were registered between seed yield /plant and all studied characters, except days to maturity that was negative and significant for the two selection criteria except, for days of maturity, which were negative and significant for the two selection criteria. Heritability in narrow sense was high (<50%) for number of pods /plant in F_4 and F_5 and differed from low to moderate for the remaining characters.

Keywords: phenotypic, genotypic, correlation, coefficients, heritability.

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1. Introduction

Faba bean (*Vicia faba* L.) is a temperate zone protein crop. In Egypt, there is little chance to increase the cultivated area. Therefore, it is important to obtain varieties with higher yields through breeding programs (Selection) to increase seed yield from Egyptian faba bean varieties alone will not be active (Haridy, 2017; Metwali and Bakheit, 2011). The primary goal of plant breeders is the genetic improvement of the crop yield and its contributions. The importance of genetic variability in any breeding program is well documented for different species as it provides a basis for active selection (Ahmed *et al*., 2008). Soliman *et al*. (2012) used three selection procedures i.e. direct selection of seed yield, index selection, and independent screening levels of yield index. Testing methods for recording pedigree and grain yield in early generations have been described in most plant breeding texts. These breeding procedures offer the advantage of rapid fixation of preferred alleles through selection. Shalaby *et al*. (2001) applied the effectiveness of the present study of selection methods to improve the yield of faba bean. The main objective of this study was to compare the relative efficiency of two selection procedures *i.e*. that is, pedigree and bulk selection to improve earliness, seed yields and their properties in faba bean.

2. Materials and methods

The present study was conducted in the Experimental Farm at the Faculty of Agriculture, Al-Azhar University (Assiut Branch), Assiut, Egypt during the period of 2016/2017, 2018/2019, 2019/2020 growing seasons. The materials used in this study are 1000 F3 families that were traced to random plants F2 from Misr 1x Giza 3. Parents Misr 1 and Giza 3 were obtained from the Department of Leguminous Crops, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.

2.1 Experiments planning

In the 2016/2017 season, 1000 individual F3 families were cultivated from the population, Misr 1 x Giza 3 in a breeding nursery in unrefined experiments in the field. The seeds were sown in ridges 3 meters long and 60 cm apart in hills spaced 20 cm apart, leaving one plant in each hill. At maturity, 160 plants were selected for each of the two parameters, number of pods /plant and seed yield /plant, to obtain the F4 families. Parents and F3 bulk population have also grown. In the growing season 2018/2019, 200 of selected F4 families from population Misr 1 x Giza 3 with the original parents, F4' bulk random sample a mixture of an equal number of seeds from each plant were grown in a randomized complete blocks design with three replicates to obtain F5 families. Each plot was in a single row of 3 m long, 60 cm apart and 20 cm between hills for each selection criterion, i.e. number of pods /plant and seed yield /plant. At maturity, 20 families were

selected for two criteria from 160 F4 families of both experimental species for the number of pods / plant and seed yield /plant in the field and preserved to give the F5 families in the 2019 /2020 season, 20 families of F5 generation were selected based on selection criteria for number of pods / plant and seed yield / plant, as well as a bulk sample of F5, parents and the comparison cultivar (Giza 429) that was implanted on 27th October in a randomized complete blocks design with three replications. Each family grew in a single row of 3 meters long, 60 cm between rows, and 20 cm between hills with one plant /hill. The recommended practices were applied in the production of faba bean during the growing seasons. The results were recorded on ten guarded plants /plot for each of families, parents, bulk and comparison cultivar (Giza 429).The following characters were measured *i.e*. days to maturity (day), as number of days from sowing to 95 % maturity of pods, plant height at harvest (cm), from the soil surface to the top of the main stem, number of pods /plant, seed index (100-seed weight (gm) at harvest stage measured from the formula:

$$\text{Seed index} = \frac{\text{seed yield / plant (gm)}}{\text{No.of seeds /plant}} \times 100$$

and seed yield / plant (gm).

2.2 Statistical analysis

Data were analyzed using randomized complete blocks design (RCBD) according to Guimaraes and Fehr (1989). The studied population data was subjected to analysis of variance of RCBD on a plot mean basis. Various genetic parameters were calculated, *i.e*., variance, heritability, and expected genetic advance. Genotypic and phenotypic variance (σ^2g and σ^2ph) under various breeding methods were calculated from predicted mean squares (Table 1) as follows:

Table (1): Analysis of variance and expected mean squares.

S.O.V	D.F	M.S	E.M.S
Replication	r-1	M3	$\sigma^2e+g\sigma^2r$
Genotype	g-1	M2	$\sigma^2e+r\sigma^2g$
Error	(r-1) (g-1)	M1	σ^2e

Where: r and g = number of replications and genotypes, respectively. σ^2e and σ^2g = error variance and genetic variance, respectively.

Achieved response and expected gain for selection: The achieved response "R" and the expected gain of selection "Δg" according to Falconer (1981), were calculated as follows: The achieved response "R" = mean deviation of the offspring from the mean population. The expected gain $\Delta g = S.h^2$. Where, S = Selection differential, the mean phenotypic value of the two selected

parents expressed as a deviation from the population mean, dependent on selection intensity and phenotypic standard deviation, *i.e*., S= i. σ_{ph}. Where, i= selection intensity. σ_{ph} = the phenotypic standard deviation. Selection response is dependent on character inheritance and the amount of selection applied as measured by selection differential. $\Delta g = h^2_{n.s}$. i. σ_{ph}.

2.2.1 Phenotype and genotype coefficient of variability

The phenotypic coefficient of variation (PCV) and genotype coefficient (GCV) were calculated as ($\sigma p / \overline{X}$) 100 and ($g / \overline{X}$) 100 respectively. Genetic variance calculated according to the following formula:

$\sigma^2 g = (M_2 - M_1)/r$

$\sigma^2 p = \sigma^2 g + M_1/r$

2.2.2 Heritability in the narrow sense

Heritability in the narrow sense was estimated using correlation and lineage regression according to Smith and Kinman (1965), as follows:

Parent–offspring generation	r_w	$h= b/2r_{xy}$
F_3, F_4	7/8	4/7b F_4, F_3
F_4, F_5	15/16	8/15b F_5, F_4

According to Falconer (1981), from the response equation, $R = Sh^2$. We discussed earlier from the point of view of selection response prediction, where heritability is estimated as the ratio of response to selection differential.

2.2.3 Correlations between studied characters

Statistical analysis was performed as described by Steel and Torrie (1980). The phenotypic and epigenetic correlation coefficients as described by Johnson *et al*. (1955) were calculated as follows:

Phenotypic correlation $rp_{xy}= Covp_{xy}/ (\sigma p_x.\sigma p_y)$

Genotypic correlation $rg_{xy}= Covg_{xy}/ (\sigma g_x.\sigma g_y)$

3. Results and Discussion

Two cycles of pedigree selection were achieved in one population of faba bean (*Vicia faba* L.) derived from crossbreeding between Misr 1 /Giza 3 in generations F_3, F_4 and F_5. Direct pedigree selection was applied to the number of pods /plant and seed yield /plant. Description of the base population (F_3 generation); means and variation in characteristics of individual plants in the F_3 generation in the population are shown in Table (2). The only base population (F_3 generation) used in this study consisted of 1000 F_3 families per population that were traced to a random sample of single F_2 plants .The overall means of the 1000 individual F_3 families for each of the studied traits were presented in Table (2). The obtained results in Table (2) showed that the number of days to maturity ranged from 133.55 to 171.35 days with an average 167.88 days, the minimum of plant height was 122.12 to 149.41 cm with an average 144.15 cm. The minimum

number of pods /plant was 31.66 while the maximum was 52.12 pods with an average of 39.78 pods. The 100-seed weight ranged from 41.11 gm to 68.24 with an average of 55.38 gm. The seed yield /plant ranged from 42.06 to 90.77 gm with an average of 65.04 gm. These results indicating that a wide range of genetic variability among selected families. Similar results were obtained by Mohamed and Abd-El-Haleem (2011a, 2011b). The phenotypic variance (σ^2ph) was 965.35 for days to maturity; 686.19 for plant height; 45.28 for number of pods /plant: 98.16 for seed index and 165.25 for seed yield /plant. The coefficients of variation (C.V%) were 16.22 for days to maturity, 15.33 for plant height, 15.75 for number of pods /plant, 12.68 for seed index as well as 16.46 for seed yield /plant. These results showed sufficient phenotypic variability according to pedigree selection which increases the homozygosity. Similar results were in line with those obtained by Haridy (2017).

Table (2): Means and phenotypic variance (σ^2ph) and coefficient of variance (C.V%) from the base population (F_3) for Misr 1 x Giza 3 and its parents of faba bean.

Item	Days to maturity	Plant height	No. of pods /plant	Seed index	Seed (yield /plant)
Means ± S.E	167.88 ± 0.98	144.15± 0.78	39.78± 0.35	55.38± 0.29	65.04± 0.85
Max.	171.35	149.41	52.12	68.24	90.77
Min.	133.55	122.12	31.66	41.11	42.06
σ^2ph	965.35	686.19	45.28	98.16	165.25
CV%	16.22%	15.33%	15.75%	12.28%	16.46%
Misr 1	154.75	135.75	45.15	50.58	65.12
Giza 3	161.24	145.65	35.26	64.25	59.85

3.1 Analysis of variance and average performance

Analysis of variance in the selected families for two criteria *i.e*. number of pods /plant and seed yield /plant together with the parents was studied. The bulk population and the survey of cultivar Giza 429 for days to maturity, plant height, number of pods / plant, seed index and seed production per plant in the first cycle (F_4 generation) and cycle 2 (F_5 generation) of the population of Misr 1 x Giza 3 are shown in Tables (3) and (4). The results revealed highly significant differences between families in the F_3, F_4 and F_5 generations in the population upon selection pursuit on the basis of no. pods /plant and seed yield /plant, respectively.

3.1.1 Number of pods /plant criterion

Mean number of days to maturity for the selected families was 167.88, (Table 2), 150.25 and 141.67 days (Table 3) in the F_3, F_4 and F_5 generations, respectively. The selected families were in early maturity compared to the bulk populations of the F_3, F_4, and F_5 generations. In the fifth generation (F_5), all families were compared earlier with

the bulk populations and the check variety (Giza 429). These results are in agreement with the results obtained by Ahmed *et al.* (2008) and Haridy (2017). For plant height, the average performance of the selected families was 144.15 (Table 2), 152.26 and 155.56 cm (Table 3) in the F_3, F_4 and F_5 generations, respectively. The mean plant height value of the bulk populations was lower than that of the selected families in the F_3, F_4, and F_5 generations. The mean plant height of the F_5 generation was higher than that of the highest parent (Giza 3) and the check variety (Giza 429). These results are consistent with the findings of Djokic *et al.* (2011) and Haridy (2017). The mean number of pods /plant of the selected families were 39.78, 49.25 and 54.69 pods in the F_3, F_4, and F_5 generations, respectively. The mean number of pods /plant from the bulk populations was below the mean of the selected families in the F_3, F_4, and F_5 generations. The value of the number of pods /plant of the F_5 generation was greater than that of the greatest parent (Misr 1) and the check variety (Giza 429). These results are consistent with the current findings of Metwali and Bakheit (2011), and Haridy (2018). It is noteworthy that the seed index (100- seed weight) of the selected families showed values of 55.38 (Table 2), 58.28, and 64.43 gm (Table 3), in the F_3, F_4 and F_5 generations, respectively.

Table (3): Families mean, bulk population , two parents and the check variety for all characters studied in two selection cycles of faba bean.

Item		Day to maturity	Plant height	Number of pods /plant	seed index	Seed yield /plant
F_4	Families	150.25	152.26	49.25	58.28	81.25
	Bulk	151.12	148.16	46.19	57.16	77.15
	Parent 1	155.66	133.72	46.05	52.26	62.12
	Parent 2	160.15	142.55	36.18	54.44	60.13
	Check	151.32	150.16	46.54	56.77	67.45
	L.S.D 0.05	5.85	5.14	2.35	3.01	7.96
	L.S.D 0.01	8.96	8.05	4.88	4.95	11.65
F_5	Families	141.67	155.56	54.69	64.43	87.46
	Bulk	143.27	151.88	49.37	60.59	80.89
	Parent 1	155.69	134.75	46.59	52.36	62.19
	Parent 2	160.36	143.85	36.33	54.52	60.45
	Check	152.89	150.22	46.54	56.19	67.25
	L.S.D 0.05	5.70	5.73	4.14	3.43	6.57
	L.S.D 0.01	7.60	7.50	6.44	5.25	9.47

The selected families of the population exceeded than that in the bulk population F_3, F_4 and F_5 generations .It should be noted that in the F_5 generation, the selected families of the population exceeded the bulk population, the highest parent (Giza 3) and the check variety (Giza 429). It should be noted that, in the F_5 generation, the selected families of the population exceeded the bulk population, the highest parents (Giza 3) and the check variety (Giza 429). These results

took the same direction with the results obtained by Shalaby *et al.* (2001), Metwally and Bakhit (2011), and Haridy (2018). Mean performances of seed yield /plant of selected families were 65.04 (Table 2), 81.25, and 87.46 gm (Table 3), in the F_3, F_4 and F_5 generations, respectively. The average of selected families in the F_3, F_4 and F_5 generations exceeded the average of the bulk population. In the F5 generation, all families significantly exceeded the bulk, the highest parent Misr 1 and the check variety Giza 429, except for Family no. 9 and 110. These results are consistent with those of Abul-Ezz (2005), and Haridy (2017).

3.1.2 Seed yield/plant criterion

When the selection criterion was imposed on the seed yield /plant, the mean number of days to maturity for selected families was 167.88 (Table 2), 145.25 and 136.55 days (Table 4), in the F_3, F_4 and F_5 generations, respectively. The selected families were in the early maturity stage compared to the bulk populations in the three generations. In the fifth generation (F_5), the mean number of days to maturity was earlier compared to the bulk populations, the earlier parent (Misr 1) and the check variety (Giza 429). These results are consistent with the results obtained by Ahmed *et al*. (2008). The mean of plant height for the selected families was 144.15 (Table 2), 153.06 and 156.56 cm (Table 4) in the F_3, F_4 and F_5 generations, respectively. The plant height mean of the bulk populations was lower than that of the selected families in the F_3, F_4, and F_5 generations. The average plant height of the selected families was taller than the taller parent (Giza 3) and the check variety (Giza 429). These results are consistent with those of Haridy *et al.* (2012) and Haridy (2017). The mean number of pods /plant for the selected families was 39.78 (Table 2), 54.27, and 57.57 pods (Table 4) in the F_3, F_4 and F_5 generations, respectively. The number of pods /plant from the bulk populations was lower than that in the selected families in the F_3, F_4, and F_5 generations. The average number of pods /plant of the selected families was greater than the greatest parent (Misr 1) and the check variety (Giza 429). These results are consistent with the findings of Metwally and Bakhit (2011), and Djukic *et al*., (2011). Seed index for selected families recorded 55.38 (Table 2), 62.79 and 69.35 (gm) (Table 4) in the F_3, F_4 and F_5 generations, respectively. The selected families of the population exceeded the bulk population in the F_3, F_4 and F_5 generations. In the F_5 generation, the mean of seed index of the selected families exceeded the bulk population, the highest parent (Giza 3) and the check variety (Giza 429). These results are similar with whose reported by Shalaby *et al*. (2001) and Abu al-Ezz (2005). It was clear that the mean seed yield / plant of the selected families was 65.04 (Table 2), 86.36, and 95.82 gm (Table 5) in the F_3, F_4 and F_5 generations, respectively.

Table (4): Average families, bulk population, two parents and check variety for all studied characters in the two selection cycles of faba bean.

Item		Day to maturity	Plant height	Number of pods /plant	seed index	Seed yield /plant
F_4	Families	145.25	153.06	54.27	62.79	86.36
	Bulk	146.02	149.56	48.79	60.06	81.15
	Parent 1	153.36	133.82	46.75	52.49	62.32
	Parent 2	157.75	142.75	36.48	54.78	60.43
	Check	150.92	150.12	46.44	56.26	67.32
	L.S.D 0.05	4.5	5.21	3.25	3.02	8.27
	L.S.D 0.01	7.48	7.21	6.24	5.01	10.03
F_5	Families	136.55	156.56	57.57	69.35	95.82
	Bulk	140.16	153.16	51.17	65.46	86.71
	Parent 1	153.2	133.75	46.69	52.56	62.49
	Parent 2	157.86	142.85	36.33	54.62	60.65
	Check	150.69	150.12	46.44	56.19	67.35
	L.S.D 0.05	4.45	4.73	5.14	4.53	7.77
	L.S.D 0.01	6.3	6.78	9.04	6.47	10.77

Table (5): Average families of seed yield /plant in the fifth generation (F_5) when selection was based on number of pods /plant and seed yield /plant in faba bean.

Number of pods /plant				Seed yield/plant			
Family no.	Mean	Family no.	Mean	Family no.	Mean	Family no.	Mean
3	88.66	92	87.66	13	95.77	230	96.67
6	88.76	110	71.46	40	95.67	240	86.77
9	75.46	422	87.96	46	98.47	297	96.97
34	90.46	423	88.06	70	95.97	309	97.07
53	89.86	465	87.86	81	83.47	341	97.87
54	88.96	498	89.76	90	99.87	392	96.07
57	89.66	530	90.57	95	93.47	419	97.67
58	89.96	552	90.26	125	98.58	456	97.97
60.	89.46	563	87.55	186	98.27	491	97.77
Average			87.46	Average			95.82

The mean of the selected families in the F_3, F_4 and F_5 generations of the population exceeded the mean of the bulk population. In the F_5 generation, all families significantly outperformed the bulk, the highest parent of Misr 1 and the check variety (Giza 429). The mean of the selected families in the F_3, F_4 and F_5 generations of the population exceeded the mean of the bulk population. In the F_5 generation, all families significantly outperformed the bulk, highest parent (Misr1) and the Check variety (Giza 429), except for the family no. 81 and 240 (Table 5). These results are consistent with those of Sabah *et al*. (2002) and Haridy (2017).

3.2 Genetic parameters

The genetic parameters calculated for the studied population were the phenotypic (P.C.V) and (GCV) coefficient of variation as well as the phenotypic (rp) and genotype (rg) correlation were determined.

3.2.1 Number of pods/plant criterion

Estimates of phenotype and genotype

coefficients for variability (Table 6) were 4.58 and 3.78; 4.47 and 4.07% in F_4 and F_5 generations in days to maturity, respectively. Corresponding values were 1.53 and 1.45; 1.48 and 1.44% in F_4 and F_5 generations in plant height, respectively. Furthermore, in the number of pods /plant, the corresponding values were 17.31 and 13.12; 14.46 and 13.21% in F4 and F5 generations, respectively. Moreover, the corresponding estimates were 10.33 and 8.11; 8.84 and 8.32% in F_4 and F_5 generations at 100 seed weight, respectively. Finally, the values corresponding to the seed yield per plant were 11.25 and 8.39; 9.79 and 8.95% in the F_4 and F_5 generations, respectively. Small differences were observed between PCV and GCV. In all generations, indicating the importance of genetic effects controlling the inheritance of all characters. Heritability in narrow sense was high (< 50%) for number pods/plant in F_4 and F_5 and differed from low to moderate for the remaining traits. These results prove that the genotypic variation decreases due to increasing of homogeneity. Our findings confirmed with those obtained by Soliman *et al.* (2012).

Table (6): Genotypic (σ^2g), phenotypic (σ^2ph), their coefficients of variability and heritability estimates of the studied traits when selection was based on number of pods/plant in faba bean.

Traits		σ2 ph	σ2g	p.c.v	g.c.v	Heritability in narrow sense
Day to maturity	F_4	47.32	32.20	4.58	3.78	42.27
	F_5	40.23	33.26	4.47	4.07	45.29
Plant height	F_4	5.44	4.90	1.53	1.45	23.24
	F_5	5.33	5.04	1.48	1.44	29.53
Number of pods /plant	F_4	72.66	41.75	17.31	13.12	51.45
	F_5	62.53	52.20	14.46	13.21	53.55
seed index	F_4	36.24	22.35	10.33	8.11	24.52
	F_5	32.40	28.75	8.84	8.32	29.65
Seed yield /plant	F_4	83.57	46.45	11.25	8.39	45.31
	F_5	73.36	61.26	9.79	8.95	49.89

3.2.2 Seed yield/plant criterion

Estimates of phenotype and genotype coefficients of variability (Table 7) were 4.66 and 3.98; 4.82 and 4.09% in F_4 and F_5 generations on days to maturity, respectively. The corresponding values of plant height were 4.29 and 3.58; 3.69 and 3.64% in the F_4 and F_5 generations, respectively. Furthermore, those estimates were 16.02 and 12.42; 14.68 and 13.62% in F_4 and F_5 generations in number of pods /plant, respectively. Moreover, the values were 10.68 and 7.43; 8.71 and 8.14% in F_4 and F_5 generations at 100 seed weight, respectively. The corresponding values in seed yield per plant were 10.33 and 8.15; 8.82 and 8.25% in F_4 and F_5 generations, respectively. Heritability in the narrow

sense was high (more than 50%) for the number of pods /plant and seed yield /plant in F_4 and F_5 and from low to medium for the remaining characters. These results are consistent with previous studies by Lithy and Abdel-Aal (2004).

Table (7): Genotypic (σ^2g), phenotypic (σ^2ph), their coefficients of variability and heritability estimates of the studied characters when selection was based on seed yield/plant in faba bean.

Traits		σ2 ph	σ2g	p.c.v	g.c.v	Heritability in narrow sense
Day to maturity	F_4	45.85	33.46	4.66	3.98	40.22
	F_5	43.25	31.24	4.82	4.09	44.25
Plant height	F_4	43.19	29.97	4.29	3.58	22.26
	F_5	33.45	32.44	3.69	3.64	26.33
Number of pods /plant	F_4	75.55	45.46	16.02	12.42	52.45
	F_5	71.45	61.45	14.68	13.62	54.55
seed index	F_4	44.97	21.77	10.68	7.43	23.12
	F_5	36.44	31.89	8.71	8.14	27.66
Seed yield /plant	F_4	79.56	49.49	10.33	8.15	50.35
	F_5	71.29	62.55	8.82	8.25	51.88

3.3 Generation for all studied characters

Based on selection criterion number of pods /plant, in F_5 generation, phenotypic and genotypic correlation coefficients between days to maturity and all other traits were negative with one exception for the two selection criteria (Table 8). The Phenotypic and genotypic correlation coefficients were positive and significant between the seed yield /plant and both plant height (0.734 and 0.625), number of pods /plant (0.895 and 0.726), while it were negative and significant between seed yield /plant and days to maturity (-0.877 and -0.785) for the population (Misr 1 x Giza 3) of faba bean. These results are consistent with those found by Alan and Ceren (2007) and Haridy *et al*. (2012) who found that the phenotypic and genotypic correlation coefficients were positive and significant between seed yield/plant and both of plant height, number of pods /plant, and seed index, while it was negative and significant with days to maturity. Based on seed yield /plant criteria, in F_5 generation, phenotypic and genotypic correlation coefficients (Table 9) were positive and significant between seed yield/plant and both plant height (0.734 and 0.625), number of pods /plant (0.895 and 0.726) and was moderate to low seed index (0.465 and 0.216), while it was negative and significant between seed yield/plant and days to maturity (-0.918 and -0.765) for the Misr 1 x Giza 3 population. These results are consistent with those found by Tadesse *et al*. (2011) who found that, the phenotypic and genotypic correlation coefficients were positive and significant between seed yield /plant and both plant height, number of pods/plant and seed index,

while it were negative and significant between days to maturity.

Table (8): Phenotypic (above diagonal) and genotypic (below diagonal) correlations among pairs of the studied traits at F_4 and F_5 Generations when selection was dependent on the number of pods/plant in faba bean.

Traits		Days to maturity	Plant height	No. of pods/plant	Seed index	Seed yield/plant
Days to maturity	F_4	*	-0.799	-0.831	-0.953	-0.809
	F_5	*	-0.877	-0.982	-0.966	-0.918
Plant height	F_4	-0.547	*	0.985	0.498	0.624
	F_5	-0.637	*	0.994	0.752	0.734
No. of pods /plant	F_4	-0.596	0.883	*	-0.653	0.858
	F_5	-0.663	0.992	*	-0.655	0.895
Seed index	F_4	-0.446	0.414	-0.342	*	0.334
	F_5	-0.535	0.475	-0.445	*	0.465
Seed yield/plant	F_4	-0.659	0.535	0.632	0.205	*
	F_5	-0.785	0.625	0.726	0.216	*

Table (9): Phenotypic (above diagonal) and genotypic (below diagonal) correlations among pairs the studied traits in F_4 and F_5 generations characters when selection was dependent on seed yield/plant in faba bean.

Traits		Days to maturity	Plant height	No. of pods/plant	Seed index	Seed yield/plant
Days to maturity	F_4	*	-0.855	-0.955	-0.995	-0.854
	F_5	*	-0.954	-0.957	-0.787	-0.868
Plant height	F_4	-0.549	*	0.883	0.716	0.658
	F_5	-0.647	*	0.993	0.767	0.755
No. of pods /plant	F_4	-0.598	0.857	*	-0.672	0.852
	F_5	-0.664	0.877	*	-0.717	0.865
Seed index	F_4	-0.487	0.445	-0.441	*	0.344
	F_5	-0.608	0.479	-0.485	*	0.472
Seed yield/plant	F_4	-0.662	0.534	0.615	0.202	*
	F_5	-0.795	0.635	0.713	0.217	*

These results revealed that the selection for plant height and no. of pods /plant can increase the seed yield /plant.

3.4 The actual and expected response to selection for the studied traits

3.4.1 Number of pods/plant criterion

The criterion for the number of pods /plant was shown in (Table 10) for the F_4 and F_5 generations of the population (Misr 1 x Giza 3). The actual response to the number of days to maturity selection (Table 10) was -9.55 and -8.58 days in the F_4 and F_5 generations, respectively. The predicted response was biased estimated in the F_4 and F_5 generations and valued at -3.55 and -3.13 days, respectively. Actual plant height response was 4.55 and 3.35 cm in F_4 and F_5 generations, respectively. The expected gain from indirect selection of plant height was 2.05 and 1.96 cm in the same order. Expected direct response to selection values for the number of pods /plant in the population was 4.18 and

3.35 in F_4 and F_5 generations respectively. The actual direct response to the number of pods /plant was 6.33 and 5.44 F4 and F5 generations, respectively. Actual responses to the selection estimates for the seed index were 7.12 and 6.15 g. in the F_4 and F5 generations of the population, respectively. Whereas, the expected gain from indirect selection of seed index was 4.75 and 3.27 grams in F_4 and F5 generations, respectively. The actual seed yield /plant response was 8.33 and 7.91 g in the F_4 and F_5 generations, respectively. The expected response to the selection of seed yield /plant was 5.08 and 4.46 gm in the F_4 and F_5 generations of the population, respectively. These results revealed that the selection after two cycles of pedigree selection led to increase in all studied traits. These results are consistent with the results obtained by Haridy *et al.* (2012) and Haridy (2017).

Table (10): Selection of actual and expected indirect response for all studied traits when selection was based on number of pods/plant and seed yield/plant in faba bean population (Misr 1 x Giza 3).

Selection criteria		Number of pods /plant		Seed yield/plant	
Characters		Actual response	Expected response	Actual response	Expected response
Days to maturity	F_4	-9.55	-3.55	-9.85	-4.55
	F_5	-8.58	-3.13	-8.70	-4.42
Plant height	F_4	4.55	2.05	3.95	3.15
	F_5	3.35	1.96	3.50	2.87
No. of pods /plant	F_4	6.33	4.18	4.45	4.75
	F_5	5.44	3.35	3.30	3.85
Seed index	F_4	7.12	4.75	6.96	4.05
	F_5	6.15	3.27	6.56	3.36
Seed yield/plant	F_4	8.33	5.08	9.89	6.25
	F_5	7.91	4.46	9.22	5.35

3.4.2 Seed yield/plant criterion

Table (10) shows the seed yield /plant criterion for the F_4 and F_5 generations of the population (Misr 1 x Giza 3). The actual response to selection for the number of days to maturity (Table 10) was -9.85 and -8.70 days in the F4 and F5 generations, respectively. Whereas the expected response was biased estimated in the F_4 and F_5 generations and reported -4.55 and -4.22 days, respectively. The actual response to plant height was 3.95 and 3.50 cm in the F_4 and F_5 generations, respectively. While the expected gain from indirect selection of plant height was 3.15 and 2.87 cm in F_4 and F_5 generations, respectively. The expected direct response to the selection for number of pods /plant in the population was 4.75 and 3.85 in the F_4 and F_5 generations, respectively, however the actual direct response to the number of pods /plant was 5.45 and 4.30 in the F_4 and F_5 generations, respectively. In addition, the actual response to the

selection values of the seed index was 6.96 and 6.56 in the F_4 and F_5 generations of the population, respectively. The expected gain from indirect selection of the seed index was 4.05 and 3.36 gm in the F_4 and F_5 generations, respectively. Moreover, the actual response to the seed yield /plant was 9.89 and 9.25 g, in the F_4 and F_5 generations respectively. The expected response to the seed yield /plant selection was 6.25 and 5.35 in the F_4 and F_5 generations of the population, respectively. These results suggesting that the two cycles of pedigree selection for these materials were enough for improvement of these studied traits with using two selection criteria i.e no. of pods /plant and seed yield /plant. Similar results were obtained by Haridy (2017).

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