Egypt. J. Plant Breed. 21(2):339 – 361 (2017)

BREEDING FOR RUST RESISTANCE AND SOME ECONOMIC CHARACTERS IN SNAP BEAN

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ABSTRACT

This study was conducted to improve some new promising snap bean (Phaseolus vulgaris L.) lines by selection for some economic characters and rust [Uromyces appendiculatus (Pers.) Unger] resistance. Two F_3 populations of snap bean (Concessa x Paulista and Concessa x Samantha) were used in this study as the main genetic material in addition to check cultivars (Concessa, Paulista and Samantha). Results showed that all studied trait means improved by selection. Thirty selected lines and three commercial cultivars were evaluated for rust reaction and some economic characters during two successive autumn seasons (2014 and 2015). Twenty three lines showed absolute resistance against rust in both seasons. Seven breeding lines showed variable severity (3.0-60.0%) over the two years of investigation, being more pronounced in 2015. The genotype FA 1-3 was categorized as highly resistant (hypersensitive). While, Paulista and Samantha cultivars were rated as susceptible (30.00-58.33%). It could be concluded that susceptibility of lines and climatic conditions may be primary factors in disease widespread. Epidemiological work carried out during study years revealed an intense disease severity during the sixth week after planting, though the infection was apparently taking place during the fifth week. The disease severity in second season was greater than in the first one and this was attributed to the favorable infection conditions. The lower dew point coincides with the fifth week after planting, however, it seems probable that atmospheric humidity does not influence directly the primary infection, but it may influence the progress of the pustule as related to the genetic composition of given genotypes. Estimated coefficient of variance (CV%) values indicated that most of the new selected lines had enough homogeneity in most studied characters as compared with the check cultivars. The large portion of phenotypic variance (σ^2_p) was due to the genetic variance (σ^2_g). Also, estimated broad-sense heritability showed high values (64% to 97%) in all traits, except pod weight trait, indicating that the observed significant phenotypic differences among the studied genotypes are of genetic nature and there are small environmental effects on the phenotypic variation. Therefore, yield and pod quality as well as rust resistance traits can be improved through selection based on phenotypic observations in snap bean. The promising selected lines of snap bean FA 1-16, FA 2-6, FA 2-13, FA 2-14, FA 2-15 and FA 2-17 could be considered for certification (after more evaluation). They had homogeneity, pod quality and resistant to rust disease.

Key words: ***Phaseolus vulgaris, Snap bean, Uromyces appendiculatus, Dew point, Rust resistance, Selection, Heritability.***

INTRODUCTION

Snap bean, *Phaseolus vulgaris* L., is considered one of the most important vegetable crops in Egypt for local market and export. Snap bean give a high income for farmers and the crop period is short, therefore, the same area can be cultivated more than two crops a year, as well as the lack of pest problems and pesticides. Snap beans also need high number of workers, so, it is a good source of agricultural employment in Egypt.

Common bean rust, caused by *Uromyces appendiculatus* (Pers.) Unger, is a destructive disease for dry and snap beans worldwide and is a particularly endemic and severe disease in eastern and southern Africa (Kimani *et al* 2002). Yield loss attributed to bean rust ranges from 18 to 100% and damage is particularly high in humid and tropical areas, where severe epidemics are frequent (Stavely and Pastor-Corrales 1989). Rust management methods used by farmers include cultural practices especially sanitation, intercropping, fungicides and tolerant varieties. Use of resistant varieties is regarded as the most effective and economically viable strategy for rust management. Control of this disease by using resistant cultivars has becomes necessary to the present day agricultural technology. Resistant and tolerant cultivars to bean rust are recommended as the most cost–effective management method. Identification of resistant or tolerant varieties needed a suitable and precise screening method against rust pathogens (Ariyarathne and Pradeep Nuwan 2001). Mutunga *et al* (2002) and Hamed *et al* (2012) found that immune type of resistance being dominant to the resistance type. Hamed *et al* (2012) evaluated thirty snap bean genotypes for rust reaction and found that two genotypes were rated as immune to this disease; eight other genotypes were categorized as highly resistant (hypersensitive) and four genotypes were resistant, however, the remaining 16 genotypes were rated as susceptible. Also, El-Awady and Hamed (2015) evaluated 22 snap bean genotypes for rust reaction and found that 4 genotypes were rated as immune to this disease; 4 other genotypes were categorized as highly resistant (hypersensitive) and only one genotype was resistant, however, the remaining 13 genotypes were rated as susceptible.

Favorable conditions for rust onset are temperatures ranging from 17°C to 25°C, high relative humidity (RH) (>95%) for at least 7 to 8 hours (dew formation is critical for infection), interspersed with dryer periods that favor dispersal (Mendes and Bergamin Filho 1989). Local adaptation and genotypes from different climatic regions may exhibit different environmental reaction. Temperature changes of only 5°C to 6°C for 4 to 8 hours can, significantly, influence the epidemiology of the disease (Schein 1961). Optimum temperatures for pathogen germination range from 12°C to 17°C (Harter *et al* 1935), 10°C to 25°C (Naito 1951), 12.5°C to 18°C (Shands and Schein 1962), 15°C to 24°C (Bell and Daly 1962) and 17.5°C to 22.5°C (Imhoff *et al* 1981). Germination decreased rapidly and germ tubes were shorter above and below the temperatures reported by Harter *et al* (1935). No germination occurred at very low temperatures (below 1.8°C to 4°C) or at high temperatures (above 27.5°C to 35°C) as reported by Imhoff *et al* (1981). Imhoff *et al* (1982) found that sporulation from previously active pustules ceased altogether within 3 days when plants were transferred to 27°C.

Humidity and leaf surface moisture plays a key role in both germination and infection. Hydration of urediniospores was found to increase germination and shorten the germination time (Curtis 1966). Harter *et al* (1935) reported that within appropriate temperature ranges, high levels of infection obtained when plants were exposed to a RH of 96% or higher, also, provided free moisture was present on leaves. Imhoff *et al* (1982) observed that a greater percentage of pustules erupted under humid conditions and more spores were produced by pustules exposed to humid conditions than those exposed to low RH. Moreover, Harter *et al* (1935) found that at least 8-hour exposure was a prerequisite for infection by uredinospores, with an increase in the number of infections taking place after a 10-hour exposure, and an optimum of between 12 to 18 hours. Mendes and Bergamin Filho (1989) reported that a minimum of 4 hours of high humidity necessary for the development of pustules, and attained maximum infection (measured as the number of sporulating pustules per leaf) after 22 hours. Exposure to periods of more than 48 hours of high humidity resulted in lower levels of infection, apparently due to deterioration in the vigor of the host (Harter *et al* 1935).

Rapid population growth as well as the increasing of snap bean exported quantities in Egypt forced researchers to step up their research efforts on snap bean to maximize yield, yield quality and disorders resistance as well as increase surplus for exportation. Recently, there are intensive efforts for improvement snap bean productivity in Egypt through breeding procedures depending mainly on the presence of genetic differences that permits effective selection. Many researchers used selection to obtain new yielding lines of common beans with high pod quality (Bertoldo *et al* 2010, Menezes *et al* 2011 and Nosser 2011). Costa *et al* (2010) selected four homozygous lines had statistically equal or higher yields than chick varieties and resistant to two races of *U. appendiculatus*. Also, Wasonga *et al* (2010) indicated the possibility of selecting homogenous new snap bean lines with high yield and rust resistance. Hamed (2012) indicated that the pedigree selection as a breeding method is effective for improving yield and its components in dry bean.

In plant breeding, the estimation of variance components and broad sense heritability (BSH) are very important in genetic analysis of quantitative traits. Salib (2006) found moderate estimates of BSH for plant height and high values for number of days to flowering, green pod yield/plant and pod length characters. Broad sense heritability estimates were 62.01%-93.07% for plant height, 30.64%-86.30% for number of days to flowering, 43.16%-65.66% for green yield, 43.77%-78.28% for pod weight and 55.04%-71.67% for pod length (Hamed and Khalil 2010). Nosser (2011) on snap bean observed slight differences between phenotypic (P.C.V) and genotypic (G.C.V) coefficient of variance in the traits plant height, pod weight, pod length, pod diameter and total green yield. Also, he found moderate to high heritability for all these traits (up 63%), indicating the importance of the genetic effect in controlling the inheritance of these traits. Hamed (2012) found that large portion of phenotypic variance (σ^2p) was due to the genetic variance (σ^2g). Furthermore, estimated BSH showed high values (73.70% to 97.78%) in plant height, number of days to flowering, pod length and dry yield traits, indicating that the observed significant phenotypic differences among the studied genotypes are of genetic nature and there are small environmental effects on the phenotypic variation. Therefore, these characters can be improved through selection based on phenotypic observations in early segregating generations.

Thus, the objective of the present investigation was to develop and evaluate some new promising snap bean lines and select the best one to be used as a new cultivar with high yielding, high quality and resistance to rust disease in relation to prevailing environmental conditions in Egypt.

MATERIALS AND METHODS

This study was conducted during the period from 2012 to 2015 at Kaha Vegetable Research Farm, Kaliobia Governorate, ARC, Egypt. Two F_3 populations of snap bean, Phaseolus vulgaris L., produced by Hamed *et al* (2012) were used as the main genetic material of study. The first population was obtained from the cross Concessa × Paulista and the second population was obtained from the cross Concessa × Samantha in addition to three check cultivars Concessa, Paulista and Samantha.

In autumn season of 2012, about 1500 plants from each F_3 population (Base) and the three check cultivars were grown for evaluation and selection. The experiment was conducted in a randomized complete block design (RCBD) with three replications. Each replication consisted of 15 rows for each F_3 population and two rows for each check cultivar. The selection was performed in the two F_3 populations for different characters, *viz.*, earliness, high number of pods/plant, suitable pod diameter, tall pods and rust tolerance. Selection intensity was 10% for each of the two studied populations. Also, an equal number of seeds composited from plants of each F3 population to produce F_4 bulk seeds.

During summer season of 2013, the two check cultivars and 150 selected plants from each F_3 population were grown and evaluated for their F_4 families in addition to F_4 bulk populations and the three check cultivars. The experiment was conducted in a randomized complete block design (RCBD) with three replications and all entries were grown in a single row. Fifteen plants were selected from each F_4 population. Also, an equal number of seeds composited from each F_4 population to give F_5 bulk seeds. In autumn season of 2013, 15 F_5 selected families of the two populations and bulk seeds in addition to the three check cultivars were grown with three replications in a randomized complete block design for evaluation. In the three seasons, sowing dates were on the first week of September for the autumn seasons and the first week of March for the summer season. Individual plants were planted in 3.0 meter rows. Each row included 30 plants spaced 10 cm apart within rows. Rows were spaced 75 cm apart in plots.

Data were recorded from the 10 most healthy, vigorous and guarded plants from each family in F_3, F_4 and F_5 generations. The means of the ten plants were subjected to the statistical and genetic analyses for the following characters: number of days to flowering, pod length (cm), pod diameter (mm) and number of pods/plant in addition to rust resistance. The genetic parameters were estimated in F_3, F_4 and F_5 generations.

Selection continued until pure lines were established. After that in the summer season of 2014, Seeds of the selected lines were grown to produce the F6 generation. Thirty inbred lines of snap bean selected from the two studied crosses using pedigree selection. In the autumn seasons of 2014 and 2015, the 30 selected lines (in F_6 generation) were grown with the commercial cultivars (Concessa, Paulista and Samantha) as checks as shown in Table (1) and the combined data across the two seasons were calculated. Seeds of the thirty three genotypes (thirty selected lines and three commercial cultivars) were cultivated on September 6 and 9 in 2014 and 2015, respectively. A randomized complete block design with three replicates was used in this study. In the two seasons, each plot consisted of two rows, each row was 0.70 m wide and 3.0 m long and the plants were spaced at 7 cm apart. The recommended agricultural practices were done but without using fungicides.

Data were taken and recorded on the studied characters and the mean of each genotype was used in the statistical analysis. The coefficient of variance (CV%) was estimated for all grown genotypes among individual plants concerning some important characters, i.e., plant height, pod length, pod diameter and pod weight to determine the degree of homogeneity for each genotype (line). The studied characters in the evaluation experiment were plant height (cm), number of days to flowering, total green yield per feddan (kg), pod weight (g), pod length (cm), pod diameter (mm) and rust [*Uromyces appendiculatus* (Pers.) Unger] reaction.

Disease severity assessment was determined based on detection of the first visible symptoms in both 2014 and 2015 seasons, that coincides with disease severity assessment was made at the fifth week of planting date. Infection types of bean rust were evaluated after the fungus had fully established under natural field conditions (after the fifth week of planting date) by using the 1-6 scale described by Stavely *et al* (1989).

Table 1. Pedigree of the studied snap bean genotypes.

Entry	Pedigree	From	Origin	Entry	Pedigree	From	Origin
FA 1-2	F_6 38/1-1-2	Con^z × ^{y}Paul	Egypt	FA 2-2	F_6 39/6-1-2	Con × ^{x}Sam	Egypt
FA 1-3	F_6 38/1-1-3	Con × Paul	Egypt	FA 2-3	F_6 39/6-1-3	Con × Sam	Egypt
FA 1-4	F_6 38/1-1-4	Con × Paul	Egypt	FA 2-6	F_6 39/6-2	Con × Sam	Egypt
FA 1-5	F_6 38/1-1-5	Con × Paul	Egypt	FA 2-7	F_6 39/6-2-1	Con × Sam	Egypt
FA 1-12	F_6 38/1-12	Con × Paul	Egypt	FA 2-8	F_6 39/6-2-2	Con × Sam	Egypt
FA 1-14	F_6 38/6-4-4	Con × Paul	Egypt	FA 2-9	F_6 39/6-2-3	Con × Sam	Egypt
FA 1-15	F_6 38/6-5-1	Con × Paul	Egypt	FA 2-13	F_6 39/6-3-1	Con × Sam	Egypt
FA 1-16	F_6 38/6-5-2	Con × Paul	Egypt	FA 2-14	F_6 39/6-3-2	Con × Sam	Egypt
FA 1-19	F_6 38/6-5-3	Con × Paul	Egypt	FA 2-15	F_6 39/6-4-2	Con × Sam	Egypt
FA 1-24	F_6 38/6-5-4	Con × Paul	Egypt	FA 2-17	F_6 39/6-4-3	Con × Sam	Egypt
FA 1-25	F_6 38/6-5-5	Con × Paul	Egypt	FA 2-22	F_6 39/6-6-1	Con × Sam	Egypt
FA 1-34	F_6 38/40-5	Con × Paul	Egypt	FA 2-23	F_6 39/6-6-2	Con × Sam	Egypt
FA 1-37	F_6 38/44-4	Con × Paul	Egypt	FA 2-26	F_6 39/6-6-3	Con × Sam	Egypt
FA 1-41	F_6 38/47-4-2	Con × Paul	Egypt	FA 2-33	F_6 39/6-6-4	Con × Sam	Egypt
FA 1-42	F_6 38/47-4-3	Con × Paul	Egypt	FA 2-35	F_6 39/7-1	Con × Sam	Egypt
Concessa	(Check)	Harris Moran Co.	U.S.A.				
Paulista	(Check)	Royal Sluis Co.	Netherlands				
Samantha	(Check)	Seminis Co.	U.S.A.				

^{Z}Con: Concessa, ^{y}Paul: Paulista and ^{x}Sam: Samantha.

Infection grading 1, 2 and 3 were considered incompatible (resistant) and 4, 5 and 6 were considered compatible (susceptible) as shown in Table (2) and Fig. 1. Thirty leaves/plot were taken to estimate disease severity of each particular genotype representing the amount of area diseased. The percentage of infection was determined on the lower surface of leaf.

The percentage of infection for each particular genotype was calculated by using the following formula:

$$\text{D.I.} = \frac{\text{Sum of } (n \times v)}{6\,N} \times 100$$

Where: D.I. = Disease index, n = Number of leaflets in each category, v = Numerical value of each category and N = Total number of leaflets in sample.

Table 2. Disease scale used for evaluation of snap bean genotypes for rust reaction.

Rating score	Description	Reaction to disease	
1	No rust symptoms	Immune	Incompatible
2	Necrotic spots without sporulation	Highly resistant (hypersensitive)	"
3	Pustules < 300 µm in diameter	Resistant	"
4	Pustules 300-500 µm in diameter	Susceptible	Compatible
5	Pustules 500-800 µm in diameter	Moderately susceptible	"
6	Pustules > 800 µm in diameter	Highly susceptible	"

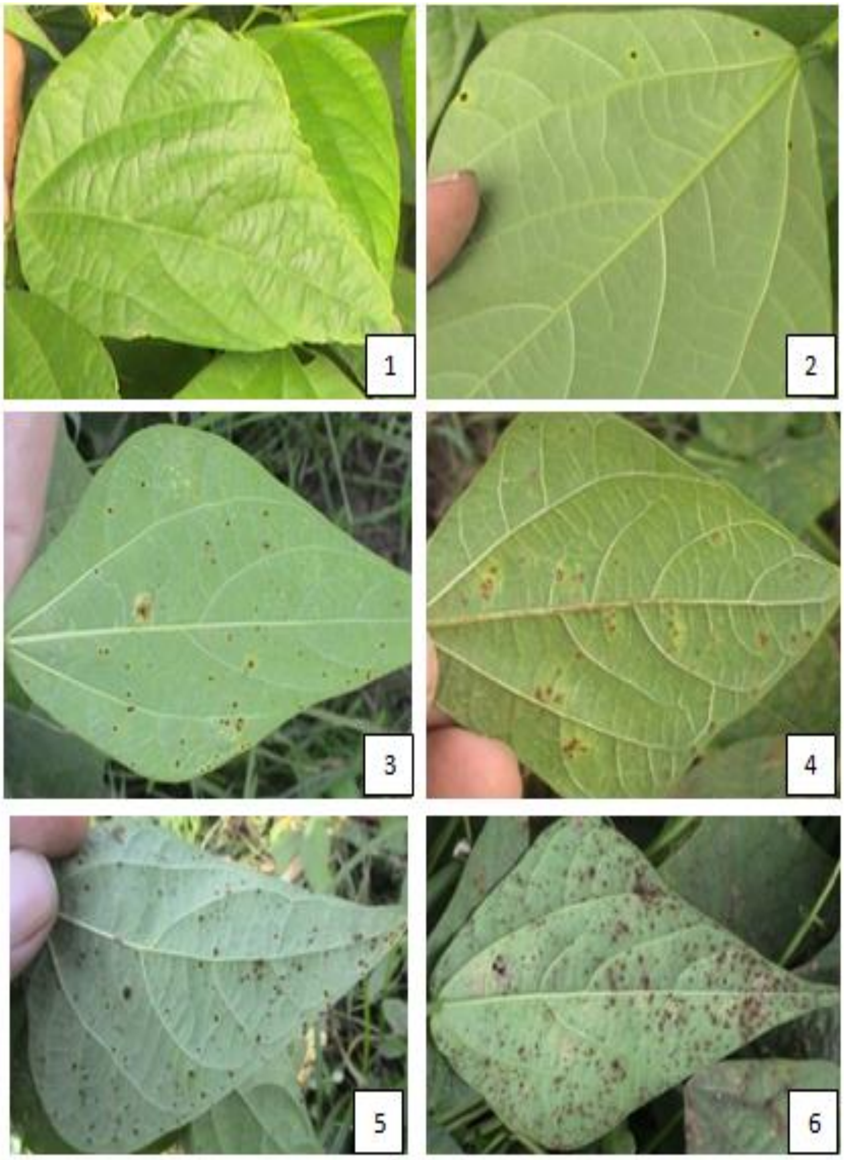

Fig. 1. Disease scale used for evaluation of snap bean genotypes for rust reaction (1= immune, 2= highly resistant, 3= resistant, 4= susceptible, 5=moderately susceptible, and 6= highly susceptible).

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Weekly temperatures (^oC), relative humidity (%) and dew point temperature at the experimental site during period of study (September and October in both 2014 and 2015 seasons) were kindly provided by the Central Laboratory for Agricultural Climat (CLAC), Ministry of Agriculture and Land Reclamation, Egypt as shown in Table (3) and Fig. 2.

Table 3. Average weekly climate records at Kaliobia Governorate in 2014 and 2015.

Months	Weeks	2014			2015		
		Average temp. (^oC)	Average hum. (%)	Average dew point	Average temp. (^oC)	Average hum. (%)	Average dew point
September*	1st	٢٨,٢٩	٥٢,٤٣	١٤,٦٠	٢٨,٣٧	٥٣,٠٠	١٥,١٦
	2nd	٢٧,٢٩	٥٥,٤٣	١٥,٣٧	٣٠,٠٠	٦١,٤٣	١٧,٢١
	3rd	٢٧,١٩	٥٣,٨٦	١٤,٠٩	٢٩,١٠	٤٦,١٤	١٥,٢٩
	4th	٢٧,٦٩	٥٢,٤٣	١٤,٧٧	٢٩,٢٧	٤٤,٠٠	١٤,٨٦
October**	1st	٢٣,٧٤	٥٢,٤٣	١٢,٤٧	٢٦,٨١	٥٦,٧١	١٦,٨٠
	2nd	٢٤,٢١	٦٠,٤٣	١٤,٤٩	٢٥,٤٠	٥٨,٧١	١٥,٧٩
	3rd	٢٣,٤١	٦٠,٢٩	١٣,٠٦	٢٥,١٧	٦٢,٠٠	١٦,١٤
	4th	٢٢,٨٠	٥٢,٢٩	٧,٦٤	٢٥,٢٣	٥٦,٥٧	١٤,٢٤
	5th	٢١,٣٨	٦٣,٠٠	١٢,٠٢	٢٠,٨٨	٥٩,٨	١١,٩٨
Average		٢٥,١١	٥٥,٨٤	١٣,١٧	٢٦,٦٩	٥٥,٣٧	١٥,٢٧

The start of planting (*) that coincide with onset of infection (**)

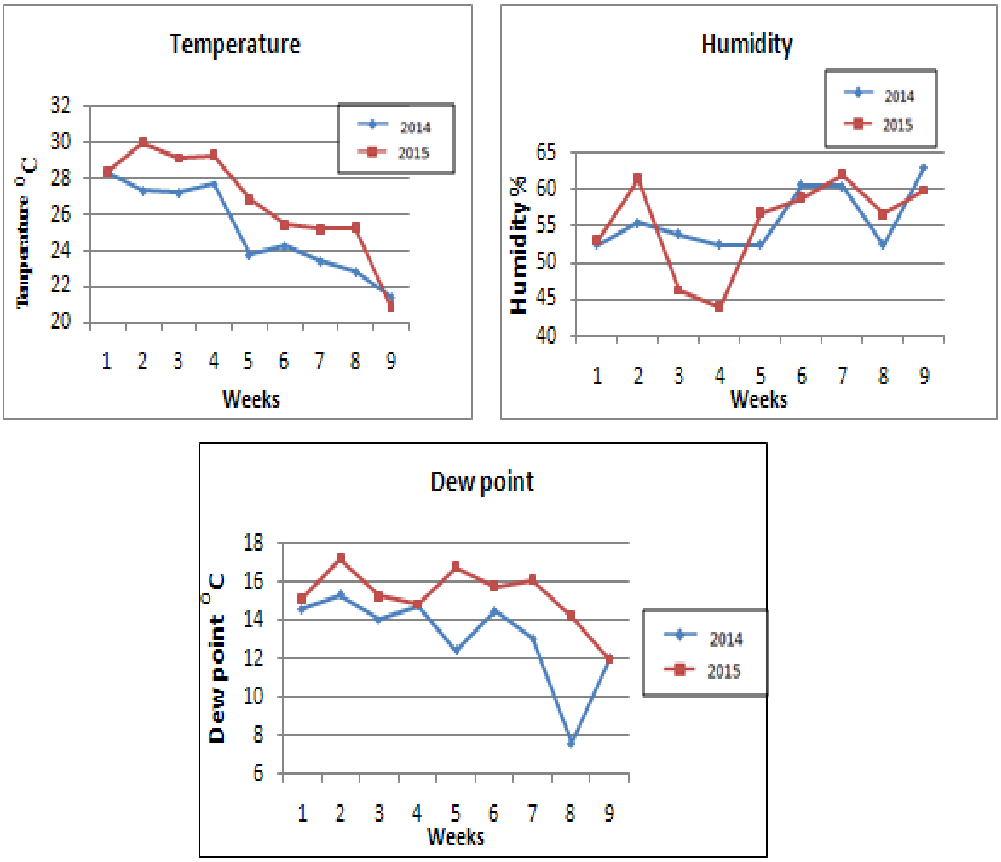

Fig. 2. Average weekly temperature, humidity and dew point during study period in two seasons 2014 and 2015.

Realized response to selection was expressed as percent change in the population mean relative to bulk population and two check cultivars (Falconer 1989). Disease severity data were transformed before statistical analysis using angular transformation method. An analysis of variance (ANOVA) for all characters was carried out to determine the significant differences between evaluated genotypes and mean comparisons were based on the LSD test. Also, the Bartlett's test of the variance of error for genotypes in both seasons (2014 and 2015) was homogeneous for all traits. So, the combined analysis of variance for the two seasons was computed for all traits according to Snedecor and Cochran (1989). Coefficient of variance, Genotypic and phenotypic coefficients of variation and broad sense heritability were estimated according to Singh and Chaudhary (1995).

RESULTS AND DISCUSSION

1- Selection experiment

Number of days to flowering, number of pods per plant, pod length and pod diameter mean values of the base population (F_3) and selected families in F_4 and F_5 generations of the two studied hybrid populations (Concessa x Paulista and Concessa x Samantha) along with total bulked seeds as well as check cultivars (Concessa, Paulista and Samantha) grown during three consecutive seasons are presented in Table (4).

Table 4. Number of days to flowering, number of pods/plant, pod length (cm) and pod diameter (mm) for base, selected and bulk populations as well as parents of snap bean.

Generation	Population I			Population II			Concessa	Paulista	Samantha
	Base	Selected	Bulk	Base	Selected	Bulk			
Number of days to flowering									
F_3	42.67	--	--	43.67	--	--	48.00	44.33	48.67
F_4	--	46.33	47.67	--	45.67	47.00	48.33	46.33	48.33
F_5	--	45.67	45.33	--	45.00	46.33	49.67	47.00	48.67
Number of pods/plant									
F_3	16.83	--	--	17.83	--	--	11.65	17.13	12.40
F_4	--	20.67	15.77	--	20.00	16.37	12.03	16.10	12.10
F_5	--	21.23	16.67	--	22.03	17.23	11.63	15.50	12.67
Pod length (cm)									
F_3	12.28	--	--	12.25	--	--	12.23	12.00	13.37
F_4	--	13.27	12.20	--	14.18	12.72	12.23	12.13	12.93
F_5	--	13.23	12.27	--	14.23	12.47	11.97	12.20	13.13
Pod diameter (mm)									
F_3	7.60	--	--	7.10	--	--	8.37	8.30	6.37
F_4	--	7.03	7.37	--	6.77	7.27	8.20	8.03	6.40
F_5	--	7.10	7.53	--	6.80	7.27	8.30	8.10	6.47

Number of days to flowering

Grand mean values of selected populations in F_4 generation were increased compared with the previous generation (it may be because selection focused during this generation only on rust tolerance and pod quality) but it decreased in F_5 generation compared with the F_4 generation. In F_4 and F_5 generations, grand mean values of selected populations were decreased compared with the bulk seeds in the two populations, reflecting the effectiveness of pedigree selection method to improve this trait. In comparison with the check cultivars, the selected generations in the two populations were earlier than the check cultivars in all seasons. These results agree with those of Hamed (2012) who selected some of dry bean lines from single plants superior in earliness.

The actual selection response (Table 5) showed values of 3.66 and -0.66 days in the F_4 and F_5 generations, respectively, in the first population and 2.00 and -0.67 days in the F_4 and F_5 generations, respectively, in the second population. The realized gain as percentage of the mid parent was not significant in the F_4 generation in the two studied population, however, it was highly significant (-5.52% and –8.48%) in the first and second populations of the F_5 generation, respectively. It was significant in the F_4 generation only as percentage of the bulk population. Also, it was highly significant in the F_4 and F_5 generations as percentage of the check cultivar Samantha and in the F_5 generation of cultivar Paulista.

Number of pods per plant

Grand mean values of selected populations in F_4 and F_5 generations were increased compared with the previous generation and the bulk seeds in the two populations as a result of pedigree selection. In comparison with the check cultivars, the selected generations in the two populations surpassed that of check cultivars in all seasons. These results agree with the findings of Bertoldo *et al* (2010), Nosser (2011) and Hamed (2012) who indicated that simple selection method can be applied for number of pods per plant character in common bean.

The actual selection response (Table 5) showed values of 3.84 and 0.56 pods in the F_4 and F_5 generations, respectively, in the first population and 2.17 and 2.03 pods in the F_4 and F_5 generations, respectively, in the second population. The realized gain as percentage of the mid-parents was positive and ranged from 46.91% to 81.32% in the two populations. The realized gain as percentage of the bulk populations was positive and ranged from 22.17% to 31.07% in the two populations. Meanwhile, it ranged from 24.22% to 73.88% as percentage of the check cultivar Paulista and from 65.29% to 73.88% as percentage of the check cultivar Samantha.

Pod length:

Grand mean values of selected populations in F_4 and F_5 generations were increased compared with the previous generation and the bulk seeds in the two populations, reflecting the effectiveness of pedigree selection method to improve this trait (Table 4). In comparison with the check cultivars, the selected generations in the two populations possessed longer pods than check cultivars in all seasons. These results are in agreement with these reported by Bertoldo *et al* (2010), Nosser (2011) and Hamed (2012), who indicated that simple selection method can be applied for pod length trait in common bean.

The actual selection response (Table 5) showed values of 0.99 and -0.04 cm in the F_4 and F_5 generations, respectively, in the first population

Table 5. The actual and realized response to selection relative to mid-parents, bulk population and check cultivars (Paulista and Samantha) for some economic characters in two snap bean populations.

Items	Population I		Population II		Population I		Population II	
	F_4	F_5	F_4	F_5	F_4	F_5	F_4	F_5
	Number of days to flowering				Number of pods/plant			
Actual response	3.66	-0.66	2.00	-0.67	3.84	0.56	2.17	2.03
Realized response to selection (%) relative to:								
Mid-parents	-02.11	-05.52**	-05.50	-08.48**	46.91**	56.45**	65.70**	81.32**
Bulk population	-02.81*	00.75	-02.83*	-02.87	31.07*	27.35**	22.17*	27.86**
Paulista	00.00	-02.83	-01.42	-04.26**	28.39*	36.97**	24.22*	73.88**
Samantha	-04.14**	-06.16**	-05.50**	-07.54**	70.83**	67.56**	65.29**	73.88**
Items	Pod length (cm)				Pod diameter (mm)			
Actual response	0.99	-0.04	1.93	0.05	-057	0.07	0.33	0.03
Realized response to selection (%) relative to:								
Mid-parents	08.95**	09.43**	12.72**	13.39**	-13.42**	-13.41**	-7.26**	-7.98**
Bulk population	08.77**	07.82**	11.48**	14.11**	-04.61**	-05.71**	-06.88**	-06.46**
Paulista	09.40**	08.44	16.90**	16.64	-12.45**	-12.35**	-15.69**	-16.05**
Samantha	02.63*	00.76	09.67**	08.38**	09.89**	09.74**	05.78**	05.10*

and 1.93 and 0.05 cm in the F_4 and F_5 generations, respectively, in the second population. The realized gain as percentage of the mid-parents ranged from 8.95% to 13.39% in the two populations. The realized gain as percentage of the bulk populations ranged from 7.82% to 14.11% in the two populations. Meanwhile, it ranged from 8.44% to 16.90% as percentage of the check cultivar Paulista, but it ranged from 0.76% to 9.67% as percentage of the check cultivar Samantha.

Pod diameter

Grand mean values of selected populations in F_4 and F_5 generations were decreased compared with the previous generation and the bulk seeds in the two populations (except the F_5 in the two populations which were higher than its F_4). In comparison with the check cultivars, the selected generations in the two populations possessed lower pod diameter than cultivar Paulista but still had higher diameter than cultivar Samantha in all seasons. These results are in agreement with those reported by Nosser (2011), who indicated that simple selection method can be applied for pod thickness trait in snap bean.

The actual selection response (Table 5) showed values of -0.57 and 0.07 cm in the F_4 and F_5 generations, respectively, in the first population and 0.33 and 0.03 cm in the F_4 and F_5 generations, respectively, in the second population. The realized gain as percentage of the mid-parents ranged from -7.26% to -13.42% in the two populations. The realized gain as percentage of the bulk populations ranged from -4.61% to -6.88% in the two populations. Meanwhile, it ranged from -12.35% to -16.05% as percentage of the check cultivar Paulista, but it was positive and ranged from 5.10% to 9.89% as percentage of the check cultivar Samantha.

2- Evaluation experiment

Degree of homogeneity

Estimates of coefficient of variance (CV%) for plant height, number of days to flowering, pod weight, pod length and pod diameter characters for the thirty lines and three check cultivars evaluated at autumn season of 2015 are presented in Table (6).

In general, the degree of homogeneity differed among the studied genotypes in the same character. The data showed that most of the selected lines reflected low or close CV% values compared with those given by the three check cultivars, indicating high homogeneity for most studied traits of these lines. These results confirm those of Bertoldo *et al* (2010), Menezes *et al* (2011), Nosser (2011) and Hamed (2012) who indicated that it is possible to select new homogeneous common bean progenies using simple selection method.

Screening for rust reaction

Data obtained on the reaction of snap bean genotypes against rust disease under natural infection conditions in the 2014 and 2015 autumn seasons are presented in Table (7). In each season, significant differences in disease severity percentage were found among the evaluated genotypes.

Among 30 breeding lines evaluated, 23 lines showed absolute resistance against rust in both seasons 2014 and 2015 (Table 7). Seven breeding lines showed variable severity over the two years of investigation, being more pronounced in 2015. The genotype FA 1-3 was categorized as highly resistant (hypersensitive). While, Paulista and Samantha cultivars were rated as susceptible (30.00-58.33%). In this respect it could be concluded that susceptibility of lines and climatic conditions may be primary factors in disease widespread (Stavely *et al* 1989), however, the inoculum charge could not be ignored (Pivonia and Yang 2004), though discrepancy in this respect (Harter *et al* 1935).

These results indicate that the pedigree selection as a breeding method was effective for improving rust resistance trait. Also, these results are in agreement with Costa *et al* (2010) and Wasonga *et al* (2010), who indicated the possibility of selecting homogeneous new snap bean lines with high yield and rust resistance.

Table 6. Estimates of coefficient of variance (CV%) of the new selected snap bean lines and check cultivars (autumn season 2015).

Genotype	Plant height	No. days to flowering	Pod weight	Pod length	Pod diameter
FA 1-2	11.17	3.44	14.03	5.07	5.16
FA 1-3	6.84	5.56	19.78	7.18	4.66
FA 1-4	10.36	4.17	17.46	6.16	4.36
FA 1-5	9.75	3.55	9.72	4.76	6.32
FA 1-12	10.07	7.72	7.74	6.63	9.82
FA 1-14	14.13	2.14	16.34	5.74	8.28
FA 1-15	8.36	2.00	14.33	4.91	6.38
FA 1-16	10.18	5.48	14.56	7.13	6.94
FA 1-19	14.64	3.43	16.31	6.22	6.18
FA 1-24	17.24	3.36	11.98	7.37	9.04
FA 1-25	10.99	7.69	15.45	6.01	8.14
FA 1-34	17.48	7.42	12.12	8.22	2.58
FA 1-37	14.42	8.07	15.95	3.77	6.15
FA 1-41	11.18	2.46	16.78	10.11	8.94
FA 1-42	13.05	3.64	15.06	5.47	6.81
FA 2-2	14.47	4.84	11.78	6.68	6.02
FA 2-3	14.89	4.66	12.66	6.45	5.00
FA 2-6	11.67	5.15	5.88	6.54	7.66
FA 2-7	11.02	2.34	13.65	6.69	6.75
FA 2-8	14.99	5.85	15.38	7.93	9.06
FA 2-9	13.47	3.94	16.14	7.20	7.95
FA 2-13	11.11	5.55	13.78	5.46	6.97
FA 2-14	8.37	5.05	13.53	5.32	7.51
FA 2-15	7.24	3.66	13.35	6.32	7.40
FA 2-17	11.69	6.18	16.22	4.81	7.54
FA 2-22	10.62	7.05	11.80	7.69	6.59
FA 2-23	7.49	3.39	15.79	6.90	8.46
FA 2-26	9.77	4.30	14.95	7.10	9.00
FA 2-33	9.59	2.02	12.22	5.00	6.19
FA 2-35	6.85	3.90	12.53	9.59	8.68
Concessa	16.99	4.13	13.55	7.06	5.03
Paulista	18.44	5.37	16.18	9.07	6.33
Samantha	17.78	4.32	16.82	6.71	6.32

Table 7. Infection type and disease severity (%) of rust disease for snap bean genotypes evaluated under natural infection conditions in 2014 and 2015 autumn seasons.

Genotype	Infection type		Disease severity (%)			Genotype	Infection type		Disease severity (%)		
	2014	2015	2014	2015	Mean		2014	2015	2014	2015	Mean
FA 1-2	4	4	11.67	20.00	15.83	FA 2-2	1	1	0.00	0.00	0.00
FA 1-3	2	2	3.00	3.17	3.09	FA 2-3	1	1	0.00	0.00	0.00
FA 1-4	1	1	0.00	0.00	0.00	FA 2-6	1	1	0.00	0.00	0.00
FA 1-5	1	1	0.00	0.00	0.00	FA 2-7	1	1	0.00	0.00	0.00
FA 1-12	4	4	11.67	21.67	16.67	FA 2-8	1	1	0.00	0.00	0.00
FA 1-14	1	1	0.00	0.00	0.00	FA 2-9	1	1	0.00	0.00	0.00
FA 1-15	1	1	0.00	0.00	0.00	FA 2-13	1	1	0.00	0.00	0.00
FA 1-16	1	1	0.00	0.00	0.00	FA 2-14	1	1	0.00	0.00	0.00
FA 1-19	1	1	0.00	0.00	0.00	FA 2-15	1	1	0.00	0.00	0.00
FA 1-24	1	1	0.00	0.00	0.00	FA 2-17	1	1	0.00	0.00	0.00
FA 1-25	1	1	0.00	0.00	0.00	FA 2-22	1	1	0.00	0.00	0.00
FA 1-34	5	5	40	41.67	40.83	FA 2-23	1	1	0.00	0.00	0.00
FA 1-37	4	5	28.33	45.00	36.67	FA 2-26	1	1	0.00	0.00	0.00
FA 1-41	5	6	48.33	60.00	54.17	FA 2-33	1	1	0.00	0.00	0.00
FA 1-42	4	5	16.67	26.67	21.67	FA 2-35	1	1	0.00	0.00	0.00
Concessa	1	1	0.00	0.00	0.00						
Paulista	6	6	57.97	58.33	58.15						
Samantha	5	4	38.30	30.00	34.17						
LSD at 5%			3.60	3.26	2.96						

Climatic conditions and rust resistance

In Kaliobia Governorate, the average weekly temperatures, the relative humidity and the dew point during the course of study in the two seasons (2014 and 2015) were determined. In the first week of October 2014, the average temperature (23.74 ^{o}C), average humidity (52.43%) and average dew point (12.47 ^{o}C) were extrapolated along, with the average temperature (26.81 ^{o}C), average humidity (56.71 %) and average dew point (16.80 ^{o}C) were extrapolated in the same week of 2015. The average dew point in 2014 and 2015 were 14.77 and 14.86, respectively, in the fourth week of planting (Fig. 2). Evidently, the dew point affecting infection as a result of effect correlated with the wetness and water films on the surface of leaves. In this regard, Imhoff *et al* (1981) reported that the optimum temperature for uredospore infection is ranging between 17 ^{o}C and 22 ^{o}C, meanwhile, Mendes and Bergamin Filho (1989) indicated that the water films are of paramount importance for infection.

Moreover, Harter *et al* (1935) reported that rust development is favored by cool to moderate temperature with most conditions that result in prolonged periods of free water on the leaf surface for 10 hours. Repeating disease cycles may occur at 10-14 days intervals under favorable conditions.

The inoculum charge and alternating periods of high humidity and windiness at fairly cool temperatures are, therefore, important. Although wind accounts for dissemination over long distances were not considered in the present work, along with other agents, such as migratory birds, animals, insects, clothing, water, vehicles and implements their effects, which can also play a role in this regard. Nagarajan and Singh (1990) and Harter *et al* (1935) concluded that the occurrence of suitable climatic conditions was far more conducive for the development of an epidemic than the presence of large amounts of inoculum.

From the pathological point of view, the present work revealed that a lag period of several weeks being important for rust development. The dew temperature and its duration may be a primary factor related to rust development in regions with limited rain fall as in Kaliobia governorate. When wetness conditions are optimal, chances for infections in a field are usually higher during the night and early morning than daytime because relative humidity is higher and leaf wetness duration is longer in the night than in daytime (Ariyarathne and Pradeep Nuwan, 2001). Further investigations are needed to cover the points related to photoperiod and light intensity and their consequences on the progress of infections (Souza *et al* 2007).

Performance of the selected lines

Means of the evaluated selected lines and check cultivars in the 2014 and 2015 autumn plantings and combined analysis of both seasons are presented in Table (8). Significant differences were observed among the genotypes for all studied traits.

Combined analysis of both seasons showed significant differences for plant height character among the evaluated genotypes (Table 8). Plant height ranged from 22.08 cm to 43.57 cm. The maximum height value was recorded by the selected lines FA 1-5 and FA 2-14, while the shortest plants (22.08 cm) were found in the cultivar Samantha. By comparing the selected lines with the check cultivars, most of selected lines were taller than the three check cultivars with significant differences.

Significant differences were observed among the evaluated genotypes for number of days to flowering (Table 8). The recorded number of days to flowering ranged from 37.17 to 46.17 days for the line FA 1-34 and the cultivar Samantha, respectively. Compared with the check cultivars, most of the selected lines were significantly the earliest ones.

Data obtained on total green yield/feddan of snap bean genotypes evaluated in the 2014 and 2015 autumn plantings are presented in Table (8). Combined analysis of both seasons showed significant differences for this trait among the evaluated genotypes. Total green yield of the evaluated genotypes ranged from 2.715 to 5.147 ton/feddan.

Table 8. Mean performances of the evaluated selected lines of snap bean for some economic characters.

Characters / Genotypes	Plant height (cm)			No. days to flowering			Total green yield (ton/fed)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
FA 1-2	42.37	41.17	41.77	40.00	38.33	39.17	3.921	4.228	4.074
FA 1-3	42.07	41.50	41.78	41.67	38.33	40.00	2.758	3.278	3.018
FA 1-4	40.00	36.87	38.43	41.67	38.33	40.00	3.485	3.634	3.560
FA 1-5	44.80	42.33	43.57	42.00	40.00	41.00	3.475	3.571	3.523
FA 1-12	42.67	40.77	41.72	40.33	38.67	39.50	3.737	4.183	3.960
FA 1-14	36.97	35.33	36.15	45.67	43.33	44.50	2.879	3.300	3.090
FA 1-15	37.67	35.33	36.50	42.00	40.00	41.00	3.301	3.617	3.459
FA 1-16	36.67	36.33	36.50	41.67	38.00	39.83	4.803	4.937	4.870
FA 1-19	31.93	28.57	30.25	43.33	39.67	41.50	3.696	4.378	4.037
FA 1-24	31.67	29.67	30.67	42.00	38.67	40.33	3.637	3.835	3.736
FA 1-25	31.87	29.33	30.60	41.33	37.00	39.17	3.295	3.552	3.423
FA 1-34	26.80	24.67	25.73	39.00	35.33	37.17	2.437	2.993	2.715
FA 1-37	28.67	26.33	27.50	40.67	37.67	39.17	2.600	3.327	2.964
FA 1-41	38.87	37.00	37.93	41.00	38.00	39.50	2.852	3.387	3.119
FA 1-42	38.67	35.10	36.88	41.67	38.00	39.83	2.824	3.200	3.012
FA 2-2	34.10	32.33	33.22	41.33	38.67	40.00	3.821	4.246	4.033
FA 2-3	33.80	30.73	32.27	41.00	37.67	39.33	3.385	3.983	3.684
FA 2-6	35.67	35.07	35.37	41.67	38.00	39.83	4.287	4.442	4.364
FA 2-7	36.40	34.27	35.33	42.00	40.00	41.00	3.622	4.074	3.848
FA 2-8	31.67	29.33	30.50	41.33	37.67	39.50	3.306	3.645	3.475
FA 2-9	43.67	41.83	42.75	41.33	37.67	39.50	3.164	3.452	3.308
FA 2-13	43.93	42.33	43.13	45.67	41.67	43.67	5.078	5.216	5.147
FA 2-14	44.80	41.37	43.08	45.67	41.67	43.67	4.730	4.816	4.773
FA 2-15	36.73	35.00	35.87	46.67	41.67	44.17	4.322	4.672	4.497
FA 2-17	36.60	35.67	36.13	45.67	41.67	43.67	4.562	4.546	4.554
FA 2-22	38.43	36.00	37.22	44.33	37.67	41.00	3.471	3.797	3.634
FA 2-23	35.70	33.80	34.75	45.00	42.00	43.50	2.911	3.311	3.111
FA 2-26	36.93	35.37	36.15	41.00	38.33	39.67	2.987	3.680	3.334
FA 2-33	38.67	37.00	37.83	45.67	45.67	45.67	3.289	3.530	3.410
FA 2-35	43.83	42.03	42.93	46.33	43.33	44.83	2.821	3.347	3.084
Concessa	30.10	30.07	30.08	45.67	43.33	44.50	3.519	3.750	3.635
Paulista	32.20	31.50	31.85	44.67	41.67	43.17	3.676	4.267	3.972
Samantha	21.87	22.30	22.08	47.00	45.33	46.17	3.271	3.727	3.499
LSD at 5%	2.48	3.14	1.89	0.77	0.96	0.92	0.656	0.429	0.371

Table 8. Cont.

Characters / Genotypes	Pod weight (g)			Pod length (cm)			Pod diameter (mm)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
FA 1-2	4.37	4.20	4.28	12.23	12.40	12.32	7.13	7.13	7.13
FA 1-3	4.97	4.87	4.92	15.70	15.67	15.68	6.63	6.63	6.63
FA 1-4	5.17	5.27	5.22	16.03	15.90	15.97	6.43	6.43	6.43
FA 1-5	4.27	4.33	4.30	12.00	11.90	11.95	6.97	7.07	7.02
FA 1-12	3.23	4.43	3.83	10.70	10.90	10.80	6.93	6.83	6.88
FA 1-14	4.47	3.47	3.97	12.00	11.53	11.77	7.73	6.73	7.23
FA 1-15	5.27	4.63	4.95	13.80	13.60	13.70	7.87	7.37	7.62
FA 1-16	6.03	4.97	5.50	14.80	13.93	14.37	8.23	7.77	8.00
FA 1-19	4.60	4.43	4.52	13.07	12.97	13.02	7.30	6.97	7.13
FA 1-24	4.97	5.13	5.05	12.90	13.47	13.18	7.83	7.43	7.63
FA 1-25	4.73	4.43	4.58	13.37	13.17	13.27	7.47	7.17	7.32
FA 1-34	4.57	4.53	4.55	13.83	13.50	13.67	6.67	6.63	6.65
FA 1-37	4.10	4.13	4.12	12.47	12.60	12.53	7.13	7.03	7.08
FA 1-41	5.03	4.17	4.60	14.33	12.80	13.57	6.97	6.83	6.90
FA 1-42	4.47	4.43	4.45	12.43	12.23	12.33	7.63	7.63	7.63
FA 2-2	5.43	5.00	5.22	14.97	14.37	14.67	7.23	6.93	7.08
FA 2-3	3.87	4.13	4.00	12.07	12.57	12.32	7.07	7.03	7.05
FA 2-6	4.63	5.43	5.03	12.53	14.40	13.47	7.23	7.57	7.40
FA 2-7	5.43	5.30	5.37	14.87	14.10	14.48	7.20	7.70	7.45
FA 2-8	4.77	5.23	5.00	12.97	13.97	13.47	6.63	6.60	6.62
FA 2-9	5.70	4.90	5.30	14.67	13.77	14.22	7.63	7.37	7.50
FA 2-13	5.07	5.17	5.12	13.83	13.43	13.63	7.73	7.60	7.67
FA 2-14	5.50	5.03	5.27	13.87	13.67	13.77	8.13	7.80	7.97
FA 2-15	5.17	4.90	5.03	13.37	13.50	13.43	7.73	7.50	7.62
FA 2-17	5.07	5.23	5.15	14.90	15.37	15.13	7.30	7.20	7.25
FA 2-22	4.77	3.47	4.12	13.23	12.13	12.68	7.03	6.83	6.93
FA 2-23	5.37	4.67	5.02	13.90	12.97	13.43	7.63	7.50	7.57
FA 2-26	5.67	4.73	5.20	14.03	13.10	13.57	7.87	7.27	7.57
FA 2-33	5.23	4.43	4.83	14.03	13.30	13.67	7.40	6.93	7.17
FA 2-35	5.67	4.60	5.13	14.57	13.73	14.15	7.90	7.03	7.47
Concessa	4.73	4.73	4.73	12.37	12.13	12.25	8.37	8.30	8.33
Paulista	5.10	4.97	5.03	11.93	12.23	12.08	8.47	8.37	8.42
Samantha	3.77	3.40	3.58	12.77	12.53	12.65	6.47	6.40	6.43
LSD at 5%	0.13	0.46	0.41	0.54	0.61	0.55	0.35	0.27	0.27

The genotype FA 2-13 produced the highest significant total green yield (5.147 ton/feddan) followed by the genotype FA 1-16 (4.870 ton/feddan) without significant differences between them and with significant differences from the three check cultivars (Concessa, Paulista and Samantha). The lowest green yield was detected in Line FA 1-34 (2.715 ton/feddan). Six out of the 30 selected lines gave green yield, significantly, higher than the check cultivars, indicating the effectiveness of the selection for improving this trait. These results confirm previous reports of Bertoldo *et al* (2010), Costa *et al* (2010), Wasonga *et al* (2010), Menezes *et al* (2011), Nosser (2011) and Hamed (2012) who indicated the possibility of selecting homogeneous new common bean lines with high yield.

Concerning pod weight trait, significant differences were observed among the evaluated genotypes (Table 8). Mean weight of green pod of the evaluated genotypes ranged from 3.58 g to 5.50 g. The highest weight of pods was shown by the selected lines FA 1-16 and FA 2-7 (5.37 g) followed by line FA 2-9 (5.30 g) without significant differences between them and also without significant differences from the check cultivar Paulista (5.03 g). The lowest value of pod weight was exhibited by cultivar Samantha (3.58 g).

Pod length reflected also a great variation among the evaluated genotypes (Table 8). The selected lines produced mean pods ranging from 11.77 cm to 15.97 cm in length. The longest pods were shown by the selected line FA 1-4 (15.97 cm) with significant differences from the check cultivars Concessa, Paulista and Samantha (12.25, 12.08 and 12.65 cm, respectively). These data indicated that the selection is effective for improving pod length trait.

Regarding pod diameter trait (Table 8), the cultivar Paulista showed the highest value (8.42 mm), meanwhile, the lowest values were recorded in the cultivar Samantha and the line FA 1-4 (6.43 mm). All the selected lines showed pod diameter values between the values of the cultivars Paulista and Samantha.

Components of variances

Estimates of components of variance, i.e., environmental (σ^2e), genetic (σ^2g) and phenotypic (σ^2p) variance, genotypic (GCV) and phenotypic (PCA) coefficient of variation, GCV/PCV ratio and broad sense heritability (BSH) for the studied traits are presented in Table (9). All studied traits except pod weight showed low difference between phenotypic and genetic variance indicating that the large portion of the phenotypic variance (σ^2p) was due to the genetic variance (σ^2g) and the significant differences among the snap bean selected lines are of genetic nature.

Estimates of GCV% and PCV%, respectively, for the studied traits were 15.02 and 15.70% for plant height, 5.55 and 5.88% for number of days to flowering, 15.83 and 18.06% for total green yield, 10.03 and 12.52% for pod weight, 8.27 and 9.01% for pod length, 6.58 and 7.33% for pod diameter and 151.57 and 153.57% for rust severity (Table 9). Also, the GCV/PCV ratio for the studied traits ranged from 0.80 (pod weight) to 0.99 (rust severity). Obtained broad sense heritability values for the studied traits ranged from 64% to 97%, suggesting high values of heritability in all studied characters, except pod weight trait.

Table 9. Coefficient of variation (CV), components of variance ($б^2e$, $б^2g$ and $б^2p$), genotypic and phenotypic coefficient of variation (GCV% and PCV%) and broad sense heritability (BSH) for studied traits.

Characters / Components	Plant height	No. days to flowering	Total green yield	Pod weight	pod length	Pod diameter	Rust severity
CV%	**4.59**	**1.93**	**8.69**	**7.49**	**3.59**	**3.22**	**24.74**
$ó^2_e$	**2.67**	**0.64**	**0.10**	**0.13**	**0.23**	**0.06**	**6.55**
$ó^2_g$	**28.67**	**5.27**	**0.34**	**0.23**	**1.22**	**0.23**	**245.91**
$ó^2_p$	**31.34**	**5.91**	**0.44**	**0.35**	**1.45**	**0.29**	**252.45**
BSH	**0.91**	**0.89**	**0.77**	**0.64**	**0.84**	**0.81**	**0.97**
GCV%	**15.02**	**5.55**	**15.83**	**10.03**	**8.27**	**6.58**	**151.57**
PCV%	**15.70**	**5.88**	**18.06**	**12.52**	**9.01**	**7.33**	**153.57**
GCV/PCV	**0.96**	**0.94**	**0.88**	**0.80**	**0.92**	**0.90**	**0.99**

In general, it is noticed that the differences between phenotypic and genotypic variance for all studied traits except pod weight trait were low, since the estimated GCV/PCV ratios were high (from 0.80 to 0.99). In other words, the large portion of phenotypic variance (σ^2_P) was due to the genetic variance (σ^2_g). Consequently, estimated BSH showed high values for all traits, except pod weight trait, indicating that the observed significant phenotypic differences among the studied breeding lines are of genetic nature and there are small environmental effects on the phenotypic variation. Therefore, the studied characters except pod weight trait can be improved through selection based on phenotypic observations in early segregating generations in snap bean. These results confirm findings of Nosser (2011) and Hamed (2012), who indicated that plant height, number of days to flowering, yield, pod weight, pod length and pod thickness characters were influenced by genetic more than non-genetic factors and the differences between GCV and PCV were narrow with respect to genetic advance. Also, Salib (2006), Hamed and Khalil (2010), Nosser (2011) and Hamed (2012) found that BSH ranged from moderate to high for the same studied characters and suggested selection for improving these traits.

CONCLUSION

It can be concluded that the pedigree selection as a breeding method is effective for improving yield, pod quality and rust resistance in snap bean. Also, from this selection program, we found that the promising selected lines of snap bean FA 1-16, FA 2-6, FA 2-13, FA 2-14, FA 2-15 and FA 2-17 could be considered for certification (after more evaluation). They had homogeneity, high productivity, high pod quality and resistance to rust disease. With regard to rust incidence, it has been proven that the lower dew point that coincided at the fifth week in this study plays an important role in this regard. However, the atmospheric humidity does not influence directly the primary infection, but it may influence the progress of postulate as related to the genetic composition of given genotypes.

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التربية لمقاومة الصدأ وبعض الصفات الإقتصادية فى الفاصوليا الخضراء

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أجريت هذه الدراسة بمزرعة بحوث الخضر فى قها بمحافظة القليوبيه التابعة لمركز البحوث الزراعية– مصر خلال الفترة من ٢٠١٢ إلى ٢٠١٥ بهدف إستنباط بعض السلالات الجديده المبشره من الفاصوليا الخضراء والتى تتميز بالمحصول العالى وصفات الجودة المرغوبة بالإضافة الى المقاومة لمرض الصدأ وذلك عن طريق الإنتخاب. تم إستخدام عشيرتين فى الجيل الثالث من هجن الفاصوليا الخضراء (كونسيسا xبوليستا، وكونسيساx سامنثا) فى بداية هذه الدراسة بالإضافة إلى الأصناف التجارية كونسيسا، وبوليستا، وسامنثا. وأشارت النتائج إلى أن جميع متوسطات الصفات المدروسة زادت بالإنتخاب. وجد أن الظروف المناسبه لحدوث الاصابه هى نقطه الندى حيث انها تجمع بين درجه الحراره المناسبه للإصابه والبلل المناسب حيث أن الرطوبه الجويه المسجله للدراسه قد لاتكون مناسبه لحدوث الاصابه حيث تراوحت بين (٥٢،٤٣ و ٥٦،٧١٪) فى موسمى التقييم. تم إستنباط ثلاثين سلالة جديده من الفاصوليا الخضراء فى الجيل السادس وتقييمهم خلال الموسمين الخريفيين المتعاقبين ٢٠١٤، و٢٠١٥ ووجد أن سبعه من التراكيب الوراثية كانت قابلة للإصابة حيث تراوحت شدة الإصابة بهم من ٣،٠٠٪ الى ٦٠،٠٠٪، وصنف التركيب الوراثي FA 1-3 بأنه عالي المقاومه. أما باقى التراكيب الوراثية للاصناف التجاريه بوليستا، وسامنثا فكانت عاليه الاصابه حيث تراوحت بين ٣٨،٣٠٪، و ٥٨،٣٣٪ اما الصنف التجارى كونسيسا فلم يظهر عليه أى مظهر للإصابة. تم تقدير معامل الإختلاف داخل السلالات الجديده ولوحظ أن معظم السلالات بها درجات مناسبه من التجانس لمعظم الصفات المدروسه مقارنة بالأصناف التجارية. وأشارت النتائج إلى أن معظم التباين الكلى يرجع إلى التباين الوراثى وكذلك كانت كفاءة التوريث عاليه لكل الصفات المدروسه ما عدا صفة وزن القرن وتراوحت من ٦٤٪ الى ٩٧٪ مما يدل على أن الإختلافات المعنويه بين الطرز الوراثيه تحت الدراسه تعود إلى التباين الوراثى مع وجود تأثيرات بسيطه للبيئه مما يؤكد أنه يمكن إستنباط سلالات جديده من الفاصوليا الخضراء ذات محصول عالى وصفات جودة مرغوبة ومقاومة للصدأ عن طريق الإنتخاب لتلك الصفات إعتمادا على التباين المظهرى. كما أشارت النتائج إلى أن السلالات المنتخبه FA 1-16، FA 2-6، وFA 2-13، وFA 2-14، وFA 2-15، و FA 2-17 تعتبر مبشره ويمكن تسجيلها كأصناف جديدة من الفاصوليا الخضراء (بعد مزيد من التقييم) لتجانسها العالى ومحصولها المرتفع وصفات الجوده الجيده بالإضافة لمقاومتها لمرض الصدأ.

المجلة المصرية لتربية النبات ٢١(٢) : ٣٣٩- ٣٦١ (٢٠١٧)