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Selection for Increasing Seed Yield of Broad Bean (*Vicia faba* L.)

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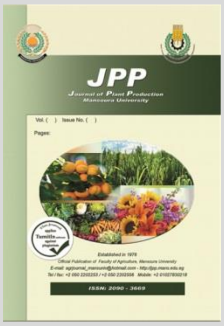

ABSTRACT

The investigation was conducted during three successive seasons of 2016/2017, 2018/2019 and 2019/202020 to study the effect of selection in Giza 3 variety for increasing seed yield of broad bean. The selected genotypes were evaluated in an experimental farm at the Faculty of Agriculture at Al-Azhar University, Assiut Branch. The results showed that the average values in cycle 2 were higher than the averages in cycle 1 for all studied traits, except for the number of days to maturity, its average values in the cycle 1 were higher than the average values in the cycle 2. Also, the selected plants recorded higher valuesthan the average values of the base population and the check cultivar. The actual response to selection was higher than the expected response to selection in all studied traits. The phenotypic and genotypic coefficients of variability recorded lower values in cycle 2 and higher values in cycle 1 of all the studied traits. The phenotypic and genotypic correlation coefficients were positive and significant between seed yield per plant , plant height , number of pods per plant and weight of 100 seeds , except for days to maturity were negative and significant. High heritability values were recorded in the narrow sense (<50%) for seed yield /plant in cycle 1 and cycle 2, and ranged from low to medium for the remaining traits.

***Keywords*: Broad bean, Selection, Variability, Correlation, Heritability**

INTRODUCTION

Broad beans (*Vicia faba* L.) are the first legume crop in the Arab Republic of Egypt in terms of cultivated area, total production and consumption, as green and dry seeds are consumed in human nutrition due to their high protein content of about 28%, carbohydrates 58%, in addition to many vitamins and other nutrients. When breeding for the purpose of obtaining a high yield, the breeder must take care of three main things. The first is to identify the germplasm that has the desired traits. Second, it was necessary to make a decision in which broad bean populations should potential parents be used for the crossbreed. Third, the breeder must specify the method that can be followed in breeding. Haridy (2017) showed that number of pods per plant were good features of indirect selection to improve yields. Haridy (2018) showed that direct selection of seed yield per plant was accompanied by an increase in yield of 7.9% (g) after two cycles of selection calculated as a deviation from the better parent mean. Ahmed *et al*. (2008) reported that there was significant importance of genetic variation for effective selection. Abd-El-Haleem *et al.* (2012) indicated that proportional method were good indirect selection methods to improve yields. The aim of this research was to evaluate the breeding potential of commercial variety (Giza 3) of faba beans after two cycles of selection for seed yield per plant. Also, family means, variances, heritability, response and correlated response to selection were determined for yield and other traits.

MATERIALS AND METHODS

The present study was carried out at Experimental Farm Faculty of Agriculture, Al-Azhar University at Assiut Branch during the period of 2016/2017, 2018/2019 and 2019/2020 growing seasons. The parents Misr 1 and Giza 3 were obtained from Legume Crops Section, Field Crops Research Institute, Agriculture Research Center, Giza, Egypt.

Experiments Layout:

In 2016/2017 season, the plants of Giza 3 were sown in a breeding nursery in non – replicated experimental in the field. Seeds were planted in ridges 3m long and 160 cm apart in hills spaced 25cm apart and one plant was left per hill. At maturity, 100 families were selected from Giza 3.

In the 2018/2019 season, the base population (Giza 3), check cultivar (Misr 1) and the 100 selected plants (cycle one) were evaluated in a randomized complete block design with three replications. Each 100 family and both of the base population and check cultivar were sown in single row plots 3m long 60 cm wide and 25cm between hills. Seedling was thinned to one plant per hill. All the cultural practices were maintained at optimum levels for maximum faba beans productivity.

In 2019/2020 season, the best 10 families were selected from the 100 families in the previous season with the base population and the chicks variety (Misr 1) sown on 28th. of October in a randomized complete block design with three replications. Each family was grown in single row three meters and long 60cm apart and 25cm between hills with one plant/hill. Recommended cultural practices for faba bean production were adopted throughout the growing seasons. The following traits were measured on a sample of ten random plants replicate from each family, base population and check i.e. number of branches/plant, number of pods/plant, days to maturity, 100-seed weight (g.) and seed yield/plant (g).

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Statistical Analysis:

Experiment data were analyzed using a randomized complete block design (RCBD) according to Guimaraes and Feshr (1989). Data of the studied populations were subjected to the regular analysis of variance of RCBD on plot mean basis. The different genetic parameters, i.e., variance, heritability, expected genetic advance were calculated. The genotypic and phenotypic variance ($\sigma^2 g$ and $\sigma^2 ph$) under different breeding methods were calculated from the mean squares expectation (Table1) as follows:

The analysis of variance and expected mean squares for each trait at each cycle of selection were performed at plot mean basis as outlined by Al-Jibouri *et al.* (1958). The form of analysis of covariance is analogous. The genotypic and phenotypic variances were calculated according to Al-Jibouri *et al.* (1958). Phenotypic (PCV) and genotypic (GCV) coefficients of variability were calculated according to Burton (1952) and heritability was estimated as:

$$h^2 = (\delta^2_g / \delta^2_p) x100.$$

The predicted response from selection in seed yield /plant was collocated from cycle one families according to the following formula as given by Falconer (1960).

The expected gain $\Delta g = i\ \sigma ph^2$. Whereas, the response to selection of 10% superior plants in cycle two families was estimated as $i\ \sigma ph^2$. in both cycle one and cycle two families the correlated response in trait Y when selection is applied to seed yield/plant x is:

$$CRy = ih_x\ h_y\ r_A\ \sigma py$$

Where CRy= the correlated response of the trait y, i = the intensity of selection, h_x = the square root of heritability of trait y. r_A = the genetic correlation between x and y traits, σpy = the phenotypic standard deviation of the trait.

RESULTS AND DISCUSSION

Analysis of variance and mean performance:

Analysis of variance for selected families reviled highly significant difference among the selected families of both first and second cycles of selection for all studied traits, except. days to maturity trait was significant only in the families of the second selection cycle (Table 1).

Table 1. Mean squares of analysis of variance for the studied traits of the both two cycles of selection.

Source of variance		d.f	Days to maturity	Plant height (cm)	Number of pods / plant	100-seed weight (g)	Seed yield / plant (g)
Reps	C_1	2	95.69	77.98	12.99	0.44	35.54
	C_2	2	65.44	54.98	10.66	0.38	22.65
Families	C_1	101	197.85**	187.66**	65.95**	55.16**	81.22**
	C_2	11	107.56*	121.75**	45.66**	62.11**	67.55**
Error	C_1	202	19.87	16.78	9.64	5.12	15.88
	C_2	22	22.21	14.88	7.75	6.14	16.49

***,** significant at 0.05 and 0.01 level of probability, respectively.**

Average traits under study from each of the base populations, check variety (Misr-1) and two cycles of family selection are shown in Table 2.

The average of the selected family was higher than the average of both the base population (Giza-3) and the check variety (Misr-1) in all the characteristics under study, except for day to the maturity characteristic, the select plants were less than the base population (Giza-3) and the check variety (Misr-1) in the cycle one and cycle two. These results are broadly consistent with those reported by Brim *et al.* (1959), Bahy and Ezzat. (1987), Shalaby *et al.* (2001), Sabah *et al*. (2002), Abd-Elezz (2005) and Haridy *et al*. (2014).

Table 2. Means of the studied traits over all families in both the first and second cycles of selection.

	Days to maturity	Plant height (cm)	Number of pods / plant	100-seed weight(g)	Seed yield /plant (g)
Cycle 1	149.14	151.15	47.14	53.17	65.17
Base–population (Giza-3)	159.04	141.44	40.07	50.33	59.02
Check variety (Misr-1)	154.55	148.61	44.94	51.15	61.01
Cycle 2	145.56	153.45	53.58	56.32	72.36
Base–population (Giza-3)	159.25	142.74	41.22	52.41	57.43
Check variety (Misr-1)	153.58	149.64	45.48	53.25	59.65

The selected family means (Table 3) showed that 45 out of the 100 families surpassed significantly or highly significantly, the base population in seed yield /plant. Whereas, only thirty-seven families (family 4, 6, 9, 11, 13, 14, 18, 23, 24, 30, 32, 34, 38, 39, 46, 43, 47, 51, 52, 56, 62, 64, 65, 66, 70, 71, 72,75, 79, 81, 85,86, 87, 91, 92, 98 and 100) exceeded highly significantly the check cultivar Misr-1 in seed yield/ plant. When studying the cycle 2 (Table 4), all the select plants were higher than the base population (Giza-3), the highest select plants were only six families (4, 33, 43, 45, 65 and 87) with a percentages of 18.99, 39.50, 30.75, 28.48, 26.81 and 34.28%, respectively. Regarding the comparison of selected families with the check cultivar (Misr-1), six families outperformed 118.55 to 139.88% in seed / plant yield. This variety can be used and included in crop breeding programs and early ripening. These results are broadly consistent with those reported by Bahy and Ezzat. (1987), Haridy *et al*. (2012) and Haridy *et al*. (2014).

Genetic variance components and heritability.

The genetic components of variance, genotypic GCV and phenotypic PCV coefficients of variability and the heritability estimates are shown in Table 5. It appears that the C_1 families possessed considerable amount of genotypic and phenotypic variability for all the studied treats. Consequently, high estimates of heritability were obtained. Otherwise, the variability C_2 families decreased rapidly for all the studied treats. Consequently, the heritability estimates dropped from 89.96, 91.06, 85.38, 90.72 and 80.45% to 87.49, 87.78, 83.03, 90.11 and 75.59% for days to maturity, number pods /plant, 100- seed weight and seed yield, respectively. These results were expected because of the low number of selected families (ten) which were superior in seed yield /plant. Narrow sense heritability ranged from 35.74 to 55.67% in cycle 1 and 33.46 to 52.35% in cycle 2. Agreement with those of Bahy and Ezzat (1987) Metwali and Bakheit (2011) and Djukic *et al*. (2011).

Table 3. Means of seed yield/plant for 100 families derived from selected plant cycle one, base population, and check variety of the faba bean.

Family. No	Seed yield/ plant	Family. No	Seed yield/ plant	Family. No	Seed yield/ plant	Family. No	Seed yield/ plant
1	66.43	27	63.44	53	62.56	79	81.96
2	56.89	28	50.16	54	65.68	80	68.06
3	51.76	29	65.44	55	72.99	81	77.27
4	70.33	30	70.44	56	79.00	82	51.16
5	69.33	31	64.76	57	57.51	83	49.77
6	72.09	32	70.33	58	59.19	84	64.04
7	55.98	33	64.29	59	65.89	85	70.13
8	49.32	34	69.99	60	52.61	86	79.93
9	75.55	35	68.88	61	67.89	87	80.56
10	51.88	36	59.34	62	72.89	88	67.94
11	77.78	37	54.21	63	67.21	89	61.39
12	66.78	38	72.78	64	72.78	90	64.51
13	75.99	39	71.78	65	66.74	91	71.82
14	79.44	40	74.54	66	72.44	92	77.83
15	48.49	41	58.43	67	67.71	93	56.34
16	62.76	42	51.77	68	58.17	94	58.02
17	68.85	43	78.00	69	53.04	95	64.72
18	78.65	44	54.33	70	71.61	96	51.44
19	47.67	45	51.00	71	70.61	97	66.72
20	66.66	46	69.23	72	73.37	98	71.72
21	60.11	47	78.44	73	57.26	99	66.04
22	63.23	48	52.33	74	50.60	100	71.61
23	70.54	49	50.94	75	76.83	Giza-3	59.02
24	76.55	50	65.21	76	53.16	Misr-1	61.01
25	55.06	51	71.30	77	62.56	L.S.D 5%	6.37
26	56.74	52	81.10	78	65.68	L.S.D 1%	8.40

Table 4. Means of seed yield/plant in cycle two of the ten selected families in cycle two and their percentage from the base population and check variety.

Fam. No	Mean	Mean as a percentage from	
		Giza 3	Misr 1
4	70.98**	23.60	18.99
16	65.78*	14.54	10.28
27	64.53*	12.36	8.18
33	83.21**	44.89	39.50
43	77.99**	35.80	30.75
45	76.64**	33.45	28.48
65	75.64**	31.71	26.81
73	64.09*	11.60	7.44
87	80.1**	39.47	34.28
95	64.64*	12.55	8.37
Giza-3	57.43		
Misr-1	59.65		
L.S.D 5%	6.50		
L.S.D 1%	8.55		

*** exceeded the base population Giza-3 at 0.05 level of probability.**

Table 5. Genotypic (σ^2g), phenotypic (σ^2P), their coefficients of variability and heritability estimates of the studied traits.

Traits		σ^2g	σ^2P	GCV	PCV	$h^2_{(b.s)}$	$h^2_{(n.s)}$
Days to	C_1	59.33	65.95	5.17	5.45	89.96	43.77
maturity	C_2	51.78	59.19	4.94	5.29	87.49	45.67
Plant height	C_1	56.96	62.55	4.99	5.23	91.06	50.22
(cm)	C_2	35.62	40.58	3.89	4.15	87.78	51.67
Number of	C_1	18.77	21.98	9.19	9.95	85.38	49.33
pods / plant	C_2	12.64	15.22	6.63	7.28	83.03	47.89
100-seed	C_1	16.68	18.387	7.68	8.07	90.72	35.74
weight(g)	C_2	18.66	20.70	7.67	8.08	90.11	33.46
Seed yield/	C_1	21.78	27.07	7.16	7.98	80.45	55.67
plant (g)	C_2	17.02	22.52	5.70	6.56	75.59	52.35

Expected and realized gains from selection:

Expected and realized gains from selection to seed yield/plant are presented in Table 6. The results indicate that the realized gain higher than the expected gain in cycle 1 and cycle 2 for all studied traits. The expected gain in cycle 1 was higher than the expected gain in cycle 2 for all studied traits. After two generations, the realized gain for seed yield /plant reached 12.71 and 14.93% from the base population and check variety, respectively. The realized correlated response to selection for seed yield/plant reached 7.50% in plant height, 29.99% in number pods/plant, and 8.60% in day to maturity, and 7.46% in 100-seed weight after two generations. Comparing the results of expected and realized gain from selection, it could be noticed that, generally there was a quite good agreement between predicted and realized gains in all studied traits in both cycle one and cycle two families. The results presented here showed a similar estimate with both Bahy and Ezzat. (1987), Haridy *et al.* (2012), Haridy *et al.* (2014), Haridy (2017) and Haridy (2018).

Table 6. Expected and realized gains from selection in units of measurement and in percent % of the base population and check variety.

Traits		Expected gain	Realized gain			
		Units	Giza-3		Check variety	
			Units	%	Units	%
Days to	C_1	7.36	-9.90	6.23	-5.41	3.50
maturity	C_2	7.27	-13.69	8.60	-8.02	5.22
Plant	C_1	8.22	9.71	6.87	2.54	1.71
height(cm)	C_2	6.81	10.71	7.50	3.81	2.55
Number of	C_1	4.79	7.07	17.64	2.2	4.90
pods/plant	C_2	3.87	12.36	29.99	8.1	17.81
100-seed	C_1	3.17	2.84	5.64	2.02	3.95
weight(g)	C_2	3.15	3.91	7.46	3.07	5.77
Seed yield /	C_1	6.15	10.42	4.16	6.82	6.15
plant(g)	C_2	14.93	26.00	12.71	21.31	14.93

Phenotypic and genetic correlation coefficients for the second cycle for all studied traits

Based on the experience (Table 7)., it was found in cycle 1 that the phenotypic and genetic correlation coefficients between days to maturity and all studied traits were negative. The phenotypic and genotypic correlation coefficients were positive and significant between the seed yield / plant and both plant height (0.5005 and 0.4115), the number of pods / plant (0.7345 and 0.5085) and 100-seed weight (0.2105 and 0.0815), while they were negative and significant between seed yield / plant and the number of days to maturity (0.6855 and 0.5355). These results are consistent with those found by Bahy and Ezzat (1987), Alan and Serene (2007) and Haridy *et al.* (2012) who found that the phenotypic and genetic correlation coefficients were positive and significant between the seed / plant yield, both plant height, number of pods / plant and seed spread, while it was negative and large between days of maturity. Also, it was found that the seed yield / plant, in cycle 2, the phenotypic and genotypic correlation coefficients were positive and (Table 10) significant between seed yield / plant and both plant height (0.6105 and 0.5015), number of pods / plant (0.7715 and 0.6025) and 100 - seed weight (0.3415 and 0.0925) While it was negative and significant between seed yield / plant and days of maturity (-0.7945 and -0.6615). These results are consistent with those found by Lithy and Abdel-Aal (2004), Tadesse *et al.* (2011) and Haridy *et al.* (2012) who found that 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 was negative and significant between days of maturity.

Table 7. Phenotypic (above diagonal) and genotypic (below diagonal) correlation the studied trait pairs at cycle 1 and cycle 2 in faba bean.

traits		Days to maturity	Plant height (cm)	No. of pods/ plant	100-seed weight (g)	Seed yield/ plant (g)
Days to	C_1	*	-0.6755	-0.7075	-0.8295	-0.6855
maturity	C_2	*	-0.7535	-0.8585	-0.8425	-0.7945
Plant height	C_1	-0.4235	*	0.8615	0.3745	0.5005
(cm)	C_2	-0.5135	*	0.8705	0.6285	0.6105
No. of	C_1	-0.4725	0.7595	*	-0.7765	0.7345
pods/plant	C_2	-0.5395	0.8685	*	-0.7785	0.7715
100-seed	C_1	-0.3225	0.2905	-0.2185	*	0.2105
weight (g)	C_2	-0.4115	0.3515	-0.3215	*	0.3415
Seed yield/	C_1	-0.5355	0.4115	0.5085	0.0815	*
plant (g)	C_2	-0.6615	0.5015	0.6025	0.0925	*

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الانتخاب لزيادة محصول البذور في الفول البلدي

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تم إجراء البحث خلال ثلاث مواسم 2017/2016 و2019/2018 و2020/2019 للانتخاب لزيادة محصول البذور في صنف جيزة 3 للفول البلدي. تم تقييم الطرز الوراثية المنتخبه في مزرعة تجريبية بكلية الزراعة بجامعة الأزهر فرع أسيوط، أظهرت النتائج أن متوسط القيم في الدورة الانتخابية الثانية أعلى من المتوسطات في الدورة الانتخابية الأولى لجميع الصفات المدروسة، باستثناء صفة عدد الأيام حتى النضج كان متوسط قيمها في الدورة الانتخابية الأولى أعلى من متوسط قيمها في الدورة الانتخابية الثانية. أيضًا، سجلت النباتات المنتخبة قيماً أعلى من متوسط قيم العشيرة الأساسية وصنف المقارنة. كانت الاستجابة الفعلية للنباتات المنتخبة أعلى من الاستجابة المتوقعة للنباتات المنتخبة في جميع الصفات المدروسة، سجلت التباينات المظهرية والوراثية قيمًا أقل في الدورة الثانية وقيمًا أعلى في الدورة الأولى لجميع الصفات المدروسة. كانت معاملات الارتباط المظهرية والوراثية موجبة ومعنوية بين حاصل البذور للنبات، وارتفاع النبات، وعدد القرون للنبات ووزن 100 بذرة، باستثناء صفة عدد الأيام حتى النضج كانت سالبة ومعنوية، تم تسجيل قيم وراثية عالية بالمعنى الضيق (أكثر من 50٪) لمحصول البذور/ نبات في الدورة الانتخابية الأولى والدورة الانتخابية الثانية، وتراوحت من منخفض إلى متوسط للصفات المتبقية.