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STRAW AND SEED YIELDS IMPROVEMENT IN FLAX VIA SELECTION FOR SOME YIELD COMPONENTS IN EARLY GENERATIONS OF SOME FLAX HYBRIDS

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ABSTRACT

The breeding materials used in this study were 40 families of flax derived from four crosses {P_1 (Giza7) **x** P_4 (S.402/3/3/10), P_2 (Giza 8) **x** P_6 (Ariane), P_3 (S.329/2/23/6) **x** P_5 (S.421/43/14/10) and P_4 **x** P_6} as well as a bulk of each cross in F_3 and F_4 generations in addition two check varieties (Sakha 1 and Sakha 2). These genotypes were grown in Randomized Complete Block Design with three replicates at Etay El-Baroud Exp. Sta., El-Beheira Governorate during the two successive seasons (2004/05 and 2005/06). The present study was aimed to compare the improvement resulting from application of independent culling levels selection (ICL) method with the hybrid bulk for straw and seed weight in early segregating generations of flax hybrids. The results obtained could be summarized as follows:

1- Using of ICL method in most cases, was more efficient in improving straw weight per plant through selection for its two important components, plant height and technical length than bulk population. Also, number of capsules per plant and 1000-seed weight could be used as selection criteria to improve seed weight per plant in both of F_3 and F_4 generations . In the meantime these traits gave low discrepancy between phenotypic coefficient of variability (PCV) and genotypic coefficient of variability (GCV) values with high heritability (H) as well as high genetic advance (GA%).
2- Also, clear wide variation was noticed between mean performances for most studied traits in F_3 and F_4 generations of the four crosses when using ICL selection method compared with other entries (the four bulk crosses and two check varieties) under study. These results indicated the amount of improvement which occurred by using this method of selection.
3- Selection for straw weight per plant and its two important components in two crosses (P_1xP_4 and P_3xP_5) as well as selection for seed weight per plant and its components in the cross (P_2xP_6) may be recommended for isolating superior genotypes characterized by high straw and seed yields in latter generations. High genetic advance with high heritability may be attributed to a high degree of additive gene effects, for these characters, hence these crosses are likely to respond to direct selection
4- Phenotypic correlation coefficients among eight characters indicated that maximization of straw weight may be obtained by selection for number of basal branches per plant, plant height and technical length. Seed weight exhibited significant positive correlation with number of capsules per plant and straw weight for all crosses. The positive correlation between straw weight and seed weight per plant, supports the evidence for the possibility of selection genotypes characterized by high straw yielding ability and simultaneous high seed potentialities (dual purpose type).

Keywords: flax, independent culling levels selection, segregating generations, correlation.

INTRODUCTION

Genetic variability together with heritability and genetic advance estimates would provide the best feature of the amount of the gain to be expected from selection (Burton, 1952 and Johnson *et al.,*1955). Miller and Rawlings (1967) stated that realizing substantial genetic advance through selection for different yield component, needs sufficient genetic variability. Katiyar *et al.,* (1974) stated that genetic coefficient of variation helps in measurement of the range of genetic diversity in a trait and provides means to compare the genetic variability in quantitative traits.

Handling of a complex character like yield is the most important consideration in flax breeding programs. Plant breeding commonly select for yield components that indirectly increase yield. Hoffman (1961), defined pedigree and bulk population breeding as the most useful methods for flax (*Linum usitatissimum* L.). Momtaz *et al.,* (1977) found that number of capsules per plant seems to be the simplest character for any flax breeder if selection is for high seed yield. Kumare and Chauhan (1982) found that 1000-seed weight and seeds per capsule may be considered simultaneous characters for selection between flax varieties. Frank and Hollosi (1985) recorded that 1000-seed weight and No. of seed per capsule have high heritability estimates and were suitable for use as selection principle for seed yield. They added that No. of capsules, No. of seeds per capsule and 1000-seed weight were all inter-correlated. For breeding high yielding flax varieties, selection can be practiced for higher No. of capsules per plant, seed index, plant height and technical length. Independent culling was made using No. of capsules per plant and seed index (Mourad, 1983 and Abo-Kaied, 2003) for improving seed yield per plant. Also, No. of basal branches, technical length and plant height could be used as selection criteria for improving straw yield per plant (Abo-Kaied, 2003 and Abo-Kaied *et al.,* 2006). Mourad (1983) found that independent culling levels selection (ICL) for straw yield and its components, plant height and No. of basal branches / plant gave seed and straw yields which did not differ significantly from selection indices or even from some mean of seed or straw yield obtained by individual trait selection based on breeding value per plant for yield and yield components in each of three flax crosses.

The major target of flax breeders is to produce high yielding varieties for each of straw, seed yields as well as high quality of both fiber and oil. Therefore, the present investigation aimed to study the magnitude of variability, heritability estimates and expected genetic advance under selection for straw, seed weight / plant and their components in the F_3 and F_4 flax generations in some hybrids of flax. These parameters were used to compare the improvement resulting from application of ICL method with the bulk hybrid for straw and seed weight in early segregating generations of some flax hybrids.

MATERIALS AND METHODS

In an earlier study (Zahana,2003) fifteen hybrids derived from crossing between six parental genotypes (P_1 = Giza 7, P_2 = Giza 8, P_3 = S.329/2/23/6, P_4 = S.402/3/3/10, P_5 = S.421/43/14/10 and P_6 = Ariane) of flax, using a half diallel mating system, were utilized to estimate, combining ability and type of gene action in F_1 generation. Four {C_1 (P_1 x P_4), C_2 (P_2 x P_6), C_3 (P_3 x P_5) and C_4 (P_4 x P_6)} out of fifteen crosses, showed high breeding potentialities.

In 2003/04 season, the F_1 seed bulk of the four crosses were grown at Giza Res. Sta. of Agric Res. Center in order to evaluate their F_2 progenies. At harvest, 200 guarded plants were taken from each cross to study straw and seed weight per plant as well as their components characters. Selection was practiced within each of the four F_2 progenies using plant height, technical length, number of capsules per plant and 1000-seed weight as selection criteria with 5% selection intensity.

In the method of Independent Culling Levels (ICL), a certain level of merit was established for each trait, and all individuals below that level are discarded regardless of the superiority or inferiority of their other traits, Hazel and Lush (1942). The level of merit for each individual trait was estimated as the mean of that trait plus one standard deviation. The levels of merit for different traits in F_2 and F_3 generations of the four flax crosses under study were as follows:

Table1: Minimum levels of selection for the different traits by ICL method in F_2 and F_3 generations of the four flax crosses.

Crosses	Plant height (cm)		Technical length (cm)		No. of Capsules / plant		1000 – seed weigh (g)	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
C_1= (P_1xP_4)	88.70	94.02	67.70	76.37	29.80	30.54	7.07	7.82
C_2= (P_2xP_6)	90.50	98.10	69.70	75.65	26.74	32.90	9.05	9.59
C_3= (P_3xP_5)	85.00	92.12	65.40	73.84	27.50	29.81	9.24	9.77
C_4= (P_4xP_6)	97.10	113.92	75.70	88.04	21.71	20.93	7.51	7.59

In 2004/05 season, 40 F_3 families and F_3 bulk of each cross as well as two check commercial varieties (Sakha 1 and Sakha 2), were grown in Randomized Complete Block Design (RCBD) with three replicates at Etay El-Baroud Exp.Sta., El-Beheira Governorate. Each block contained 46 entries. A plot consisted of 3 rows for each F_3 family and 3 rows for each parent. Rows were 3 m long and 20 cm apart. Spacing within row was 5 cm. Selection was practiced within F_3 families of each cross in the same way as that followed in F_2.

In 2005/06 season, 40 F_4 families and F_4 bulk of each cross as well as two check commercial varieties were grown in RCBD with 3 replication at Etay El-Baroud Exp.Sta. Plot size, row length and spacing between and within rows were the same as F_3 generation. The normal recommended agronomic practices for flax cultivation were applied in both generations.

At harvest, 60, 60 and 20 plants from ICL selection procedures, F_3, F_4 crosses and two check commercial varieties, respectively were sampled to measure straw weight per plant, plant height, technical length, number of basal branches per plant, seed weight per plant, number of capsules per plant, 1000-seed weight and number of seeds per capsule.

Statistical analysis:

Data were subjected to regular analysis of variance of RCBD according to Snedecor and Cochran (1980). The expected genetic advance from selection (GA) in both F_3 and F_4 generations was calculated for each trait according to Allard (1960) using the following formula:

$GA = K\ \sigma_{ph}.\ H$ where:

K is the selection differential at 5% intensity = 2.06, σ_{ph} is the square root of the phenotypic variance (standard deviation) and H is the heritability in broad sense, $\{(\sigma^2_g/\sigma^2_{ph}) \times 100\}$ for the character being evaluated. The phenotypic (PCV) and genotypic (GCV) coefficient of variation for families in each generation was computed as $(\sigma_{ph} \times 100)/\bar{x}$ and $(\sigma_g \times 100)/\bar{x}$, where σph is the square root of the phenotypic variance of families, σ_g is square root of genotypic variance of families and $\bar{x}$ is the general mean of families. Estimates of standard phenotypic correlation coefficients (r) among all possible pairs of studied traits were computed by using mean data of 40 families selected by ICL method from four crosses (C_1:C_4) in F_4 generation only.

RESULTS AND DISCUSSION

Straw weight per plant and its components:

Analysis of variance showed that mean squares due to entries (40 families selected by ICL method belong to four promising crosses, four bulk crosses and two check commercial varieties, Sakha 1 and Sakha 2) in F_3 and F_4 generations were significant for straw weight / plant and its two important components, plant height and technical length as presented in Table 2.

Table 2. Mean squares from ANOVA for straw weight and its components of F_3 and F_4 families of four crosses from ICL selection method (C_i), bulk crosses (bulk C_i) and two check commercial varieties (Sakha 1 and Sakha 2).

Genotypes		Straw weight Per plant (g)		Plant height (cm)		Technical Length (cm)		No. of basal branches	
		MS g	MS e	MS g	MS e	MS g	MS e	MS g	MS e
C_1	F_3	10.224**	0.202	433.168**	18.045	127.592**	4.385	0.441**	0.173
	F_4	7.563**	0.292	313.671**	49.234	111.171**	28.497	0.229**	0.096
C_2	F_3	6.326**	0.757	143.296**	11.664	62.728**	5.874	0.309**	0.096
	F_4	2.254**	0.506	40.973**	1.796	59.491**	2.216	0.264**	0.013
C_3	F_3	4.628**	0.576	128.133**	14.536	100.783**	17.197	0.157*	0.083
	F_4	2.241**	0.204	174.831**	1.846	86.200**	1.352	0.264**	0.119
C_4	F_3	6.201**	0.932	156.331**	9.631	51.248**	7.728	0.156**	0.046
	F_4	2.162**	0.505	141.068**	1.642	68.996**	2.405	0.107**	0.040
Bulk C_1	F_3	4.759**	0.577	79.210**	10.576	24.296**	10.469	0.327	0.295
	F_4	7.023**	0.614	249.358**	32.282	73.937**	33.582	0.214	0.186
Bulk C_2	F_3	3.407**	0.607	53.751**	9.239	59.427**	5.564	0.148**	0.067
	F_4	10.194**	0.784	14.345**	6.143	27.385**	6.002	0.397**	0.195
Bulk C_3	F_3	4.111**	0.480	134.054**	14.445	103.022**	13.034	0.149*	0.079
	F_4	5.523**	0.375	75.380**	12.635	18.105**	3.972	0.104	0.093
Bulk C_4	F_3	6.366**	0.860	89.629**	9.105	34.617**	5.837	0.225	0.194
	F_4	2.183**	0.681	109.717**	21.610	59.549**	28.059	0.141	0.117
Sakha 1	F_3	2.745**	0.087	252.923**	17.753	84.192**	4.826	0.042**	0.018
	F_4	3.877**	0.311	192.275**	15.932	68.560**	6.846	0.059**	0.032
Sakha 2	F_3	0.384**	0.021	116.205**	14.514	61.974**	10.904	0.103**	0.055
	F_4	1.081**	0.177	126.021**	20.123	64.580**	7.176	0.101**	0.056

***, ** : Indicate significant and highly significant, respectively.**

The results indicated that these entries showed reasonable degree of variability for these characters. On the other hand, mean square due to no. of basal branches / plant was significant for most entries except both of bulk C_1 (Giza 7 **x** S.402/3/3/10) and bulk C_2 (Giza 8 **x** Ariane) in both F_3 and F_4 generations as well as bulk C_3 (S.329/23/6 **x** S.421/43/14/10) in F_4 only, indicating low genetic variability among these bulk crosses for this character. Such variability among different flax genotypes in straw weight and its components was also reported by Abo El-Zahab *et al.,* 1994; Abo El-Zahab and Abo-Kaied, 2000; Abo-Kaied, 2003 and Abo-Kaied *et al*., 2006.

Data in Table 4 showed that the mean performances of F_3 and F_4 families which belonged to the four crosses by using ICL were higher than means of the bulk cross and also were higher than the two check varieties, Sakha 1 and Sakha 2 for straw weight and its components. Also, the clear wide variation between means performances of F_3 and F_4 generations was obtained for the four crosses which are using ICL selection method when compared with other entries under study. These results, indicated the amount of improvement which occurred by using this method of selection.

The range of entry means (Table 4) showed wide variation either for each cross under selection or bulk cross for all studied characters in both generations. This indicated the presence of superior segregates in each cross and bulk cross in this breeding material.

Variability for each entry, estimated by phenotypic (PCV) and genotypic (GCV) coefficients of variability, reached maximum values for straw weight / plant of C_1 and bulk C_1, followed by number of basal branches of C_1 and bulk C_2, plant height of C_1 and bulk C_1 and technical stem length of C_1 and bulk C_3 for both F_3 and F_4 progenies. The observed narrow range between PCV and GCV, which gave almost similar values for the four crosses under selection by ICL method (C_1 to C_4) followed by the four bulk crosses was mainly due to genetic differences as evidenced for high broad sense heritability for most studied traits in both F_3 and F_4 generations. These results indicated the possibility of using these yield traits in selection index with give more weight for plant height and technical length for improving straw weight / plant. Also, these results reflect the importance of selection for these traits which gave high heritability estimates. This conclusion may be supported by evidences that yield components traits are genetically controlled, Abo El-Zahab *et al.* (1994), El-Hariri *et al.* (2002a) and Abo-Kaied (2003). In contrast, the wide range observed between PCV and GCV with moderate or low broad sense heritability for no. of basal branches / plant in F_3 and F_4 generations, indicated that the genetic variability was exhausted quickly in the early segregating generations. Therefore, flax breeders oughtn't use this trait in selection for improving straw weight / plant. These results are in partial agreement with those reported by Mourad,1983; Abo El-Zahab *et al.,*1994 and Abo-Kaied,2003.

Johnson *et al.,* (1955) stated that high heritability does not always mean greater genetic gain. Since heritability in broad sense involving both additive and non-additive gene effects it will be reliable only if accompanied by high genetic advance (Ramanujan and Thirumalachari, 1967).

On the other hand, an association of high heritability along with high genetic advance is indicative of additive gene effects and consequently a high genetic gain from selection would be anticipated. Dixit *et al.* (1970) stated that high heritability was not always associated with high genetic advance, but to make effective selection, high heritability should be coupled with high genetic gain. According to Burton (1952) the genotypic coefficient of variability together with heritability estimate would give the best indication of the amount genetic advance to be expected from selection. Data in Table 4 showed that C_1 followed by bulk C_1 for straw weight / plant, C_1 followed by C_3 for plant height, C_3 followed by C_1 and C_2 for technical length and finally C_2 followed by bulk C_2 for no. of basal branches / plant gave slight discrepancy between PCV and GCV values with high heritability as well as high genetic advance (GA%) expressed as percentage of the general mean. These results obtained for the above mentioned entries, support the view that the expected gain from selection would be valid and that a substantial improvement for these variables could be expected by selecting the superior genotypes. In general, C_1 for straw weight and its two important components (plant height and technical length) and C_3 for plant height and technical length showed high heritability (H) coupled with high genetic advance (GA%) as well as narrow range between PCV and GCV. So, the high expected gain may be attributed to a high degree of additive gene effects. Therefore, the two crosses (C_1 and C_3) may be recommended for isolating superior inbred lines for these traits in later generations. The association between high heritability and high genetic advance was already reported for straw weight (Abo El-Zahab *et al.,* 1994) and for both plant height and technical length (El-Hariri *et al.*, 2002b). Generally, the application of independent culling level selection (ICL) method in most cases were more efficient in improving straw weight through using the two important components (plant height and technical length) through selection of straw weight than bulk population. This conclusion is in harmony with that reported by Mourad, 1983 and Abo-Kaied, 2003.

Seed weight per plant and its components:

Analysis of variance showed significant mean squares due to entries (forty families selected by ICL from four crosses, the same four bulk crosses and two check commercial varieties, Sakha 1 and Sakha 2) in F_3 and F_4 generations for seed weight and its important components, No. of capsules / plant, 1000-seed weight and No. of seeds / capsule for most entries (Table3). In contrast, mean squares were not significant for each of bulk C_1 for no. of capsules in F_4 in addition to No. of seeds / capsule in F_3 and F_4, bulk C_3 for No. of seeds / capsule in F_4 only, bulk C_4 for No. of seeds / capsule in F_3 and F_4 as well as 1000-seed weight in F_3 only, Sakha 1 for No. of capsules / plant in F_4 and finally Sakha 2 for No. of capsules in both F_3 and F_4 generations.

Data in Table (5) showed that the bulk of C_3 (S.329/23/6 **x** S.421/43/14/10) followed by C_2 (Giza8 **x** Ariane) and C_4 (S.402/3/3/10 **x** Ariane) gave high mean performances for both seed weight / plant and No. of capsules / plant in both F_3 and F_4 generations. C_2 followed by C_3 in F_4 gave high mean performances for 1000-seed weight. However, the cross C_4

followed by C_2 exhibited highly means performances for No. of seeds / capsule in F_4.

Table 3. Mean squares from ANOVA for seed weight and its components of F_3 and F_4 families of four crosses from ICL selection method (C_i), bulk crosses (bulk C_i) and two check commercial varieties (Sakha 1 and Sakha 2).

Genotypes		Seed weight Per plant (g)		No. of capsules Per plant		1000- seed weigh (g)		No. of seeds Per capsule	
		MS g	MS e	MS g	MS e	MS g	MS e	MS g	MS e
C_1	F_3	1.299**	0.049	293.091**	14.552	1.918**	0.137	1.575**	0.504
	F_4	2.005**	0.070	388.332**	26.096	1.857**	0.182	2.365**	0.125
C_2	F_3	1.334**	0.161	229.349**	33.514	1.857**	0.182	2.472**	0.098
	F_4	1.774**	0.068	246.564**	22.603	5.185**	0.248	0.374**	0.044
C_3	F_3	0.695**	0.196	157.649**	43.482	1.408**	0.135	1.982**	0.285
	F_4	0.961**	0.034	218.893**	43.860	1.646**	0.068	1.576**	0.475
C_4	F_3	0.285**	0.061	383.577**	73.569	0.471**	0.114	0.918**	0.296
	F_4	1.203**	0.047	261.554**	95.485	0.871**	0.047	0.240**	0.081
Bulk C_1	F_3	0.178**	0.016	78.978**	23.311	2.163**	0.064	0.639	0.941
	F_4	0.549**	0.055	40.726	33.224	2.155**	0.042	1.061	0.704
Bulk C_2	F_3	1.229**	0.111	332.787**	42.560	1.750**	0.168	1.145**	0.385
	F_4	0.610**	0.085	194.328**	21.388	1.878**	0.216	1.360*	0.180
Bulk C_3	F_3	0.832**	0.135	166.488**	28.388	0.464**	0.115	1.671	0.392
	F_4	0.411**	0.027	154.170**	25.520	0.966**	0.107	1.414**	0.797
Bulk C_4	F_3	0.198**	0.052	113.285**	44.679	0.529	0.363	1.073	0.717
	F_4	0.494**	0.016	139.457**	43.800	2.015**	0.354	0.331	0.715
Sakha 1	F_3	0.178**	0.063	13.958**	3.349	0.458**	0.019	0.602**	0.248
	F_4	0.055**	0.013	5.893	2.833	0.119**	0.028	0.497**	0.141
Sakha 2	F_3	0.009**	0.002	14.898	9.096	0.581**	0.029	0.783*	0.301
	F_4	0.095**	0.016	5.694	2.704	0.504**	0.034	0.547**	0.178

***, ** : Indicate significant and highly significant, respectively.**

The range of entry means (Table 5) revealed wide variation for the four crosses (C_1 : C_2) under selection followed by four bulk crosses and two check varieties for seed weight and its components in both F_3 and F_4 generations. This indicated the presence of superior segregates in each cross and bulk cross in the breeding material.

Estimates of phenotypic (PCV) and genotypic (GCV) coefficient of variability, heritability (H) as well as genetic advance (GA%) for seed weight and its components are presented in Table 5.The highest values with wide range between PCV and GCV estimates were recorded for the four crosses (C_1 : C_4) followed by bulk of crosses and two check varieties for all studied characters. High coefficient of variation for these characters is indicative of high magnitude of variability present in these materials for seed weight / plant and its components. Also, the high values of GCV was also reflected in the values of observed ranges for these traits, indicated that it is possible to achieve further improvement by selection.

High heritability values and high GA% with almost similar estimates of PCV and GCV in both F_3 and F_4 generations were observed in C_1 followed by

C_2 and C_3 for seed weight / plant, C_1 followed by C_2 and bulk C_2 for No. of capsules / plant and C_2 followed by bulk C_1 and C_3 for 1000-seed weight.

On the other hand, wide or moderate range between PCV and GCV with moderate or low broad sense heritability could be observed for No. of seeds / capsule of most entries under study except C_2 followed by C_1 and C_3 gave low discrepancy between PCV and GCV values with high heritability. These results, indicated that a high expected gain may be attributed to a high degree of additive gene effects, for these characters, hence these crosses are likely to respond to direct selection. On the other hand, No. of seeds per capsule and in most cases in both F_3 and F_4 generations exhibited low heritability values, indicating that selection for this trait on individual plant basis would not be effective.

The cross (C_2) showed high heritability and high genetic advance for all seed components which indicate that most probably the heritability is due to additive gene effects (Pause,1957). The present results are in partial agreement with those reported by Abo-Kaied, 2003. Generally, the cross C_2 (Giza 8 x Ariane) may be recommended for isolating superior genotypes for seed weight and its components in later generations.

It could be concluded that application of independent culling levels selection (ICL) method using, No. of capsules per plant and 1000-seed weight was more efficient in improving seed weight (Table 5). This result was in agreement with that obtained by Mourad, 1983 and Abo-Kaied, 2003. Who reported that, the ICL method for seed yield and its components were recommended to improve both seed and straw yields.

Correlation studies:

Phenotypic correlation coefficients among eight characters using the data of 40 families selected by ICL method derived from four crosses in F_4 generation are shown in Table 6.

Significant positive correlations were obtained for straw weight with number of basal branches / plant, seed weight and number of capsules / plant in all crosses (C_1:C_4) as well as with plant height of C_1, C_2 and C_4 and with technical length of C_1, C_3 and C_4 and finally with No. of seeds / capsule of C_2 only. These results, indicated that maximization of straw weight / plant may be obtained by selection for the above mentioned traits specially No. of basal branches, plant height and technical length. Also, the positive correlation between straw weight and seed weight per plant, supports the evidence for the possibility of isolating genotypes characterized with high straw yielding ability and simultaneous high seed potentialities. Also, plant height exhibited positive correlation with technical length for all crosses as well as with No. of capsules for C_2 only. While, No. of basal branches exhibited positive correlation with both of seed weight and No. of capsules in most crosses. Similar results were reported by Momtaz, 1965; Mourad, 1983 and Abo-Kaied *et al.,*2006, reported highly significant positive correlation between straw weight and seed weight / plant. Therefore, the crosses (C_1:C_4) may be recommended for isolating superior genotypes for straw and seed weights in later generations.

Table 4. Mean performance. range, phenotypic (PCV) and genotypic (GVC) coefficient of variability, broad sense heritability (H) and expected genetic advance from selection (GA%) for straw weight / plant and its components of F_3 and F_4 families of four crosses from ICL selection method (C_i), bulk crosses (bulk C_i) and two check commercial varieties (Sakha 1 and Sakha 2).

Genotypes	Mean		Range		P.C.V.		G.C.V.		H		GA %	
Straw weight / plant (g)												
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
C.1	5.30	7.22	2.46 - 7.32	3.76 - 9.69	34.85	21.99	34.51	21.57	98.03	96.14	70.38	43.56
C.2	6.94	9.22	4.14 - 9.78	7.20 - 11.40	20.92	9.40	19.63	8.28	88.04	77.56	37.94	15.02
C.3	4.99	7.64	2.55 - 8.02	5.78 - 9.53	24.90	11.31	23.30	10.79	87.56	90.92	44.91	21.19
C.4	6.11	8.35	3.12 - 9.28	6.73 - 10.45	23.55	10.16	21.71	8.90	84.98	76.66	41.22	16.05
Bulk C.1	5.44	5.17	3.44 - 9.10	2.30 - 9.38	23.16	29.61	21.71	28.28	87.87	91.25	41.91	55.66
Bulk C.2	6.09	6.80	4.04 - 8.76	4.14 - 9.75	17.50	27.11	15.86	26.05	82.17	92.31	29.62	51.56
Bulk C.3	5.11	5.75	2.50 - 8.02	2.55 - 8.19	22.89	23.60	21.52	22.78	88.33	93.20	41.66	45.31
Bulk C.4	5.77	6.80	3.12 - 9.28	4.30 - 9.31	25.23	12.54	23.47	10.40	86.49	68.81	44.96	17.77
Sakha 1	4.98	4.76	2.77 - 5.66	2.77 - 6.00	19.22	23.89	18.91	22.91	96.82	91.97	38.34	45.26
Sakha 2	4.12	4.36	2.81 - 4.39	2.81 - 6.00	8.68	13.76	8.44	12.58	94.64	83.64	16.92	23.70
Plant height (cm)												
C.1	94.02	96.15	67.20 - 116.00	81.00 - 119.00	12.78	10.64	12.51	9.76	95.83	84.30	25.23	18.47
C.2	93.10	108.54	83.00 - 112.00	101.80 - 116.20	7.42	3.40	7.11	3.33	91.86	95.62	14.05	6.71
C.3	90.12	112.53	77.80 - 106.00	101.20 - 130.60	7.25	6.78	6.83	6.75	88.66	98.94	13.24	13.83
C.4	113.92	124.09	97.60 - 135.00	108.60 - 133.40	6.34	5.53	6.14	5.49	93.84	98.84	12.25	11.25
Bulk C.1	87.83	91.95	67.21 - 99.25	67.20 - 118.80	5.85	9.91	5.45	9.25	86.65	87.05	10.44	17.78
Bulk C.2	88.51	91.47	80.00 - 96.99	84.40 - 99.80	4.78	2.39	4.35	1.81	82.81	57.18	8.16	2.82
Bulk C.3	84.52	97.55	71.60 - 99.00	85.20 - 122.60	7.91	5.14	7.47	4.69	89.22	83.24	14.54	8.81
Bulk C.4	107.58	102.92	90.60 - 120.00	86.60 - 113.40	5.08	5.88	4.82	5.27	89.84	80.30	9.40	9.72
Sakha 1	106.84	109.85	85.50 - 121.00	85.60 - 123.00	8.59	7.29	8.29	6.98	92.98	91.71	16.46	13.77
Sakha 2	106.49	107.37	88.25 - 116.16	88.20 - 117.66	5.84	6.04	5.47	5.53	87.51	84.03	10.54	10.45
Technical length (cm)												
C.1	76.37	79.83	69.00 - 89.00	70.80 - 96.00	8.54	7.63	8.39	6.58	96.56	74.37	16.99	11.68
C.2	75.65	82.42	69.80 - 90.40	73.00 - 91.20	6.04	5.40	5.75	5.30	90.64	96.28	11.29	10.72
C.3	73.84	87.74	63.60 - 88.80	81.60 - 99.40	7.85	6.11	7.15	6.06	82.94	98.43	13.41	12.39
C.4	88.04	94.27	73.20 - 97.20	84.60 - 101.20	4.69	5.09	4.33	5.00	84.92	96.51	8.21	10.11
Bulk C.1	73.50	77.99	69.00 - 91.23	69.00 - 93.80	3.87	6.37	2.92	4.70	56.91	54.58	4.54	7.16
Bulk C.2	71.35	68.73	65.50 - 86.10	60.20 - 79.20	6.24	4.40	5.94	3.88	90.64	78.08	11.65	7.07
Bulk C.3	67.98	75.20	57.00 - 80.80	73.00 - 91.40	8.62	3.27	8.06	2.89	87.35	78.06	15.51	5.25
Bulk C.4	82.19	85.10	66.80 - 90.20	70.00 - 95.00	4.13	5.24	3.77	3.81	83.14	52.88	7.08	5.70
Sakha 1	81.22	83.29	67.30 - 92.79	66.60 - 88.00	6.52	5.74	6.33	5.45	94.27	90.01	12.67	10.64
Sakha 2	84.83	85.64	72.00 - 92.75	70.00 - 95.55	5.36	5.42	4.86	5.11	82.41	88.89	9.10	9.92
No. of basal branches / plant												
C.1	1.85	1.56	0.40 - 2.60	1.00 - 2.20	20.68	17.70	16.13	13.49	60.79	58.10	25.90	21.18
C.2	1.69	2.20	1.00 - 2.80	1.80 - 2.80	18.94	13.48	15.73	13.14	68.95	95.06	26.91	26.39
C.3	1.82	1.78	1.20 - 2.60	0.92 - 2.62	12.58	16.70	8.62	12.38	46.94	54.96	12.16	18.91
C.4	1.48	1.62	0.80 - 2.00	1.20 - 2.20	15.43	11.62	12.98	9.17	70.74	62.27	22.48	14.90
Bulk C.1	1.81	1.63	0.50 - 2.20	0.40 - 2.20	18.27	16.39	5.68	5.90	9.66	12.99	3.64	4.38
Bulk C.2	1.42	1.67	1.00 - 2.20	1.00 - 2.40	15.62	21.74	11.55	15.52	54.73	50.98	17.61	22.83
Bulk C.3	1.82	1.87	1.20 - 2.60	1.04 - 2.60	12.24	9.92	8.39	3.18	46.94	10.26	11.84	2.10
Bulk C.4	1.70	1.78	1.10 - 2.50	1.00 - 2.60	16.16	12.23	6.03	5.10	13.92	17.40	4.63	4.38
Sakha 1	1.73	1.72	1.11 - 1.98	1.23 - 2.00	6.81	8.16	5.14	5.54	56.96	46.12	8.00	7.75
Sakha 2	1.74	1.65	0.80 - 1.98	0.80 - 2.20	10.66	11.11	7.32	7.37	47.18	44.07	10.36	10.08

Table 5. Mean performance. range, phenotypic (PCV) and genotypic (GVC) coefficient of variability, broad sense heritability (H) and expected genetic advance from selection (GA%) for seed weight / plant and its components of F_3 and F_4 families of four crosses from ICL selection method (C_i), bulk crosses (bulk C_i) and two check commercial varieties (Sakha 1 and Sakha 2).

Genotypes	Mean		Range		P.C.V.		G.C.V.		H		GA %	
Seed weight / plant (g)												
	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4	F_3	F_4
C.1	1.56	1.65	0.62 - 2.86	0.45 - 3.22	42.14	49.41	41.34	48.54	96.23	96.52	83.55	98.24
C.2	1.77	2.44	0.39 - 3.28	1.74 - 4.17	37.60	31.52	35.25	30.91	87.91	96.17	68.08	62.44
C.3	1.87	2.61	0.53 - 2.98	1.60 - 3.48	25.71	21.68	21.78	21.29	71.76	96.45	38.01	43.07
C.4	1.59	2.44	1.02 - 2.41	1.40 - 3.53	19.37	25.99	17.16	25.48	78.52	96.13	31.33	51.47
Bulk C.1	1.15	1.01	0.62 - 1.65	0.45 - 2.73	21.14	42.20	20.20	40.03	91.24	89.97	39.74	78.22
Bulk C.2	1.64	1.73	0.39 - 2.73	0.80 - 2.50	39.03	26.10	37.22	24.21	90.95	86.04	73.12	46.26
Bulk C.3	1.64	1.57	0.53 - 2.98	0.75 - 2.26	32.15	23.53	29.43	22.75	83.81	93.41	55.51	45.28
Bulk C.4	1.55	1.53	1.02 - 2.41	0.91 - 2.30	16.52	26.51	14.18	26.08	73.64	96.74	25.06	52.84
Parent1	1.15	1.26	0.90 - 2.10	1.07 - 2.10	21.18	10.71	17.01	9.34	64.47	75.97	28.13	16.77
Parent2	1.37	1.41	1.20 - 1.60	1.23 - 2.00	3.97	12.67	3.41	11.53	73.71	82.73	6.03	21.59
No. of capsules / plant												
C.1	26.54	27.53	14.20 - 53.54	11.37 - 52.97	37.24	41.32	36.30	39.91	95.04	93.28	72.90	79.40
C.2	29.90	37.19	12.12 - 56.36	21.31 - 57.95	29.24	24.37	27.02	23.23	85.39	90.83	51.44	45.61
C.3	29.81	40.77	12.21 - 54.81	18.10 - 60.78	24.32	20.95	20.69	18.74	72.42	79.96	36.27	34.51
C.4	33.93	40.16	16.65 - 71.30	20.64 - 77.30	33.33	23.25	29.96	18.53	80.82	63.49	55.49	30.41
Bulk C.1	22.98	21.65	12.40 - 41.19	10.95 - 39.95	22.33	17.02	18.75	7.31	70.48	18.42	32.42	6.46
Bulk C.2	28.57	28.52	7.93 - 56.80	9.81 - 48.81	36.86	28.22	34.43	26.62	87.21	88.99	66.23	51.73
Bulk C.3	27.04	27.80	10.25 - 54.81	10.22 - 51.95	27.55	25.79	25.09	23.56	82.95	83.45	47.07	44.33
Bulk C.4	33.44	30.07	16.77 - 62.39	15.75 - 46.96	18.37	22.68	14.30	18.78	60.56	68.59	22.92	32.04
Sakha 1	19.49	18.40	13.05 - 26.45	13.22 - 21.27	11.07	7.62	9.65	5.49	76.01	51.93	17.33	8.15
Sakha 2	21.54	22.34	13.00 - 23.50	13.05 - 23.81	10.34	6.17	6.46	4.47	38.95	52.50	8.30	6.67
1000-seed weight (g)												
C.1	7.82	9.19	6.51 - 9.00	7.73 - 11.48	10.22	8.56	9.85	8.13	92.84	90.19	19.55	15.91
C.2	9.19	11.70	7.73 - 11.48	8.26 - 13.54	8.56	11.24	8.13	10.96	90.19	95.21	15.91	22.04
C.3	9.76	11.20	8.18 - 11.22	9.50 - 12.47	7.02	6.61	6.68	6.47	90.44	95.85	13.08	13.05
C.4	6.89	9.56	6.32 - 8.02	8.60 - 10.40	5.75	5.63	5.00	5.48	75.72	94.56	8.97	10.97
Bulk C.1	7.78	8.59	6.51 - 9.00	7.13 - 10.27	10.92	9.87	10.75	9.77	97.05	98.07	21.82	19.93
Bulk C.2	9.19	9.30	7.73 - 11.11	7.63 - 11.13	8.32	8.51	7.91	8.01	90.38	88.52	15.48	15.52
Bulk C.3	9.41	9.40	8.11 - 10.41	8.18 - 10.84	4.18	6.04	3.62	5.69	75.22	88.93	6.47	11.06
Bulk C.4	7.18	7.35	6.12 - 8.74	6.32 - 9.96	5.85	11.15	3.28	10.12	31.35	82.43	3.78	18.93
Sakha 1	9.07	9.23	7.44 - 9.47	8.91 - 9.61	4.31	2.16	4.21	1.88	95.77	76.28	8.50	3.39
Sakha 2	9.58	9.60	8.20 - 9.86	8.23 - 9.97	4.60	4.27	4.48	4.12	94.95	93.33	8.99	8.21
No. of seeds/capsule												
C.1	6.20	6.42	4.60 - 7.90	4.50 - 7.81	11.68	13.82	9.63	13.45	67.98	94.71	16.36	26.97
C.2	6.43	6.87	4.56 - 7.80	6.20 - 7.70	14.12	5.14	13.84	4.83	96.05	88.34	27.94	9.35
C.3	6.51	6.25	5.30 - 8.30	4.10 - 8.35	12.49	11.60	11.56	9.70	85.63	69.88	22.04	16.70
C.4	6.91	7.11	5.40 - 7.80	6.50 - 7.80	8.01	3.98	6.59	3.24	67.76	66.38	11.18	5.44
Bulk C.1	6.47	6.72	4.12 - 7.70	4.10 - 8.57	9.20	8.85	5.29	5.13	33.10	33.64	6.27	6.13
Bulk C.2	6.15	6.35	4.13 - 8.70	5.00 - 7.80	10.04	8.10	8.18	5.02	66.36	38.39	13.72	6.40
Bulk C.3	6.46	6.21	4.20 - 8.30	4.10 - 8.10	9.14	11.07	4.83	7.31	27.94	43.61	5.26	9.94
Bulk C.4	6.51	6.45	4.20 - 7.80	4.80 - 7.81	9.19	7.74	5.29	4.40	33.15	32.32	6.28	5.15
Sakha 1	7.05	6.98	5.92 - 8.50	5.52 - 8.52	6.35	5.83	4.87	4.94	58.82	71.68	7.70	8.61
Sakha 2	6.40	6.72	5.45 - 8.03	5.30 - 7.80	7.99	6.36	6.27	5.22	61.55	67.36	10.13	8.82

Table 6. Phenotypic correlation coefficients among eight characters using data of 40 families selected by ICL method derived from four flax crosses (C_i) in F_4 generation.

Characters		Straw weight/ plant	Plant height	Technical length	No. of basal branches	Seed weight /plant	No. of Capsules /plant	1000-seed weight
Plant height	C.1	0.615**						
	C.2	0.295*						
	C.3	-0.210						
	C.4	0.268*						
Technical length	C.1	0.271*	0.271*					
	C.2	-0.110	0.889**					
	C.3	-0.310*	0.750**					
	C.4	0.280*	0.859**					
No. of basal Branches per plant	C.1	0.718**	0.718**	-0.188				
	C.2	0.261*	-0.284	-0.294*				
	C.3	0.308*	-0.251	-0.032				
	C.4	0.287*	-0.657	-0.652**				
Seed weight Per plant	C.1	0.729**	0.021	-0.286*	0.840**			
	C.2	0.597**	-0.113	-0.283*	0.715**			
	C.3	0.820**	-0.607**	-0.665**	0.222			
	C.4	0.364**	-0.617**	-0.659**	0.911**			
No. of capsules Per plant	C.1	0.953**	0.118	-0.257*	0.795**	0.953**		
	C.2	0.469**	0.255*	0.034	0.367**	0.640**		
	C.3	0.851**	-0.303*	-0.463**	-0.019	0.906**		
	C.4	0.342**	-0.542**	-0.571**	0.816**	0.864**		
1000-seed weight	C.1	0.255*	-0.552**	-0.322*	-0.307*	0.315*	0.423**	
	C.2	-0.050	-0.414**	-0.340*	0.321*	0.251*	0.519**	
	C.3	-0.240	-0.532**	-0.102	0.548**	0.324*	0.405**	
	C.4	0.030	-0.118	-0.074	0.178	0.245	-0.236	
No. of seeds Per capsule	C.1	-0.04	0.133	0.342**	-0.071	-0.039	-0.262*	-0.585**
	C.2	0.357**	0.055	0.033	-0.060	0.313*	-0.152	0.165
	C.3	0.100	-0.232	-0.498**	0.184	0.159	-0.019	0.019
		70	-0.099	-0.208	0.117	0.080	-0.116	0.100

***, **: Indicate significant and highly significant, respectively.**

Seed weight exhibited significant positive correlation with number of capsules per plant and straw weight for all crosses. Whereas, this trait showed positive correlation with 1000-seed weight for C_1, C_2 and C_3 only. In contrast, it showed negative association with technical length for all crosses and with plant height for C_3 and C_4 only. These results are in harmony with that reported by Mourad,1983; Abo El-Zahab *et al.,* 1994 and Abo-Kaied *et al.,* 2006.

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تحسين محصولي القش والبذور بالانتخاب لبعض مكوناتهما في الأجيال المبكرة لبعض هجن الكتان

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أجريت هذه الدراسة بمحطة البحوث الزراعية بايتاي البارود– م البحيرة، علي عدد ٤٠عائلة منتخبة بطريقة الانتخاب المستقل للصفات علي مستويات (ICL) من أنسال أربعة هجن كتان ناتجة من التهجين بين ستة آباء (١=جيزة٧، ٢=جيزة٨، ٣= س٦/٢٣/٢/٣٢٩ ، ٤=س١٠/٣/٣/٤٠٢، ٥= س ١٠/١٤/٤٣/٤٢١، ٦= إريانا) بالإضافة إلى إجمالي كل هجين من الهجن السابقة (١x٤، ٢x٦ ، ٣x٥ ، ٤x٦) بالإضافة إلى الصنفين التجاريين سخا ١ ، سخا ٢ وذلك في تصميم قطاعات كاملة العشوائية ذات الثلاث مكررات في الجيلين الثالث والرابع خلال موسمي ٢٠٠٥/٢٠٠٤، ٢٠٠٦/٢٠٠٥ وذلك بهدف مقارنة التحسين الناتج عن استعمال طريقة (ICL) مع إجمالي كل هجين بالإضافة إلى الصنفين التجاريين علي محصولي القش والبذرة ومكوناتهما وذلك باستخدام عدد من المقاييس الوراثية المختلفة. وتتلخص أهم النتائج فيما يلي.

١- تشير النتائج بصفة عامة إلى أن استخدام طريقة الانتخاب المستقل للصفات علي مستويات (ICL) في معظم الحالات كان أكثر فعالية في تحسين وزن القش من خلال الانتخاب لصفتي الطول الكلي والطول الفعال ، ولتحسين محصول البذرة من خلال الانتخاب لصفتي عدد الكبسولات / نبات ووزن الألف بذرة مقارنة بإجمالي الهجن في كلا الجيلين الثالث والرابع لذلك بمكن استخدام تلك الصفات في الانتخاب لتحسين هاتين الصفتين حيث أظهرت التقدير الوراثية لتلك الصفات أقل فارق بين معاملي الاختلاف الظاهري والوراثي مع درجة توريث عالية وأعلي درجة تحسين وراثي متوقع من الانتخاب.

٢- كذلك تشير النتائج إلى التباين الواضح بين متوسطات الجيلين الثالث والرابع لمعظم الصفات تحت الدراسة للأربعة هجن التي تم ممارسة الانتخاب فيها وهذا يوضح مقدار التحسين الناتج من تطبيق طريقة (ICL) في الانتخاب.

٣- تشير النتائج إلى إمكانية عزل تراكيب وراثية مبشرة في الأجيال الانعزالية التالية من الهجينين (جيزة٧x س١٠/٣/٣/٤٠٢) ، (س٦/٢٣/٢/٣٢٩ x س١٠/١٤/٤٣/٤٢١) لتحسين محصول القش للنبات واهم مكونين من مكوناته (الطول الكلي والطول الفعال) وكذلك يمكن تحسين وزن البذور للنبات ومكوناته من خلال أنسال الهجين (جيزة٨ x إريانا)، لذلك فمن المتوقع أن تعطي الثلاث هجن هذه انعزالات متجاوزة الحدود في الأجيال المتقدمة لتلك الصفات. بالإضافة إلى أن هذه الهجن لتلك الصفات السابقة والتي أظهرت أعلي درجة تحسين وراثي متوقع من الانتخاب علاوة علي أعلي درجة توريث، مما يشير إلى أن هذه الصفات يتحكم في توريثها فعل الجينات المضيفة، لذلك يمكن ممارسة الانتخاب المباشر في تحسينها.

٤- تشير دراسة الارتباط الظاهري بين الصفات تحت الدراسة إلى أن هناك ارتباط موجب ومعنوي بين صفة وزن القش/ نبات وكلا من عدد الفروع القاعدية والطول الكلي والطول الفعال . كذلك كان هناك ارتباط موجب ومعنوي بين محصول البذور/ نبات وكلا من عدد الكبسولات ووزن ١٠٠٠ بذرة ووزن القش / نبات لكل الهجن تحت الدراسة. والارتباط الموجب بين محصولي القش والبذور/ نبات يعطي إمكانية للمربي لانتخاب تراكيب وراثية تمتاز بارتفاع كلا من وزن البذور ووزن القش / نبات (الطراز ثنائي الغرض).