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YIELD, GENETIC PARAMETERS, CORRELATION AND ANATOMY FOR SOME FLAX GENOTYPES

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ABSTRACT

Two field experiments were carried out at Giza Agric. Res. Stan, during 2017/2018 and 2018/2019 reasons to evaluate ten flax genotypes concerning yield, yield components, technological traits, genetic parameters, phenotypic correlation and anatomical studies, either in flax stems or in seeds. Results obtained can be summarize as follows: Analysis of variance revealed that the flax cultivar Giza 10 ranked first concerning plant height, technical length, fiber yield /plant as well as per faddan, long fiber% and fiber fineness characters. Meanwhile, the newly flax cultivars Giza 11 and Giza 12 achieved maximum values for number of capsules/plant as well as per faddan, oil yield/faddan and oil percentage. Phenotypic and genotypic variances were higher for fiber fineness, capsules set%, plant height, number of capsules/plant, seed index, seed yield/plant and technical length characters. Environmental variance promote low estimate for most traits except plant height and technical length which recorded slight increase. Estimates of either phenotypic or genotypic coefficient of variation (P.C.V. and G.C.V.) had high values for seed yield/ plant, seed index, number of capsules/ plant, long fiber%, capsule set%, upper branching zone length, technical length and plant height. Heritability in broad sense recorded high estimates for all studied characters except number of seeds/ capsule and upper branching zone length. Moreover, the estimates of genetic advance expected from selection were high for most of studied characters. Correlation coefficient (r) values were positive and highly significant between plant height and technical length and also between number of upper branches, and each of straw yield/ plant and straw yield/faddan, capsule set %, seed index and oil yield/ fad. Moreover, positive highly significant correlation effect was found between number of capsules/ plant and each of capsule set%, seed index, seed yield/ plant, seed yield/faddan and oil yield/ faddan. Anatomical manifestation for flax stems indicated that the cultivar Giza 10 gave the maximum fiber area/ cross section and fiber index, followed by Giza 9 and Sakha 3. Seeds of the newly flax cultivar Giza 11 and Giza 12 recorded the greatest cotyledons area and cotyledons as a percentage per the corresponding total cross section area of flax seeds. Flax variety Sakha 5 ranked third in this criterion.

Key words: ***Flax, Yield, Genetic parameters, Correlation coefficient, Anatomy, Heritability, Genetic gain.***

INTRODUCTION

Approximately 200 species of linum are known. Flax stem fiber is now being processed and used for a number of products such as linen cloth, cigarette paper, erosion control mats, reinforcing material in plastics and particle composite products. Flaxseed had some components making it beneficial for human and animals nutrition, it has a high content of alpha linolenic acid (Omega 3 fatty acid) and lignans essential protecting against cancer, heart diseases. Fresh oil (boiled oil) is beneficial for use for natural paints, printers ink and varnish. Furthermore, the wood parts of flax straw (shives) are used in making hardboard wood.

Therefore, it is necessary to increase flax productivity per unit area which could be achieved by using high yielding varieties. Flax varietal

differences, variability among various genotypes and relationship studies were reported by many investigators (Zahran *et al* (1984), Nasr El-Din *et al* (1991),

Regarding anatomical manifestation study, many workers found differences in either flax stems or seeds (El-Shimy *et al* 1993), (El-Emary *et al* 2006) and (El-Shimy *et al* 2015).

The purpose of this investigation was to evaluate ten flax genotypes including newly two cultivars for yield, yield components, and their relation to yield. Moreover, estimate genetic parameters and anatomical structure of flax stems (at the middle region) in addition to transverse sections of seeds for each flax genotype.

MATERIALS AND METHODS

Two field experiments were carried out at Giza Agric. Res. Station during the two successive seasons of 2017/2018 and 2018/2019 on Nov. 4th 2017and 6th of Nov. 2018. Table (1), illustrated the pedigree and classification for the ten flax genotypes under study.

Table 1. Pedigree and classification (dual type, D, oil type, O, Fiber type, F.) of ten flax genotypes.

No.	Genotypes	Pedigree	Classification
1	Sizar	Introduced from Netherlands	D
2	Sakha 1	I.1485 x Bombay	D
3	Sakha 2	I.2348 x Hera	D
4	Sakha 3	I.2569 x Belinka	F
5	Sakha 5	I.370 x I.2561	O
6	Sakha 6	S.2419 x Giza 8	D
7	Giza 9	S.240/ 140/ 5/ 10 x Bombay	F
8	Giza 10	420/ 140/ 5/ 10 x Bombay	F
9	Giza 11	Giza 8 X S.2419	D
10	Giza 12	S.2419 x S.148/6/1	D

The soil texture of experimental area was clay loam in both seasons. Trials were conducted in four replications using a randomized complete block design. The plot size was 2x3 meters ($6m^2$), each plot contains ten rows spaced 20 cm apart, sixty seeds were sown in each row at 5cm distance (600 seeds/ plot). The recommended agricultural practices for flax production were followed. At full maturity stage, ten guarded plants were taken at random from each plot to estimate flax yield components, in

addition to two plants that were chosen from each plot, at only the second season, to study anatomical characters. Straw, fiber and seed yield/ fad (faddan= 4200m^2) were taken on plot area basis. Oil percentage was determined as a sample of seeds from the four replications for each genotype by using Soxhlet apparatus (A.O.A.C.1995).

The following characters were recorded:

A- yield and yield components:

A-1- straw yield and related characters:

Plant height (cm), technical length (cm), upper branching zone length (cm), number of upper branches, straw yield/ plant (g), fiber yield/ plant (g), straw yield/ faddan (Ton), fiber yield / faddan (kg) retting straw / faddan (Ton), straw loss by setting %, shive (woody part of stems) per faddan (ton) and shive of retted straw %.

A-2-Seed yield and related characters:

$$\left(\frac{\text{No. of capsule/ plant}}{\text{No. of upper branches}} \times 100 \right),$$

Number of capsules/plant, capsule set%

Numbers of seeds/ capsule, seed index (1000 seeds weight in grams), seed yield/ plant (g), seed yield/ faddan (Kg) and oil yield/ faddan (Kg).

A-3-Technological characters:

Long fiber%, fiber fineness (Nm) = 20 fiberills (N) with 100mm long (L) were weighted in mg (G) and used for estimating the metrical numbers (N.m.) according as follow:

$$N.m. = \frac{N \times L}{G}$$

A- 4 oil percentage:

Analysis of variance was done according to Snedecor and Cochran (1982) and means were compared by least significant differences (L.S.D.) at 5% and 1% levels of probability in both season after testing the homogeneity of errors according to Bartlett's test. Therefore, combined analysis was performed for each character over the two seasons as described by Le-Clerg *et al* (1966).

B- Genetic parameters:

Statistical analysis was made on plot mean basis to obtain the estimates of phenotypic, genotypic and environmental variances by equating the mean sum of squares for genotypes and error.

1- Genotypic variance: (Burton and De Vane 1953 and Virk *et al* 1971)
2- Phenotypic variance it was estimated as suggested by Marher *et al* 1971 and Verma and Singh 1971).
3- Environmental variance as reported by (Mather *et al* 1971).
4- Heritability in broad sense was estimated as suggested by Hanson *et al* (1956).
5- Genetic coefficient of variation (G.C.V)
6- Phenotypic coefficient of variation (P.C.V.)
7- The genetic advance expected from selection (G.A.) according to Miller *et al* (1958).
8- G.A.% was calculated as a percentage between G.A. and the general mean (X) of each character.

C- Correlation coefficient study:

The associations among straw, fiber and seed yields with their attributes as average of the two seasons were subjected to simple correlation coefficient.

D- Anatomical manifestation study:

In the second season, at full maturity of flax plants when standing in the field, specimens were taken from the main stems at the middle region of technical length, in addition to full maturity seeds were chosen from the same plants for each genotype. After killing and fixing these samples for 36 hours by using formalin, acetic acid and alcohol (F.A.A.) solution. Paraffin wax method was used to obtain transverse sections from both stems and seeds. Stems were microtomed at 25 microns by sliding microtome, but seeds were done at 20 microns by using rotary microtome. The slides were smeared with mayer albumen solution before mounting the ribbon of transverse sections, which stained in 0.5% safranin solution to make nucleus and lignified tissues with red colour, in addition to stain these sections with 1 % light green dissolved in clove oil which gave the cytoplasm and cell wall green colour.

D-1- Stem anatomical characters:

Total cross section area (mm^2), cortex area (mm^2), fiber area (mm^2), xylem area (mm^2) and pith area (mm^2), in addition to fiber index (mm^3) which calculated from the product of fiber area (mm^2) x technical stem length (mm), these measurement represented the fiber which flax plant contain in volume (mm^3).

D-2- Seed anatomical characters:

Total cross section area (mm^2), test area (mm^2), cotyledons area (mm^2) and the percentage between cotyledons area and the corresponding total cross section area.

RESULTS AND DISCUSSION

1. Yield and yield components:

1.1 Straw yield and related characters:

Mean values of straw yield and related characters for ten flax genotypes (combined analysis over both seasons) are presented in Table (2). Data showed significant differences among all flax genotypes for studied traits. The flax variety Giza 10 ranked first and reported maximum values for plant height (102.39 cm), technical length (82.35 cm), fiber yield/ plant (0.499 g) as well as per faddan. (705.50 kg), followed by Giza 9 and Sakha 3 in this case. But Sakha 5 cultivar was the lowest in plant height (66.94 cm) and technical length (50.77 cm). Meanwhile, the newly flax cultivar Giza 11 produced the highest values in number of upper branches/plant (58.59) and straw yield/ plant (2.50 g), followed by either Giza 12 (57.92) and (2.49 g) or Sakha 3 which recorded 53.84 and 2.46 for the previous two characters, respectively. The flax variety Sakha 2 showed the highest estimates for straw yield/faddan (4.42 ton), retting straw/ faddan (3.59 ton), shive (woody part of stems) with estimate of 3.171 ton, and shive percentage of retted straw (88.86%). The lowest estimates in relation to the three traits mentioned before were obtained by Giza 10 and Giza 9. Coefficient of variability (C.V.%) estimates were relatively high for straw characters except for shive of retted straw% (4.11%) and straw yield/ plant (6.78%). Such differences among flax genotypes regarding straw yield and its components were also reported by Nasr El-Din *et al*., (1991), Mostafa (1994), Abo-kaied *et al* (2008), Hussein (2012) and El-Shimy *et al* (2015 and 2016).

Table 2. Mean values of straw yield and related characters for ten flax genotypes (combined analysis across 2017/2018 and 2018/2019seasons).

Genotypes	Plant height (cm)	Technical length (cm)	Upper branching zone length (cm)	Number of upper branches	Straw yield/ plant (g)	Fiber yield/ plant (g)
Sizar	92.87	75.49	17.38	46.61	2.15	0.188
Sakha 1	93.79	72.59	21.20	49.52	2.33	0.241
Sakha 2	84.00	61.23	22.77	53.84	2.46	0.204
Sakha 3	94.51	70.69	23.82	40.31	2.08	0.288
Sakha 5	66.94	50.77	16.08	52.23	2.40	0.217
Sakha 6	91.74	68.26	23.49	50.38	2.33	0.219
Giza 9	98.95	75.23	23.73	39.43	2.15	0.365
Giza 10	102.39	82.35	20.04	49.38	2.18	0.499
Giza 11	83.07	65.09	17.97	58.59	2.50	0.229
Giza 12	92.27	70.44	21.82	57.92	2.49	0.237
Grand mean	90.05	69.21	20.83	49.82	2.31	0.269
C.V. %	11.11	12.61	13.63	12.94	6.78	35.46
L.S.D. 5%	5.89	5.64	4.72	13.85	0.14	0.05
Genotypes	Straw yield/ fad. (ton)	Fiber yield/ fad. (Kg)	Retting straw/ fad. (ton)	Straw loss by retting %	Shive (woody part of stems/fad (ton)	Shive of retted straw %
Sizar	3.66	381.25	2.85	22.13	2.469	86.63
Sakha 1	3.99	452.35	3.44	13.78	2.988	86.86
Sakha 2	4.42	419.15	3.59	18.78	3.171	88.33
Sakha 3	3.28	514.50	2.95	10.06	2.436	82.58
Sakha 5	3.92	463.50	3.06	21.94	2.596	84.84
Sakha 6	3.70	448.75	2.75	25.68	2.301	83.67
Giza 9	3.14	549.75	2.72	13.38	2.170	79.78
Giza 10	3.47	705.50	3.11	10.37	2.404	77.30
Giza 11	4.05	455.75	3.28	19.01	2.824	86.10
Giza 12	4.11	465.00	3.37	18.00	2.905	86.20
Grand mean	3.774	485.55	3.11	17.31	2.626	84.23
C.V. %	10.57	18.53	9.67	30.38	12.50	4.11
L.S.D. 5%	0.544	31.38	0.44	2.26	0.07	4.43

1.2- Seed yield and related characters:

Mean values of seed yield and related characters for ten flax genotypes (combined analysis over both seasons) are presented in Table (3).

Results illustrated that the flax genotypes differed significantly in all the seven seed characters. The flax varieties Giza 11 and Giza 12 achieved highest number of capsules/plant (47.58 and 46.51), seed index (12.19 and 11.90 g), seed yield/plant (3.36 and 3.26 g), seed yield/ fad. (784.50 and 712.75 kg) and oil yield/ fad. (345.18 and 311.12 kg), respectively.

Table 3. Mean values of seed yield and related characters for ten flax genotypes (combined analysis across 2017/2018 and 2018/2019 seasons).

Genotypes	Number of capsules/ plant	Capsule set %	Number of seeds/ capsule	Seed index (1000 seeds weight (g)	Seed yield/ plant (g)	Seed yield/ fad. (Kg)	Oil yield/ fad. (Kg)
Sizar	**28.76**	**61.70**	**6.38**	**5.95**	**1.33**	**451.00**	**171.29**
Sakha 1	**31.08**	**62.76**	**6.71**	**8.34**	**2.05**	**613.50**	**243.13**
Sakha 2	**38.16**	**70.88**	**6.67**	**8.80**	**2.08**	**646.25**	**259.28**
Sakha 3	**27.11**	**67.25**	**7.60**	**4.93**	**1.06**	**422.50**	**146.48**
Sakha 5	**43.94**	**84.13**	**7.70**	**7.19**	**2.18**	**670.00**	**286.36**
Sakha 6	**25.46**	**50.54**	**6.14**	**5.61**	**1.21**	**450.75**	**168.67**
Giza 9	**21.66**	**54.93**	**7.78**	**5.15**	**1.18**	**445.50**	**155.39**
Giza 10	**27.58**	**55.85**	**7.78**	**4.98**	**1.34**	**511.25**	**181.44**
Giza 11	**47.58**	**81.21**	**6.73**	**12.19**	**3.36**	**784.50**	**345.18**
Giza 12	**46.51**	**80.30**	**6.99**	**11.90**	**3.26**	**712.75**	**311.12**
Grand mean	**33.78**	**66.96**	**7.05**	**7.50**	**1.91**	**570.80**	**226.83**
C.V. %	**28.02**	**17.77**	**8.76**	**36.71**	**44.33**	**22.86**	**31.54**
L.S.D. 5%	**2.30**	**1.98**	**0.91**	**0.22**	**0.59**	**36.07**	**13.46**

The flax variety Sakha 5 ranked first in capsule set% (84.13%), it laid second in number of seeds/capsule (7.70) and the third position concerning number of capsules/ plant (43.94), seed yield/ plant (2.18 g), seed yield/ fad. (670.00 kg) and oil yield/ fad.(286.36 kg).On the other hand, the flax variety Sakha 3 was the lowest regarding seed index (4.93 g), seed yield/plant (1.06 g), seed yield/ fad. (422.50 kg) and oil yield/fad.(146.48 kg).The remaining flax genotypes ranked intermediate between the highest and lowest seed characters under study. The estimates of C.V.% were high in all seed characters except number of seeds/ capsule which recorded the lowest percentage (8.76%). Such variability in seed traits among flax genotypes was reported by El-Shimy *et al* (2002), Ghaniem (2004), Abo-Kaied *et al* (2007), El-Refaie and Omar (2012) and El-Shimy *et al* (2016).

1.3 Technological characters

From Table (4), results indicated significant differences among flax genotypes in relation to the three technological characters i.e., long fiber %, fiber fineness and oil%. Long fiber% ranged from 10.18 up to 19.80% which were obtained from Sakha 2 and Giza 10, respectively.

Table 4. Mean values of technological characters among ten flax genotypes (combined analysis of 2017/2018 and 2018/2019seasons0.

Genotypes	Technological Characters		
	Long fiber%	Fiber fineness (Nm)	Oil%
Sizar	10.42	140.29	37.98
Sakha 1	11.34	168.96	39.63
Sakha 2	10.18	159.10	40.12
Sakha 3	15.69	189.85	34.67
Sakha 5	11.82	167.34	42.74
Sakha 6	12.13	162.86	37.42
Giza 9	17.51	192.64	34.88
Giza 10	19.80	203.90	35.49
Giza 11	11.25	181.61	44.00
Giza 12	11.31	179.81	43.65
Grand mean	13.15	174.64	39.06
C.V.%	25.23	10.68	9.10
LSD 5%	2.14	1.29	0.50

The high variation of the long fiber % is due to the variation in technical length of different flax genotypes (fiber and dual purpose types) under study.

The descending arrangement, after the flax variety Giza 10 was Giza 9 (17.51%), Sakha 3 (15.69%), Sakha 6 (12.13%), Sakha 5 (11.82%), Sakha 1 (11.34%), Giza 12 (11.31%), Giza 11 (11.25%) and Sizar (10.42%). The estimate of C.V.% was high (25.23%) for long fiber % which indicated great variability in this case.

Owing to fiber fineness, the flax variety Giza 10 reported maximum value (203.90 Nm), followed by Giza 9 (192.64 Nm), Sakha 3 (189.85 Nm),

Giza 11 (181.61 Nm), Giza 12 (179.80 Nm), Sakha 1 (168.96 Nm), Sakha 5 (167.34 Nm), Sakha 6 (162.86 Nm), Sakha 2 (159.10 Nm), and the lowest one was Sizar (140.29 Nm).

Concerning oil percentage character, data showed that the new cultivar Giza 11 recorded the highest percentage (44.00%), followed by Giza 12 (43.65%), Sakha 5 (42.74%), Sakha 2 (40.12%), Sakha 1 (39.63%), Sizar (37.98%), Sakha 6 (37.42%), Giza 10 (35.49%), Giza 9 (34.88%) and the lowest one was Sakha 3 (34.67%). The oil% is indication of the oil yield relative to the corresponding seed and not a quality character.

Limited variability was for noticed fiber fineness and oil% as shown in Table (4). The differences among flax genotypes regarding technological characters were confirmed by Mostafa (1994), Abo-Kaied *et al* (2008), Hussein (2012) and El-Shimy *et al* (2015).

2. Genetic Parameters

Table (5) shows the estimates of phenotypic (P.V.) and genotypic (G.V.) variances they showed similar trend for each of straw yield and related character (A), seed yield and related characters (B) and technological traits (C). It is clear that fiber fineness promote maximum estimates (348.03 and 347.83), followed by capsule set % (107.39 and 106.93), plant height (100.04 and 95.91), number of capsules/ plant (89.62 and 88.99) and technical length (76.11 and 72.32) for P.V. and G.V., respectively. The lowest estimates for both two variances were obtained by seed yield/ plant (0.37 and 0.36), number of seeds/ capsule (0.36 and 0.27), straw yield/ plant (0.025 and 0.023) and finally fiber yield/ plant (0.0093 and 0.0090), respectively. The remaining flax traits occupied an intermediate position in this case.

Owing to the environmental variance, plant height, technical length and upper branching zone length recorded relatively high environmental variance of 4.13, 3.79 and 2.66, respectively. The remaining characters were less in environmental variances, but more affected by genetical system.

Estimates of phenotypic coefficient of variation (P.C.V.), genotypic coefficient of variation (G.C.V.), heritability% and genetic advance expected from selection for 13 characters of ten flax genotypes are presented in table (6).

Table 5. Estimates of phenotypic, genotypic and environmental variance for 14 traits of ten flax genotypes.

		Variances		
Characters		Phenotypic (P.V.)	Genotypic (G.V.)	Environmental (E.V.)
A	Plant height (cm)	100.04	95.91	4.13
	Technical length (cm)	76.11	72.32	3.79
	Upper branching zone length (cm)	8.06	5.40	2.66
	Straw yield/ plant (g)	0.025	0.023	0.002
	Fiber yield/ plant (g)	0.0093	0.0090	0.0003
B	Number of capsules per plant	89.62	88.99	0.63
	Capsules set %	107.39	106.93	0.46
	Number of seeds per capsule	0.363	0.265	0.098
	Seed yield/ plant (g)	0.37	0.36	0.01
	Seed index (1000 seed weight) (g)	7.58	7.57	0.01
C	Long fiber %	11.03	10.48	0.55
	Fiber fineness (Nm)	348.03	347.83	0.20
	Oil %	12.64	12.61	0.03

Where:
Straw yield and related characters.
Seed yield and related characters.
Technological characters.

Data in table (6) revealed that either P.C.V. or G.C.V. estimates were greatly varied among the thirteen flax traits, values P.C.V. ranged from 3.58 for fiber yield/plant to 67.63 for seed yield/ plant. While, G.C.V. ranged from 3.54 to 66.52 for the same two characters previously mentioned. Moreover, the minimum P.C.V. and G.C.V. values were noticed in oil %, straw yield/ plant and fiber yield/ plant.

Concerning heritability%, most of characters recoded high heritability%. The descending arrangement showed that fiber fineness achieved maximum value of 99.94%, followed by seed index (99.87%), oil% (99.76%), capsule set% (99.57%), number of capsules/ plant (99.30%), seed yield/plant (97.30%), fiber yield/ plant (96.77%), plant height (95.87%), technical length (95.02%), long fiber% (95.01%) and straw yield/ plant (92.00%).

Table 6. Estimates of phenotypic coefficient of variation (P.C.V.), genotypic coefficient of variation (G.C.V.),broad sense % and expected genetic advance under 5% selection intensity as % of general mean (G.A.%) for 13 traits of ten flax genotypes.

Characters		(P.C.V.)	(G.C.V.)	Heritability %	G.A. %
A	Plant height (cm)	11.10	10.89	95.87	21.94
	Technical length (cm)	12.60	12.29	95.02	24.68
	Upper branching zone length (cm)	13.63	11.14	67.00	18.82
	Straw yield/plant (g)	6.93	6.58	92.00	12.99
	Fiber yield/plant (g)	3.58	3.54	96.77	7.19
B	Number of capsules/plant	28.03	27.92	99.30	57.31
	Capsules set%	15.27	15.24	99.57	31.33
	Number of seeds/ capsule	8.54	7.30	73.00	12.91
	Seed yield/ plant (g)	67.63	66.52	97.30	13.53
	Seed index (1000 seed weight) (g)	36.71	36.69	99.87	75.47
C	Long fiber%	24.50	23.91	95.01	47.97
	Fiber fineness (Nm)	10.6848	10.6791	99.94	21.99
	Oil%	9.11	9.09	99.76	18.69

Where:
Straw yield and related characters.
Seed yield and related characters.
Technological characters.

Meanwhile, two flax traits recorded intermediate heritability ratios i.e., number of seeds/ capsule (73.00%) and upper branching zone length (67.00%).The heritability% values were varied depending in flax genotypes and their ability to pass these traits to successive generation. The high values of heritability for some characters were due the high genetic effect of those traits in comparative with the environmental impact.

For genetic advance expected from selection as a percentage of grand mean (G.A.%), data showed that flax traits which plant breeder could use to improve among them are seed index (75.47%), number of capsules / plant (57.31%) and long fiber% (47.97%). But the flax characters which have less opportunity in this case were capsule set% (31.33%), technical length (24.68%), fiber finesses (21.99%), plant height (21.94%), upper branching zone length (18.82%), oil% (18.69%), seed yield/ plant (13.53%),

straw yield/ plant (12.99%) and number of seeds/ capsule (12.91%). The results of the genetic parameters were in agreement with those obtained by Frank and Hollosi (1985), Satapathi *et al* (1987), El-Shimy *et al* (1997) and Abo-Kaied *et al* (2008).

3- Correlation coefficient study

Correlation coefficient values (r) among different studied characters are presented in Table (7). Interrelationship between plant height and technical length was highly significant and positive, no- significant positive r values were found with upper branching zone length, fiber yield/plant and fiber yield/fad. The r value was only significant and positive among technical length and fiber yield/plant as well as per fad. Correlation coefficient values between number of upper branches and each of straw yield/plant, straw yield/faddan, seed index, seed yield/plant, seed yield/ feddan and oil yield/faddan were highly significant and positive, but only significant and positive with retting straw/faddan, shive yield/faddan and capsule set%. The r value between straw yield/ plant and each of straw yield/ faddan, shive yield/faddan, seed index, seed yield/ plant as well as per faddan and oil yield/faddan was highly significant and positive, in addition to significant and positive values among retting straw/faddan and capsule set%. While, fiber yield/ plant was highly significantly positive with fiber yield/ faddan and only significant positive with number of seeds/capsule. The r value among straw yield/faddan and each of retting straw/fad., shive yield/faddan, number of capsules/ plant, seed index, seed yield/plant and oil yield/ fad appeared to be highly significant and positive, but it was only significant and positive with capsule set%. Fiber yield/faddan were highly significantly and positively correlated with number of seeds/ capsule. The relation between retting straw/ faddan and each of shive yield/ faddan, seed index, seed yield/faddan and oil yield/faddan indicated highly positive correlation. The trait shive yield/ faddan was highly significantly and positively correlated with each of seed index, seed yield/faddan and oil yield/ faddan, while only significant and positive with capsule set%. The associations between number of capsule/plant and each of capsule set%, seed index, seed yield/plant, seed yield/faddan and oil yield/ faddan were positive and highly significant capsule sit% character was highly significantly and positively correlated with each of seed index, seed yield/plant, seed yield/faddan and oil yield/faddan.

The value between seed index and each of seed yield/plant or per faddan and oil yield/faddan appeared to be highly significant and positive. The same significance and positive r values had recorded between seed yield/plant and either seed yield/faddan or oil yield/faddan, in addition to between seed yield/faddan and oil yield/faddan. These results were in agreement with those obtained by El-shimy *et al* (2002), Abo-Kaied *et al* (2008), Hussein (2012) and El-shimy *et al* (2015). It can be concluded that correlation results in this investigation promote principal knowledge to flax breeders about the possibility for selection in flax genotypes which are characterized by tall technical length for plant height and fiber yield/plant as well as per fad. Moreover, more number of capsules/plant and capsule set% to select for high seed and oil yields.

4- Anatomical manifestations study

4-1- Stem anatomical characters

Mean values of different tissues area per cross section at the middle region of flax stems and fiber index estimates for ten genotypes are presented in Table (8).

Table 8. Estimates of tissues area per cross section at the middle region of stems and fiber index for ten flax genotypes.

Genotypes	Total cross section area mm^2	Cortex area mm^2	Fiber area mm^2	Xylem area mm^2	Pith area mm^2	Fiber index mm^3
Sizar	**4.02**	**0.42**	**0.60**	**1.15**	**1.85**	**4.53**
Sakha 1	**5.74**	**0.47**	**0.72**	**2.75**	**1.80**	**5.23**
Sakha 2	**7.79**	**1.53**	**0.75**	**3.06**	**2.45**	**4.59**
Sakha 3	**7.00**	**1.15**	**1.25**	**2.00**	**2.60**	**8.84**
Sakha 5	**6.90**	**0.66**	**1.10**	**2.98**	**2.16**	**5.58**
Sakha 6	**6.54**	**0.60**	**0.72**	**2.20**	**3.02**	**4.91**
Giza 9	**5.50**	**0.30**	**1.60**	**1.68**	**1.92**	**12.04**
Giza 10	**4.91**	**0.42**	**1.81**	**1.32**	**1.36**	**14.54**
Giza 11	**6.97**	**0.98**	**0.85**	**3.18**	**1.96**	**5.53**
Giza 12	**6.68**	**0.92**	**0.84**	**3.07**	**1.85**	**5.92**
Grand mean	**6.21**	**0.75**	**1.024**	**2.34**	**2.10**	**7.17**
C.V. %	**18.37**	**52.20**	**4.00**	**32.99**	**22.65**	**48.79**

Data illustrated that total cross section area ranged from 4.02 up to 7.79 mm^2 for Sizar and Sakha 2, cortex area ranged from 0.30 to 1.53 mm^2 for Giza 9 and Sakha 2, fiber area ranged from 0.60 to 1.81 mm^2 for Sizar and Giza 10, respectively.

The latest character indicated that Giza 10 achieved are highest fiber area per cross section (1.81 mm^2), followed by Giza 9 (1.60 mm^2), Sakha 3 (1.25 mm^2), Sakha 5 (1.10 mm^2) and the lowest one was Sizar (0.60 mm^2). The remaining flax genotypes ranked in intermediate position between the high and low fiber area. For xylem area/ cross section, results revealed that Giza 11 recorded are highest estimate (3.18 mm^2), followed by Giza 12 (3.07 mm^2), Sakha 2 (3.06 mm^2), Sakha 5 (2.98 mm^2), Sakha 1 (2.75 mm^2), Sakha 6 (2.20 mm^2) and the lowest xylem area was obtained by Sizar (1.15 mm^2). The flax variety Sakha 6 recorded the greatest Pith area (3.02 mm^2), but the variety Giza 10 was the smallest one (1.36 mm^2) due to small cross section area. In the same time, the pith area for Giza 10 become greater in comparison with the corresponding total cross section area (4.91 mm^2), which representation the fiber flax type.

Regarding fiber index character, it illustrated fiber quantity for flax plant in volume. Variety Giza 10 ranked first (14.54 mm^3), followed by Giza 9 (12.04 mm^3), Sakha 3 (8.84 mm^3), Giza 12 (5.92 mm^3), Sakha 5 (5.58 mm^3), Giza 11 (5.53 mm^3), Sakha 1 (5.23 mm^3), Sakha 6 (4.91 mm^3), Sakha 2 (4.59 mm^3) and the lowest one was Sizar (4.53 mm^3). Similar regularity which had been showed in fiber index was found also in fiber yield/ faddan character. These results are in agreement with those obtained by El-Shimy *et al* (1993), Abo-Zaied (1997), Ghoniem (2004), El-Emary *et al* (2006) and El-Shimy *et al* (2015). Figures 1, 2 and 3 exhibited the highest, intermediate and lowest either for fiber area/ cross section or fiber index. The coefficient of variability (C.V. %) was in high magnitude in all traits except for fiber area.

4-2- Seed anatomical characters

Estimates of economical used tissues area in cross section at the middle length for seeds of the ten flax genotypes are presented in Table (9).

Results indicated that each of total cross section area (T.C.S.), cotyledons area (C.) and cotyledons as a percentage per total cross section area (C./ T.C.S x 100) take similar arrangement among all flax genotypes under study and their oil yield/ faddan which was discussed before. The

descending regularity was Giza 11, Giza 12, Sakha 5, Sakha 2, Sakha 1, Giza 10, Sizar, Sakha 6, Giza 9 and the lowest estimate obtained by Sakha 3 for the three characters viz., T.C.S., C. and C. /T.C.S. %. Figs 4, 5 and 6 showed the greatest, intermediate and lowest cotyledons percentage per their corresponding total cross section area at the middle length of flax seed. Similar results were recorded by El-Emary *et al* (2006) and El-Shimy *et al* (2015). The coefficient of variability (C.V. %) were high in all the four seed anatomical characters.

Table 9. Estimates of economical seed tissues area in cross section at the middle region for seeds of ten flax genotypes.

Genotypes	Total cross section area mm^2	Test area mm^2	Cotyledons area mm^2	Cotyledons as a% per total cross section area %
Sizar	**4.25**	**0.85**	**3.40**	**81.65**
Sakha 1	**5.04**	**0.52**	**4.52**	**89.68**
Sakha 2	**6.25**	**0.59**	**5.66**	**90.56**
Sakha 3	**2.85**	**0.85**	**2.00**	**70.18**
Sakha 5	**6.72**	**0.57**	**6.15**	**91.52**
Sakha 6	**4.08**	**0.88**	**3.20**	**78.43**
Giza 9	**3.84**	**0.84**	**3.00**	**78.13**
Giza 10	**4.75**	**0.75**	**4.00**	**84.21**
Giza 11	**7.80**	**0.50**	**7.30**	**93.59**
Giza 12	**7.00**	**0.55**	**6.45**	**92.14**
Grand mean	**5.26**	**0.69**	**4.57**	**85.01**
C.V. %	**30.48**	**22.78**	**38.12**	**9.13**

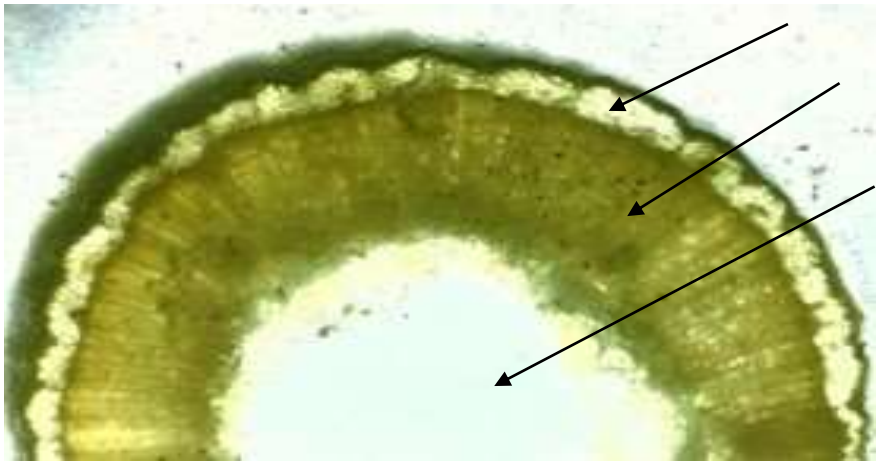

Fig. 1. Cross section of main stem for Giza 10 variety at the middle region. The greatest fiber production (fiber index) f= fiber sx = secondary xylem p = pith).

Fig 2. Cross section of main stem for Sakha 3 variety at the middle region the intermediate fiber production (fiber index).

Fig. 3. Cross section of main stem for the introduce Sizar CV. at the middle region the lowest fiber production (fiber index)

Giza 11 seeds

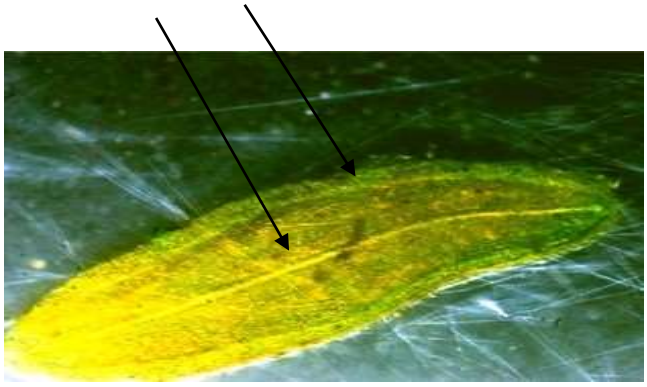

Fig. 4. Cross section of Giza11 cultivar seed at the middle length .The greatest cotyledons area% per its total cross section (greatest oil yield production) T = resta c= cotyledon.

Sakha 5 seeds

Fig. 5. Cross section of Sakha 5 cultivar seed at the middle length .The intermediate Cotyledons area% per its total cross section (intermediate oil yield production).

Sakha 3 seeds

Fig. 6. Cross section of Sakha 3 cultivar seed at the middle length .The lowest cotyledons area%per its total cross section (Lowest oil yield production

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المحصول, الثوابت الوراثية, الارتباط و التشريح لبعض التراكيب الوراثية في الكتان

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أقيمت تجربتان حقليتان في محطة البحوث الزراعية بالجيزة خلال موسمى٢٠١٧/٢٠١٨ و ٢٠١٨/٢٠١٩ وذلك لتقييم عشرة تراكيب وراثية من الكتان من حيث المحصول ومكونات المحصول, الصفات التكنولوجية, الارتباط الظاهري, التشريح لكل من الساق والبذور. ويمكن تلخيص النتائج فيما يلي:- احتل صنف الكتان جيزة ١٠ المكانة الأولي في صفات ارتفاع النبات, الطول الفعال, محصول الألياف للنبات و للفدان, النسبة المئوية للألياف الطويلة, نعومة الألياف. بينما حقق الصنفين الجديدين جيزة ١١, جيزة ١٢ أعلي القيم لعدد الكبسولات/نبات, دليل البذور (وزن ١٠٠٠ بذرة), محصول البذرة/نبات كما للفدان, محصول الزيت/فدان, النسبة المئوية للزيت. تقديرات كل من التباين الظاهري والوراثي مرتفعة في صفات نعومة الألياف, النسبة المئوية للعقد, ارتفاع النبات, عدد الكبسولات/نبات , الطول الفعال. في حين كانت تقديرات التباين البيئي منخفضة في معظم الصفات ماعدا صفتي ارتفاع النبات, الطول الفعال حيث كانتا مرتفعتان نسبيا. تقديري معامل التباين الظاهري والوراثي كانتا مرتفعين في صفات محصول البذرة/نبات, دليل البذور, عدد الكبسولات/نبات, النسبة المئوية للألياف الطويلة, النسبة المئوية للعقد, طول منطقة التفريع القمي وكانت تقديرات مدي التحسين الوراثي المتوقع من الانتخاب مرتفعة في معظم الصفات تحت الدراسة. أشارت قيم معامل الارتباط الظاهري معنوية مرتفعة وموجبة بين صفة ارتفاع النبات والطول الفعال وكذلك بين عدد الفروع القمية وكل من محصول القش/نبات كما للفدان, محصول الساس للفدان, النسبة المئوية للعقد, دليل البذور, محصول الزيت/فدان بالإضافة إلي وجود ارتباط مرتفع وموجب بين عدد الكبسولات/النبات وكل من النسبة المئوية للعقد, دليل البذور, محصول البذرة للنبات و للفدان, محصول الزيت/فدان. أظهرت الدراسة التشريحية للساق أن الصنف جيزة ١٠ حقق أعلي مساحة للألياف في القطاع العرضي وأيضا في دليل الألياف (حجم الألياف/نبات) ويليه جيزة ٩ ثم سخا ٣. في حين حقق الصنف جيزة ١١ ويليه الصنف جيزة ١٢ أكبر مساحة الفلقات البذور وكذلك النسبة المئوية لمساحة الفلقات بالنسبة للمساحة الكلية للقطاع العرضي لبذرة كل تركيب وراثي من الكتان ويليهما الصنف سخا ٥ حيث يحتل المكانة الثالثة في هذه الحالة.

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