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COMPARING SOME LOCAL AND IMPORTED FLAX CULTIVARS AND IMPROVEMENT OF THE FIBER PROPERTIES

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ABSTRACT

Six flax genotypes (five fiber flax cultivars and one dual purpose) were evaluated concerning yield, yield components, technological traits, genetic parameters, phenotypic correlation, anatomical studies and improving fiber characters of Giza 11 (dual purpose) cultivar by increasing seeding rates. The experiments were conducted at Giza Agric. Res. Station, during 2017/2018 and 2018/2019 seasons as a primary trial to study the effect of seeding rates (60, 70 and 80 kg/fed) on yield and its components of Giza 11 cultivar and 2019/2020 and 2020/2021 seasons as a main trial to evaluate six flax cultivars, including local and imported ones. Results revealed that, maximum straw, fiber yields per fed, fiber area and fiber index of Giza 11 cultivar were obtained when seeding rate was applied at the rate of 80 kg/fed. Marlin and Sakha 3 recorded the highest estimates in plant height, technical length, fiber yield/fed. and fiber percentage. Meanwhile, Giza 11 ranked first in seed yield, related characters and xylem area. The environmental variance promote low estimate for most traits, except technical length, plant height, and fiber length. Correlation analysis indicated that, the traits like plant height, technical stem length, straw yield/plant, and fiber length had a strong positive significant relationship with flax cultivars in yield and its components. Whereas, number of capsules per plant, number of seeds per capsule would also be kept in mind while designing a breeding program to improve the seed yield. Regarding stem anatomical characters, Sakha 3 recorded a maximum value for total cross-sectional area and cortex area, while Marlin achieved the highest value of fiber area and fiber index characters.

Key words: ***Linum usitatissimum, Anatomical characters, Genetic parameters, Seeding rates, Fiber properties***

INTRODUCTION

Flax is one of the oldest important crops grown for fiber and oil (Deng *et al* 2011). Flax is a self-pollinated crop widely adapted to temperate climates all around the world. It has a lengthy history of cultivation in countries with warm and cool temperate climates (Belonogova and Radulgina 2007). Seed oil is chosen for its health benefits in the prevention of diseases such as cancer, high blood pressure, diabetes and cardiovascular disease. The boiling oil is used as painting ink and varnish industries, the cake which remained after seeds squeeze is used for animal nutrition. The flax fiber, which extracted from flax stem by retting process is a good raw material for textile, Linen is valued for its strength, luster, durability and moisture absorbency. It is resistant to outlook by microorganisms and its smooth surface repels. Many investigators reported differences between flax cultivars in yield and its components such as El - Shimy *et al* (2002), Ghaniem (2004), Abo- Kaied *et al* (2007), and Hussein (2012). Concerning anatomical studies, El-shimy *et al* (2019) found anatomical differences in flax stem tissues, regarding flax seeding rates, several of variables interact and have an impact on flaxseed's productive potential. Increasing seeding rates from the optimal rate can lead to intraspecific competition (between plants) and interspecific competition (with other plants) for light, water and nutrients, resulting in fewer number of capsules, decreased number of plants within the plot, reduced seed and oil yields (Vereshchahin *et al* 2020 and Sahin *et al* 2022).

The main target of the present investigation was to improve fiber properties in Giza 11 (dual purpose) cultivar by increasing seeding rate, as well as to evaluate six flax cultivars, including local and imported ones, in terms of yield, yield components, technological characters, anatomical characters, and genetic parameters. These cultivars included five fiber flax and one dual purpose.

MATERIALS AND METHODS

Two field experiments were carried out at the farm of Giza Research Station, Agric., Res. Center, Egypt during the two successive seasons (2019/2020 and 2020/2021), among some local and introduced flax cultivars which are presented in Table (1).

Table 1. Sources of different flax genotypes of dual purpose types (D) and fiber types (F).

Genotype	Pedigree	classification
Giza 11	Giza 8 x S.2419	D
Aveiana	Imported from Belgium	F
Christene	Imported from Holland	F
Lisette	Imported from Holland	F
Marlin	Imported from Holland	F
Sakha3	I.2569 x Belinka	F

Sowing date was Nov 4th, in 2019 and Nov 6th, in 2020. The experimental design was a randomized complete block design with three replications. The plot size was 6m^2 (2x3m). Each plot contains ten rows spaced 20 cm apart. Fiber cultivars were sown at the rate of 50 kg/fed and 80 kg/fed (higher seeding rates) for Giza 11 cultivar (dual purpose), according to a primary experiment which was carried out during the two previous seasons (2017/2018 and 2018/2019) at the farm of Giza Research Station, Agric., Res. Center to study the effect of three seeding rates (60, 70 and 80 kg / fed) on yield and its components of Giza 11 cultivar. Treatments were randomly arranged in a randomized complete block design with three replications. Normal cultural practices for flax production was done as recommended. At full maturity, ten guarded plants were taken at random to record the following characters:

A- Yield and yield components

1- Straw yield and related characters: plant height (cm), technical length (cm), fruiting zone length (cm), straw yield/plant (g), straw yield/fed (ton) and fiber yield/fed (kg), (1fed = 4200 m^2).
2- Seed yield and related characters: number of capsules/plant, number of seeds/capsule, seed yield/plant (g), seed index (g) and seed yield/fed (kg).

B- Technological characters

Fiber length (cm), Total fiber percentage% and oil percentage which was determined by Soxhlet extraction apparatus according to the method described by AOAC (2000).

Analysis of variance was done according to Snedecor and Cochran (1982). Means were compared by least significant differences (LSD) at 5% level of probability in both and across seasons after testing the homogeneity of errors according to Bartlett's test (Bartlett, 1937). Therefore, combined analysis was performed for each character across the two seasons as described by Le - Clerg *et al* (1966).

C- Anatomical study

At full maturity of flax plants, specimens were taken from the flax main stems at the middle part of technical length. After ratting and fixing theses specimens for 36 hours by using formalin, acetic acid and alcohol (F.A.A.) solution. Paraffin Wax method was used to obtain cross section from flax stem. These stems for each sample were macerated at 25 microns in thinness by using sliding microtome.

The slides were smeared with mayer albumen solution before mounting the ribbon of transverse section, which stained with 0.5% safranin solution to stain nucleus and lignified tissues with red color and station these section with 1% light green dissolved in clove oil which gave the cytoplasm and cell wall green color.

Stem anatomical characters for local and imported cultivars

Total cross section area (mm^2), cortex area (mm^2) fiber area (mm^2), xylem area (mm^2), pith area (mm^2) and fiber index (mm^3) which calculated as follows:

Fiber index (mm^3) = fiber area (mm^2) per each cross section x technical stem length (mm).

D- 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.

- Genotypic variance: (Burton and De Vane 1953 and Virk *et al* 1971)
- Phenotypic variance it was estimated as suggested by Mathur *et al* (1971) and Verma and Singh (1971).
- Environmental variance as reported by Miller *et al* (1958).

D- Correlation coefficient study

Correlation analysis was performed to measure the strength of the relationship between the examined features and to calculate their relationship among straw, fiber and seed yields with their attributes (combined analysis across both seasons) by calculating the simple correlation coefficients (Al- Jibouri *et al* 1958 and Dewey and Lu 1959).

RESULTS AND DISCUSSION

1. The primary trial

Mean values of yield, related characters and anatomical characters for (dual purpose type) Giza11 (combined analysis across both seasons) as affected by seeding rates are presented in Table (2). Data showed significant differences in straw yield and related characters by using different seeding rates, increasing seeding rates from 60 kg/fed up to 80 kg/fed increased plant height (124.82 cm), technical stem length (115.75 cm), straw yield/plant (1.70 g), straw yield/fed (3.68 ton) and fiber yield/fed (674.91 kg). Regarding fruiting zone length, sowing Giza 11by 60 kg/fed recorded the highest value in fruiting zone length (13.64 cm).

Table 2. Combined Main values effects of Giza 11 cultivar on yield and its attributes and anatomical characters as affected by seeding rates

Seeding rates	Straw yield and its components					
	Plant height (cm)	**Technical length (cm)**	**Fruiting zone length (cm)**	**Straw yield/Plant (g)**	**Straw yield/fed (ton)**	**Fiber yield/fed (kg)**
60 kg/fed	**106.98**	**93.34**	**13.64**	**1.36**	**3.11**	**546.74**
70 kg/fed	**114.19**	**102.60**	**11.60**	**1.48**	**3.42**	**621.41**
80 kg/fed	**124.82**	**115.75**	**9.07**	**1.70**	**3.68**	**674.91**
LSD (0.05)	**8.75**	**9.00**	**2.27**	**0.12**	**0.22**	**23.28**

Seed yield and its components

	Number of capsules/plant	**Number of seeds/capsule**	**Seed yield/plant (g)**	**Seed index (g)**	**Seed yield/fed (kg)**
60 kg/fed	**15.32**	**7.61**	**1.26**	**8.48**	**417.61**
70 kg/fed	**22.16**	**9.77**	**1.53**	**9.81**	**486.16**
80 kg/fed	**18.86**	**9.15**	**1.35**	**9.32**	**431.61**
LSD (0.05)	**4.16**	**0.34**	**0.04**	**0.97**	**44.92**

Technological characters

	Fiber length (cm)	**fiber percentage**	**Oil percentage**
60 kg/fed	**90.98**	**17.58**	**38.04**
70 kg/fed	**99.87**	**18.17**	**39.90**
80 kg/fed	**111.91**	**18.34**	**38.53**
LSD (0.05)	**9.25**	**0.38**	**1.62**

Anatomical characters

	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)**
60 kg/fed	**6.92**	**0.97**	**0.76**	**3.18**	**1.94**	**4.74**
70 kg/fed	**6.81**	**0.93**	**0.80**	**3.11**	**1.91**	**4.80**
80 kg/fed	**6.78**	**0.88**	**0.89**	**3.09**	**1.89**	**4.97**
LSD (0.05)	**0.03**	**0.04**	**0.08**	**0.05**	**0.12**	**0.16**

The competition of crops with weeds was severe at low plant density and resulting in short height and low straw yield (Beyene *et al* 2022). The optimum density plays an important role in increasing straw yield per unit area, more plants per unit area mean that individual stems will be thinner and more elongation which resulted in higher straw yield per plant as well as per fed. These results are in harmony with those of El-Deeb (2002), Abd El-Daiem (2004), Mousa (2006) and Sahin *et al* (2022).

Results indicated that, there were significant differences of seeding rates on seed yield and its component. Sowing Giza 11 by seeding rate of 70 kg /fed increased number of capsules/plant (22.16), number of seed/capsules (9.77), seed yield/plant (1.53 g), Seed index (9.81 g) and seed yield/fed (486.16 kg). Plants with the optimal seeding rate had a greater area per plant, more feeding area, and more above ground space for photosynthesis. They absorbed more nutrients, received more light and prepared more photosynthesis, which produced more seed yield, when plant population exceeded optimum seed rate, competition among plants for light, and nutrients becomes severe, and consequently, the plant grows slowly. Similar results were reported by Sorour *et al* (1992), Abou-Zaid and El- Gazzar (2001) and Sahin *et al* (2022).

Results presented in Table (2) indicated significant differences among seeding rates in relation to the technological characters, maximum fiber length (111.91 cm) and fiber percentage (18.34 %) was produced by higher seed rate of 80 kg/fed. Higher seeding rate leads to higher fiber content. More plants per unit area mean that, plant stems will be thinner and causes increasing the proportion of fiber in each stem, while the medium seeding rate of 70 kg/fed produced higher oil percentage (39.90 %). The present results are in agreement with those reported by Abo- Kaied *et al* (2008) and El-Shimy *et al* (2019).

Results in Table (2) and Fig (1) revealed that, there were significant differences of three seeding rates on different tissues area per cross section at the middle region of flax stems and fiber index estimates. Giza 11 with seeding rate of 60 kg/fed achieved the maximum estimates in total cross-sectional area (6.92 mm^2), cortex area (0.97 mm^2), xylem area (3.18 mm^2) and Pith area (1.94 mm^2), while sowing Giza 11 with 80 kg/fed gave the higher values for fiber area (0.89mm^2) and Fiber index (4.97mm^3). It means that, high plant density per unit area caused an increment in fiber, as resulted from tallest technical stem length and relatively thinner flax plants. Then, consequently more fiber yield which had observed in flax characteristics (El-Shimy *et al* 2020). The present findings are similar with those recorded by Zuk *et al* (2015) and Nag *et al* (2019).

Giza 11 with 60 kg/fed **Giza 11 with 70 kg/fed** **Giza 11 with 80 kg/fed**

Fig. 1. Cross section of Giza 11 cultivar as affected by seeding rates.

2- The main trial

1. Yield and yield components:

1.1. Straw yield and related characters:

Mean values of straw yield and related characters for six flax genotypes (combined analysis across both seasons) are presented in Table (3). Data showed significant differences among all flax genotypes for studied traits. The introduced flax cultivar Marlin and the local cultivar Sakha 3 reported maximum values for plant height (134.30 and 130.46 cm), technical length (124.98 and 122.56 cm), straw yield/plant (1. 53 and 1.51 g), straw yield/fed (3.83 and 3.78 ton) and fiber yield/fed (785.44 and 773.95 kg), followed by Aveiana and Giza11. Lisette cultivar was the lowest in plant height (110.45 cm), technical length (95.62 cm), straw yield/plant (1.17g), straw yield/fed (2.93 ton) and fiber yield/fed (461,55 kg), followed by Christene. Regarding fruiting zone length, Lisette recorded highest value in fruiting zone length (13.83 cm). Giza 11 (dual purpose type) ranked fourth in straw yield and its attributes with seeding rate of 80 kg/fed, Giza11 surpassed the other imported cultivars Lisette and Christene (fiber types) in straw yield and its attributes were due to high planting density. It has been reported that plant density was found to have a significant impact on all straw characteristics and its components. The number of plants per unit area is important for high straw and fiber yield in flax cultivation.

Table 3. Combined mean values of genotypes for straw yield and its attributes, across seasons 2019/2020 and 2020/2021.

Genotypes	Plant height (cm)	Technical length (cm)	Fruiting zone length (cm)	Straw yield/plant (g)	Straw yield/fed (ton)	Fiber yield/fed (kg)
Giza11	**123.19**	**113.47**	**9.72**	**1.27**	**3.26**	**594.34**
Marlin	**134.30**	**124.98**	**9.32**	**1.53**	**3.83**	**785.44**
Lisette	**110.45**	**95.62**	**14.83**	**1.17**	**2.93**	**461.55**
Aveiana	**129.97**	**120.18**	**9.79**	**1.45**	**3.61**	**636.58**
Christene	**117.55**	**104.31**	**13.55**	**1.23**	**3.08**	**528.91**
Sakha 3	**130.46**	**122.56**	**7.90**	**1.51**	**3.78**	**773.95**
LSD (0.05)	**10.65**	**11.50**	**3.05**	**0.12**	**0.31**	**63.33**

Plant density plays an important role in increasing production per unit area and it is dependent on the expected growth of a particular crop and cultivar. 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), El-Shimy *et al* (2016), El-Shimy *et al* (2019) and Sahin *et al* (2022).

1.2. Seed yield and related characters

Mean values of seed yield and related characters for six flax genotypes (combined analysis across both seasons) are presented in Table (4). Data showed significant differences among all flax genotypes for studied traits. The local flax cultivar Giza 11 (dual purpose type) ranked first for seed yield and related characters under study, followed by Lisette and Christene (fiber types). Giza 11 gave the highest values for no. of capsules/plant

(19.73), no. of seeds/capsule (9.43), seed yield/plant (1.58 g), seed index (9.38 g) and seed yield/fed (444.76 kg). Both of the introduced flax cultivar Marlin and the local cultivar Sakha 3 recorded minimum values for number of capsules/plant (9.72 and 10.55), number of seeds/capsule (6.43 and 6.46 g), seed yield/plant (1.13 and 1.19 g), seed index (5.51 and 5.82 g) and seed yield/fed (316.80 and 330.70 kg). Giza11 (dual purpose type) surpassed the other cultivars (fiber types) in seed yield and its attributes, it has the ability to produce a seed yield in addition to the fiber yield due to higher plant density than recommended, this behavior may be due to interaction between the genotype and the plant density. Such findings are in agreement with those reported by El-Borhamy (2003), Abd El-Fatah and El-Essawy (2006),Wadan (2013), El- Borhamy *et al* (2017) and Sahin *et al* (2022).

Table 4. Combined mean values of genotypes for seed yield and its attributes in seasons 2019/2020 and 2020/2021.

Genotypes	Number of capsules/plant	Number of seeds/capsule	Seed yield/plant (g)	Seed index (g)	Seed yield/fed (kg)
Giza11	19.73	9.43	1.58	9.38	444.76
Marlin	9.72	6.43	1.13	5.51	316.80
Lisette	17.36	7.36	1.45	7.58	392.07
Aveiana	12.01	6.60	1.24	6.88	320.29
Christene	12.50	7.79	1.31	7.72	331.47
Sakha 3	10.55	6.46	1.19	5.82	330.70
LSD (0.05)	2.23	0.44	0.15	0.65	39.11

1.3. Technological characters

Results in Table (5) indicated significant differences among the six flax genotypes in relation to the technological characters *i.e.*, fiber length, fiber percentage and oil percentage. Marlin ranked first and recorded highest values in fiber length (122.32cm) and fiber percentage (20.52%) followed by Sakha 3 (119.96 cm and 20.47%, respectively) without significant differences, followed by Aveiana and Giza 11. It could be concluded that high planting density increased plant competition for environmental factors and induced elongation of plants and increase in technical stem length and fiber length. Similar results were also obtained by Borhamy (2017), and Sahin *et al*(2022),who found that there was an increase in fiber length when the plant density increased, while local cultivar Giza 11 (dual purpose) ranked first in oil percentage (38.95 %). The present results are in agreement with those reported by Abo-Kaied *et al* (2008), and El-Shimy *et al* (2019).

Table 5. Combined mean values of genotypes for technological characters in seasons 2019/2020 and 2020/2021.

Genotypes	Fiber length (cm)	fiber percentage	Oil percentage
Giza11	110.83	18.22	38.95
Marlin	122.32	20.52	34.72
Lisette	96.23	15.74	37.26
Aveiana	117.68	17.62	36.66
Christene	101.53	17.17	37.50
Sakha 3	119.96	20.47	34.69
LSD (0.05)	11.12	0.97	0.82

2. Genetic Parameters

Table (6) indicated that, the estimates of phenotypic (PV) and genotypic (GV) variances showed similar trend for each of straw yield and related characters (A), seed yield and related characters (B) and technological traits (C). It is clear that technical length recorded maximum estimates (159.20 and 119.24), followed by fiber length (136.86 and 99.49), plant height (104.62 and 70.34), for PV and GV, respectively.

Table 6. Estimates of phenotypic, genotypic and environmental variance for 11 traits across six flax genotypes.

	Characters	Phenotypic (P V)	Genotypic (G V)	Environmental (EV)
		Variances		
A	**Plant height (cm)**	**104.62**	**70.34**	**34.28**
	Technical length (cm)	**159.20**	**119.24**	**39.96**
	Fruiting zone length (cm)	**7.49**	**4.67**	**2.82**
	Straw yield/plant (g)	**0.03**	**0.02**	**0.01**
B	**Number of capsules per plant**	**16.96**	**15.46**	**1.5**
	Number of seeds per capsule	**1.38**	**1.32**	**0.06**
	Seed yield/plant (g)	**0.04**	**0.03**	**0.01**
	Seed index (1000 seed weight) (g)	**2.08**	**1.96**	**0.12**
C	**Fiber length (cm)**	**136.86**	**99.49**	**37.36**
	Fiber%	**3.78**	**3.50**	**0.28**
	Oil%	**2.67**	**2.47**	**0.2**

Where: A- Straw yield and related characters. B- Seed yield and related characters. C-Technological characters.

The lowest estimates for both two variances (PV and GV) ranged for straw yield/plant (0.03 and 0.02) up to (16.96 and15.46) for number of capsules/plant, respectively. Owing to the environmental variance, technical length, plant height, and fiber percentage recorded relatively high environmental variance of 39.96, 34.28 and 37.36, respectively. The remaining characters were less in environmental variances, but more affected by genetic variance as reported by El-Shimy *et al* (2019), Patial *et al* (2019) and Abdul and jassim (2022).

3. Correlation coefficient estimates

Correlation analysis was performed to measure the strength of the relationship between the examined features (combined analysis across both seasons). Data presented in Table (7) for correlation coefficient values among all studied characters showed that the traits like plant height, technical stem length, straw yield/plant and fiber length had a strong positive and significant relationship with straw yield/fed at phenotypic level, which provide a better solution for the improvement of straw yield in flax.

Table 7. Phenotypic correlation coefficients among straw, seed and their component traits as well as some technological traits across 6 flax genotypes (data of combined analysis).

Characters	2	3	4	5	6	7	8	9	10	11	12	13	14
Plant height (cm)	0.991 **	-0.781	0.921 **	0.943 **	0.879 *	-0.513	-0.410	-0.562	-0.482	-0.364	0.988 **	0.727	-0.609
Technical length(cm)	1.000	-0.847 *	0.928 **	0.952 **	0.904 *	-0.503	-0.380	-0.531	-0.465	-0.348	0.993 **	0.771	-0.596
Fruiting zone length (cm)		1.0	-0.778	-0.807	-0.818 *	0.326	0.237	0.280	0.316	0.147	-0.818	-0.751	0.517
Straw yield/Plant (g)			1.0	0.994 **	0.952 **	-0.688	-0.577	-0.642	-0.640	-0.475	0.951 **	0.707	-0.714
Straw yield/fed (ton)				1.0	0.957 **	-0.623	-0.508	-0.581	-0.582	-0.402	0.967 **	0.718	-0.681
Fiber yield/fed (kg)					1.0	-0.637	-0.478	-0.627	-0.646	-0.423	0.939 **	0.911 **	-0.743
Number of capsules/plant						1.0	0.827 *	0.948**	0.870 *	0.951 **	-0.490	-0.582	0.781
Number of seeds/capsule							1.0	0.848 *	0.919 **	0.824 *	-0.402	-0.351	0.856 *
Seed yield/plant (g)								1.0	0.881 *	0.897 *	-0.538	-0.577	0.815 *
Seed index (g)									1.0	0.790	-0.497	-0.598	0.899 *
Seed yield/fed (kg)										1.0	-0.338	-0.391	0.655
Fiber length(cm)											1.0	0.769	-0.613
Fiber percentage												1.0	-0.670
Oil percentage													1.0

2 = Technical length (cm), 3 = Fruiting zone length (cm), 4 = Straw yield/plant (g), 5 = Straw yield/fed (ton), 6 = Fiber yield/fed (kg), 7 = Number of capsules/plant, 8 = Number of seeds/capsule, 9 = Seed yield/plant (g), 10 = Seed index (g), 11 = Seed yield/fed (kg), 12 = Fiber length (cm), 13 = Fiber% and 14 = Oil%

In our study, it was noticed that fruiting zone length, number of capsules per plant, number of seeds per capsule, seed index+ and oil percentage also had a strong positive and significant relationship with seed yield/fed at phenotypic level. Whereas, number of capsules per plant, number of seeds per capsule would also be kept in mind while designing a breeding program to improve the seed yield. These results are in agreement with those obtained by Hussein (2012), Hassanein *et al* (2012), Sharma and Paul (2016), Paul *et al* (2016), Paul and Chopra (2017), Patial *et al* (2018) and El-shimy *et al* (2019). It can be concluding that the association results in this study helped the flax breeders to the possibility of selection among flax genotypes which are characterized by technical length for highly straw and fiber yields. Moreover, more number of capsules/plant and number of seeds/plant could be used as selection criteria for highly seed and oil yields.

4. Anatomical study

Mean values of different tissues area per cross section at the middle region of flax stems and fiber index estimates for six genotypes are presented in Table (8) and Fig (2) (Hand - cut cross sections of maturity stems for local and imported flax cultivars). Results showed that Sakha 3 recorded the maximum value for total cross-sectional area (7.05 mm^2) and cortex area (1.16 mm^2), while the imported cultivar Lisette gave the minimum value for these traits.

Table 8. Means of tissues area per cross section at the middle region of stems and fiber index for six 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)
Giza11	6.95	0.92	0.80	3.13	1.95	4.83
Marlin	5.58	0.37	1.60	1.16	1.81	11.78
Lisette	3.87	0.37	0.61	3.03	3.02	3.82
Aveiana	5.41	0.82	0.88	1.76	1.86	5.52
Christene	6.08	0.57	0.69	2.18	2.59	4.50
Sakha 3	7.05	1.16	1.24	2.01	1.92	8.81
LSD (0.05)	0.43	0.06	0.04	0.05	0.05	0.20

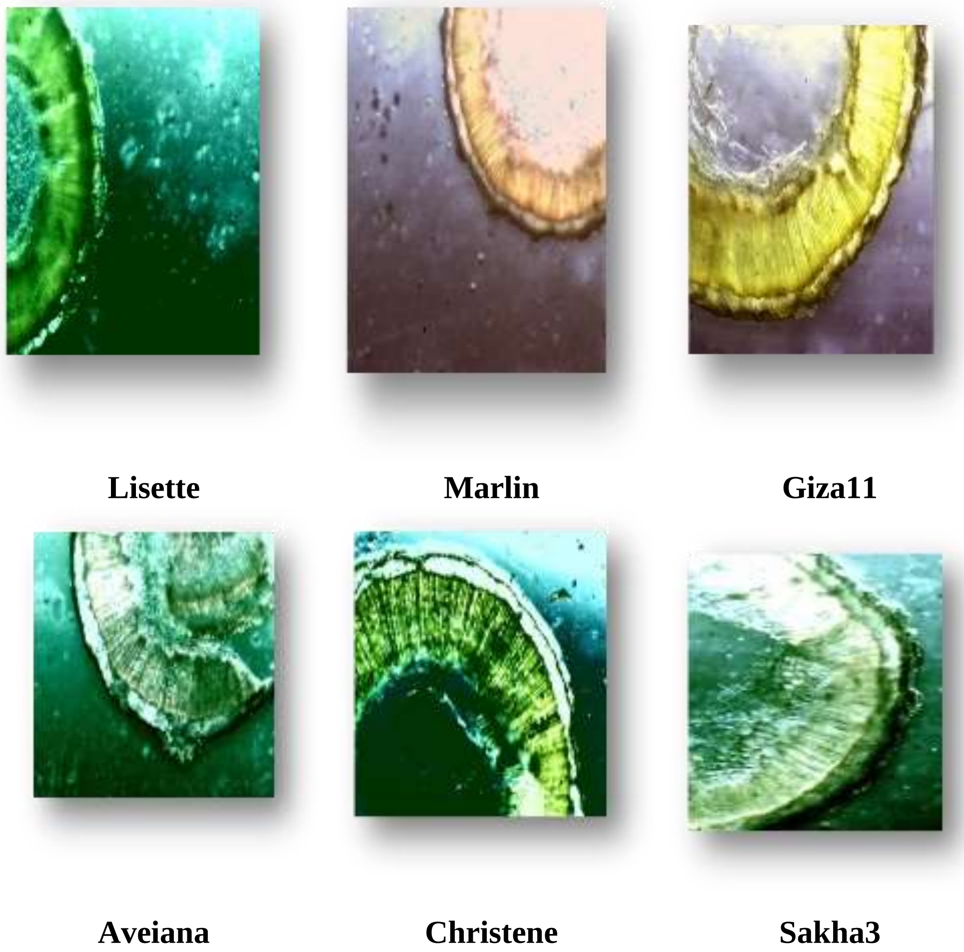

Fig. 2. Cross section of local and imported flax cultivars.

Fiber area indicated that Marlin achieved the highest value (1.60 mm^2), followed by Sakha 3 (1.24 mm^2) and the lowest one was Lisette (0.61 mm^2). Concerning xylem area, results indicated that Giza 11 recorded the highest estimate (3.13 mm^2) and the lowest xylem area was obtained by Marline (1.16 mm^2). The flax cultivar Lisette recorded the greatest Pith area

(3.02 mm^2), while the cultivar Marline had the smallest one (1.81mm^2) due to small cross section area. In the same time, the pith area for Marline was greater than the corresponding total cross section area (5.58 mm^2), which represent the fiber flax type. Fiber index character showed that fiber quantity for flax plant in volume ranged from 3.82 mm^3 to 11.78 mm^3 for Lisette and Marline, respectively. The local cultivar Giza 11 (dual purpose) ranked fourth in the fiber index, this result can help the plant breeder to improve the fiber area by higher seeding rate. These results are in agreement with those reported by El-Emary *et al* (2006), El-Shimy *et al* (2015), El-Shimy *et al* (2019) and Vereshchahin *et al* (2020).

CONCLUSION

The data obtained from this investigation could be useful for flax researchers and fiber producers. In addition, the results of this research should be implemented to increase the productivity and fiber extraction of flax. The findings of the study revealed that the seeding rate treatments improved the yield by contributing to the character efficiency of flax, leading to higher straw yield and fiber traits. Marlin and the local cultivar Sakha 3 reported maximum values for fiber area, fiber index, straw, fiber yields, and related characters, while Giza 11 (dual purpose cultivar) ranked first for oil percentage, xylem area, seed yield, and related characters. In general, it can be concluded that raising flax fiber can be achieved by planting the dual flax cultivar Giza 11 with 80 kg / fed as resulted from tallest technical stem length, relatively thinner flax plants and more fiber yield which was observed in flax characteristics.

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REFERENCES

Abd El-Daiem, M.A. (2004). Evaluation of some flax genotypes under different plant densities .MSc .Thesis Fac of Agric El-Azhar University, Egypt.

Abd El-Fatah, A.A.E and I.I. El-Essawy (2006). Effect of seeding rate on growth and yield of two flax cultivars. J. Agric. Tanta Univ. **32**(4): 831- 844.

Abdul, Q. H. J. and M. A. Jassim (2022). Stability analysis of some genotypes in flax (*Linum usitatissimum* L.) Nat. Volatiles and Essent. Oils, **9** (2): 382-396

Abo-Kaied, H.M.H., M.A. Abd El-Dayem and M.D.H. Dewdar (2007). Simultaneous selection for high yielding and stability of some economic flax characters. J. Agric. Sci. Mansoura Univ. **32** (5): 3289 – 3301.

Abo-Kaied, H.M.H., A.M.M. El-Refaie and A.E.A. Zahana (2008). Comparative study for yield and yield components of some flax families with the two commercial cultivars Sakha 1 and Sakha 2. J. Agric. Sci. Mansoura Univ. **33** (7): 4681- 4693.

Abou-Zaid, T. A. and A. El-Gazzar (2001). Effect of seeding rate and nitrogen levels on yield and quality of some flax cultivars. J. Agric. Res., Tanta University, Egypt, **27** (7): 620 - 632.

Al - Jibouri, H.A., P.A. Miller and H.F. Robinson (1958). Genotypic and environmental variances and covariance in an upland cotton cross of interspecific origin. J. Agron. **50**: 633 - 636.

AOAC (2000). Official method of analysis.17th ed. Association of Official Analytical Chemist's. Washington, D.C., U.S.A.

Bartlett, M.S. (1937). Properties of sufficiency and statistical tests. Proceedings of Royal Statistical Society, Series A., **160**: 265-282.

Belonogova, M. and G. Radulgina (2007). Biotechnology of flax (*Linum usitatissimum* L). J. Functional Plant Science and Biotechnology **1** (2): 327-346.

Beyene, A., Y. Alemayehu, A. Wakijira and H. Legesse (2022). Influence of seeding rates on seed yield, oil content, oil yield and other yield attributes of four linseed (*Linum usitatissimum* L), cultivars in Horo Guduru District,Western Ethiopia. Cogent Food and Agric. **8**: 1- 19.

Burton, G.W. and E.M. De Vane (1953). Estimating heritability in tall fescue (*Fescue arundinaceas* L.) from replicated clonal material. J. Agron. **45**: 478 - 481.

Deng, X., S. Long, D. He, X. Li, Y. Wang, D. Hao, C. Qiu and X. Chen (2011). Isolation and characterization of polymorphic microsatellite markers from flax (*Linum usitatissimum* L.). Afr. J. Biotech. **10**: 734-739.

Dewey, D.R. and K.H. Lu (1959). A correlation and path coefficient analysis of components of crested wheat grass and seed production. J. Agron. **51**: 515–518.

El-Borhamy, A.M.A. (2003). Effect of plant density and retting method on some flax cultivars. M.Sc.Thesis, Fac. Agric., Kafr El-Sheikh, Tanta Univ. Egypt.

El-Borhamy, A.M.A, E.N. M. Mohamed and M.S. Abd Al-Sadek (2017). Comparison of yield, its components and chemical composition of some flax genotypes. J. Plant Production, Mansoura Univ. **8** (1): 13-17.

El-Deeb, E. A. (2002). Comparative studies of some quantitative and qualitative traits of some flax genotypes. Ph.D. Thesis, Fac. Agric., Moshtohor, Zagazig University, Egypt.

El-Emary, F.A., M.F. El-Nady and A.A. Abdel-Fatah (2006). Studies on some dual purpose flax (*Linum usitatissimum* L.) genotypes grown under the Egyptian Delta conditions. J. Agric. Res. Tanta Univ. **32**: 544-566.

El-Shimy, G.H., M.S. Abd Al-Sadek and R.A. Abd El-haleem (2015). Comparative analysis of yield and anatomical manifestation of six flax genotypes. Egypt. J. Agric. Res. **93** (1): 67-84.

El-Shimy, G.H., A.M.M. El-Refaie, M.S. Abd Al-Sadek (2019). Yield, genetic parameters and correlation for some flax genotypes. J. Plant Breed. **23** (8):1647-1668.

El-Shimy, G.H., S.H.A. Mostafa and M.A. Abd El-Dayem (2002). Effect of NPK fertilizer levels on yield and its components of some flax genotypes. Annals of Agric. Sci., Moshtohor **40**: 67-79.

El-Shimy, G.H., S.H.A. Mostafa and S.Z.A. Zedan (2016). Performance of some flax genotypes, chemical composition of fibers, seeds and their relation to yield. Annals of Agric. Sci. Moshtohor **54** (4): 819 - 826.

El-Shimy, K.S.S., G.Y. M. Hammam, S.A.H. Allam, S.H.A. Mostafa and E.M.M. El-Gedwy (2020). Effect of nitrogen fertilizer rates and plant density on straw, fiber yield and anatomical manifestations of some flax cultivars. Annals of Agric. Sci., Moshtohor **58** (4): 855 – 870.

Ghaniem, A.E.M. (2004). Effect of Gibberellic acid (GA3) and 2, 4- D on growth and yield of flax. M. Sc. Thesis, Fac. Agri., Cairo Univ. Egypt.

Hassanein, M.S., M.A.A. Al-Kordy and D.M. El-Hariri (2012). Evaluation, correlation and path coefficient analysis among straw yield and its attributes of fiber flax (*Linum usitatissimum* L.) cultivars. J. Appl .Sci. Res., **8** (3): 1539-1546.

Hussein, M.M.M. (2012). Evaluation of productivity and quality for some local and introduced flax (*Linum usitatissimum* L.) cultivars under different pulling dates in sandy soil. Minufiya J. Agric. Res. **37**: 1171-1190.

Le Clerg, E.L., W.H. Leonard and G.C. Anderow (1966). Field Plot Technique. 2nd Ed., Burgess publ. Co., Minn eapolis, Minnesota, U.S.A. 373 pp.

Mathur, S.C., P.K. Mathur and R.P. Chandola (1971). Genetic variability in cumin (*Cuminum cyminum* L.). Indian J. Agric. Sci. **41**: 513-515.

Miller, D.A., J.C. Williams, H.F. Robinson and R.F. Comstock (1958). Estimates of genotypic and environmental variance and covariance and their implication in selection. J. Agron. **50**: 126-131.

Mostafa, S.H.A. (1994). Yield and quality of flax as affected by cultivar and some environmental factors. Ph. D. Thesis, Fac. Agric., Moshtohor, Zagazig Univ., Egypt.

Mousa, A.M.A. (2006). Response of some flax cultivars for soil and foliar application nutrients. Ph. D. Thesis, Fac. Agric., El- Azhar University, Egypt.

Nag, S., J. Mitra and P.G. Karmakar (2019). An overview on flax (*Linum usitatissimum* L.) and its genetic diversity. Int. J. of Agri. Environment and Biotechnology **8** (4): 805-817.

Nasr El-Din, T., E.A.F. El-Kady and A.M. Hella (1991). Response of some flax strains and Giza 5 cultivar to nitrogen and its effect on yield and quality. Egypt. J. Appl. Sci. **6** (6): 178-185.

Patial, R, S. Paul and D. **Sharma (2018**). Correlation and path coefficient analysis for improvement of seed yield in linseed (*Linum usitatissimum* L.). Int. J. Curr. Microbiol. App. Sci. **7** (3): 1853-1860.

Patial, R., S. Paul, D. Sharma, V.K. Sood and K. Nimtt (2019). Morphological characterization and genetic diversity of linseed (*Linum usitatissimum* L.). J. Oilseeds Res. **36** (1): 8-16.

Paul, S., K.U. Arpna and D. Sharma (2016). Estimation of phenotypic divergence in (*Linum usititassimum* L.) for yield-related traits under changing climate in the central hills of the northwest Himalayas, Bangladesh J. Bot. **45** (5) 1163-1171.

Paul, S.K.N. and P.P. Chopra (2017). Correlation and genetic diversity of linseed (*Linum usitatissimum* L.) genotypes based on principal component analysis in Mid-Hills of North-West Himalayas. J.Pharmacognosy and Phytochemistry **6**: 287-290**.**

Sahin, H.A., S. Aytaç and A. El Sabagh (2022). Yield and yield criteria of flax fiber (*Linum usititassimum* L.) as influenced by different plant densities. Oilseed Crops: Sustainable Management and Prospects for Crop Diversification **14** (8): 4710 – 4715, (https://doi.org/10.3390/su14084710).

Sharma, D. and S. Paul (2016). Genotype × environment interaction and phenotypic stability analysis of linseed (*Linum usitatissimum* L.) in mid-hills of North-West Himalayas. J. Appl. Natural Sci. **8** (4): 2040-2048.

Snedecor, G.W. and W.G. Cochron (1982). Statistical Methods 7th ed., Iowa State Univ., Press, Ames, Iowa.

Sorour, S.R., S.H. Abou-Khadrah, M. Zahran and Nemeat Alla (1992). Effect of different potassium and nitrogen rates on growth and yield of some sugar beet cultivars. Proc. 5th Conf. Agron., Fac. Agric. Zagazig Univ., 13-15 Sept., (2): 1027-1043.

Vereshchahin, I., N. Kandyba and X. Lu Xiao (2020). Using scanning electronic microscopy in anatomical studies of flax. UDC 631.52:677.1:633.521.

Verma, G. and K.P. Singh (1971). Selection based on multiple characters in barnyard millet (*Echinochloa aestivum* L.). J. Madras Agric. **58**: 194-198.

Virk, D.S., S.C. Anand and A.S. Khehra (1971). Heritability of some quantitative characters in wheat (*Triticum aestivum* L.). J. Madras Agric. **58**: 199-201.

Wadan, A. (2013). Optimizing and describing the influences of planting dates and seeding rates on flax cultivars under middle Egypt region conditions. J. Sci. Res. and Rev. **1**(2): 28-39.

Zuk, M., D. Richter, J. Matuła and J. Szopa (2015). Linseed, the multipurpose plant. Industrial Crops and Products. J. Plant Sci. **75**:165 -177.

مقارنة بعض أصناف الكتان المحلية والمستوردة وتحسين صفات الألياف

مايسة سعيد عبد الصادق، دعاء إسماعيل محمود و ريهام حامد حسن أحمد
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تم تقييم ستة تراكيب وراثية من الكتان (خمسة أصناف ليفية وصنف واحد ثنائي الغرض) بالنسبة للمحصول ومكوناته، والصفات التكنولوجية، والقياسات الوراثية، والارتباط الظاهري، والدراسات التشريحية وتحسين خصائص الألياف في صنف جيزة ١١ (ثنائي الغرض) عن طريق زيادة معدلات التقاوي. تم تنفيذ التجارب الحقلية بمحطة البحوث الزراعية بالجيزة, معهد بحوث المحاصيل الحقلية, مركز البحوث الزراعية خلال المواسم (٢٠١٧/٢٠١٨ و ٢٠١٨/٢٠١٩) كتجربة أولية لدراسة تأثير معدلات التقاوي (٦٠، ٧٠، ٨٠ كجم/فدان) على الحاصل ومكوناته لصنف جيزة ١١ والمواسم (٢٠١٩/٢٠٢٠ و ٢٠٢٠/٢٠٢١) كتجربة رئيسية لتقييم ستة أصناف من الكتان تشتمل علي أصناف محلية ومستوردة. أوضحت النتائج أن أعلي حاصل من القش والألياف للفدان ومنطقة الألياف ودليل الألياف لصنف جيزة ١١ تم الحصول عليها عند أستخدام معدل التقاوي ٨٠ كجم/فدان. سجل الصنف مارلين وسخا ٣ أعلى تقديرات في طول النبات، الطول الفعال، محصول الألياف/للفدان والنسبة المئوية للألياف. بينما أخذ الصنف جيزة ١١ المرتبة الأولى في محصول البذور والصفات المرتبطة بها ومنطقة النسيج الخشبي. وقد لوحظ أن التباين البيئي قد أدي إلي تقديرات منخفضة لمعظم الصفات باستثناء الطول الفعال وارتفاع النبات وطول الألياف. أوضح تحليل الارتباط أن الصفات مثل ارتفاع النبات، وطول الساق الفعال، وحاصل القش/نبات، وطول الألياف لها علاقة معنوية موجبة قوية مع أصناف الكتان في المحصول ومكوناته. بينما سيوضع في الاعتبار صفات عدد الكبسولات للنبات و عدد البذور بالكبسولة أثناء تصميم برنامج التربية لتحسين حاصل البذور. فيما يتعلق بالصفات التشريحية للساق، سجل الصنف سخا ٣ أعلي قيمة للمساحة الكلية للمقطع العرضي ومنطقة القشرة، بينما حقق الصنف مارلين أعلى القيم في صفات المساحة الليفية و مؤشر الألياف.

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