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Efficiency of Mass Selection and Selfing with Selection Breeding Methods on Improving Some Important Characters of Three Eggplant Cultivars

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Abstract: The current work aims to investigate the efficiency of two selection breeding methods; mass selection and selfing with selection, on improving some imperative characters of the local Egyptian eggplant (Balady) cultivars; Black Oval, Black Long and White Long. Estimation of heritability percentages in broad sense for the various characters of vegetative growth, fruits yield and its components as well as the phenotypic correlation coefficient estimates between all possible pairs among the various studied characters were also under consideration. In this respect, three field experiments were conducted during three consecutive summer seasons of 2005-2007, at the Experimental Station Farm, Alexandria University, Alexandria, Egypt. The estimated coefficients of variation (C.V.%) values for the vegetative growth characters; plant height, stem diameter, both numbers of branches and leaves plant^{-1}; and fruit characteristics; i.e., fruit- length, -diameter, -weight, number of fruits plant^{-1} and total fruits yield plant^{-1} in a relatively large population of each cultivar of eggplant exposed enough variability for the intentions of selection and improvement. Variability levels within the studied characters turned down as a result of practicing the two breeding methods, but with more severe reductions in the second selfed progenies, relative to the second cycle of mass selection populations. Heritability (%) in broad sense estimates were high for most characters; within the ranges of 73.51% to 97.91% in eggplant Black Oval, 35.20% to 94.96% in Black Long and from 53.24% to 94.74% in White Long cultivars, which suggested that selection in these characters, would be effective. The estimated values of the phenotypic correlation coefficients among the various possible pairs of the studied characters illustrated, generally, that only two out of 36 interrelationships in both Black Oval and White Long cultivars and 16 out of the 36 possible relationships in cultivar Black Long are appeared to be pronounced. The correlation between fruits number plant^{-1} and fruits yield plant^{-1} characters was found desirable for the target of selection in this study, particularly, for either Black or White Long eggplant cultivars.

Key words: Egg plant · Balady cultivars · Mass selection · Individual plant selection · Variability · Heritability in broad sense · Correlation coefficient

INTRODUCTION

Eggplant or brinjal (*Solanum melongena* L., 2n = 24) is an agronomically important solanaceous crop grown primarily for its fleshy tender fruits. It is grown in both subtropics and tropics areas, native to India and China [1]. Egypt is the third country of eggplant production. Since, the greatest eggplant producers are China (17 million tons year^{-1}), India (8 million tons), Egypt (1 million tons) and Turkey (0.9 million ton) [2].

The most widely produced eggplant cultivars in Egypt, are known to be different commercial local (Balady) types; Black Oval (*Solanum melongena* var. *esculentum*) and both Black and White Long (*S. melongena* var. *serpentinum*), which vary in most of their vegetative growth and fruit quality characters [3, 4]. Although, these cultivars are generally characterized with enormous amounts of variabilities as well as no resonance breeding programs for the purification of these cultivars were conducted for a long time. Moreover, the grower's seeds are not often produced by seeds production specialists. Therefore, a remarkable deterioration and a lot of problems, concerning fruits quality and quantity characters; i.e., variable maturity, erratic shapes, various sizes, discolor and less productivity became obvious. Accordingly, it is crucial to exploit effective breeding programs for eggplant improvement depending on selection assessments.

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Mass selection method depends on selection of superior plants from a population. Only superior plants, which have desirable characters, for the basis of their phenotypic performances are chosen and bulked together to grow the following generation. The purpose of this breeding method is to obtain a high frequency of superior genotypes within the population [5]. Selfing with selection of individual plants method increases the effectiveness of the practiced selection and the amount of genetic improvement achieved in a breeding program by increasing the frequency of the desirable alleles [6]. Some investigators, Ragheb, [7]; Pirinc and Pakyurek, [8]; Duman *et al*., [9] studied the effects of mass and individual plant selection practices for improving various characters of solanaceous vegetable crops.

Heritability is an index for calculating the relative influence of environment on expression of genotypes [10]. Other studies, Ragheb, [7]; Abd-El-Hadi *et al*., [11]; Kushwah and Bandhyopadhya, [12]; Singh and Kumar, [10] estimated numerous important characters of eggplant.They reported that the estimated percentages of heritability in broad sense for most characters were high values. Phenotypic correlation coefficient is an important appliance for the breeder to help in selecting a difficult measured character through the selection of another easier in measuring. In this respect, several studies estimated the relationships among the different pairs of the assorted characters of Egyptian eggplant [11, 13, 14].

This work was undertaken with the aim of studying the efficiency of two selection breeding methods; mass- and selfing with selection; on the improvement of some important characters of the three common local types of eggplant. Heritability percentages in broad sense were estimated for the various characters of vegetative growth, fruits yield and its components. The phenotypic correlation coefficients between all possible pairs among the different studied characters were also estimated.

MATERIALS AND METHODS

The present study was performed in three successive summer seasons of 2005-2007, at the Experimental Station Farm, Alexandria University, Egypt.

2005 Summer Season

Growing of Original Populations and Variability Estimations: Seeds of the three diverse genetic populations of Balady cultivars of eggplant, namely Black Oval, Black Long and White Long were separately sown in the nursery on April and the seedlings were transplanted on June, 2005. The experimental area for each cultivar consisted of 60 rows, 4 m long and 0.7 m wide, with 0.35 m between plants within rows. All other agricultural practices; like fertilization, irrigation and plant protection against weeds, diseases and insects; were achieved.

Development of the First Mass Selection Cycle and the First Individual Plant Selection: The two breeding methods; mass selection and selfing with selection; started with commercial populations consisting of about 800 plants from each of the three different used eggplant genotypes. At the flowering stage, the best 28, 26 and 38 plants from the three original populations; Black Oval, Black Long and White Long, respectively, were primarily selected on the basis of the general performance of their visual vegetative growth traits. The selection criteria used in the primary selection were based on the following desirable characters; long plant height, more number of branches plant^{-1}, more number of leaves plant^{-1} and thicker stem diameter.

To produce the seeds of the first selfed progenies of the individually selected plants, some floral buds were selfed and bagged by paper bags till the assurance of fruits setting. At the same time, the other floral buds were left free for fruits setting and ripening to produce the first cycle of mass selection.

At fruits maturity, a second and more severe selection practice was conducted within the primary selected plants, according to the desirable fruit's characteristics; i.e., more number of fruits plant^{-1}, medium fruits weight and medium fruit length and diameter. Then, at the full matured fruits stage, the seeds of each selected plants, from each genotype; were separately extracted, dried and stored to be used in the next generation. According to the used selection criteria, the number of the finally selected progenies from each genotype came out to be 10 for both Black Oval and Black Long and 16 for White Long cultivar.

Data Recorded: The measurements of the various interested studied characters of eggplant plants were recorded as follows:

Vegetative Growth Characters: At the beginning of flowering stage; the following vegetative growth traits were measured on the basis of individual plants such as plant height (cm), stem diameter (cm), number of branches plant^{-1} and number of leaves plant^{-1}.

Fruits Yield and its Components: Samples of five random fruits, at the maturity stage, of each plant were harvested to determine the following fruit characteristics; length (cm), diameter (cm) and weight (g). While, number of fruits plant^{-1} and total fruits yield plant^{-1} (g) were estimated on the basis of individual plants. All data of the various studied traits were recorded to be used for calculating the statistical variability parameters; mean ($\bar{x}$), range (R) and coefficient of variation (C.V.%).

2006 Summer Season

Seeds Production of the Second Cycle of Mass Selection and the Individual Plant Selection for the Second Selfed Progenies: Seeds of the first cycle of mass selection and the seeds derived from the first selfed progenies (S_1's) of each eggplant genotype were separately sown in three experiments on April and their seedlings were transplanted on June, 2006. Each experimental area consisted of 60 rows, 4.0 m long and 0.7 m wide and the plant spacing was 0.35m. Selection, in the same forgoing basis, was again practiced within- and between- the selfed progenies of the selected plants of each genotype to maintain the most promising progenies for the next cycle of mass selection and selfing with selection. At the flowering stage, some of the developing floral buds were selfed to produce the seeds of the second selfed progenies; whereas, all the other flowers were left to produce the seeds of the second cycle of mass selection. Then, the seeds of each selected selfed progenies were separately, extracted, dried and stored to be used in the evaluating experiments. Likewise, to obtain the seeds of the second cycle of mass selection, the produced seeds from all selected plants were extracted, dried and bulked together. Numbers of the finally selected progenies, from the second selfed progenies of the selected plants of each genotype, came down to be only four for each of the three used genotypes; Black Oval and both Black and White Long.

2007 Summer Season

Evaluation of the Derived Genetic Populations (C_2) and (S_2's): Seeds of the original populations (O.P.), the second mass selection cycle populations (C_2) and those of the four second selfed progenies of each genotype; Black Oval [S_2(BO-1) to S_2(BO-4)], Black Long [S_2(BL-1) to S_2(BL-4)] and White Long [S_2(WL-1) to S_2(WL-4)]; were separately sown in the nursery on April and the seedlings were separately transplanted on June, 2007. A randomized complete blocks design, with three replicates was used. Each plot consisted of four rows; 3.5 m long and 0.7 m wide, with a spacing of 0.35 m between plants. All agricultural practices for the eggplants production were adopted. Means, ranges and coefficients of variation were calculated for all studied traits, as mentioned before. All recorded data of all evaluated populations of each genotype were also used to estimate the phenotypic correlation coefficients among all possible pairs of the studied traits.

Statistical Analyses: Data of all the aforementioned characters were arranged and statistically analyzed as elucidated by Al-Rawi and Khalf-Allah, [15], using Co-State Software computer program [16]. The differences among the various means were tested, using Duncan's multiple range test (L.S.R) at 0.05 level of probability.

Estimations of Heritability Percentages in Broad Sense ($H^2_{b.s.}$%) and Phenotypic Correlation Coefficients: Heritability percentages in broad sense ($H^2_{b.s.}$%) for the studied traits and the phenotypic correlation coefficients among all possible pairs of the studied traits were calculated according to Allard, [17] and Mather and Jinks, [18], respectively.

RESULTS AND DISCUSSION

Data presented in Table 1 showed the estimated values for the statistical parameters; means, ranges and coefficients of variation (C.V. %) for all studied characters of the original populations of three eggplant genotypes; i.e., Black Oval, Black Long and White Long. Within the original population of Black Oval genotype, the highest variability magnitudes were found to be those of the characters fruit weight and total fruits yield plant^{-1}, since they showed the highest estimated C.V.% values of 85.41% and 82.16%, respectively. The characters fruits number plant^{-1} and both leaves and branches numbers plant^{-1} reflected also relatively high variability levels; since their estimated C.V.% values were 65.98%, 54.47% and 43.39%, in that order. On the contrary, the plant height showed the lowest value of variability (16.36%) of all studied characters.

Concerning the Black Long genotype, the results in Table 1 showed that the highest variability magnitudes were found in both characters number of leaves and branches plant^{-1}, since their estimated C.V.% values were found to be 75.94% and 66.49%, respectively. The characters fruit weight, number of fruits plant^{-1} and total fruits yield plant^{-1} showed relatively moderate variabilities, with the estimated C.V.% values of 43.77%, 40.73% and 34.18%, each in order. On the contrary, the three remaining characters; i.e., plant height, fruit length and diameter; reflected the lowest variability estimates; 22.67%, 21.85% and 17.56%, correspondingly.

Table 1: Means ($\bar{x}$), ranges and coefficients of variation (C.V.%) estimates of the studied characters in the original populations of the three commercial eggplant Balady cultivars; Black Oval, Black Long and White Long

	Genotypes								
	Balady Black Oval			Balady Black Long			Balady White Long		
Characters	$\bar{x}$	Range	C.V.%	$\bar{x}$	Range	C.V.%	$\bar{x}$	Range	C.V. %
Plant height (cm)	78	45-108	16.36	72.99	32-117	22.67	67.33	35-111	23.16
Branches number plant^{-1}	5.26	1.0-6.0	43.39	4	1.0-5.37	66.49	5	1.0-6.97	75.79
Leaves number plant^{-1}	74.54	21-222	54.47	52.66	7-180	75.94	51.23	7-190	59.25
Fruit length (cm)	9.34	6.3-12.8	24.2	12.11	9-17.3	21.85	10.9	7.3-16.3	40.5
Fruit diameter (cm)	8.35	5.2-9.6	26.95	2.63	1.8-3.6	17.56	2.67	1.9-4.9	58.41
Fruit weight (g)	193.08	110-215	85.41	42.9	36-49	43.77	41.57	30-56	56.66
Fruits number plant^{-1}	10.24	12-Jun	65.98	25.04	21-29	40.73	27.48	21-33	82.03
Fruits yield plant^{-1} (g)	1997.6	1180-2925	82.16	1069.6	850-1235	34.18	1128.4	895-1280	69.09

Regarding the White Long genotype, data in Table 1 showed also that most of the studied characters reflected comparatively high variability levels. The highest estimated C.V.% value was that of the character number of fruits plant^{-1} (82.03%), followed by those of number of branches plant^{-1} (75.79%), total fruits yield plant^{-1} (69.09%), number of leaves plant^{-1} (59.25%), fruit diameter (58.41%) and fruit weight (56.66%), respectively. On the other hand, plant height character revealed the lowest C.V.% value (23.16%).

The aforementioned results indicated clearly that the used original populations of the three eggplant genotypes were characterized by high variability magnitudes for most of the studied characters. Such results, generally; suggested the presence of good prospects for selection and improvement in the agronomic characters under consideration, in each of the three studied populations, which meant that good genotypes could be derived through the two practiced selection methods. Such results were generally in accordance with those obtained by Ragheb, [7]; Sharma and Kishan [19]; Mohanty, [20]; Singh and Kumar, [10], who found that the magnitudes of the phenotypic coefficients of variability in eggplant were high for most of their studied characters. However, Baha-Eldin, *et al*., [21, 22] found low variability values for their studied characters in eggplant. The obtained results showed also that the detected ranges for the various studied characters in the three original populations of eggplant were wide, which suggested clearly the high potentialities for improving those characters. Accordingly, the presence of high variation levels, in the used original populations, for the studied characters, supported the high possibilities of conducting successful and efficient selection aiming to introduce new genotypes, with better performances than those of the corresponding original populations.

Effectiveness of Mass- and Selfing with Selection on the Investigated Characters: The results of the comparisons among the different statistical parameters means, ranges and coefficients of variation of the vegetative growth characters; plant height, stem diameter, number of branches plant^{-1} and number of leaves plant^{-1}; for the six different evaluated populations for each of the three eggplant cultivars; i.e., the original population (O.P.) of the considered eggplant cultivar with the derived populations from the second cycle of mass selection (C_2) and the four second selfed-progenies; whose numbers were S_2(BO-1) to S_2(BO-4) for Black Oval, S_2(BL-1) to S_2(BL-4) for Black Long and S_2(WL-1) to S_2(WL-4) for White Long are presented in Table 2. The obtained results reflected, generally, high or relatively high improvement (increases), with different magnitudes, in vegetative growth characters of the three eggplant cultivars, through the tow practiced different breeding methods; viz. the second cycle of mass selection and the individual plant selection for two generations, comparing with the original populations. Nevertheless, the individual plant selection method, using selfing with selection for two generations, showed more superior effect on improving all vegetative growth characters; plant height, stem diameter, number of branches plant^{-1} and number of leaves plant^{-1}, compared with the second cycle of mass selection method in the three eggplant based on increasing means values or reductions of coefficients of variation (C.V.%) values. After the second cycle of mass selection, the vegetative growth characters for the three eggplant genotypes were improved, since, the estimated increments, relatively to their original population, were noticed to be within the ranges of 2.14 to 17.02% for plant height, 4.08 to 86.67% for stem diameter, 8.58 to 74.76% for number of branches plant^{-1} and from 3.10 to 40.19% for number of leaves plant^{-1}. Also, the individual plant selection method,

Table 2: Means (X), ranges and coefficients of variation (C.V.%) estimates for vegetative growth characters of the six evaluated populations of the eggplant Balady cultivars Black Oval, Black Long and White Long in 2007 summer season.

Plant characters	Plant height (cm)			Stem diameter (cm)			Number of branches plant^{-1}			Number of leaves plant^{-1}		
Parameters Populations	X	Range	C.V.%	X	Range	C.V.%	X	Range	C.V.%	X	Range	C.V.%
Black Oval genotypes O.P.	82.10c	61-95	13.12	1.65c	1.3-2.2	12.12	2.33e	1.0-3.0	28.37	80.50d	50-113	13.02
C2	96.07b	82-107	6.71	3.08a	2.8-3.5	6.82	2.53de	2.0-3.0	20.16	112.85a	64-122	10.90
S2(BO-1)	96.23b	87-111	6.66	2.90b	2.5-3.3	6.55	2.80c	2.0-4.0	22.86	101.50b	85-110	10.46
S2(BO-2)	101.57a	89-115	6.67	3.06a	2.8-3.4	5.56	3.33b	2.0-4.0	18.32	88.53c	67-98	8.19
S2(BO-3)	100.86a	88-109	5.62	2.87b	2.7-3.1	4.18	2.63cd	2.0-4.0	23.57	99.18b	59-103	10.28
S2(BO-4)	97.40b	87-109	6.39	3.10a	2.7-3.4	6.77	3.97a	3.0-5.0	19.14	81.80d	62-94	8.42
Black Long genotypes O.P.	77.33c	62-92	11.41	1.94d	1.4-2.3	14.43	2.40d	1.0-4.0	40.42	75.27e	35-12	12.88
C2	79.37c	68-88	8.90	2.07c	1.7-2.6	9.66	2.70c	2.0-4.0	25.93	79.49d	40-126	9.29
S2(BL-1)	88.83ab	69-97	7.00	2.25b	2.0-2.6	8.44	2.80c	2.0-4.0	21.79	80.54d	56-93	9.24
S2(BL-2)	89.80a	78-99	6.88	2.46a	2.2-2.7	7.72	3.13ab	2.0-4.0	21.73	86.49c	54-90	8.63
S2(BL-3)	87.13b	79-99	6.27	2.22b	2.0-2.5	6.76	3.10b	2.0-4.0	21.29	92.45b	59-97	8.53
S2(BL-4)	89.40a	78-99	6.63	2.26b	2.0-2.6	7.96	3.33a	2.0-4.0	21.32	97.93a	61-102	8.28
White Long genotypes O.P.	74.70d	65-86	8.99	2.45c	1.7-3.1	15.51	2.10c	1.0-3.0	33.81	77.82c	59-109	14.17
C2	76.30cd	68-86	7.42	2.55bc	1.9-2.9	12.16	3.67b	2.0-5.0	23.02	80.23bc	63-116	11.48
S2(WL-1)	83.77a	78-95	5.34	2.65b	2.4-3.1	7.55	4.10a	3.0-5.0	18.54	81.55bc	68-111	9.38
S2(WL-2)	78.53bc	68-89	6.56	2.94a	2.6-3.3	6.80	3.80ab	3.0-5.0	20.03	86.23ab	66-121	10.86
S2(WL-3)	79.67b	72-89	6.70	2.94a	2.5-3.4	7.82	4.10a	3.0-5.0	18.54	92.17a	69-118	11.25
S2(WL-4)	83.83a	75-92	7.18	2.80a	2.4-3.4	9.64	3.97ab	3.0-5.0	18.14	85.42ab	60-105	9.61

O.P. = Original population. C2= Second cycle of mass selection.

S2(BO-1) – S2(BO-4) = Progenies of the second selfed generation of four individual selections of Balady Black Oval cultivar.

S2(BL-1) – S2(BL-4) = Progenies of the second selfed generation of four individual selections of Balady Black Long cultivar.

S2(WL-1) – S2(WL-4) = Progenies of the second selfed generation of four individual selections of Balady White Long cultivar.

Values having similar alphabetical letter (s) do not significantly differ, using Duncan's multiple range test (L.S.D) at 0.05 probability level.

using selfing with selection for two generations, increased the means (more improvements) of the studied characters in all derived selfed progenies of the three used cultivars. The estimated increments of the vegetative growth characters of the second selfed progenies for the three cultivars were found to be in the ranges from 5.13 to 23.71% for plant height, from 8.16 to 87.88% for stem diameter, from 12.88 to 95.24% for number of branches plant^{-1} and from 1.62 to 30.10% for number of leaves plant^{-1}. Such relatively high or high improvements, attained on vegetative growth characters through mass selection and selfing with selection, indicated clearly that these breeding methods were more efficient in concentrating the genes or alleles of vegetative growth (taller plants, thicker stem diameter and more numbers of branches and leaves plant^{-1}) of eggplant cultivars. These results might be expected, since these characters seemed to be simply inherited. So, the successful selection for taller plant, thicker stem, more numbers of branches and leaves could be related to the type of gene action involved in the inheritance of these characters, that seemed to be additive, particularly with plant height and number of branches [14, 23, 24]. Yet, Singh and Mital, [25] noticed that both additive and non-additive and dominance effect were greater than additive in the inheritance of plant height and number of branches, respectively.

The detected great amounts of variability that appeared to be present in the original populations for the vegetative growth characters, in addition to the estimated values of broad sense heritability with moderate, relatively high or high magnitudes, which were estimated in the current study, in the three eggplant cultivars, offered good opportunities for the realized improvements. Similarly, high estimated broad sense heritability values for such vegetative growth characters were obtained by some authors such as Bora and Shadeque, [26]; El-Sharkawy *et al*., [13]; Abd-El-Hadi *et al*., [11]; Prabhu and Natarajan, [27].

Pertaining the fruit characteristics of eggplant; i.e. fruit -length, -diameter, -weight, number of fruits plant^{-1} and fruits yield plant^{-1}, the comparisons among the mean values of the five fruit characters of the original populations (O.P's.) with those of the second cycle of mass selection (C2) and that of the individual plant selection for two generations; S_2(BO-1) to S_2(BO-4), S_2(BL-1) to S_2(BL-4) and S_2(WL-1) to S_2(WL-4) in the three eggplant cultivars, respectively are presented in Table 3. The results, concerning the performance of fruit length character, illustrated that all derived populations of the three used cultivars, were characterized by a reduced fruit length; reflecting an improvement, since the selection for this character was directed towards a shorter fruit length as a desirable form. The means fruit length of the three

Table 3: Means (X), ranges and coefficients of variation (C.V.%) estimates for fruit characteristics and fruits yield of the six evaluated populations of the eggplant Balady cultivars; Black Oval, Black Long and White Long in 2007 summer season

Plant characters	Fruit length (cm)			Fruit diameter (cm)			Fruit weight (g)			No. of fruit plant^{-1}			Total fruits yield plant^{-1} (g)		
Parameters															
Populations	X	Range	C.V.%	X	Range	C.V.%	X	Range	C.V.%	X	Range	C.V.%	X	Range	C.V.%
Black Oval genotypes															
O.P.	12.90a	9.7-16.5	15.57	9.47a	7.2-12.8	16.05	191.43b	124-199	15.12	10.23e	8-15	16.57	1970.5c	1480-2940	23.82
C2	11.31c	9.8-12.8	8.66	7.62c	6.6-8.9	9.06	188.57b	165-209	7.90	10.87d	9-13	9.57	2047.6c	1020-2665	11.82
S2(BO-1)	11.72bc	10.1-13.2	8.45	7.92bc	7.0-8.9	8.33	199.79b	169-226	6.67	13.70b	12-16	9.42	2733.3a	2450-3410	10.39
S2(BO-2)	11.47c	9.8-12.9	8.54	7.22d	5.9-8.3	9.00	218.06a	192-239	6.67	13.23c	11-15	9.22	2876.2a	2300-3240	7.82
S2(BO-3)	12.22ab	10.5-14.6	7.45	7.91bc	6.6-8.7	8.22	177.05c	164-200	7.42	13.83ab	12-16	8.89	2419.5b	1985-2910	8.97
S2(BO-4)	12.28ab	10.4-13.6	7.25	8.11b	7.2-8.9	6.78	167.34c	165-221	9.16	14.20a	12-16	8.73	2357.0b	1610-2650	6.98
Black Long genotypes															
O.P.	15.53a	10.8-19.7	12.27	3.40a	2.9-4.0	9.48	43.28a	36.3-48.8	8.50	25.23d	21-31	10.15	1088.0c	900-1310	10.11
C2	13.36b	10.9-14.9	7.26	3.23b	2.9-3.5	6.19	41.64ab	38.2-48.7	6.46	33.60a	28-37	6.52	1308.7a	1090-1635	6.64
S2(BL-1)	12.77bc	10.7-14.3	6.89	3.18b	2.7-3.5	7.23	38.66c	35.0-41.6	5.36	32.00b	29-37	6.34	1222.8b	1014-1370	6.77
S2(BL-2)	12.73bc	10.7-14.3	6.36	2.98c	2.7-3.3	6.07	40.83abc	37.5-49.1	6.27	30.83c	28-35	6.39	1257.1b	1105-1410	6.81
S2(BL-3)	12.19c	10.7-14.3	6.32	2.96c	2.7-3.3	6.08	38.45c	34.0-42.5	6.14	31.87b	29-35	6.28	1230.2b	1100-1440	8.01
S2(BL-4)	12.20c	10.6-13.6	6.72	3.00c	2.7-3.4	5.33	40.12bc	37.8-44.3	4.79	32.17b	29-38	6.22	1288.8b	1175-1470	7.08
White Long genotypes															
O.P.	13.69a	10.9-17.3	10.81	3.76a	2.3-4.6	14.24	41.52a	30.8-56.1	15.27	27.90c	21-36	12.58	1143.2c	915-1325	10.53
C2	12.19b	11.0-13.8	6.73	3.56b	3.0-4.5	12.64	40.30b	37.3-44.5	4.17	31.00b	27-37	7.90	1246.7b	1140-1475	6.17
S2(WL-1)	11.41bc	9.8-12.0	6.01	3.28cd	3.0-3.6	6.10	39.01c	36.6-42.0	3.95	34.03a	30-37	6.46	1325.8a	1210-1465	5.33
S2(WL-2)	11.71bc	10.6-12.0	5.89	3.30c	3.0-3.6	6.67	38.80c	37.0-41.8	3.07	33.27a	30-37	6.73	1289.2a	1110-1400	5.48
S2(WL-3)	11.51bc	10.7-12.4	4.78	3.19de	2.9-3.6	6.27	40.81ab	39.5-42.8	3.23	31.60b	29-37	6.93	1290.3a	1175-1475	5.93
S2(WL-4)	10.67c	9.5-11.5	5.90	3.10e	2.7-3.5	7.42	38.68c	37.0-43.4	3.70	31.37b	28-35	5.96	1212.5b	1105-1390	6.15

O.P. = Original population. C2= Second cycle of mass selection.

S2(BO-1) – S2(BO-4) = Progenies of the second selfed generation of four individual selections of Balady Black Oval cultivar.

S2(BL-1) – S2(BL-4) = Progenies of the second selfed generation of four individual selections of Balady Black Long cultivar.

S2(WL-1) – S2(WL-4) = Progenies of the second selfed generation of four individual selections of Balady White Long cultivar.

Values having similar alphabetical letter (s) do not significantly differ, using Duncan's multiple range test (L.S.D) at 0.05 probability level.

Table 4: Estimates of heritability percentages (in broad sense) for the studied characters of the eggplant Balady cultivars; Black Oval, Black Long and White Long

Eggplant cultivars	Balady Black Oval	Balady Black Long	Balady White Long
Parameter			
Characters	$H^2_{b.s.}$%	$H^2_{b.s.}$%	$H^2_{b.s.}$%
Plant height (cm)	94.97	35.20	73.43
Stem diameter (cm)	86.67	69.23	94.74
Branches number plant^{-1}	88.75	81.08	86.49
Leaves number plant^{-1}	88.62	94.96	53.24
Fruit length (cm)	82.35	40.97	88.50
Fruit diameter (cm)	73.51	90.91	77.78
Fruit weight (g)	97.91	52.63	83.56
Fruits number plant^{-1}	86.67	50.65	60.98
Fruits yield plant^{-1}	95.36	46.19	82.77

$H^2_{b.s.}$% = Heritability percentages in the broad sense

cultivars were reduced after the second cycle of mass selection by 12.33, 13.97 and 10.96% in Black Oval, Black Long and White Long, in that order relative to their original populations. It was also noticed that all selfed progenies, within the three cultivars, revealed reduction in fruit length, relative to their original populations. These results reflected the efficiency of the two practiced selection methods to improve this character. Such an efficiency in improving through selection might be referred to the high variation present in the original population for this character in addition to the additive gene effects involved in its inheritance; as illustrated by Singh and Singh, [24] and Melad *et al*., [14], who stated that the additive gene effects were more important in the inheritance of such character. The detected heritability values, in the present investigation, confirmed also such an achieved important, since the estimated heritability percentages were found to be 82.35% in Balady Black Oval, 40.97% in Balady Black Long and 88.50% in Balady White Long cultivars (Table 4).

The results, concerning the general performance of fruit diameter character, illustrated that all selected populations, derived from the three eggplant cultivars, through the two practiced breeding methods, gave a narrower diameter, reflecting a realized improvement. These results indicated generally that the improvement, attained in this character through mass selection and individual plant selection, appeared to be due to concentrating the genes or alleles of narrow fruits diameter in the selected populations. This result might be expected, since fruit diameter seemed to be controlled by additive gene effects as illustrated by Singh and Singh, [24] and was reflected on the estimated high heritability levels in the three cultivars; Black Oval, Black Long and White Long; which were estimated by high values; 73.51%, 90.91% and 77.78%, in that order (Table 4).

Fruit weight character reflected some slight improvement that reached 1.49%, 3.79% and 2.94% for Black Oval, Black Long and White Long cultivars, respectively after the second cycle of mass selection. It was also noticed that most of second selfed progenies, within each cultivar, showed significant decreases on fruit weight than those of their original populations. This result might be related to the additive gene effect involved in the inheritance of this character as reported by Singh and Singh, [24] and Melad *et al*., [14], who found that additive gene effects played a greater role than non-additive gene effects in the inheritance of fruit weight character. Such a recognized efficiency of selection on improving the fruit weight could be also related to the estimated values of heritability in broad sense that gave high values of 97.91%, 52.63% and 83.56% in Balady Black Oval, Balady Black Long and Balady White Long cultivars, correspondingly (Table 4).

Increments of 6.26%, 33.17% and 11.11%, over the original population means, on number of fruits plant^{-1} of the three eggplant cultivars; Black Oval, Black Long and White Long, in that order, were attained after the second cycle of mass selection. In the case of selfing with selection method, the increments in number of fruits plant^{-1} were noticed to be within the ranges of 29.33 to 38.81% in Black Oval, 22.20 to 27.51% in Black Long and from 12.44 to 21.97% in White Long, relative to their respective original populations. Such obtained high improvements of such character, through mass- and selfing with selection, could be due to concentrating genes or alleles responsible for high number of fruits plant^{-1} in the progenies of the selected eggplant populations. Also, such recognized improvements on this character might be related to the additive effects involved in its inheritance as pointed out by Singh and Singh, [24], who mentioned that additive gene effects were more pronounced than non-additive gene effects in the inheritance of number of fruits plant^{-1} character. The estimated values of heritability, in broad sense, which appeared to be either intermediate or relatively high in the three cultivars, seemed to be effective in realizing such an efficiency of selection to improve this character, as reported by Baha-Eldin, *et al*., [22]; Ragheb, [7]; Abd-El-Hadi *et al*., [11].

Fruits yield plant^{-1} character reflected various degrees of improvements in the three eggplant cultivars, which reached 3.91%, 20.28% and 9.05% in Black Oval, Black Long and White Long, respectively, after the second mass selection cycle. This character was also highly improved in all second selfed progenies of three cultivars. The great amount of variability, that was presented in the original populations for fruits yield plant^{-1}, offered good opportunities for the realized improvements through two practiced selection methods. Such an efficiency in improving fruits yield plant^{-1} through selection might be also related to its relatively high or high heritability percentages involved; that were estimated in broad sense by 95.36%, 46.19% and 82.77% in Black Oval, Black Long and White Long cultivars, each in order (Table 4), which agreed also with the results of Bora and Shadeque, [26]; Ragheb, [7]; El-Sharkawy *et al*., [13]; Abd-El-Hadi *et al*., [11], who detected high estimates for heritability percentages of this character.

Heritability is an important parameter in selection program. The estimated values of the broad sense heritability ($H^2_{b.s.}$%) are listed in Table 4. The estimates of heritability were high or relatively very high for the most characters of three eggplant cultivars. For instance, very high to high heritability estimates in broad sense were detected in fruit weight (97.91%), fruits yield plant^{-1} (95.36%), plant height (94.97%), branches number plant^{-1} (88.75%), leaves number plant^{-1} (88.62%) and fruits number plant^{-1} (86.67%) of Balady Black Oval; leaves number plant^{-1} (94.96%), fruit diameter (90.91%) and branches number plant^{-1} (81.08%) of Balady Black Long and stem diameter (94.74%), fruit length (88.50%), branches number plant^{-1} (86.49%), fruit weight (83.56%) and fruits yield plant^{-1} (82.77%) of Balady White Long cultivar. The high heritability indicates that the characters were less managed by environmental factors. These findings supported the earlier results of Bora and Shadeque [26]; Ragheb, [7]; Kushwah and Bandhyopadhya, [12]; Singh and Kumar [10], who recorded high heritability in broad sense for most of the characters in eggplant and suggested that selection in these studied characters would be effective.

Table 5: Phenotypic correlation coefficients (significant and highly significant positive and negative detection relationships) among the different pairs of the studied characters of the three used Eggplant Balady cultivars; Black oval, White Long and Black Long

	Balady Black Oval		Balady White Long	Balady Black Long				
Eggplant cultivars Plant parameters	Leaves number plant^{-1}	Fruits number plant^{-1}	Fruits yield plant^{-1} (g)	Branches number plant^{-1}	Fruit diameter (cm)	Fruit weight (g)	Fruits number plant^{-1}	Fruits yield plant^{-1} (g)
Plant height (cm)				0.309**	0.183**	-0.213**		
Stem diameter (cm)				0.221**	0.252**	-0.169*	0.257**	0.151*
Branches number plant^{-1}	-0.155*						0.153*	
Leaves number plant^{-1}			-0.219**					
Fruit length (cm)							0.291**	0.287**
Fruit diameter (cm)						-0.310**	0.227**	
Fruit weight (g)		0.303**					-0.431**	0.203**
Fruits number plant^{-1}			0.725**					0.773**

* = Significant at 0.05 of probability level ** = Highly significant at 0.01 of probability level

Concerning the variability magnitudes that were maintained within the selected populations, after the second mass selection cycle or individual plant selection for two generations of selfing with selection, the foregoing results indicated that these magnitudes were generally reduced in all selected populations. These results reflected the efficiency of the two practiced selection methods to improve the fruit characters. However, the degree of such a reduction in variability differed considerably from one character to another according to the type of the gene action involved in the inheritance of a particular character and also from one generation to another and to the type of the practiced breeding method.

The obtained results concerning the phenotypic correlation coefficients among all possible pairs of the studied characters of the three eggplant Balady cultivars; Black Oval, Black Long and White Long indicated that only two out of all possible 36 relationships for each eggplant Black Oval and White Long and 16 relationships for Balady Black Long cultivar were estimated with either significant or highly significant values (Table 5), whereas, the other correlation coefficients were not high enough to be significant.

Regarding to the Balady Black Oval cultivar, the results indicated that the two correlation coefficient values between fruits number plant^{-1} and fruit weight appeared to be positive; whereas, the correlation between number of branches plant^{-1} and number of leaves plant^{-1} was found to be negative. Apparently, such two relationships were thought to be undesirable and unreasonable; for the objectives of selection in the present study. Accordingly the results clearly indicated that when selection for any of these characters, the other correlated one should be taken into consideration to avoid any indirect harmful effect. However, Kushwah and Bandhyopadhya, [12] detected a negative significant correlation between fruit weight and number of fruits plant^{-1} and also Khurana *et al*., [28] found a positive association between the number of branches plant^{-1} and number of leaves plant^{-1}. Pertaining to the Balady White Long cultivar, the presented results in Table (5) illustrated the detected desirable (positive) relationship was found between fruits number plant^{-1} and fruits yield plant^{-1}. This result agreed completely with the findings of Vadivel and Bapu [29, 30]; Melad *et al.*, [14]. On the contrary, negative and undesirable correlation between number of leaves plant^{-1} and fruits yield plant^{-1} was detected, suggesting that an attention should be given in breeding programs to both characters having an undesirable correlation.

For the Balady Black Long cultivar, the results of correlation coefficients among all possible pairs of the studied characters indicated that desirable and positive correlations were detected between the pairs of the characters; 1) plant height with each of number of branches plant^{-1} and fruit diameter. 2) stem diameter with each of number of branches plant^{-1}, fruit diameter, fruits number plant^{-1} and fruit yield plant^{-1}. 3) number of branches plant^{-1} and fruits number plant^{-1} characters, suggesting clearly that selection for any character would result subsequently in increasing another one. 4) fruit length with each of fruits number plant^{-1} and fruits yield plant^{-1}. 5) fruit diameter and fruits number plant^{-1}. 6) fruits yield plant^{-1} with each of fruit weight and fruits number plant^{-1} (Table 5). Such desirable relationships, obtained in the present work, seemed to be in harmony with those reported by Khurana *et al*., [28] between fruit diameter and fruit weight; El-Sharkawy *et al*., [13] between fruit weight and total fruits yield and Prabhu and Natarajan, [27] between fruits yield with each of fruit weight, fruit length and fruits number plant^{-1}. On the other hand, desirable negative correlation were detected between the pairs of the characters; fruit weight with each of plant height, stem diameter, fruit diameter and fruits number plant^{-1}. These wanted relationships suggested clearly that selection for longer and thicker stem would subsequently result in decreasing fruit diameter and fruit weight and increasing fruits number plant^{-1}, which agreed with the goal of this study.

CONCLUSION

Generally, the obtained results of the current investigation concluded that both practiced selection methods; two cycles of mass selection and selfing with selection for two generations; were found effective in isolating good eggplant genotypes derived from the three used commercial eggplant Balady cultivars; Black Oval, Black Long and White Long, which showed superiority, over their respective original populations, in all studied characters. Accordingly, the results clearly illustrated that the mass selection program proposed more opportunities for further selection and improvement than selfing with selection. However, it should be mentioned that selfing with selection may help in developed improved pure lines faster.

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To evaluate the potential of genomic selection (GS), a selection experiment with GS and phenotypic selection (PS) was performed in an allogamous crop, common buckwheat (Fagopyrum esculentum Moench). To indirectly select for seed yield per unit area, which cannot be measured on a single-plant basis, a selection index was constructed from seven agro-morphological traits measurable on a single plant basis. Over 3 years, we performed two GS and one PS cycles per year for improvement in the selection index.Â Although the level of linkage disequilibrium in the breeding population was low, the target trait was improved with GS. Traits with higher weights in the selection index were improved more than those with lower weights, especially when prediction accuracy was high. Efficiency of Mass Selection and Selfing with Selection Breeding Methods on Improving Some Important Characters of Three Eggplant Cultivars.Â The present study included anatomical studies of the stems and leaves of 7 cultivars of Ficus carica were investigated. The anatomical examination of the cross sections of the above mentioned stemsâ€¦ (More). View PDF. Cite. Save. The Allen Institute for Artificial IntelligenceProudly built by AI2 with the help of our. The integration of recurrent selection methods with inbred line development programs follows with the classical example of B73, the public line derived from BSSS that generated billions of dollars to the hybrid industry. The chapter continues with the inheritance of quantitative traits, and methods of line development and hybrids. Finally, the concepts of heterotic groups, heterotic patterns, and inbred line recycling are detailed for exploiting heterosis and hybrid stability including multi-trait selection utilizing indices.Â 1996. Evaluation of U.S. Corn Belt and adapted maize cultivars and their diallel crosses. Maydica 41:317â€"324.Google Scholar.Â An evaluation of effects of mass selection and seed irradiation with thermal neutrons on yields of corn. Crop Sci.