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BOTANICAL STUDIES ON SOME FIBROUS FLAX (*Linum usitatissimum* L.) GENOTYPES GROWN UNDER DELTA CONDITIONS

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ABSTRACT

The present investigation was carried out to study the anatomical and yield characters of five fibrous flax genotypes, i. e. Escalina, Ilona, strain 109/2, strain 110/1 and strain 113 during 2004/2005 and 2005/2006 seasons at Sakha Agricultural Research Station. Analysis of two seasons results showed significant differences among the five flax genotypes in all characters under study. Flax strain 110/1 gave the highest value for technical stem length, number of capsules/plant, number of seeds/plant, seed yield/plant and per fed., fiber length and fiber strength. Whereas, the strain 109/2 gave the highest values for straw. and fiber yield per fed. The imported Escalina gave the highest values of upper branching zone length, straw yield/plant, fiber yield/plant, total fiber percentage and fiber fineness.

Measurement of transverse sections of stem, leaf and root of flax genotypes under study was carried out at blooming stage. Data recorded that, the highest values of phloem fiber layer thickness and phloem fiber diameter were found in stem of strains 110/1 and 113. All studied flax genotypes produced a value of xylem tissue higher than phloem tissue. The highest values of xylem and phloem tissue were recorded in strain 113. Concerning root parameters, the highest value of root diameter was recorded in strain 110/1, while the lowest value was found in the imported Escalina genotype. Anatomical studies of leaf of the studied flax genotypes indicated that, the highest thickness values of lamina, palisade and spongy tissues were recorded in strain 113. Also, the highest values of length and width of mean vascular bundle were recorded in strain 113.

INTRODUCTION

Flax (*Linum usitatissimum* L.) belong to family Linaceae is a traditional source of fiber and oil. It plays a great role in developing the National Economy by exportation and local fabrication. Moreover, many industries had been established on its fiber and seed yield. Flax is considered the second fiber crop after cotton. It is grown for the production of seed and fiber. Different variety types are grown for each use. Fibers are used in the textile industry to make fabrics, sails, fiber hoses and ropes and shires is used in making particle board. and 50% of flax fibers and their products are exported. The fiber consists of bundles of fiber cells, from a few to 50 cells (Jacobson, 1958). The fibers in the flax plant are situated in the stem as extra-xylary fibers (phloem fibers) (Fahn, 1990). These fiber cells are composed almost entirely of cellulose. They are joined together by middle lamella which is consisted mainly of pectin but also contains lignin and a component soluble in alkalis. The flax area in Egypt was about 30.000 feddan in 2003/2004 season,

(Kineber, 2003). Kineber (1991) and Mostafa (1994) indicated that, the flax genotypes significantly differed in growth and yield characters.

The main objectives of the present study are to describe the anatomical differences and yield characters among the five fibrous flax genotypes as well as fiber parameters.

MATERIALS AND METHODS

Two field experiments were conduced during 2004/2005 and 2005/2006 seasons in a heavy clay soil at Sakha Research Station Farm, Kafr El-Sheikh Governorate, Egypt. Five fibrous genotypes of flax were used as follow:-

1- Escalina: A fiber type imported from Holland.
2- Ilona: A fiber type imported from Holland.
3- Strain 109/2: A fiber type selected by pedigree method from the cross Belinka 2E X I. 2096.
4- Strain 110/1: A fiber type selected by pedigree method from the cross Belinka R_3 X I. 2569.
5- Strain 113: A fiber type selected by pedigree method from the cross I. 2195 X Belinka.

The experiments were laid out in a randomized complete block design with four replications. Seeds of each genotype were sown on 18 November 2004/2005 and 21 November 2005/2006 seasons, in 12 rows, 4 meters long and 12.5 cm apart. Plot size was 6 m^2 (1.5 x 4 m). Seed rate used was 60 kg/feddan. Other cultural practices were carried out as usual.

At harvest time, ten guarded plants were taken at random from each plot to determine yield components. Seeds and straw yield of flax/fed. were estimated from an area of 4 m^2 from the central area of each plot. Data collected included straw characters and seed yield and their relations as follows:-

1- Technical stem length (cm).
2- Main stem diameter (mm).
3- Straw yield (g/plant).
4- Straw yield (ton/fed.).
5- Total fiber percentage.
6- Fiber yield (k/fed.)
7- Upper branching zone length (cm).
8- Number of capsules/plant.
9- Number of seeds/plant.
10- Seed yield (g/plant).
11- Seed yield (kg/fed.)

For preparing transverse sections, the stem, root and leaf specimens were taken at blooming stage (95 days after sowing) during the second season. Stem and root pieces of 4-5 mm in length were taken from 10th internode and about 2 cm from the tip of the main roots, respectively. Concerning the leaf pieces 5 mm in length were taken from the fourth leaf including the midrib. Specimens were killed and fixed in formalin alcohol acetic acid mixture (FAA, 1:18:1 v/v), washed and dehydrated in alcohol series. The dehyderated specimens were infilterated and embedded in paraffin (52-54 °C m. p.). The embedded specimens were sectioned on a rotary microtome at a thickness of 10 – 12 µ m. Sections were mounted on slides and deparaffinised. Staining was accomplished with safranine and light green, cleared in xylol and mounted in Canada balsam (Gerlach, 1977).

Measurements of transverse sections of stem of five fibrous flax genotypes were stem diameter, vascular bundle and fiberous layer thickness, and diameter of fiber. Measurement of transverse sections of root of studied flax genotypes were root and vascular cylinder diameters. Measurement of transverse sections of leaves of studied flax genotypes were leaf lamina, palisade, spongy tissues thickness and vascular bundle wideness.

Statistical analysis:

Statistical analysis was performed using analysis of variance technique by means of IRRISTAT computer software package.

RESULTS AND DISCUSSION

Straw, seed yield and their related characteristics:

Mean values of straw yield, seed yield and their related characteristics for five fibrous flax genotypes during 2004/2005 and 2005/2006 seasons are presented in Tables (1 and 2). Analysis of variance revealed significant differences between means of the five flax genotypes. The means of technical stem length ranged from 78.96 to 88.12 cm in 2004/2005 season and from 75.11 to 93.47 cm in 2005/2006 season. Strain 110/1 gave the highest technical length in both seasons, whereas the imported Escalina gave the shortest technical length. The highest length of upper branching zone length was obtained from imported Escalina in both seasons. The means of stem diameter ranged from 1.57 to 1.81 mm in the first season and from 1.6 to 1.9 mm in the second one. The strain 109/2 gave the thinnest_plants in both seasons.

Table (1): Means of straw, seed yield and its components of flax genotypes during 2004/2005 season.

Genotypes / Characters	2004/2005				
	Escalina	Ilona	Strain 109/2	Strain 110/1	Strain 113
Technical stem length (cm)	78.96 c	82.18 b	80.67 bc	88.12 a	87.96 a
Upper branching zone length (cm)	8.87 a	8.0 7 a	6.26 c	7.36 b	7.96 b
Main stem diameter (mm)	1.81 a	1. 61 c	1,57 c	1.71 b	1.62 bc
Straw yield/plant (g)	0.968 a	0. 712 c	0.512 b	0.789 b	0.793 b
Number of capsules/plant	6.87 ab	6..20 b	7.88 a	8.01 a	6.82 b
Number of seeds/plant	50.31 b	4 9.47 b	€3.20 a	70.30 a	56.00 ab
Seed yield/plant (g)	0.220 c	0 .223 c	0.296 b	0.329 a	0.26 b4
Straw yield/fed. (ton)	3.819 bc	3.620 c	4.655 a	3.965 b	3.961 b
Seed yield/fed. (kg)	0.315 b	0.319 b	0.333 b	0.409 a	0.316 b

Values having the same alphabetical letters within a column are not significantly different (P < 0.05).

The means of straw yield/plant ranged from 0.512 and 0.482g for the strain 109/2 to 0.968 and 1.039g for the imported Escalina in both seasons, respectively. For number of capsules/plant, the strain 110/1 gave the highest values of 8.01 and 7.63 in both seasons, respectively. Whereas, the lowest value was recorded by the imported Ilona 6.20 and 5.92 in both seasons. The means of number of seeds per plant ranged from 50.31 and 44.82 for

imported Escalina to 70.30 and 66.96 for strain 110/1 in both seasons respectively.

Table (2): Means of straw, seed yield and its components of flax genotypes during 2005/2006 season.

Genotypes / Characters	2005/2006				
	Escalina	Ilona	Strain 109/2	Strain 110/1	Strain 113
Technical stem length (cm)	75.11 c	85.41 b	83.38 b	93.47 a	92.58 a
Upper branching zone length (cm)	11.96 a	9.41 b	5.70 c	8.26 b	8.45 b
Main stem diameter (mm)	1.90 a	1.66 b	1.60 c	1.72 b	1.63 b
Straw yield/plant (g)	1.038 a	0.811 c	0.482 d	0.851 b	0.880 b
Number of capsules/plant	6.12 b	5.92 b	7.59 a	7.63 a	6.32 ab
Number of seeds/plant	44.62 b	47.24 b	60.67 a	66.96 a	51.89 ab
Seed yield/plant (g)	0.196 d	0.213 c	0.285 b	0.313 a	0.245 b
Straw yield/fed. (ton)	4.095 b	4.123 b	4.382 a	4.298 ab	4.396 a
Seed yield/fed. (kg)	0.281 b	0.296 b	0.321 b	0.389 a	0.316 b

Values having the same alphabetical letters within a column are not significantly different (P < 0.05).

For seed yield/plant, strain 110/1 gave the highest value of 0.329 and 0.313 g in both seasons, respectively, whereas the imported Escalina gave the lowest value for this characters in both seasons. The highest value of straw yield/fed. was obtained from the strain 109/2 in the first season, whereas the strain 113 gave the highest value for the same character in the second season. Concerning seed yield/fed., the strain 110/1 gave the highest values, whereas the imported Escalina gave the lowest values in both seasons.. Such results are in harmony with those obtained by Kineber (1994); Kineber and El-Kady (1996 and 1998) and El-Kady and Kineber (2004).

Technological characters:

Statistical analysis showed significant differences among means of the five genotypes in technological characters i. e. fiber yield per plant and per feddan, fiber percentage, fiber length, fiber strength and fiber fineness as show in Tables (3 and 4).

Table (3): Means of technological characters of flax genotypes during 2004/2005 season.

Genotypes / Characters	2004/2005				
	Escalina	Ilona	Strain 109/2	Strain 110/1	Strain 113
Fiber yield/plant (g)	0.182 a	0.127 cb	0.092 c	0.144 b	0.153 b
Total fiber percentage	18.75 ab	17.85 c	16.01 b	16.29 b	19.23 a
Fiber yield/fed. (kg)	0.716b	0.646 c	0.838 a	0.729 bc	0.762 b
Fiber fineness (Nm)	440.21a	428.71 b	370.78 d	361.78 e	396.78 c
Fiber strength (R.K.M)	79.80a	70.23 b	56.12 c	80.01 a	51.87 c
Fiber length (cm)	75.81d	81.00 c	76.78 d	85.10 a	83.21 b

Values having the same alphabetical letters within a column are not significantly different (P < 0.05).

Table (4): Means of technological characters of flax genotypes during 2005/2006 season.

Genotypes / Characters	2005/2006				
	Escalina	Ilona	Strain 109/2	Strain 110/1	Strain 113
Fiber yield/plant (g)	0.195 a	0.145 b	0.087 c	0.157 b	0.178 ab
Total fiber percentage	18.76 ab	17.85 c	17.95 cb	18.50 b	20.25 a
Fiber yield/fed. (kg)	0.768 a	0.736 b	0.787 a	0.715 b	0.690 c
Fiber fineness (Nm)	438.71 a	417.67 b	369.78 c	358.71 d	378.67 c
Fiber strength (R.K.M)	69.81 a	62.73 b	51.32 c	71.21 a	50.72 c
Fiber length (cm)	73.12 c	81.10 b	80.78 cb	68.16 a	81.18 b

Values having the same alphabetical letters within a column are not significantly different ($P < 0.05$).

Imported Escalina exhibited the highest means of fiber yield/plant and fiber fineness, whereas the strain 113 gave the highest value of total fiber percentage. On the other hand, strain 109/2 gave the highest value of fiber yield per fed., whereas strain 110/1 gave the tallest fiber and the highest value of fiber strength. These results are in partial agreement with those obtained by Kineber (1994); Kineber and El-Kady (1996 and1998) and El-Kady and Kineber (2004).

Anatomical studies:

The stem structure of flax plants as seen in transverse sections consists of the epidermis, ground tissue and vascular system (Fig. 1). Ground tissue was differentiated into cortex and pith. The vascular collateral bundles were arranged in a complete cylinder (Siphonostele: ectophloic). Measurements of transverse sections of stems, leaves and roots of the five fibrous flax genotypes show significant anatomical differences at blooming stage. Data presented in Table (5) and illustrated in Fig. (1) indicated that, phloem fiber layer thickness differed significantly among the studied flax genotypes. Values of phloem fiber layer thickness ranged from 65µm in strain 109/2 to 103µm in strain 110/1 and strain 113 with a mean of 91.8µm. Insignificant differences were recorded between strain 110/1, strain113 and Ilona in this respect. Also diameter of fiber differed significantly among the studied flax genotypes. Values of fiber diameter ranged from 20µm in strain 109/2 to 28µm in strain 110/1 with a mean of 23.6µm. It should be noted that, the highest values of phloem fiber layer thickness and fiber diameter were recorded by strain 110/1.

In addition, the amount of conductive tissues (xylem and phloem) differed significantly among flax genotypes under study. All studied flax genotypes gave values of xylem tissue thickness higher than phloem tissue. Values of xylem tissue thickness ranged from 150µm in strain 109/2 to 305µm in strain 113 with a mean of 226µm. While, the thickness of phloem tissue ranged from 30µm in Ilona and strain 110/1 to 56µm in strain 113 with a mean of 43.2µm.

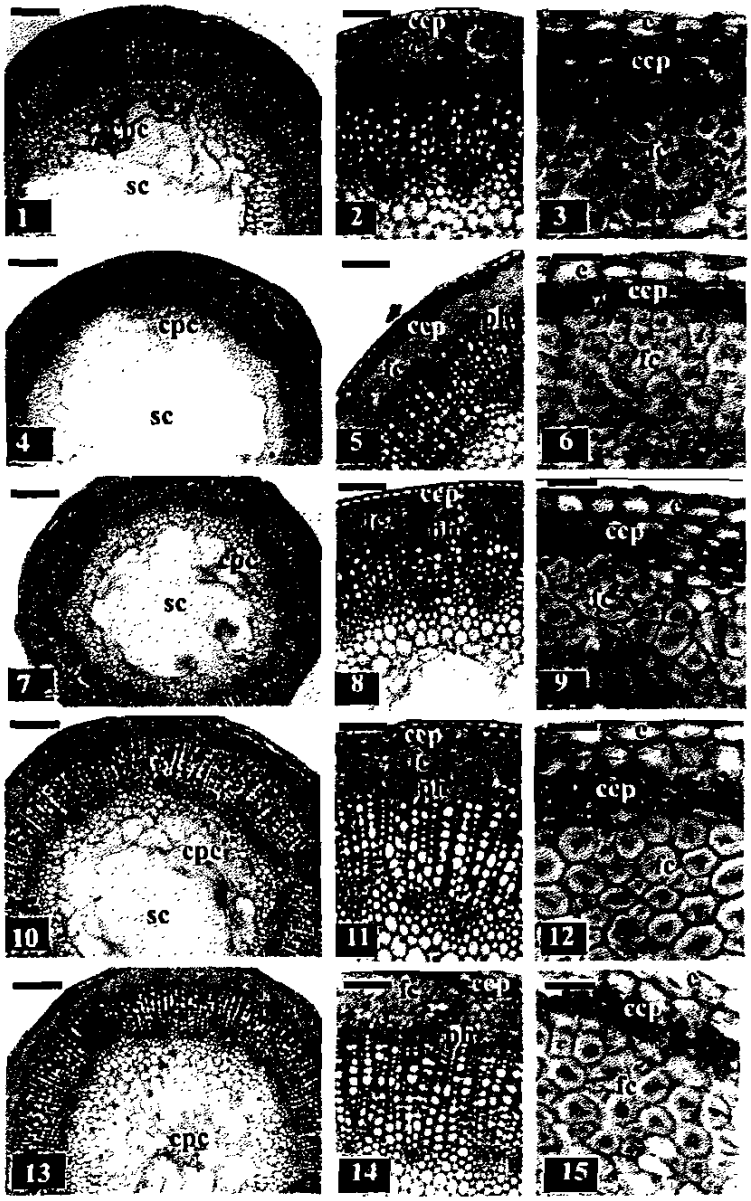

Fig. (1): Stem cross sections of five flax genotypes; 1-3: Escalina, 4-6: *Ilona*, 7-9: *Strain* 109/2, 10-12: *strain* 110/1, 13-15: Strain 113. e = epidermis, ccp = crushed cortical parenchyma, fc = fibereous cells, ph = phloem, x = xylem, cpc = crushed pith cells, sc = stem cavity.

Concerning anatomical root parameters, the root internal structure of flax plants is similar to other dicotyledons plants. It consists of the exodermis, ground tissue and the vascular system (Fig. 2). Ground tissue was differentiated into cortex and pith. The radical vascular bundles were arranged in a complete protostele (haplostele) cylinder. Data presented in Table (6) and illustrated in Fig. (2) show that, diameter of root ranged from 1.55mm in Escalina to 2.40mm in strain 110/1 with a mean of 2.01mm. Vascular cylinder (Haplostele) differed significantly among the studied flax genotypes. The differences among the tested flax genotypes could mainly be attributed to both the differences in their genetical constitution and their response to the environmental conditions.

Table (5): Anatomical parameters of stem of five flax genotypes.

Parameters / Genotypes	Fiber layer thickness (µm)	Fiber diameter (µm)	Xylem t. thickness (µm)	Phloem t. thickness (µm)
Escalina	88 b	25 c	225 c	55 a
Ilona	100 ab	22 d	175 d	30 c
Strain 109/2	65 c	20 e	150 e	45 b
Strain 110/1	103 a	28 b	275 b	30 c
Strain 113	103 a	35 a	305 a	56 a
Means	91.8	26	226	43.2

Values having the same alphabetical letters within a column are not significantly different ($P < 0.05$).

Regarding the anatomical parameters of the leaf, the leaf blade internal structure of flax plants is similar to other dicotyledons plants. It consists of upper and lower epidermis and mesophyll tissue, which differentiated into palisade and spongy parenchyma. Epidermis is one layer of a completely arranged parenchymatous cells, which are flattend parallel to the leaf surface. Mesophyll tissue differentiated into palisade and spongy tissues. The palisade parenchyma cells are elongated and completely arranged. The spongy parenchymatous cells are loosely arranged with numerous large intercellular spaces. Data in Table (7) and Fig (2) show that, the anatomical parameters under study differ significantly. The highest value of lamina thickness was found in strain 113, while the lowest value was recorded in Ilona genotype. The highest values of palisade and spongy tissues were found in strain 113, while the lowest values were recorded in Ilona. The wideness of the mean vascular bundle differ also significantly in the studied flax genotypes. The lowest values of length and width of the mean vascular bundle were obtained in Ilona, while the highest values were recorded in strain 113. These anatomical differences among the five tested flax genotypes could mainly be attributed to both the differences in their genetical constitution and their response to environmental conditions. Anatomical results clear and support the results of yield (fiber and straw) parameters.

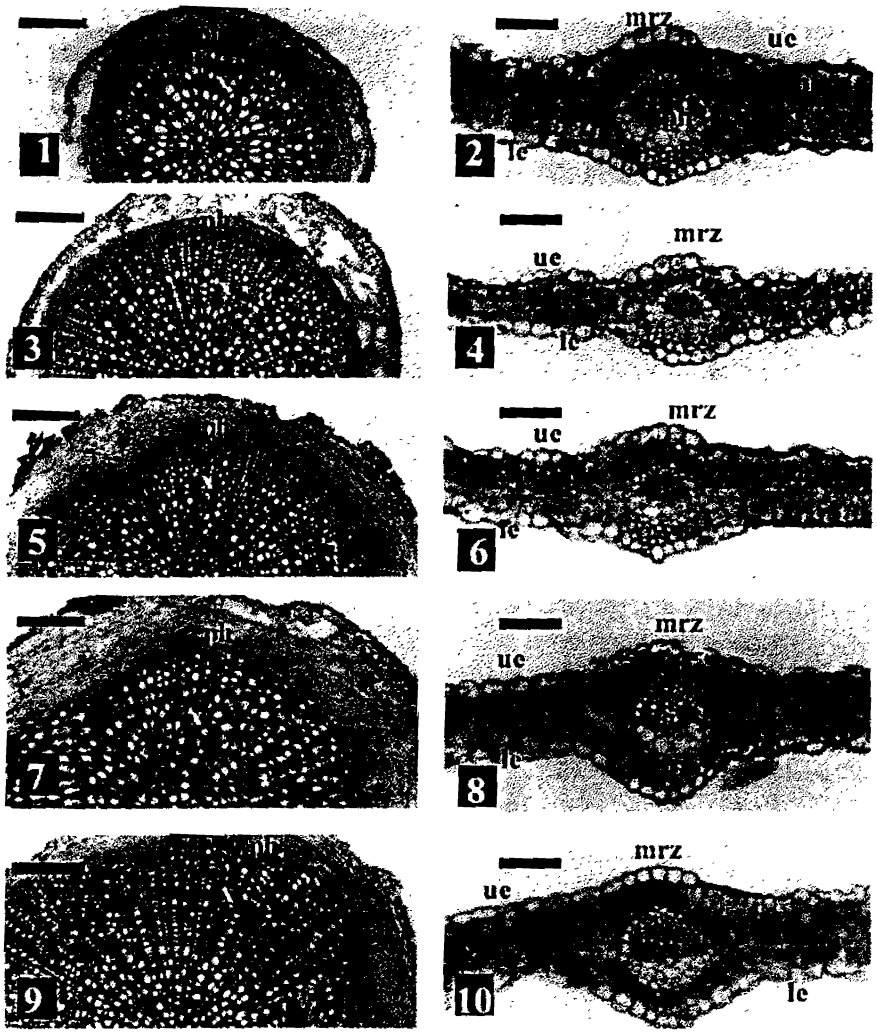

Fig. (2): Root and leaf cross sections of five fibrous flax. 1-2: Escalina, 3-4: Ilona, 5-6: Strain 109/2, 7-8: Strain 110/1, 9-10: Strain 113. ph: phloem, x = xylem, ue = upper epidermis, le = lower epidermis, pt = palisade tissue, st = spongy tissue, mrz = midrib zone.

Table (6): Histological structure parameters of root of five flax genotypes.

Parameters / Genotypes	Diameter (mm)	V. cylinder diameter (µm)	Xylem vessel diameter (µm)
Escalina	1.55 d	1200 d	48 a
Ilona	1.80 c	1550 c	23 bc
Strain 109/2	2.13 b	1825 b	28 b
Strain 110/1	2.40 a	2000 a	45 ab
Strain 113	2.18 ab	2000 a	48 a
Means	2.01	1715	38.4

Values having the same alphabetical letters within a column are not significantly different (P < 0.05).

Table (7): Histological structure parameters of leaf of five flax genotypes.

Parameters / Genotypes	Lamina thickness (µm)	Palisade t. thickness (µm)	Spongy t. thickness (µm)	Mean v. bundle	
				Length (µm)	Width (µm)
Escalina	175 a	50 b	65 a	160 bc	195 ab
Ilona	105 c	25 d	30 c	100 de	150 c
Strain 109/2	160 b	50 b	50 b	115 d	160 b
Strain 110/1	160 b	40 c	50 b	150 c	160 b
Strain 113	176 a	60 a	65 a	175 a	200 a
Messans	155.2	45	52	140	173

Values having the same alphabetical letters within a column are not significantly different (P < 0.05).

From the previously mentioned results under the present investigation, it could be concluded that, the highest values of technical stem length, phloem fiber thickness, fiber diameter, fiber strength, fiber length and number of capsules and seeds/plant were produced from flax strain 110/1. While, the highest values of straw yield/fed., xylem tissue thickness and fiber percentage were recorded by strain 113. On the other hand, the highest value of fiber yield/fed. was produced from strain 109/2.

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دراسات نباتية على بعض الطرز لكتان الألياف المنزرعة تحت ظروف الدلتا

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أجري هذا البحث بمزرعة محطة البحوث الزراعية بسخا – محافظة كفرالشيخ خلال موسمي ٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦م وذلك بهدف إجراء دراسات نباتية (تشريحية ومحصولية) لخمس طرز ليفية من الكتان وهي: مستورد إسكالينا و إيلونا وثلاث سلالات ليفية مبشرة (سلالة ٢/١٠٩ ، ١/١١٠ و١/١١٣).

وقد دلت النتائج على وجود فروق معنوية بين التراكيب الوراثية في معظم الصفات المدروسة حيث تفوقت السلالة ١/١١٠ في صفات طول الساق وعدد الكبسولات للنبات وعدد البذور ووزن النبات ووزن البذور للفدان وكذا طول الألياف ومتانتها. بينما تفوقت السلالة ٢/١٠٩ في صفات محصول القش للفدان ومحصول الألياف للفدان كما أعطت أقل قطر للساق وهي صفة مرغوبة. كما تفوق المستورد إسكالينا في صفات طول الجزء الثمري ووزن القش ومحصول الألياف للنبات والنسبة المؤية الكلية للألياف ونعومة الألياف.

كما أجريت دراسات تشريحية لسيقان وجذور وأوراق هذه الطرز الليفية للكتان أثناء مرحلة الإزهار وأظهرت النتائج اختلافات معنوية في الصفات محل الدراسة. لقد وجد أن السلالة ١١٣ تحتوي سيقانها على أكبر سمك لطبقة الألياف اللحائية وكذا قطر الليفة. كما احتوت سيقان طرز الكتان محل الدراسة على كميات من أنسجة الخشب تفوق أنسجة اللحاء. وقد تفوقت السلالة ١١٣ في محتواها من تلك الأنسجة الوعائية. أما بخصوص صفات الجذور التشريحية فقد وجد أن جذور السلالة ١/١١٠ أكبر من حيث القطر بينما كانت جذور المستورد إسكالينا أقل قطرا. كما أوضحت صفات الأوراق التشريحية أن السلالة ١١٣ ذات أنصال ،أنسجة عمادية وإسفنجية أكثر سمكا كما احتوت عروقها الوسطية على حزم وعائية أكثر اتساعا.