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Relative Efficiency of Some Selection Methods in Improving Some Quantitative Traits of Two Flax Crosses

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ABSTRACT

Two experiments were grown at Gemmeiza Agricultural Research Station – Egypt, during the two successive seasons of 2019/2020 and 2020/2021. Two flax crosses ($Sakha_6$ x $Sakha_4$) and ($Sakha_6$ x $Giza_{11}$) were grown at F_5 and F_6 generations, according to three methods of selection, selection indices (S.I), individual trait selection based on breeding value per plant (B.V) and independent culling levels selection (ICL). Among F_5 and F_6 generations comparable narrow range were detected for fiber yield per plant, total plant height, technical stem length and straw yield per plant in two flax crosses. Low values of PCV and GCV were found for fiber yield per plant, total plant height, technical stem length and straw yield per plant among the two flax crosses. The most values of heritability were high, these indicate showed that selection for these traits in the genotypes would be most effective for the expression of these traits in the succeeding generations. The results indicated that, the various selection procedures differed in their ranking sequence for means of fiber yield per plant and its components over the two generations, this may be due to the interaction between the genotype selected by different procedures and the environment. The results indicated that, the selection indices were more effective than the other selection procedures in improving the most characters under study.

1. INTRODUCTION

Flax (*Linum usitatissimum*, L.) probably the most ancient fiber and oil seed crop is a self-pollinated crop, 2n = 30 flax (*Linum usitatissimum*, L.) is a member in the family Linaceae. It is also called flaxseed or linseed when it is used as oilseed and referred to as fiber flax or just flax (in Europe) when it is used for fiber **(Vaisey-Genser and Morris, 2003)**.

Flax oil used as an industrial drying oil due to its height linolenic acid content **(Muir and Westcott, 2003)**. However, some flax genotypes have been developed which contain very low level of linolenic acid in their oil, making them suitable for use edible oil **(Rowland 1991)**. The fiber extracted from straw is use to produce strong yarns are used for making twines, canvas bags, quality papers etc.

Plant breeders are continuously searching for more effective methods of selection in early breeding generations in order to obtain superior genotypes from a population with a minimum input of labor and time. The major target of flax breeders is to produce height and good quality yielding varieties and for fiber and seed yields.

Successful pure-line breeding in self-pollinated plants, like flax by using pedigree selection method requires superior segregating population from which homozygous lines could be selected, the major disadvantage of this method is the difficulty to identify height yielding lines in early generation **(Salas and Fridet, 1995)** for this reason, breeders may delay selection until lines are approaching homozygosity and when sufficient seeds is available to carry out preliminary field test.

Plant breeders use biometrical techniques to assess genetical variability among and within genotypes, to develop selection criteria, heterotic parents for hybridization, effective breeding procedures and varietal stability **(Singh, 1990)**. Variability plays an important key role in plant breeding program and observed the limit of selection for different plant properties.

Hence, it becomes necessary to partition the observed variability into heritable and non-heritable components measured as genotypic and phenotypic coefficients of variation (GCV and PCV) and heritability. The mathematical genetical theory, in the form of selection index, developed by **Smith (1936)** is the basis for simultaneous selection of several traits.

A selection index most often aims at giving appropriate weight to the components maximizing gains from selection **(Falconer, 1983)**. Selection index was constructed to help selecting for several important traits simultaneously. Judicious use of such as sewing threads, linen fabrics, linen threads and the coarser grades

conventional and restricted selection indices is of a great importance to the breeder **(Shabana *et al*., 2015)**.

Different selection methods i.e., phenotypic individual trait selection, independent culling levels selection and selection index are used by plant breeders to improve yield in different crops **(Tikka *et al*. (1978), Joshi *et al*. (1985) Yadav and Singh (1988), Shabana *et al*. (2015) and Costa *et al*. (2008)**.

The present investigation aimed to study the magnitude of variability, heritability estimates and expected genetic advance under selection for fiber and seed yields per plant and its components, and comparisons of three methods of selection, selection indices (S.I), individual trait selection based on breeding value per plant (B.V) and independent culling levels selection (ICL) for two flax crosses.

2. MATERIALS AND METHODS

The two experiments were grown at Gemmeiza Agricultural Research Station – Egypt, during the two successive seasons of 2019/2020 and 2020/2021. Breeding materials used in this investigation were F_5 and F_6 generations of the two flax crosses ($Sakha_6$ x $Sakha_4$) and ($Sakha_6$x $Giza_{11}$).

These breeding materials were planted at the field in three replicates using randomized complete block design in 3 rows 2m long, spaced 10 cm apart and 5 cm between hills. Data were recorded on four agronomical characteristics, fiber yield per plant (FY), and three of its more important components, total plant height (TPH), technical stem length (TSL), and straw yield per plant (STY). The four variables were used in 16 different selection procedures according to the three methods of selection, selection indices (S.I), individual trait selection based on breeding value per plant (B.V) and independent culling levels selection (ICL). Data were statistically analyzed as the procedure given by **(Snedecor and**

Cochran 1980). Estimated of phenotypic (PCV) and genotypic (GCV) coefficients of variances were computed followed **(Burton, 1952)**:

Estimated of selection index in F_5, and F_6 generations:

The calculation necessary for construction of selection indices can be described under the following headings:

1. Estimates of phenotypic and genotypic variance and covariance.
2. Derivation of optimum weighing coefficients.
3. Calculation of selection indices.

Derivation of optimum weighing coefficients (b, s) and calculation of the eleven selection indices in F_5 and F_6 generations were estimated according to the equations suggested by **Smith (1936), (Hazel (1943) and Kempthorne and Nordskog (1959).**

Derivation of optimum weighing coefficients:

The general index formula mentioned by **(Smith, 1936) and (Hazel, 1943)** as follows:

$$I = b_1x_1 + b_2x_2 + \dots + b_nx_n = \sum_{i=1}^{n} b_i x_i .$$

The appropriate b, s which maximizes the advance from selection is calculated by the following formulas:

1- For improving two characters while holding the third constant, i.e. restricted selection index according **(Kempthorne and Nordskog 1959)**:

$$b = [I_m - p^{-1}GC\ (CG^{-}.\ P^{-1}\ GC)^{-1-}\ CG]\ P^{-1}Ga_i$$

2- for improving the four characters

$$b = P^{-1}Ga_i$$

3- Calculation of selection indices, phenotypic value of a plant (I) was estimated by using the formula outlined by **Smith (1936) and Hazel (1943)** as follows:

$$\mathbf{I} = \sum_{i=1.0}^{n} bi\ xi$$

$$PCV = (\sqrt{VP}\ /x^{-})\ 100 \text{ and}$$
$$GCV = (\sqrt{VG}\_\_\ /x\text{-}100)$$

Independent culling levels selection (ICL): In this method a certain level of merit was established for each trait, and all individuals below that level are discarded regardless of the superiority of their other traits **(Hazel and Lush, 1942) and (Hallauer *et al*., 2010)**.

Calculations in F_5 and F_6 generations: Phenotypic, Genotypic variance and covariance, as well as correlation coefficients and heritability estimates were calculated in F_5 generation from the data of F_5 and F_6 families of the two flax crosses. Phenotypic and Genotypic variance in F_5 and F_6 generations were calculated by the analysis of randomized complete blocks design as described by **Miller *et al*. (1958)** in Table 1.

Table 1: Analysis of variance and expected mean squares of randomized complete blocks design

S.O.V	D F	M.S	E M S
Replications	r-1	Mr	
Families	t-1	Mt	$\sigma^2e + r\ \sigma^2g$
Error	(r-1)(t-1)	Me	σ^2e

Phenotypic (σ^2p) and genotypic (σ^2g) variance were estimated by the formula:

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

$$\sigma^2g = (Mt - Me)/r$$

Calculations of Phenotypic and Genotypic covariance in F_5 and F_6 generations between pairs of traits, followed the same form as variance analysis, as suggested by **Henderson (1953)**.

Table 2: Analysis of covariance between pairs of the studied traits

S.O.V	Covariance components
Replications	3
Families	$\sigma^2 e + r\,\sigma^2 a$
Error	$\sigma^2 e$

$$H = \frac{\sigma^2 G}{\sigma^2 G + \sigma^2 E}$$

Individual trait selection based on breeding value per plant: B.V.X_1, X_2, X_3 and X_4. Fiber yield/plant and three of its more important components, total plant height, technical stem length and straw yield per plant, respectively. The regression of offspring on mid-parent, however, is very little affected and it was taken as a valid measure of heritability as shown by **(Reev and Robertson, 1953)**:

$$h^2 = bo_p$$

The regression of each F_5 offspring's on mid-parent was computed from the equation:

$$b\ yx = \frac{S(xy) - s(x)s(y)/n}{s(x^2) - [(s)]^2/n}$$

The breeding value of each F5 and F6 plants was obtained by multiplying the regression value of its off-springs on mid-parent by its phenotypic value.

Efficiency of selection procedures: The expected genetic advance from selection the best 5% of F_5 and F_6 individuals for the two flax crosses by using various selection procedures was calculated for the eight characters by using the formula suggested by **(Johanson *et al*. 1955)**.

The predicted genetic advance under selection (Δg) was calculated according to **Johanson *et al.* (1955)** from the following equation:

$$GA = h^2 n * \sigma p * K$$

Where: $h^2 n$ = heritability in narrow sense, σp = the phenotypic standard deviation and K = selection differential at 5% intensity of selection, that is 2.06.

3. RESULTS AND DISCUSSION

Heritability in F_5 and F_6 generations was estimated as the ratio of genetic variances to the phenotypic variances, according to **Allard (1960)**:

The range, mean, PCV, GCV and heritability for different characters of the two flax crosses for F_5 and F_6 generations have been shown in Table 3.

Among F_5 and F_6 generations comparable narrow range were detected for fiber yield per plant, total plant height, technical stem length and straw yield per plant in two flax crosses. In F_5 and F_6 generations the results indicated low values of PCV and GCV for fiber yield per plant, total plant height, technical stem length and straw yield per plant among the two flax crosses, and estimation of GCV and PCV for all the studied characters revealed that the phenotypic coefficient of variation SCV were higher than there. This results were in agreement with **Mirza *et al.* (1996), Mishra and Yadav (1999), Burako (2010), Leelavathi and Mogali (2018), Singh, et *al.* (2015), Sahu and Sahu (2016)**.

Heritability estimate for fiber yield per plant was (36.86%) in F_5 generation, and slightly increased to (42.27%) in F_6 generation for 1^{st} cross, while for 2^{nd} cross was (34.44%) in F_5 generation, and slightly decreased to (25.04%) in F6 generation. On the other hand, heritability estimate for total plant height was (49.55%) in F_5 generation, and slightly decreased to (46.52 %) in F_6 generation for 1^{st} cross, while for 2^{nd} cross was (33.95%) in F_5 generation, and slightly decreased to (27.49%) in F_6 generation. Heritability estimate for technical stem length was (54.17%) in F_5 generation, and slightly decreased to (43.39%) in F_6 generation for 1^{st} cross, while for 2^{nd} cross was (32.42%) in F_5 generation, and slightly decreased to (25.40%) in F_6 generation. On the other hand heritability estimate for straw yield per plant was (52.31%) in F_5 generation, and slightly decreased to (42.83%) in F_6 generation for 1^{st} cross, while for 2nd cross was (32.31%) in F_5 generation, and slightly decreased to (24.72%) in F_6 generation. These results were in agreement with **Adugna and Labuschagne (2004), Nagaraja *et al.* (2009), Singh *et al.* (2016), Abo-Kaied *et al*. (2015), Choudhary *et al.* (2017), Kumar *et al*. (2015), Patial *et al.* (2018) and Paul and Kumari (2018)**.

Table 3: Range, means, heritability, PCV and GCV estimates for FY, TPH, TSL and STY in F5 and F6 generations of the crosses ($Sakha_6$ x $Sakha_4$) and ($Sakha_6$ x $Giza_{11}$)

G		$Sakha_6$ x $Sakha_4$				$Sakha_6$ x $Giza_{11}$			
		FY	TPH	TSL	STY	FY	TPH	TSL	STY
Range	F5 Min	0.52	121.00	91.67	2.33	0.51	120.00	93.00	2.87
	F5 Max	0.65	132.00	104.00	3.53	0.58	126.67	99.00	3.60
	F6 Min	0.55	124.00	96.33	3.27	0.56	124.67	95.00	3.37
	F6 Max	0.64	132.67	105.33	4.13	0.62	130.33	101.00	4.03
Mean	F5	0.60± .02	129.09±1.3	101.24±1.3	3.26±.13	0.54±.01	123.3±1.3	95.9±1.32	3.2±.13
	F6	0.59± 01	127.94±1.24	100.37±1.3	3.7±.14	0.58±.013	127.4±1.27	97.8±1.34	3.65±.13
H	F5	36.86	49.55	54.17	52.31	34.44	33.95	32.42	32.31
	F6	42.27	46.52	43.39	42.83	25.04	27.49	25.40	24.72
PCV and GCV	F5 PCV	0.07	1.49	1.89	0.54	0.02	1.02	1.35	0.39
	F5 GCV	0.03	0.74	1.03	0.28	0.01	0.35	0.44	0.13
	F6 PCV	0.03	1.13	1.49	0.44	0.02	0.87	1.24	0.33
	F6 GCV	0.01	0.53	0.65	0.19	0.005	0.24	0.31	0.08

(FY= fiber yield per plant), (TPH=total plant height), (TSL=technical stem length), (STY= straw yield per plant), (PCV= phenotypic coefficients of variances) and (GCV= genotypic coefficients of variances)

The above mentioned suggested that a substantial genetic advance in fiber yield per plant. (FY), total plant height (TPH), technical stem length (TSL), and straw yield per plant (STY) could be expected from selection. The most values of heritability were high. These indicate that selection for these traits in the genotypes would be most effective for the expression of these traits in the succeeding generations. Therefore, a good improvement can be made if some of these traits are considered as selection criteria in future breeding program, if a heritability of a character is high, selection for such a character is fairly easy as the selected character will be transmitted to its progeny. This is because there would be a close correspondence between genotype and phenotype due to a relatively smaller contribution of environment to the phenotype. It could be indicated from the above mentioned results that a substantial amount of residual genetic variance in the population till F_6 generation, as estimated by the genetic variance components were observed. The magnitude of the genetic variability which persisted in this material was sufficient to lead for further appreciable improvement in advanced generations.

Efficiency of different selection procedures in improving fiber yield and its components, measured in terms of the expected and realized response to selection, are presented in Tables 4 and 5 for two crosses ($Sakha_6$ x $Sakha_4$) and ($Sakha_6$ x $Giza_{11}$). Results showed that the actual gains obtained by the different selection procedures for improving fiber yield per plant and its components in F_5

and F_6 generations were highest than their expected genetic advance.

For cross (Sakha$_6$ x Sakha$_4$), results showed that the actual gains obtained by the different selection procedures for improving fiber yield per plant and its components in F_5 and F_6 generations were highest than their expected genetic advance. In F_5 generation, results showed that the actual gains obtained by restricted selection index (I.W123, I.123, I.W12, I.W3, I.12, I.W1, I.W2, I.W13, I.13 and I.W23), respectively with actual efficiency values were (65.85, 63.10, 62.16, 61.57, 61.34, 60.81, 60.46, 60.34, 58.93 and 58.17), respectively.

Regarding the realized advance for improving fiber yield in F_5 generation, were higher than individual trait selection based on breeding value per plant, fiber yield per plant (BV X1) with actual efficiency values of (55.24), flowed by (I.23) with actual efficiency values of (52.31), then (ICL 1234) with actual efficiency values of (38.50).

Individual trait selection based on breeding value per plant ,total plant height , technical stem length and straw yield per plant (BV X2,BV X3 and BV X4) with actual efficiency values of (31.02, 24.12 and 22.85) indicated the lowest value than the other selection procedures for improving fiber yield per plant and its components. While, in F_6 generation, results showed that selection procedures obtained by restricted selection index (I.W123, I.W1, I.W12, I.12, I.W3, I.W2, I.13, I.W13, I.123 and I.W23), respectively, with actual efficiency values of (66.09, 64.27, 63.33, 63.16, 62.80, 62.33, 61.34, 60.28, 62.16 and 60.11, respectively.

Regarding the realized advance for improving fiber yield in F6 generation were higher than individual trait selection based on breeding value per plant ,fiber yield per plant (BV X1) with actual efficiency values of (58.70), followed by (I.23) with actual efficiency values of (59.52), followed by, straw yield per plant (BV X4) with actual efficiency values of (46.14).

Independent culling level selection, fiber yield per plant ,total plant height, technical stem length and straw yield per plant (ICL1234), exhibited highest actual gain values than selection procedures obtained by individual trait selection based on breeding value per plant for total plant height and technical stem length (BV X2 and BV X3).

For cross (Sakha$_6$ x Giza$_{11}$) results showed that the actual gains obtained by the different selection procedures for improving fiber yield per plant and its components among F_5 and F_6 generations were highest than their expected genetic advance. In F_5 generation, results showed that the actual gains obtained by restricted selection index (I.W123, I.W1, I.W3, I.12, actual efficiency values of (56.22, 52.73, 52.12, 51.28, 51.22, 50.56, 50.20, 49.71 and 49.29), respectively.

Regarding the realized advance for improving fiber yield in F5 generation was higher than individual trait selection based on breeding value per plant, fiber yield per plant (BV X1) with actual efficiency values of (49.89), followed by selection index (I.W23 and I.W13) with actual efficiency values of (48.69 and 47.12), then (ICL 1234) with actual efficiency value of (28.19).

Individual trait selection based on breeding value per plant ,total plant height , technical stem length and straw yield per plant (BV X2,BV X3 and BV X4) with actual efficiency values of (22.45, 16.94 and 16.11) indicated the lowest value than the other selection procedures for improving fiber yield per plant and its components. While, in F_6 generation, results showed that selection procedures obtained by restricted selection index (I.W3, I.W2, I.23, I.W23, I.W1, I.123, I.12, I.W123, I.W12, I.13,I.W13 and BVX1), respectively, with actual efficiency values of (65.62,65.50, 65.50, 65.38, 64.35,65.26, 65.26, 65.14, 65.14, 65.08, 64.35 and 61.35), respectively, regarding the realized advance for improving fiber yield in F_6 generation was higher than individual trait selection based on breeding value per plant and independent culling level selection.

Individual trait selection based on breeding value per plant (BV X1), fiber yield per plant with actual efficiency value of (31.99), followed by (I.23) with actual efficiency value of (59.52), followed by (ICL 1234) with actual efficiency value of (28.63). exhibited highest actual gain values than selection procedures obtained by individual trait selection based on breeding value per plant for total plant height and technical stem length (BV X2 and BV X3) with actual efficiency values of (25.68 and 17.37). These results were in agreement with those obtained by **Hazel and Luch (1942), Young (1961), Elgin *et al*. (1970)** **and Yadav and Singh (1988)**, they found that selection index method was more efficient than independent culling level selection but it was usually more expensive. The present study showed consistent increase in the relative efficiency of the succeeding index with simultaneous inclusion of each character. However, in practice, the plant breeder might be interested in maximum gain with minimum number of characters **(Ekhlaque and Ansari 2016)**.

Table 4: Efficiency of selection procedures, as percentages of F_5 and F_6 generations, for fiber yield in terms of the expected and realized response to selection of the crosses ($Sakha_6$ x $Sakha_4$) and ($Sakha_6$ x $Giza_{11}$)

$Sakha_6$ x $Sakha_4$				$Sakha_6$ x $Giza_{11}$			
F5		F6		F5		F6	
S P	R A	S P	R A	S P	R A	S P	R A
BV X1	55.24	BV X1	58.70	BV X1	49.89	BV X1	61.35
BV X2	31.02	BV X2	31.50	BV X2	22.45	BV X2	25.68
BV X3	24.12	BV X3	24.92	BV X3	16.11	BV X3	17.37
BV X4	22.85	BV X4	46.14	BV X4	16.94	BV X4	31.99
ICL 1234	38.50	ICL 1234	43.35	ICL 1234	28.19	ICL 1234	28.63
I.W123	65.85	I.W123	66.09	I.W123	56.22	I.W123	65.14
I.W12	62.16	I.W12	63.33	I.W12	51.22	I.W12	65.14
I.W13	60.34	I.W13	60.28	I.W13	47.12	I.W13	64.35
I.123	63.10	I.123	62.16	I.123	50.20	I.123	65.26
I.W23	58.17	I.W23	60.11	I.W23	48.69	I.W23	65.38
I.W1	60.81	I.W1	64.27	I.W1	52.73	I.W1	64.35
I.W2	60.46	I.W2	62.33	I.W2	49.29	I.W2	65.50
I.W3	61.57	I.W3	62.80	I.W3	52.12	I.W3	65.62
I.12	61.34	I.12	63.16	I.12	51.28	I.12	65.26
I.13	58.93	I.13	61.34	I.13	49.71	I.13	65.08
I.23	52.31	I.23	59.52	I.23	50.56	I.23	65.50

S P (Selection Procedures) and R A (Realized advance)

Table 5: Expected genetic advance for fiber and their components of F_5 and F_6 generations of the crosses ($Sakha_6$ x $Sakha_4$) and ($Sakha_6$ x $Giza_{11}$)

	G	$Sakha_6$ x $Sakha_4$				$Sakha_6$ x $Giza_{11}$			
		FY	TPH	TSL	ST Y	FY	TPH	TSL	STY
GA	F5	4.42	1.90	2.65	7.61	1.64	0.81	1.02	2.64
	F6	3.16	1.56	1.89	5.27	2.50	1.10	1.38	4.04

Comparison of selection procedures of the cross

In plant breeding, selection is applied to the populations having genetic variability for the desired characters. The genetic variability is generated by crossing different individuals or mutating genes of interest by induced mutagenesis. Main purpose of a selection program is to increase the mean of the selected portion of the population and thus to select individuals with height genotypic value. Selection in practice depends on the phenotypes of the individuals and in the absence of genotypic portion of the variance. The genetic advance from selection cannot be estimated. Many multiple trait selection protocols utilize an aggregate score, or an index, as means of differentiating genotypes possessing superior trait combination. Index selection protocols utilize simultaneous selection on a series of traits as opposed to a sequential selection **(Henning and Teuber, 1996)**. Some indices require the estimation of genetic variances, covariance, and the economical value for all traits undergoing selection. One of these is called the Smith-Hazel, or optimum index **Smith, (1936) and Hazel, (1943)**. Efficiency of a selection index depends not only on the kind of crop plant and considered traits, but also on the base population used for the estimation of coefficients in selection indices.

The cross ($Sakha_6$ x $Sakha_4$):

Means of fiber yield per plant (X_1) , total plant height(X_2) ,technical stem length (X_3), straw yield per plant(X_4) ,for the lines selected by the fourteen different selection procedures , of the F_5 and F_6 generations and the two parents of the cross ($Sakha_6$ x $Sakha_4$) with the expected genetic advance under selection are given in Table 6.

Fiber yield per plant (X_1):

Means of fiber yield per plant obtained for different selection procedures showed significant differences in F_5 generation, however there were non-significant differences in F_6 generations of means of fiber yield per plant obtained for different selection procedures. Means of fiber yield per plant for all selection procedures (I.W123, ICL_{1234}, ICL_{5678}, I.123, I.W12, I.W13, I.W1, I.W2, I.W3, I.12, I.W23, I.13, BV X_1 and I.23) with values (0.63, 0.62, 0.62, 0.62, 0.61, 0.61, 0.61, 0.61, 0.61, 0.61, 0.60, 0.60, 0.59 and 0.58) exceeded the higher and the lower yielding parent ($Sakha_6$ and $Sakha_4$) with values (0.51 and 0.54) in F_5 generation.

In F_6 generation the means of fiber yield per plant for all selection procedures (I.W123, I.W12, I.W1, I.W2, I.W3, I.12, ICL_{1234}, I.W13, I.123, I.W23, I.13, BV X_1, ICL_{5678} and I.23) with values (0.63, 0.62, 0.62, 0.62, 0.62, 0.62, 0.61, 0.61, 0.61, 0.61, 0.61, 0.60, 0.60 and 0.60) exceeded the higher and the lower yielding parent ($Sakha_6$ and $Sakha_4$) with values (0.52 and 0.523).

The results exhibit that, the selection index ranked the first and the independent culling levels selection ranked the second, while Individual trait selection based on breeding value per plant were the third for improving fiber yield per plant in F_5 generation, While, in F_6 generation selection index ranked the first and the Independent culling levels selection ranked the second, while Individual trait selection based on breeding value per plant were the third. However selection procedures (ICL_{5678}) indicated the lowest value than the other selection procedures for improving fiber yield per plant. The results indicated that the selection indices were more effective than independent culling levels selection and individual trait selection based on breeding value per plant in improving fiber yield per plant in F_5 and F_6 generations. These results were in agreement with **Aruna *et al*. (1989)**.

Total Plant height (X_2):

Analysis of variance indicated that there were non-significant differences between all of the selection procedures for total plant height in F5 generation, while there were significant differences between all of the selection procedures for total plant height in F_6 generation.

The means of total plant height for selection procedures in F_6 generation (I.W123, I.W1, I.W13, I.12, ICL_{1234}, I.W12, I.123, I.W23, I.23, I.W3, ICL_{5678}, BV X_2, I.13 and I.W2) with values of (131.20, 130.47, 130.22, 129.89, 129.73, 129.53, 129.53, 129.38, 129.27, 128.78, 128.65, 128.42, 127.87 and 127.62) respectively exceeded the higher

and the lower yielding parent ($Sakha_6$ and $Sakha_3$) with values of (118.50 and118.10).
The results exhibit that, the selection index ranked the first and the independent culling levels selection ranked the second, while individual trait selection based on breeding value per plant were the third for improving The results indicated that, the selection indices were more effective than the other present findings is in accordance with those obtained by **Tikka *et al*. (1978), Aruna *et al*. (1989), Foster *et al*. (2000), Abo-Kaied (2003), Barmana and Borah (2012) and Shabana *et al*. (2015).**

Technical stem length(X_3):

Means of technical stem length according to analysis of variance indicated that there were significant differences between all of the selection procedures for technical stem length in F_5 generation, while there were non-significant differences between all of the selection procedures for technical stem length in F_6 generation.
The means of technical stem length for selection procedures (I.123, I.W123, I.W3, I.W13, I.12, I.W1, ICL_{5678}, I.W12, ICL_{1234}, I.W2, I.13, BV X_3, I.23 and I.W23) with values of (103.64, 103.53, 103.40, 102.91, 102.73, 102.89, 102.40, 102.40, 102.14, 101.76, 101.20, 100.11, 101.11 and 101.00), respectively, exceeded the higher and the lower yielding parent ($Sakha_6$ and $Sakha_3$) with values of (88.90 and 89) in F_5 generation. While, in F_6 generation, the selection procedures (I.W123, I.W1, I.12, I.W2, ICL_{1234}, I.23, I.W12, I.123, I.W23, I.13, I.W3, I.W13, ICL_{5678} and BV X_3) with values of (103.89, 102.87, 102.29, 102.16, 102.15, 102.11, 102.00, 101.93, 101.87, 101.64, 101.33, 101.27, 101.07 and 100.76), respectively exceeded the higher and lower yielding parent ($Sakha_6$ and $Sakha_3$) with values of (90.45 and 88.77).
The selection indices ranked the first than the independent culling levels selection which ranked the second, and individual trait selection based on breeding value per plant ranked the third for improving technical stem length in F_5 generation.

total plant height in F_5 generation. However, individual trait selection based on breeding value per plant were ranked the third for improving total plant height in F_6 generation, selection indices (I.13 and I.W2) indicated the lowest value than the other selection procedures.
selection procedures in improving total plant height in F_5 and,F_6 generations .The
In F_6 generation, the selection indices ranked the first than the independent culling levels selection(ICL_{1234}) which ranked the second, and individual trait selection based on breeding value per plant ranked the third for improving technical stem length.
The results indicated that, the selection indices were more effective than the other selection procedures in improving technical stem length among F_5 and F_6 generations. The present findings are in accordance with those obtained by **Falconer (1960), Finney (1962) and Eagles and Frey (1974)**.

Straw yield per plant(X_4):

The means obtained from all of selection procedures for improving straw yield per plant obtained by the three methods of selection showed non-significant differences in F_5 generation, moreover all of selection procedures indicated significant differences in F_6 generation for improving straw yield per plant.
Selection procedures obtained by the three methods of selection (I.W123, I.123, I.W3, I.W2, I.W12, I.W13, I.12, I.23, I.W1, I.W23 and I.13) respectively, with values of (3.60, 3.53, 3.48, 3.46, 3.44, 3.44, 3.43, 3.42, 3.41, 3.40 and 3.37), respectively, for improving straw yield per plant exceeded the higher yielding parent ($Sakha_6$) and with values of (3.37). However, selection procedures (ICL_{1234}, ICL_{5678} and BV X_4) with values of (3.36, 3.34 and 3.15) exceeded the lower yielding parent ($Sakha_3$) with values of (2.55) in F_5 generation. While, inF_6 generation, the means of straw yield per plant for all selection procedures (I.W123, I.W23, I.W1, I.W3, I.12, ICL_{1234}, I.123, I.W2, I.W12, I.13, I.W13, ICL_{5678}, I.23 and BV X_4), respectively, with values of (3.98,

3.96, 3.95, 3.91, 3.91, 3.89, 3.88, 3.88, 3.87, 3.84, 3.81, 3.79, 3.79 and 3.75), respectively, exceeded the higher and the lower yielding parent ($Sakha_6$) and ($Sakha_3$) with values of (3.55 and 2.76).

The results exhibit that, the selection index ranked the first, however the independent culling levels selection ranked the second, while individual trait selection based on breeding value per plant were the third for improving straw yield per plant in F_5 and F_6 generations. The results indicated that, the selection indices were more effective than the other selection procedures in improving straw yield per plant in F5 and F6 generations. These results were agreement with **El-Dahan *et al.* (2017)**.

Table 6: Means of FY .TPH, TSL and STY obtained by the different selection procedures, of F_5 and F_6 segregating generation and the tow parents of the cross ($Sakha_6$ x $Sakha_4$)

Trait	FY		TPH		TSL		STY	
Generation	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_6
BV	0.59	0.60	127.96	128.42	100.11	100.76	3.15	3.75
ICL1234	0.62	0.61	130.00	129.73	102.14	102.15	3.36	3.89
ICL5678	0.62	0.60	129.79	128.65	102.40	101.07	3.34	3.79
I.W123	0.63	0.63	131.96	131.20	103.53	103.89	3.60	3.98
I.W12	0.61	0.62	131.00	129.53	102.40	102.00	3.44	3.87
I.W13	0.61	0.61	130.82	130.22	102.91	101.27	3.44	3.81
I.123	0.62	0.61	131.31	129.53	103.64	101.93	3.53	3.88
I.W23	0.60	0.61	130.07	129.38	101.00	101.87	3.40	3.96
I.W1	0.61	0.62	131.40	130.47	102.89	102.87	3.41	3.95
I.W2	0.61	0.62	130.91	127.62	101.76	102.16	3.46	3.88
I.W3	0.61	0.62	131.13	128.78	103.40	101.33	3.48	3.91
I.12	0.61	0.62	131.04	129.89	102.73	102.29	3.43	3.91
I.13	0.60	0.61	128.44	127.87	101.20	101.64	3.37	3.84
I.23	0.58	0.60	128.36	129.27	101.11	102.11	3.42	3.79
P1	0.51	0.52	117.30	118.50	88.90	90.45	3.37	3.55
P2	0.54	0.523	117.1	118.10	89	88.77	2.55	2.76

The results indicated that, the various selection procedures differed in their ranking sequence for means of fiber yield per plant and its components over the two generation, this may be due to the interaction between the genotype selected by different procedures and the environment. Sometimes, the method of independent culling levels and individual trait selection based on breeding value per plant were superior in improving straw yield per plant. These results were in agreement with **(Momtaz 1970)**.

The cross ($Sakha_6$ x $Giza_{11}$):

Means of fiber yield per plant (X_1), total plant height (X_2), technical stem length (X_3), straw yield per plant (X_4), seed yield per plant (X_5), number of capsules per plant (X_6), number of seeds per capsules (X_7), and seed index (X_8),for the lines selected by the fourteen different selection procedures , of the F_5 and F_6 generations and the two parents of the cross ($Sakha_6$ x $Giza_{11}$) with the expected genetic advance under selection are given in Table 7.

Fiber yield per plant (X_1):

The means of fiber yield per plant obtained for different selection procedures showed significant differences among F_5 and F_6 generations. Means of fiber yield per plant for all selection procedures (I.W123, ICL_{1234}, I.W12, I.W1, I.W3, I.12, I.23, BVX_1, ICL_{5678}, I.123, I.W23, I.W2, I.13 and I.W13) with values (0.58, 0.56, 0.56, 0.56, 0.56, 0.56, 0.56, 0.55, 0.55, 0.55, 0.55, 0.55, 0.55 and 0.54) exceeded the higher and the 0.61, 0.61, 0.61, 0.61, 0.61, 0.61, 0.60, 0.57 and 0.57) exceeded the higher and the lower yielding parent ($Sakha_6$ and $Giza_{11}$) with values (0.51 and 0.53).

The results exhibited that the selection index ranked the first and the independent culling levels selection ranked the second, while Individual trait selection based on breeding value per plant was the third for improving fiber yield per plant in F_5 generation. While, in F_6 generation selection index ranked the first, and individual trait selection based on breeding value per plant ranked the second, while independent culling levels selection were the third for improving fiber yield per plant.

The results indicated that the selection indices were more effective than independent culling levels selection and individual trait selection based on breeding value per plant in improving fiber yield per plant in F_5 and F_6 generations. These results were in agreement with the present findings is in accordance with those obtained by **Falconer (1960), Finney (1962), Eagles and Frey 1974), Tikka *et al*. (1978), Aruna *et al*. (1989), Foster *et al*. (2000) and EL-Dahan *et al*. (2017)**.

Total Plant height (X_2):

Analysis of variance indicated that, there were significant differences between all of the selection procedures for total plant height in F_5 and F_6 generations.

The means of total plant height for selection procedures (I.W123, I.12, I.W3, I.13, I.W12, I.123, I.W2, I.W13, I.W23, I.23, I.W1, ICL_{1234} and BV X_2) with values of (127.16, 125.67, 125.64, 125.62, 125.60, 125.49, 125.44, 125.42, 125.13, 125.13, 125.11, 124.84 and 123.98), respectively, exceeded the higher and the lower yielding parent lower yielding parent ($Sakha_6$ and $Giza_{11}$) with values (0.52 and 0.54) in F_5 generation. In F_6 generation, the means of fiber yield per plant for all selection procedures (I.W123, I.W12, I.W13, I.123, I.W23, I.W1, I.W2, I.W3, I.12, I.13, I.23, BV X_1, ICL_{1234} and ICL_{5678}) with values (0.61, 0.61, 0.61, 0.61, 0.61,

($Sakha_6$ and $Giza_{11}$) with values of (118.40 and 117.90). However, selection procedures (ICL_{5678}) with value of (118.40) exceeded the higher yielding parent ($Sakha_6$) in F_5 generation. While, in F_6 generation, the selection procedures (I.W23, I.W2,I.W3, I.23, I.W123, I.W12, I.123, I.12, I.13, I.W13, I.W1, BV X_2, ICL_{5678} and ICL_{1234}) with values of (129.69, 129.69,129.69, 129.69, 129.58, 129.58, 129.58, 129.58, 129.49, 129.24, 129.24, 127.24, 121.70 and 121.65) respectively exceeded the higher and the lower yielding parent ($Sakha_6$ X $Giza_{11}$) with values of (121.44 and 119.60).

The results exhibit that, the selection index ranked the first and the independent culling levels selection ranked the second, while individual trait selection based on breeding value per plant was the third for improving total plant height in F_5 generation. While, in F_6 generation, the selection indices ranked the first, followed by individual trait selection based on breeding value per plant. However, independent culling levels selections were ranked the third for improving total plant height in F_6 generation.

The results indicated that, the selection indices were more effective than the other selection procedures in improving total plant height in F_5 and F_6 generations. The present findings are in accordance with those obtained by **Tikka *et al*. (1978), Aruna *et al*. (1989), Foster *et al*. (2000), Abo-Kaied, (2003), Barmana and Borah (2012) and Shabana *et al.* (2015)**

Technical stem length (X_3):

Means of technical stem length according to analysis of variance indicated that there were significant differences between all of the selection procedures for technical stem length in F_5 and F_6 generations.

The means of technical stem length for selection procedures (I.W123, I.12, I.123, I.W13, I.W12, I.W23, I.13, ICL_{5678}, ICL_{1234}, I.W3, I.W2, I.23, BV X_3 and I.W1) with values of (98.56, 98.18, 98.02, 97.96, 97.73, 97.69, 97.69, 97.58, 97.40, 97.33, 97.31, 96.78, 96.58 and 96.40), respectively, with values of (100.16, 100.16, 100.13, 100.11, 100.07, 100.07, 100.04, 100.04, 99.91, 99.64, 99.64, 97.62, 93.70 and 93.68), respectively exceeded the higher and lower yielding parent ($Sakha_6$ and $Giza_{11}$) with values of (91.87 and 90.90).

The selection indices ranked the first than the independent culling levels selection which ranked the second, and individual trait selection based on breeding value per plant ranked the third for improving technical stem length in F_5 generation. In F_6 generation, the selection indices ranked the first than the individual trait selection based on breeding value per plant which ranked the second, while independent culling levels selection ranked the third for improving technical stem length.

The results indicated that, the selection indices were more effective than the other selection procedures in improving technical stem length among F_5 and F_6 generations. The present findings are in accordance with those obtained by **Falconer, (1960), Finney (1962) and Eagles and Frey (1974)**.

Straw yield per plant(X_4):

The means obtained from all of selection procedures for improving straw yield per plant obtained by the three methods of selection showed significant differences in F_5 and F_6 generations.

Selection procedures obtained by the three methods of selection (I.W123, I.W13, I.W2, I.12, I.123, ICL_{5678}, I.W1, I.W3, I.W12, I.W23, I.23, I.13, ICL_{1234} and BV X_4), respectively, with values of (3.74, 3.57, 3.57, 3.49, 3.47, 3.44, 3.43, 3.43, 3.42, 3.41, 3.41, 3.40, 3.35 and 3.26), respectively, for improving straw yield per plant exceeded the higher and the lower yielding parent ($Sakha_6$ X $Giza_{11}$) with values of (3.16 and 2.92) in F_5 generation. While, inF_6 generation, the exceeded the higher and the lower yielding parent ($Sakha_6$ and $Giza_{11}$) with values of (90.60 and 88.90) in F_5 generation. While, in F_6 generation the selection procedures (I.W2, I.23, I.W23, I.W3, I.123, I.12, I.W123, I.W12, I.13, I.W13, I.W1, BV X_3, ICL_{5678} and ICL_{1234})

means of straw yield per plant for all selection procedures (I.W123, I.W23, I.W2, I.W3, I.23, I.W12, I.123, I.12, I.13, I.W13, I.W1, BV X_4, ICL_{1234} and ICL_{5678}), respectively, with values of (3.94, 3.90, 3.88, 3.88, 3.88, 3.87, 3.87, 3.87, 3.87, 3.84, 3.84, 3.68, 3.57 and 3.56), respectively, exceeded the higher and the lower yielding parent ($Sakha_6$) and ($Giza_{11}$)with values of (3.18 and 3.23), respectively.

The results exhibit that, the selection index ranked the first, however the independent culling levels selection ranked the second while individual trait selection based on breeding value per plant were the third for improving straw yield per plant in F_5 generation. While, in F_6 generation, results exhibit that the selection index ranked the first, however the individual trait selection based on breeding value per plant ranked the second. While independent culling levels selection was the third for improving straw yield per plant.

The results indicated that, the selection indices were more effective than other selection procedures for improving straw yield per plant in F_5 and F_6 generations. These results were in agreement with **EL-Dahan *et al*. (2017)**.

The results indicated that, the various selection procedures differed in their ranking sequence for means of fiber yield per plant and its components over the two generations, this may be due to the interaction between the genotype selected by different procedures and the environment. Sometimes, the method of independent culling levels and individual trait selection based on breeding value per plant were superior in improving straw yield per plant.

These results were in agreement with **Momtaz (1970)**.

Table 7: Means of FY .TPH, TSL and STY obtained by the different selection procedures, of F_5 and F_6 segregating generation and the tow parents of the cross (Sakha$_6$ and Giza$_{11}$)

Traits	FY		TPH		TSL		STY	
Generation	F_5	F_6	F_5	F_6	F_5	F_6	F_5	F_6
BV	0.55	0.60	123.98	127.24	96.58	97.62	3.26	3.68
ICL1234	0.56	0.57	124.84	121.65	97.40	93.68	3.35	3.57
ICL5678	0.55	0.57	118.24	121.70	97.58	93.70	3.44	3.56
I.W123	0.58	0.61	127.16	129.58	98.56	100.04	3.74	3.94
I.W12	0.56	0.61	125.60	129.58	97.73	100.04	3.42	3.87
I.W13	0.54	0.61	125.42	129.24	97.96	99.64	3.57	3.84
I.123	0.55	0.61	125.49	129.58	98.02	100.07	3.47	3.87
I.W23	0.55	0.61	125.13	129.69	97.69	100.13	3.41	3.90
I.W1	0.56	0.61	125.11	129.24	96.40	99.64	3.43	3.84
I.W2	0.55	0.61	125.44	129.69	97.31	100.16	3.57	3.88
I.W3	0.56	0.61	125.64	129.69	97.33	100.11	3.43	3.88
I.12	0.56	0.61	125.67	129.58	98.18	100.07	3.49	3.87
I.13	0.55	0.61	125.62	129.49	97.69	99.91	3.40	3.87
I.23	0.56	0.61	125.13	129.69	96.78	100.16	3.41	3.88
P1	0.52	0.51	118.40	119.60	88.90	90.90	3.16	3.18
P2	0.54	0.53	117.90	121.44	90.60	91.87	2.92	3.23

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الكفاءة النسبية لبعض طرق الانتخاب في تحسين بعض الصفات الكمية لاثنين من هجن الكتان

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مجلة العلوم الزراعية والبيئية المستدامة

الملخص العربي

أجريت هذا التجربة بمحطة البحوث الزراعية بالجميزة في موسمين زراعيين وهما ٢٠١٩/٢٠٢٠، ٢٠٢٠/٢٠٢١ لدراسة كفاءة أساليب مختلفة من الانتخاب علي تحسين محصول الألياف من خلال الانتخاب لمحصول الألياف وثلاثة من أهم مكوناته وهي الطول الكلي والطول الفعال ومحصول القش في الجيلين الخامس والسادس لإثنين من هجن الكتان وهما (سخا ٦ X سخا ٤، سخا ٦ X جيزة ١١)، وتم اختيار بذور عدد من النباتات المتميزه في صفاتها من التراكيب الوراثية من الجيل الرابع وزراعة هذه البذور في عائلات للحصول علي الجيل الخامس والانتخاب داخل هذه العائلات وبينها لاختيار النباتات المتميزة في محصول الألياف وفي الموسم التالي تم زراعة بذور النباتات المنتخبة من عائلات الجيل الخامس وذلك للحصول علي الجيل السادس والانتخاب داخل هذه العائلات وبينها لاختيار النباتات المتميزة في صفاتها.

وتم استخدام ثلاث طرق من الانتخاب وهي:-

١. دلائل الانتخاب.
٢. الانتخاب الفردي للصفة على أساس القيمة التربوية للنبات.
٣. الانتخاب المظهري المستقل للصفة على مستويات.

وتتلخص أهم النتائج فيما يلي:-

١- أظهرت متوسطات الجيل السادس قيما أعلي من متوسطات الجيل الخامس للصفات المدروسة والتي أوضحت درجة توريث عالية الي متوسطة مع قلة الفرق بين معاملي التباين الظاهري والوراثي في كل من الهجينين حيث تشير تلك النتائج الي إمكانية استخدام هذه الصفات كعوامل انتخاب في تحسين صفة الألياف/نبات.
٢- أوضحت النتائج أن التحسين الفعلي كان أعلي من التحسين المتوقع في معظم أساليب الانتخاب المستخدمة في كلا الهجينين.
٣- لوحظ أن هناك اختلاف في ترتيب متوسطات المنتخبات في كل من الجيلين وكل من الهجينين ومن الممكن أن يكون السبب هو التفاعل بين البيئة والتراكيب الوراثية.
٤- أظهرت مقارنة كفاءة أساليب الانتخاب المختلفة أن دلائل الانتخاب كانت أكثر أساليب الانتخاب كفاءة يليها الانتخاب المظهري المستقل للصفة على مستويات ثم الانتخاب الفردي للصفة على أساس القيمة التربوية للنبات في معظم الحالات في كل من الهجينين.

من النتائج السابقه يمكن التوصيه باستخدام طريقه دلائل الانتخاب لتحسين محصول الألياف ومكوناته في الكتان وذلك لكونه الأكثر دقه وأظهر أعلي قيم محصولية مع أعلي قيم من التحسين الوراثي الفعلي.