Egypt. J. Plant Breed. 23(7):1391– 1415(2019)

DEVELOPING NEW DRY BEAN (*Phaseolus vulgaris* L.) LINES THROUGH PEDIGREE SELECTION

R.M. Galal

Horticulture Department, Faculty of Agric., Beni-Suef University, Beni-Suef, Egypt

ABSTRACT

This investigation was conducted at Sids Horticultural Research Station, Beni-Suef Governorate, Horticultural Research Institute, Agricultural Research Center, Egypt, during the period from 2015 to 2019 to study the genetic variability and heritability for some economic characters and develop some new promising dry bean lines by pedigree selection. Four bean cultivars (Phaseolus vulgaris L.) were used in this study, namely, Bronco, Giza 6, Nebraska and Diacol. These cultivars were planted for hybridization between them. Three crosses were made at flowering stage, namely Bronco x Giza 6 (Population1), Bronco x Nebraska (Population 2) and Bronco x Diacol (Population 3). Segregating generations were planted, and selection was practiced until they reached the seventh generation. Nine new F6 and F7 lines of dry bean selected were developed from the three hybrid populations using pedigree selection. The yield and its component traits i.e. plant height, number of branches/plant, number of days to flowering, dry pod length, number of dry pods/plant, number of dry seeds/pod, 100-dry seeds weight and seed yield traits were studied. Results showed highly significant differences among the families for all studied traits in all segregating generations for all hybrid populations. The families BG-7-286 and BN-8-123 possessed the highest seed yield followed by the families BG-52-367 and BG-94-478. The highest GCV and PCV was observed for number of seeds/pod, number of pods/plant, seed yield, number of days to flowering and 100- seed weight for all segregating generations in all hybrid populations. The highest estimates of broad sense heritability (BSH) were recorded by number of branches/plant, days to flowering and plant height in a descending order in all segregating generations for all hybrid populations.

Key words: ***Bean, Phaseolus vulgaris, Yield components, Pedigree selection, Promising lines, Heritability, Genetic advance.***

INTRODUCTION

Dry bean (*Phaseolus vulgaris* L.) is an important legume crop in Egypt. Recently there are intensive efforts for improvement of dry bean productivity in Egypt through breeding procedures. To achieve this goal, the breeders should choose breeding methods which facilitate the simultaneous improvement of yield and its components. The pedigree method is widely spread method in the breeding of self-pollinating plants as it allows for visual selection of plants across various generations and control of a larger number of traits. The procedure encompasses selection of superior progenies at each segregating generation and maintaining records of all parent-progeny relationships being limited by the amount of materials a plant breeder can handle (Allard 1960). Development of segregating populations in the common bean using the pedigree method has been efficient in the selection of lines with higher seed yield (Ramalho *et al* 2005, Silva *et al* 2009 and Torga *et al* 2010). Effective selection for seed yield and its components requires information on the magnitude of useful genetic variance present in the populations and earlier studies in common bean showed considerable genetic variation for seed yield and its components with the effective simple selection method for improving plant height, number of pods per plant, number of grains per pod and pod length traits as well as, the segregating F_2, F_3 and F_4 generations should be tested for the higher yield and the desirable horticultural traits. All the populations and families with undesirable traits have to be discarded and selected promising populations and individual plants in F_3 generation to be used for producing a new cultivar with good and high dry seed yield (Dursun 2007, Salehi *et al* 2008, Bertoldo *et al* 2010, Menezes *et al* 2011 and Ahmed 2013). In plant breeding, the estimation of variance components and broad sense heritability (BSH) is very important in genetic analysis of quantitative traits. Ranalli 1996, Abdel-Ati *et al* 2000, Couto *et al* 2005, Bertoldo *et al* 2010 and Hamed and Khalil 2010, found that broad sense heritability (BSH) for plant height ranged from 52 to 99%, number of days to flowering from 30.64 to 86.30%, number of pods/plant from 33.69 to 96%, number of seeds/pod from 15 to 70%, pod length from 55.04 to 71.67%, 100- seed weight from 68 to 98.92% and dry yield/plant from 62 to 91%. In the meantime, they found that contribution of the genetic effects outweighs the environmental for plant height and number of pods per plant; so the probability of gains with selection using these traits is greater than for number of grains per pod and pod length traits, which may be less successful in selection. Also, Khereba *et al* 2000, Roy *et al* 2006, Salib 2006, Makhdoomi and Dar 2011, Nechifor *et al* 2011 and Andriani *et al* 2015 showed moderate to high genetic variability on number of pod per plant and they reported moderate to high estimates of BSH for plant height, number of days to flowering, green pod yield/plant, number of pods/plant, pod length and number of seeds/pod, 100 seed weight100 seed weight and dry seed yield. On the other hand, Nosser 2011, Devi *et al* 2015, More and Borkar 2016, Jhanavi *et al* 2018, Lyngdoh *et al* 2018 and Singh *et al* 2018 found that high phenotypic and genotypic coefficient of variations were recorded for plant height, number of primary branches, pod length, pod yield/plant and pods/plant. These traits and each of number of seeds per pod, and weight of 100 seeds also showed high heritability coupled with high genetic advance, indicating the importance of the genetic effects in controlling the inheritance of these traits. The main objective of the present investigation was to develop some new promising dry bean lines and identify the best one to be used as a promising cultivar.

MATERIALS AND METHODS

This investigation was conducted at Sids Horticultural Research Station, Beni-Suef Governorate, Horticultural Research Institute, Agricultural Research Center, Egypt, during eight successive summer and fall seasons of 2015 to 2019. The soil was clay loam. Four different bean cultivars (*Phaseolus vulgaris* L.) represented a wide range of variability in their economic traits were used in this study, namely, Bronco (P_1), Giza 6 (P_2), Nebraska (P_3) and Diacol (P_4). These cultivars were grown each alone under open field conditions in one season to insure the purity of each parent before crossing. Cultivars were planted at (3rd September 2015) for hybridization between them. Three crosses were made at flowering stage as follows: Bronco x Giza 6, Bronco x Nebraska and Bronco x Diacol. Flowers of female parents were emasculated one day prior to anthesis and the pollen grains from the completely opened flowers of the male parents were applied on the stigma of female parents to produce the F_1 hybrids. In the summer season (1st March 2016), the F_1 hybrid plants were selfed to produce F_2 seeds. Seeds of the F_2 populations of each of the three hybrids were sown on 1st September 2016 to practice the pedigree selection on the plants of this segregating generation. The selection was done between and within lines for different characters, *viz.*, plant height, earliness, high number of pods/plant, high number of seeds/pod, seed yield/plant and heavy seed weight. Across the three following successive seasons (both summer and fall seasons of 2017 and summer 2018), nine inbred lines of dry bean were selected from F_2 populations of the three crosses. Seeds of the nine selected lines were grown in fall (1st week of September 2018) and summer (1st week of March 2019) seasons to produce the F_6 and F_7 generations, respectively. In the summer season of 2017 (March 8th), 360 F_3- plants from each of the three crosses in addition to the parents were sown in a randomized complete block design with three replications. These entries were grown in two rows per plot. Seeds of each family and parents were planted in hills, 15 cm apart within rows, 4 m length and 60 cm width. Also, different agricultural production practices were applied as recommended by Egyptian Ministry of Agriculture. The best 36 F_3 plants(10% selection intensity) from families of each cross for both selection criteria (seed weight/plant and 100- seed weight) were saved to give the F_4 families. In fall season of 2017 (September 5th), the 36 F_4 selected families of each cross in addition to the parents were sown in two separate experiments in a randomized complete blocks design with three replications. Each family and parent were grown in two rows 4 m long, 60 cm width and 15 cm between plants. Data were recorded as mentioned previously. The best 18 F_4 plants from 18 families of each selection criterion were saved to give the F_5 families. In the summer season of 2018 (March 5th), the 18 F_5 selected families of three populations with the parents, were sown in three replications in a randomized complete block design. The best 9 F_5 plants from 9 families of each selection criterion were saved to give the F_6 families. In the fall 2018 (September 3rd) and summer 2019 (March 7th), the 9 F_6 selected families of all populations (three families from each cross) with their parents were sown in a randomized complete block design in three replications. Each family was represented by three rows, 4 m long, 60 cm width and 5 cm between plants. After harvest, data were recorded for individual plants on a random sample of ten guarded plants from each family in F_3, F_4, F_5 and F_6 generations and selection was performed for white dry seeds, which are favorable to Egyptian consumers. The means of the ten plants were subjected to the statistical and genetically analyses for the following traits: plant height, number of branches/plant, number of days to flowering, dry pod length, number of dry seeds/pod, number of dry pods/plant, 100- dry seed weight, seed yield per plant and seed yield/feddan.

Statistical analysis

The statistical analyses were performed using analysis of variance technique by means of MSTATC computer software package (Freed *et al* 1991). Analysis of variance for randomized complete blocks design was carried out according to Snedecor and Cochran (1989). Means for both F_6 and F_7 generations were compared using Duncan's multiple range test (Duncan 1955).

Genetic parameters

Two types of heterosis [relative heterosis (MPH) and heterobeltiosis (BPH)] were estimated and expressed as percentages (Sinha and Khanna 1975).

(Mid-parent heterosis (MPH %) = (F_1 – MP)/MP × 100)

(Better parent heterosis (BPH %) = (F_1 – BP)/BP × 100)

The ‘t’ test was used to determine whether F_1 hybrid means were statistically different from mid parent and better parent means according to Wynne *et al* (1970).

Where: F_1 = The mean of the F_1 cross, MP = The mid parent mean for the cross, BP = The better parent mean for the cross. Potence ratio was calculated for F_1 generation according to Smith (1952) to determine the degree of dominance as follows:

$P = (F_1 – MP)/[0.5 (P_2 − P_1)]$.

Where P: relative potence of gene set, F_1: first generation mean, P_1: the mean of lower parent, P_2: the mean of higher parent and MP: mid-parents' value = $(P_1 + P_2)\backslash 2$. Complete dominance was indicated when P = ±1; while partial dominance was indicated when “P” is between (-1 and +1), except the value zero which indicates absence of dominance. Overdominance was considered when potence ratio exceeds ±1. The positive and negative signs indicate the direction of dominance of either parent. Coefficient of variance (C.V.) was calculated according to Steel and Torri (1981). Broad sense heritability (BSH) was estimated according to Allard (1960) and Falconer (1989) using: BSH= $(\delta^2_g / \delta^2_{ph})$ x100. Phenotypic (PCV%) and genotypic (GCV%) coefficient of variability were calculated according to Singh and Chaudhury (1985). Genetic advance (GA) was calculated with the method suggested by Allard (1960) and Singh and Chaudhury (1985) as: GA = K x σ_{ph} x BSH, where: K, constant (On the basis of intensity of the selection). Genetic advance was calculated as percent of mean (expected genetic advance) GAM % = (GA/ $\bar{X}$) x 100. GAM% according to Hadiati *et al* (2003) was classified as follows: 0 - 7% = low, 7 - 14% = medium and > 14,1 = high. In fact, genetic advance is the difference between the genetic advance of population after selection and the expected genetic advance before selection.

RESULTS AND DISCUSSION

The early generations (F_1 and F_2)

Data obtained regarding all traits of parental, F_1 and F_2 generations of the crosses, *i.e.*, Bronco x Giza 6, Bronco x Nebraska and Bronco x Diacol are presented in Table (1).

Table 1. Parental, F_1 and F_2 mean performance for the studied traits in three bean crosses along with C.V.% and mean square(MS) values for their analysis of variance.

Parameter		Plant height (cm)	Number of branches /plant	Number of days to flowering	Pod length(cm)	Number of seeds/pod	100-seed weight(g)	Number of pods /plant	Seed yield /plant(g)
F_1 (summer 2016)									
Bronco × Giza 6									
Grand mean		46.6	3.5	43.4	10.4	6.4	39.5	29.6	23.3
Mean	F_1	54.3	3.5	40.3	11.2	6.8	47.7	31.4	24.3
	Bronco	44.3	3.4	47.3	10.0	6.4	26.7	28.7	22.3
	Giza 6	41.3	3.5	42.7	10.1	6.0	44.0	28.6	23.2
M S	Families	102.6^{**}	0.2^{**}	39.2^{**}	1.8^{**}	3.9^{**}	259.8^{**}	28.6^{**}	19.6^{**}
C.V.%		2.2	1.9	1.5	2.9	3.5	1.4	3.7	5.2
Bronco × Nebraska									
Grand mean		46.9	3.5	41.6	10.4	6.2	38.2	28.2	23.4
Mean	F_1	49.3	3.5	36.3	11.0	6.3	39.7	28.3	24.0
	Bronco	44.3	3.4	47.3	10.0	6.4	26.7	28.7	22.3
	Nebraska	47.0	3.5	41.3	10.2	6.0	48.3	28.0	24.0
M S	Families	49.6^{**}	0.1^{**}	70.7^{**}	1.6^{**}	3.2^{**}	242.2^{**}	21.0^{**}	16.8^{**}
C.V.%		2.6	1.2	1.5	2.5	2.2	1.5	3.9	5.5
Bronco × Diacol									
Grand mean		44.2	3.2	45.3	10.0	5.4	37.7	26.7	20.9
Mean	F_1	49.0	3.3	40.3	10.9	6.0	38.0	28.0	22.0
	Bronco	44.3	3.4	47.3	10.0	6.4	26.7	28.7	22.3
	Diacol	39.3	3.0	48.3	9.2	3.9	48.3	23.3	18.3
M S	Families	47.1^{**}	0.1^{**}	39.2^{**}	1.5^{**}	3.2^{**}	248.2^{**}	20.9^{**}	16.8^{**}
C.V.%		2.6	1.78	1.4	2.6	2.4	1.3	4.5	6.4

Table 1. Cont.

Parameter		Plant height (cm)	Number of branches /plant	Number of days to flowering	Pod length(cm)	Number of seeds/pod	100-seed weight(g)	Number of pods /plant	Seed yield /plant(g)
F_2 (fall 2016)									
Bronco × Giza 6									
Grand mean		45.3	3.3	45.5	10.7	6.2	37.9	27.4	22.6
Mean	F_2	48.0	3.1	44.3	10.9	6.2	43.0	25.0	21.3
	Bronco	45.3	3.5	49.0	11.1	6.5	26.6	27.6	22.0
	Giza 6	42.7	3.4	43.3	10.1	5.9	44.0	29.6	24.6
M S	Families	42.8**	0.1**	39.7**	1.0**	3.5**	238.2**	30.6**	33.8**
C.V.%		2.2	2.6	2.2	1.3	2.6	1.6	4.6	5.6
Bronco × Nebraska									
Grand mean		45.5	3.4	43.3	10.7	6.0	37.1	27.1	23.1
Mean	F_2	45.0	3.2	39.7	10.5	5.5	37.3	23.0	20.0
	Bronco	45.3	3.5	49.0	11.1	6.5	26.6	27.6	22.0
	Nebraska	46.3	3.5	41.3	10.5	5.9	47.3	30.7	27.3
M S	Families	30.8**	0.1**	61.2**	0.9 **	3.2**	248.9**	44.6**	40.2**
C.V.%		1.8	3.1	2.3	3.2	2.8	1.9	4.2	2.2
Bronco × Diacol									
Grand mean		43.1	3.2	47.2	10.3	5.3	37.3	24.6	20.2
Mean	F_2	45.7	3.2	43.0	10.3	5.7	36.3	23.3	19.0
	Bronco	45.3	3.4	49.0	11.1	6.5	26.6	27.6	22.0
	Diacol	38.3	3.1	49.7	9.6	3.8	49.0	23.0	19.7
M. S.	Families	32.5**	0.1**	43.2**	0.9**	3.3**	254.8**	42.6 **	46.2**
C.V.%		3.2	2.4	2.3	1.3	3.2	1.9	5.1	3.2

****= significant at P < 0.01.**

Highly significant differences were observed in both F_1 and F_2 generations for all traits in all studied populations. For plant height, mean values of F_1 and F_2 were higher than the grand mean and mean of parents for all populations except the cross Bronco x Nebraska for F_2 generation. For number of branches/plant, mean values of F_1 were equal to or higher than the grand mean, while F_2 values were equal to or lower than the grand mean. For number of days to flowering, mean values of F_1 and F_2 were lower than the grand mean and mean of parents for all populations. For pod length, mean values of F_1 were higher than the grand mean and mean of parents for all populations. Also, mean values of F_2 were higher than the grand mean of cross 1, while mean of Bronco parent was higher than F_2 mean for all populations. For number of seeds/pod, mean values of F_1 were higher than the grand mean for all populations, while F_2 mean values were equal to or higher than grand mean of cross Bronco × Giza 6 and Bronco × Diacol, respectively. On the other hand, the parent Bronco was higher than F_1 and F_2 mean in all populations, except F_1 mean for cross 1. For 100-seed weight, mean values of F_1 and F_2 were higher than the grand mean and all parents for all crosses, except cross 3 in F_2 generation. The parents Nebraska and Diacol were higher than F_1 mean for crosses 2 and 3, respectively. Also, the parents Giza 6,Nebraska and Diacol were higher than F_2 mean for all crosses. For number of pods/plant and seed yield /plant, mean values of F_1 were higher than the grand mean and all parents for cross 1 and cross 2, while Bronco and F_1 means were higher than the grand mean for cross 3. Mean values of F_2 were lower than the grand mean and all parents for all populations.

Heterosis

Heterosis percentages over mid-parent and better parent of the F_1 crosses for all studied traits are given in Table (2). The results indicated that the expression of heterosis varied with the investigated crosses and traits. Results revealed that high values heterosis for plant height were 26.9 and 22.6% over the mid-parent and better parent for population1,respectively followed by population 2, which were 17.2 and 10.6% over the mid-parent and better parent, respectively. Results also showed that cross 1 exhibited highly significant and positive heterosis values over the mid-parent for plant height, number of seeds/pod, 100-seed weight and number of pods/plant, while were significant and positive heterosis values over the mid-parent for seed yield /plant. On the other hand, cross 1 exhibited highly significant and negative heterosis values over the mid-parent for number of branches, number of days to flowering and pod length. Cross 1 exhibited highly significant and positive heterosis values over the better parent for plant height, number of seeds/pod and 100-seed weight, and significant and positive for number of pods/plant. On the other hand, cross 1 exhibited highly significant and negative heterosis values over the better parent for number of branches and number of days to flowering.

Table 2. Mid-parent heterosis (MPH%) and heterobeltiosis (BPH%) as well as potence ratio of the studied traits in the F1 crosses of the three bean populations, summer 2016.

Parameter	Plant height (cm)	Number of branches /plant	Number of days to flowering	Pod length (cm)	Number of seeds/pod	100-seed weight (g)	Number of pods /plant	Seed yield/ plant (g)
Bronco × Giza 6								
MPH%	**26.9****	**-13.0****	**-10.4****	**-10.4****	**11.4****	**34.9****	**9.6****	**6.8***
BPH%	**22.6****	**-14.3^{ns}**	**-14.8****	**-14.8^{ns}**	**10.9^{ns}**	**8.4****	**9.4***	**4.7^{ns}**
Potance ratio	**7.7**	**-9.0**	**-2.0**	**23.0**	**3.3**	**1.4**	**55.0**	**3.4**
Bronco × Nebraska								
MPH%	**8.0****	**1.4***	**-18.1****	**-18.1****	**8.9***	**5.9****	**-7.5****	**-6.4***
BPH%	**4.9^{ns}**	**0.0^{ns}**	**-23.3****	**-23.3^{ns}**	**7.8^{ns}**	**-17.8****	**-9.9****	**-10.9****
Potance ratio	**2.7**	**1.0**	**-2.7**	**9.0**	**-1.3**	**0.2**	**-2.8**	**-1.3**
Bronco × Diacol								
MPH%	**17.2****	**3.1****	**-15.7****	**-15.7****	**13.5****	**1.3^{ns}**	**7.7***	**8.4***
BPH%	**10.6****	**-2.9^{ns}**	**-16.6****	**-16.6^{ns}**	**9.0^{ns}**	**-21.3****	**-2.4^{ns}**	**-1.3^{ns}**
Potance ratio	**2.9**	**0.5**	**-15.0**	**3.3**	**0.6**	**0.0**	**0.7**	**0.9**

ns, * and **= nonsignificant and significant at P < 0.05 and 0.01,respectively.

Cross 2 exhibited highly significant and positive heterosis values over the mid-parent for plant height and 100-seed weight, and significant and positive heterosis values over the mid-parent for number of branches and number of seeds/pod. Cross 3 exhibited highly significant and positive heterosis values over the mid-parent for plant height, number of branches and number of seeds/pod, and significant and positive heterosis values over the mid-parent for number of pods /plant and seed yield/plant. On the other hand, Cross 3 exhibited highly significant and positive heterosis values over the better parent for plant height, and highly significant negative for number of days to flowering. Abdel-Ati et al (2000) found that negative heterosis was estimated for plant length, while positive heterosis values in all studied crosses were observed by Salib (2006) for plant length. Zayed (2005) stated that the heterotic effects in common bean were generally, more pronounced in the F1 than F2 generation for seeds number in both seasons, plant height and dry seed yield in summer season. Khereba et al (2000) and Salib (2006) found a negative heterosis based on early parent in some studied crosses for yield/plant. Hamed (1999) found very low positive heterosis for pod length trait in one studied cross. Salib (2006) found extremely low negative heterosis in one cross for pod length, meanwhile, positive heterosis was found and ranged from 4.01 to 6.71% in the other crosses.

Potence ratio

Potence ratio (Table 2) that measures the average degree of dominance, confirmed the partial dominance for 100-seeds weight (cross 2) and each of number of branches, number of seeds/pod, number of pods/plant and dry seed yield in cross 3. Over dominance was detected for all studied traits in cross-1 and cross-2, except number of branches and 100-seeds weight (cross2) as well as plant height, days to flowering and pod length of cross-3. Meanwhile, complete and absence of dominance were detected for number of branches (cross-2) and 100-seeds weight (cross-3), respectively. These results reflected various degrees of dominance; *i.e.* complete dominance, partial-dominance and absence of dominance which involved in the inheritance of these characters. On the contrary, the estimated values of potence ratios in all F1 hybrids for number of days to flowering were negative. Khereba *et al* (2000) reported overdominance and complete dominance towards the early parent for number of days to flowering, meanwhile, complete and partial dominance towards the early parent and partial dominance towards the late parent was found by Salib (2006). High positive potence ratio values were reported in all studied crosses indicating overdominance towards the high parent for number of pods per plant (Khereba *et al* 2000, Zayed 2005 and Salib 2006). Complete and partial dominance towards the highest parent were reported by Hamed (1999) for pod length. Salib (2006) found partial dominance towards the lowest parent in one studied cross, meanwhile, overdominance towards the highest parent was found in the other crosses.

Evaluation of selection procedures

The analysis of variance for F_3, F_4, F_5 and F_6 families and their parents for all studied traits of the three crosses are presented in Tables (3 and 4). The mean squares indicated highly significant differences among families for all studied traits in all generations for all populations except number of branches/plant (F_3, F_5 and F_6 for all populations) and pod length (F_3 generation for populations 1 and 2).

Table 3. Parental, F_3 and F_4 mean performance for the studied traits in three bean crosses along with C.V.% and mean square(MS) values for their analysis of variance.

Parameter		Plant height (cm)	Number of branches/ plant	Number of days to flowering	Pod length (cm)	Number of seeds/pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)
F_3 (summer 2017)									
Bronco × Giza 6									
Grand mean		43.7	3.5	47.0	10.6	6.1	38.1	24.7	19.7
Mean	F_3	42.7	3.5	46.3	10.4	6.2	41.7	23.0	19.7
	Bronco	44.0	3.4	50.3	11.2	6.3	27.7	24.7	19.0
	Giza 6	44.3	3.5	44.3	10.2	5.9	45.0	26.3	20.3
M S	Families	18.2^{*}	0.02^{ns}	47.6^{**}	0.9^{ns}	3.7^{**}	241.7^{**}	29.2^{**}	16.7^{**}
C.V.%		0.8	4.3	2.5	5.3	6.1	1.7	3.8	3.9
Bronco × Nebraska									
Grand mean		44.1	3.4	43.0	10.7	5.8	37.4	24.5	19.3
Mean	F_3	42.0	3.4	37.3	10.2	5.3	36.3	22.0	18.0
	Bronco	44.0	3.4	50.3	11.2	6.3	27.7	24.7	19.0
	Nebraska	46.3	3.5	41.3	10.6	5.8	48.3	26.7	21.0
M S	Families	19.2^{**}	0.02^{ns}	99.7^{**}	0.9^{ns}	3.4^{**}	266.3^{**}	31.2^{**}	16.7^{**}
C.V.%		2.9	4.4	2.9	6.6	6.3	1.8	4.5	4.9
Bronco × Diacol									
Grand mean		42.1	3.4	48.4	10.3	5.2	37.8	22.3	17.8
Mean	F_3	42.7	3.4	44.3	10.1	5.6	35.3	23.3	19.3
	Bronco	44.0	3.4	50.3	11.2	6.3	27.7	24.7	19.0
	Diacol	39.7	3.3	50.7	9.7	3.6	50.3	19.0	15.0
M S	Families	18.2^{**}	0.02^{ns}	49.9^{**}	0.9^{*}	3.4^{**}	236.3^{**}	28.8^{**}	16.4^{**}
C.V.%		2.6	4.2	2.2	4.7	5.7	5.7	3.6	3.5

Table 3. Cont.

Parameter		Plant height (cm)	Number of branches/ plant	Number of days to flowering	Pod length (cm)	Number of seeds/pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)
F_4 (fall 2017)									
Bronco × Giza 6									
Grand mean		43.5	3.3	46.1	11.0	6.5	38.7	26.2	20.8
Mean	F4	43.0	3.4	44.3	11.2	6.5	45.7	25.3	20.3
	Bronco	42.3	3.1	50.3	11.2	6.9	26.7	26.0	20.7
	Giza 6	45.3	3.5	43.7	10.5	6.2	43.7	27.3	21.3
M S	Families	23.8**	0.1*	40.4**	1.7**	5.2**	237.9**	21.4**	14.8**
C.V.%		1.9	4.9	2.0	3.2	5.8	1.3	3.4	3.6
Bronco × Nebraska									
Grand mean		44.0	3.3	43.3	10.7	6.1	37.7	26.2	20.9
Mean	F4	44.0	3.5	37.0	10.7	5.7	39.7	25.0	20.0
	Bronco	42.3	3.1	50.3	11.2	6.9	26.7	26.0	20.7
	Nebraska	45.7	3.2	42.7	10.2	5.8	46.7	27.7	22.0
M S	Families	24.4**	0.1*	93.2**	1.3**	4.6**	228.9**	21.6**	14.7**
C.V.%		3.1	4.2	2.5	2.5	4.4	2.9	3.3	4.4
Bronco × Diacol									
Grand mean		42.3	3.3	48.0	10.4	5.4	37.5	24.3	19.3
Mean	F4	46.0	3.6	43.7	10.7	5.9	37.0	26.0	21.0
	Bronco	42.3	3.1	50.3	11.2	6.9	26.7	26.0	20.7
	Diacol	38.7	3.1	50.0	9.4	3.5	48.7	21.0	16.3
M S	Families	29.2**	0.2**	42.6**	1.3**	4.7**	238.7**	21.6**	15.2**
C.V.%		1.9	4.2	2.2	2.5	4.2	1.9	3.6	3.6

ns, * and **= nonsignificant and significant at P < 0.05 and 0.01

Table 4. Parental, F5 and F6 mean performance for the studied traits in three bean crosses along with C.V.% and mean square(MS) values for their analysis of variance.

Parameter		Plant height (cm)	Number of branches/ plant	Number of days to flowering	Pod length (cm)	Number of seeds/pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)
F_5 (summer 2018)									
Bronco × Giza 6									
Grand Mean		43.8	3.5	44.7	11.3	6.5	40.3	27.5	21.6
Mean	F_5	44.7	3.5	40.7	11.7	6.6	51.3	27.7	22.3
	Bronco	41.7	3.3	50.7	11.5	7.1	27.0	26.7	20.3
	Giza 6	44.9	3.7	42.7	10.8	5.9	42.7	28.0	22.3
M S	Families	35.7^{**}	0.1^{ns}	70.1^{**}	1.8^{**}	6.6^{**}	271.8^{**}	14.2^{**}	11.4^{**}
C.V.%		2.1	4.1	2.4	4.2	5.4	1.8	3.3	4.9
Bronco × Nebraska									
Grand Mean		43.7	3.4	42.5	11.1	6.1	37.4	27.7	22.4
Mean	F_5	44.3	3.5	36.0	11.3	5.7	41.3	28.0	23.0
	Bronco	41.7	3.3	50.7	11.5	7.1	27.0	26.7	20.3
	Nebraska	45.0	3.4	40.7	10.6	5.5	44.0	28.3	24.0
M S	Families	34.7^{**}	0.1^{ns}	112.3^{**}	1.5^{**}	5.8^{**}	203.8^{**}	14.8^{**}	12.4^{**}
C.V.%		2.4	4.3	1.7	3.8	4.8	2.9	2.1	2.7
Bronco × Diacol									
Grand Mean		41.1	3.4	47.6	10.8	5.4	38.3	26.1	21.1
Mean	F_5	44.7	3.6	42.7	11.2	5.9	39.0	28.7	24.0
	Bronco	41.7	3.3	50.7	11.5	7.1	27.0	26.7	20.3
	Diacol	37.0	3.3	49.3	9.7	3.3	49.0	23.0	19.0
M S	Families	35.7^{**}	0.1^{ns}	60.3^{**}	1.4^{**}	5.9^{**}	205.2^{**}	16.2^{**}	14.9^{**}
C.V.%		1.9	3.8	1.7	3.3	4.3	2.6	3.6	4.4

Table 4. Cont.

Parameter		Plant height (cm)	Number of branches/ plant	Number of days to flowering	Pod length (cm)	Number of seeds/ pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)
F_6 (fall 2018)									
Bronco × Giza 6									
Grand Mean		46.1	3.5	44.7	12.2	6.7	42.1	27.5	21.1
Mean	F_6	48.2	3.4	39.1	12.8	6.7	54.8	29.7	25.5
	Bronco	43.9	3.5	51.6	12.3	7.4	27.8	26.9	17.9
	Giza 6	46.3	3.6	43.3	11.6	5.9	43.6	25.8	19.9
M S	Families	42.6^{**}	0.01^{ns}	80.8^{**}	2.6^{**}	6.9^{**}	318.2^{**}	13.9^{**}	15.8^{**}
C.V.%		2.9	2.8	1.9	3.1	6.5	1.8	2.9	4.8
Bronco × Nebraska									
Grand Mean		45.5	3.5	42.7	12.0	6.5	39.4	28.2	21.3
Mean	F_6	46.3	3.5	35.8	12.0	6.6	44.7	29.8	25.3
	Bronco	43.9	3.5	51.6	12.3	7.4	27.8	26.9	17.9
	Nebraska	46.2	3.6	40.6	11.7	5.6	45.8	27.9	20.7
M S	Families	34.4^{**}	0.02^{ns}	113.3^{**}	1.4^{**}	6.3^{**}	219.7^{**}	13.7^{**}	15.4^{**}
C.V.%		2.6	2.4	1.4	2.8	6.6	2.0	3.9	5.3
Bronco × Diacol									
Grand Mean		42.7	3.6	46.9	11.6	5.6	39.7	25.8	19.9
Mean	F6	46.1	3.7	42.2	11.9	6.1	40.3	30.7	26.0
	Bronco	43.9	3.5	51.6	12.3	7.4	27.8	26.9	17.9
	Diacol	38.2	3.6	47.0	10.7	3.3	50.9	19.7	15.8
M S	Families	33.4^{**}	0.04^{ns}	61.5^{**}	1.2^{**}	6.4**	215.2^{**}	17.2^{**}	17.9^{**}
C.V.%		2.2	2.3	1.6	2.5	6.5	1.6	3.8	4.7

ns, * and **= nonsignificant and significant at P < 0.05 and 0.0,respectively.

Coefficients of variation (C.V.%) were the highest in F_6 generation for all populations for number of seeds/pod. Moreover, C.V. ranged from 6.6% (number of seeds/pod in F_6 generation for cross-1) to 0.8% (plant height in F_3 generation for the same cross-1). The means performance for F_3, F_4, F_5 and F_6 families and their parents for all studied traits of the three populations are presented in Tables (3 and 4). Mean values gradually increased, in desirable direction, from F_3 to F_5 generation in all traits of all crosses except for plant height of cross-3 in which F_5 decreased from 46 to 44.7 cm and both number of branches (cross-3) and number of seeds/pod (both cross-2 and cross-3) in which F_4 values equaled to F_5 ones. Data (Table 4) revealed that the means of F_6 generation for all traits were higher, in the desirable direction, than the grand mean and the mean of parents for all populations. These results reflect the effectiveness of pedigree selection method to improve these traits. The Population 1 gave the highest means of F_6 generation for plant height, pod length, number of seeds per pod, 100-seed weight and number of pods, while the population 3 was higher for seed yield per pant. On the other hand, The Population 2 showed earliness in flowering, compared to other populations. These results are in agreement with those obtained by Nosser (2011) and Ahmed (2013).

Genetic parameters

Estimates of genetic parameters like genotypic (GCV) and phenotypic (PCV) coefficient of variability, broad-sense heritability (BSH), genetic advance (GA) and expected genetic advance (GAM%) from selection as percentage of mean for different characters have been presented in Tables (5 and 6).

Phenotypic (PCV) and genotypic (GCV) coefficient of variances

Data in Table 5 revealed that the magnitude of phenotypic (PCV) and genotypic (GCV) coefficient of variances varied for all traits. The highest GCV and PCV was observed for number of seeds/pod, number of pods/plant, seed yield/plant, number of days to flowering and 100- seed weight for all generations in all populations, indicating the high potential for effective selection (Burton 1952). On the other hand, plant height, number of branches and pod length had moderate genotypic and phenotypic coefficient of variation, revealing that these traits provide practically average chance for selection. Phenotypic coefficient of variation was greater than genotypic coefficient of variation for all the traits, which indicated that the apparent variation is not only due to genotypes but also due partially to the influence of environment. However, it decreased from the F_3 to the F_6 generation of selection for all studied traits in all populations. These results are in agreement with those obtained by Chiorato *et al* 2010, Nechifor *et al* 2011 and Nosser 2011. Roy *et al* (2006) found that the GCV and PCV were generally high for pods/plant, 100-seed weight, seeds/pod and seed yield/plant. Plant height and pod length had moderate genotypic and phenotypic coefficient of variation.

Table 5. Genotypic (GCV%) and Phenotypic (PCV%) coefficient of variability for eight quantitative traits of three bean hybrid populations from F_3 to F_6 generations.

parameter	Plant height	Number of branches /plant	Number of days to flowering	Pod length	Number of seeds/pod	100-seed weight	Number of pods /plant	Seed yield /plant
F_3 (summer 2017)								
Bronco × Giza 6								
GCV	9.7	13.9	14.5	7.7	27.0	14.7	22.6	19.8
PCV	10.6	14.5	15.5	11.1	38.3	16.9	25.3	22.6
Bronco × Nebraska								
GCV	9.2	13.4	26.3	8.4	30.7	13.6	24.5	21.5
PCV	10.1	14.1	27.6	10.7	41.2	15.4	27.2	24.9
Bronco × Diacol								
GCV	9.7	13.4	15.8	8.4	28.1	13.2	22.2	19.8
PCV	10.5	14.1	16.6	11.5	40.6	14.8	24.5	23.1
F_4 (fall 2017)								
Bronco × Giza 6								
GCV	11.3	15.5	14.0	10.3	31.1	12.8	17.5	17.9
PCV	12.2	16.1	15.0	13.9	41.6	14.5	19.7	20.7
Bronco × Nebraska								
GCV	10.9	10.4	25.7	9.5	33.5	11.5	18.0	18.2
PCV	11.8	11.2	26.9	13.0	46.1	13.0	19.8	21.0
Bronco × Diacol								
GCV	11.4	11.5	14.7	9.3	32.5	12.7	17.2	17.7
PCV	12.4	12.1	15.4	13.2	44.6	14.2	19.1	20.3

Table 5. Cont.

parameter	Plant height	Number of branches /plant	Number of days to flowering	Pod length	Number of seeds/pod	100-seed weight	Number of pods /plant	Seed yield /plant
F_5 (summer 2018)								
Bronco × Giza 6								
GCV	13.0	21.6	20.1	10.2	34.2	9.7	13.0	14.4
PCV	14.0	22.0	21.5	13.9	47.2	11.1	14.8	16.5
Bronco × Nebraska								
GCV	13.0	21.6	28.9	9.2	36.7	10.5	13.2	14.5
PCV	13.9	22.1	30.4	13.3	51.3	11.7	14.7	16.8
Bronco × Diacol								
GCV	13.0	21.1	17.9	9.1	35.9	11.1	13.5	15.3
PCV	14.0	21.4	18.7	13.0	49.9	12.5	15.0	17.6
F_6 (fall 2018)								
Bronco × Giza 6								
GCV	14.4	12.3	22.6	11.2	35.2	9.9	12.1	14.8
PCV	15.4	12.7	23.8	14.9	46.9	11.0	13.6	17.2
Bronco × Nebraska								
GCV	12.4	12.4	29.2	8.5	36.3	10.1	12.1	14.7
PCV	13.2	12.6	30.8	12.4	51.2	11.2	13.5	17.0
Bronco × Diacol								
GCV	12.3	5.4	18.3	8.4	35.7	11.1	13.0	15.5
PCV	13.1	5.8	19.2	11.5	50.5	12.3	14.5	17.8

Broad sense heritability (BSH) and genetic advance(GA)

The heritable fraction of the variation provides the base for the plant breeder for successful selection on the phenotypic performances. As shown in Table (6), results reveal that broad sense heritability (BSH) improved considerably for all studied traits from the F_3 to F_6 generations in all populations. The highest estimates of broad sense heritability were recorded by number of branches/plant, days to flowering and plant height, in a descending order in all generations for most populations. These results are in agreement with those reported by (Khereba *et al* 2000, Couto *et al* 2005, Roy *et al.* 2006, Salib 2006, Bertoldo *et al* 2010, Hamed and Khalil 2010, Makhdoomi and Dar 2011 and Nosser 2011) who found that broad-sense heritability ranged from moderate to high for the same studied characters and suggested selection for improving these traits.

Table 6. Broad sense heritability (BSH%) and genetic advance(GA) for eight quantitative traits from F3 to F6 generations of three bean hybrid populations.

Traits	Plant height (cm)	Number of branches /plant	Number of days to flowering	Pod length (cm)	Number of seeds/pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)
F_3 (summer 2017)								
Bronco × Giza 6								
BSH%	84.4	91.7	87.7	47.6	49.9	76.6	79.6	76.8
GA	6.7	0.8	11.1	1.0	2.1	9.5	8.1	6.0
GAM%	15.7	23.5	24.0	9.3	33.6	22.7	35.4	30.5
Bronco × Nebraska								
BSH%	83.0	90.6	90.8	61.3	55.5	78.5	81.0	74.2
GA	6.8	0.8	16.5	1.2	2.1	7.7	8.5	5.9
GAM%	14.7	22.5	44.1	11.5	40.2	21.2	38.8	32.5
Bronco × Diacol								
BSH%	85.2	91.0	91.1	53.5	48.1	80.0	82.6	73.8
GA	6.7	0.8	11.8	1.1	1.9	7.4	8.3	5.8
GAM%	15.8	22.6	26.6	10.8	34.3	20.8	35.6	30.0
F_4 (fall 2017)								
Bronco × Giza 6								
BSH%	85.8	91.5	87.7	54.5	55.9	77.6	79.0	74.7
GA	7.7	0.9	10.2	1.5	2.7	9.0	6.9	5.5
GAM%	18.5	26.0	23.1	13.3	41.0	19.8	27.4	27.2
Bronco × Nebraska								
BSH%	86.3	87.6	91.0	53.2	52.9	78.9	82.6	75.6
GA	7.9	0.6	16.0	1.3	2.4	7.2	7.2	5.6
GAM%	17.9	17.2	43.1	12.2	42.9	18.0	28.7	27.9
Bronco × Diacol								
BSH%	85.5	89.7	90.9	49.7	53.1	79.4	81.1	76.2
GA	8.6	0.7	10.8	1.2	2.4	7.3	7.1	5.7
GAM%	18.6	19.2	24.7	11.6	41.8	19.8	27.3	27.2

Table 6. Cont.

Traits	Plant height (cm)	Number of branches/ plant	Number of days to flowering	Pod length (cm)	Number of seeds/ pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)
F_5 (summer 2018)								
Bronco × Giza 6								
BSH%	86.4	96.6	87.8	54.1	52.5	76.1	78.0	76.4
GA	9.5	1.3	13.5	1.5	2.9	7.7	5.6	4.9
GAM%	21.3	37.4	33.1	13.2	43.5	14.9	20.3	22.1
Bronco × Nebraska								
BSH%	87.4	96.2	90.6	47.3	51.2	79.6	80.9	74.0
GA	9.5	1.3	17.5	1.3	2.7	6.8	5.9	5.0
GAM%	21.4	37.4	48.5	11.1	46.2	16.4	20.9	21.9
Bronco × Diacol								
BSH%	86.2	97.1	91.3	48.8	51.7	79.0	81.1	75.8
GA	9.5	1.3	12.8	1.3	2.7	6.8	6.2	5.6
GAM%	21.3	36.5	30.1	11.1	45.4	17.4	21.5	23.4
F_6 (fall 2018)								
Bronco × Giza 6								
BSH%	87.3	94.9	89.6	56.0	56.1	81.8	78.7	74.9
GA	10.5	0.7	14.7	1.9	3.1	8.7	5.6	5.8
GAM%	23.7	21.2	37.6	14.7	46.3	15.8	18.8	22.6
Bronco × Nebraska								
BSH%	87.8	96.4	89.9	46.5	50.4	80.5	80.6	75.1
GA	9.5	0.7	17.4	1.2	2.7	7.1	5.7	5.7
GAM%	20.4	21.4	48.7	10.1	45.4	15.9	19.1	22.4
Bronco × Diacol								
BSH%	88.3	85.3	90.6	52.8	50.1	81.2	81.2	76.1
GA	9.4	0.3	12.9	1.3	2.7	7.1	6.3	6.2
GAM%	20.3	8.7	30.6	10.7	44.5	17.6	20.7	23.8

On the other hand, Mebrahtu and Elmi (1993) found that the heritability in broad sense was estimated as 64% for yield, 76% for plant height, 73% for number of pods/plant, and 92% for pod length. Ramalho *et al* (2005) estimated heritability as 46.3% for dry yield. Menezes *et al* (2011) estimated BSH for dry yield as 41.8%. The estimates of genetic advance (GA) were found to be in the range from 0.3% for number of branches/plant (Bronco × Diacol, F_6) to 17.5% for number of days to flowering (Bronco × Nebraska, F_5). Results showed that expected genetic advance were considered high for all traits, except both number of branches and pod length in the three populations for all generations. Expected genetic advance as a percentage of mean for seed yield per plant ranged between 22.4 and

23.8% for all populations in F_6 generation. High values of expected genetic advance were recorded for number of days to flowering, seed yield /plant, number of pods /plant and number of seeds/pod. These results are in agreement with those reported by Roy *et al* 2006, Nechifor *et al* 2011 and Andriani *et al* 2015.

Selected families (Promising lines)

The means F_6 and F_7 selected families, their parents and check cv. Nebraska for all studied traits of the three populations are presented in Table 7. For all populations, the family BG-7-286 was superior in all traits in both seasons followed by families BG-52-367, BG-94-478 and BN-8-123 in both seasons. Families BG-7-286 and BG-52-367 had the heaviest seed followed by BG-94-478 and BN-8-123 in a descending order. On the other hand, the families BG-7-286, BG-52-367, BG-94-478 and BN-8-had the tallest plant, however, the longest pod was produced by family BG-7-286 in the first season and family BN-8-123 in the second season followed by families BG-52-367, BG-94-478 BD=11-133 and BD-44-177 for both seasons. The highest number of seeds/pod were observed for the family BG-7-286 followed by BG-52-367 and BN-8-123. For number of days to flowering the families BG-7-286, BG-94-478 and BN-8-123 were the earliest in had flowering. The highest for number of branches/plant was shown by the families BG-7-286 and BD-44-177 in both seasons. The families BG-7-286 and BN-8-123 had the highest number of pods /plant followed by BG-52-367 and BG-94-478. The families BG-7-286, BN-8-123 possessed the highest seed yield /plant and seed yield/feddan followed by the families BG-52-367 and BG-94-478. These data showed that pedigree selection as a breeding method would be effective for improving yield in dry bean.

CONCLUSION

According to data obtained, we can conclude that the pedigree selection as a breeding method is effective for improving yield and its components in dry bean. Also, from this selection program, we found that the families BG-7-286 and BN-8-123 possessed the highest dry seed yield /plant and dry seed yield/feddan followed by the families BG-52-367 and BG-94-478 and we recommend using them as promising strains .

Table 7. Means of the nine promising selected lines and their parents at both F6 and F7 generations for eight traits.

Cross	Promising lines	Plant height (cm)	Number of branches /plant	Number of days to flowering	Pod length (cm)	Number of seeds/ pod	100-seed weight (g)	Number of pods/ plant	Seed yield/ plant (g)	seed yield/ fed. (ton)
F_6 (Fall 2018)										
Bronco × Giza 6	BG-7-286	55.3 a	3.9ab	34.2 h	12.8 a	7.5 a	55.1 a	31.9a	23.40a	1.8a
	BG-52-367	48.9 bc	3.1bc	40.5 d	12.0 abc	6.7 bc	55.4 a	27.3bcd	22.9ab	1.6 bc
	BG-94-478	49.0 bc	3.1c	35.5 gh	12.7 ab	5.7 de	53.0 b	28.1bc	22.7abc	1.6 bc
Bronco × Nebraska	BN-8-123	50.5 b	3.7abc	34.0 h	12.8 ab	6.8 bc	51.1 c	31.0 a	22.8 abc	1.7 ab
	BN-11-398	43.3 e	3.5abc	36.5 fg	11.7 a-d	5.6 de	46.4 d	25.0 d	17.4 fg	1.2 ef
	BN-68-227	44.2 de	3.2bc	38.5 e	11.3 cd	5.1 e	34.8 h	27.0 bcd	19.0 def	1.3 de
Bronco × Diacol	BD=11-133	44.1 de	3.5abc	37.8 ef	12.2 abc	6.3 cd	41.1 f	25.0 d	18.0 efg	1.1 efg
	BD-44-177	46.5 cd	3.9a	41.3 d	12.3 abc	6.2 cd	40.2 fg	28.5 b	20.6 cd	1.4 cd
	BD-63-212	46.5 cd	3.8ab	40.9 d	11.6 bcd	5.6 de	38.9 g	25.7 cd	17.9 efg	1.0 fg
Parents	Bronco	43.9 de	3.5abc	51.6 a	12.3 abc	7.4 ab	27.8 i	26.9 bcd	17.9 efg	1.0 g
	Giza 6	46.3 cde	3.6abc	43.3 c	11.6 bcd	5.9 d	43.6 e	25.8 cd	19.9 de	1.0 fg
	Nebraska	46.2 cde	3.6abc	40.6 d	11.7 a-d	5.6 de	45.8 d	27.9 bc	20.7 bcd	1.0 fg
	Diacol	38.2 f	3.6abc	47.0 b	10.7 d	3.3 f	50.9 c	19.7 e	15.8 g	0.8 h
F_7 (Summer 2019)										
Bronco × Giza 6	BG-7-286	57.0 a	3. a	33.7 h	12.7 abc	7.2 a	56.0 a	32.8 a	23.7 a	1.8 a
	BG-52-367	48.0 cd	3.6a	40.3 def	12.7 abc	6.7 ab	55.7 a	30.3 bc	21.3 bc	1.6 b
	BG-94-478	46.3 cde	3.4ab	36.0 g	12.9 ab	6.3 bcd	55.0 a	32.0 ab	22.3 ab	1.6 b
Bronco × Nebraska	BN-8-123	52.3 b	3.8a	34.9 gh	13.1 a	6.7 ab	53.7 b	32.0 ab	23.7 a	1.8 a
	BN-11-398	45.7 cde	3.4ab	39.0 f	11.5 de	5.4 ef	45.4 e	26.3 ef	18.0 ef	1.1 e
	BN-68-227	45.7 cde	3.1b	39.9ef	11.2def	5.3f	34.9h	27.5 de	19.0 de	1.3 d
Bronco × Diacol	BD=11-133	45.3 de	3.4ab	39.5f	12.2a-d	6.1cd	40.6f	26.0 ef	17.0 fg	1.1 e
	BD-44-177	48.3 c	3.8a	42.2cd	12.0bcd	6.0 d	40.7f	28.9 cd	20.3 cd	1.4 c
	BD-63-212	46.8 cde	3.4ab	41.9cd	11.8cde	5.3 f	39.2g	25.3 f	16.0 g	0.9 f
Parents	Bronco	45.0 e	3.7a	50.9a	11.5de	6.7 a-c	28.2 i	25.7 ef	17.0 fg	0.9 f
	Giza 6	45.7 cde	3.5ab	43.7c	10.9ef	6.1 d	44.7 e	25.8 ef	19.0 de	1.0 ef
	Nebraska	47.7 cde	3.7a	41.5de	10.9ef	5.9 de	48.0 d	27.2 e	20.3 cd	1.0 ef
	Diacol	40.3 f	3.4ab	47.4b	10.3f	3.8 g	50.9 c	20.3 g	13.7 h	0.9 f

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level, probability.

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استنباط سلالات جديدة من الفاصوليا الجافة باستخدام الانتخاب بالنسب

رافت محمد جلال

قسم البساتين (خضر)- كلية الزراعة - جامعة بنى سويف

أجريت هذه التجربه بمحطة بحوث البساتين بسدس بمحافظة بنى سويف التابعة لمركز البحوث الزراعية- مصر خلال الفتره من ٢٠١٥ إلى ٢٠١٨ لإستنباط بعض السلالات الجديده المبشره من الفاصوليا الجافه مع دراسة التباين الوراثى وكفاءة التوريث لبعض الصفات الإقتصاديه .تم إستنباط تسعة سلالات جديده من الفاصوليا الجافه فى الجيل الانعزالى السادس والسابع عن طريق الإنتخاب بالنسب بداية بالتهجين بين الصنف برونكو وثلاثة اباء هى جيزة ٦ ونبراسكا ودياكول (برونكو × جيزه ٦، برونكو × نبراسكا، برونكو × دياكول) ثم الانتخاب فى الاجيال الانعزالية الثانى حتى السابع . فى الموسم النيلى ٢٠١٨ والموسم الصيفى ٢٠١٩ تم تقييم السلالات الجديده مع الاباء والصنفين التجارى نبراسكا لعدد من الصفات الإقتصاديه وهى إرتفاع النبات وعدد الفروع على النبات وعدد الايام حتى التزهير، وطول القرن، وعدد البذور بالقرن، ووزن ١٠٠ بذره، وعدد القرون

على النبات ، ووزن البذورعلى النبات. كفاءة التوريث بمعناها العام كانت عاليه الى متوسطة لكل الصفات المدروسه مما يؤكد أنه يمكن إستنباط سلالات جديده من الفاصوليا الجافه عن طريق الإنتخاب لتلك الصفات إعتمادا على التباين المظهرى فى الأجيال الإنعزاليه المبكره. من النتائج يمكن التاكيد على أن السلالتين المنتخبتين BG-7-286 و BN-8-123 سلالتان مبشرتان ويمكن تسجيلهما كصنفين جديدين من الفاصوليا الجافه لتجانسها العالى ومحصولها المرتفع وصفات الجوده الجيده ويليهما السلالتان BG-52-367 وBG-94-478 وهما سلالتان جيدتان ايضا من ناحية التبكير والمحصول.

المجلة المصرية لتربية النبات ٢٣(٧): ١٣٩١ـ ١٤١٥ (٢٠١٩)