STUDIES ON SOME DOUBLE PURPOSE FLAX (*Linum usitatissimum* L.) GENOTYPES GROWN UNDER THE EGYPTIAN DELTA CONDITIONS

By

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ABSTRACT

Two field trials were conducted at Sakha Agric. Research Station during the two successive seasons 2004/2005 and 2005/2006. These investigations included four double purpose genotypes of flax i. e., Sakha1, Strain 22, Sakha 2 and Giza 6, which were studied the botanical characters and evaluated in relation to straw, seed yield and their component. The results obtained could be summarized as follows:-

1- Flax genotypes showed significant differences in all characters, viz., technical stem length, upper branching zone length, main stem diameter, straw yield per plant, number of capsules per plant, number of seeds per plant, seed yield per plant, straw yield per feddan, seed yield per feddan, oil seed percentage, oil yield per feddan and iodine number.
2- The promising strains 22 surpassed the other flax genotypes in all seed and technological characters and followed by Sakha 2, Sakha1 and Giza 6, respectively.
3- Sakha 2 surpassed the other genotypes in most anatomical parameters. It produced the highest values of fiber layer thickness, diameter of fiber and root, all leaf parameters and cotyledon thickness.

INTRODUCTION

The common flax plant (*Linum usitatissimum* L.) is a member of the family Linaceae. This family is widely distributed in the temperate and sub-tropical areas of the world. The seeds of flax plant is known as linseed, and from it is obtained the linseed oil of commerce. Flax seed contains from 32 to 47% oil. Linseed oil, extracted from flax seed, has an iodine number of 160 to 195 and used in the manufacture of paints, varnish, linoleum, oil cloth, printer's ink and core oil used in making forms for metal castings. Linseed oil meal produced as a by-product, is used for livestock feed. It's scope as a major oil seed crop depends upon breeders effort to evolve agronomically suitable cultivars. In

Egypt, the need of increasing the production of oil seed is widely recognized in view of the covering the gab (Kineber, 1991 and 2003) and Mostafa (1994).

To increase the linseed oil productivity, attention must be given to the development of new high yielding flax genotypes or hybrids for the growers and consumer through breeding programs. Before the initiation of any breeding program, in order to improve one or some quantitative characters, it is necessary that the materials used should be subjected to genetic analysis. The main objective of this study was to evaluate the four flax genotypes under Egyptian delta conditions for their adaptability and productivity.

MATERIALS AND METHODS

Two field trials were carried out at the Experimental farm of Agric. Res. Station, Sakha, at Kafr El-Sheikh Governorate, Egypt, during the two successive seasons (2004/2005 and 2005/2006). A complete randomized block design with four replications was used. The preceding crop was rice in both seasons.

Four genotypes of flax were used as follow:-

1- Sakha 1: a new commercial variety, selected by pedigree method from the cross (Bomby x I. 1485)
2- Strain 22: an oil type, selected by pedigree method from the cross(I. 370 x I. 2561).
3- Sakha 2: a new commercial variety, selected by pedigree method from the cross (I. 2348 x Hera).
4- Giza 6: a new commercial variety, selected by pedigree method from the cross (Giza 4 x Maroc).

Seeds of each flax genotypes were sown on 7th and 10th November 2004/2005 and 2005/2006, respectively. In ten rows, 3 meters long and 20 cm. apart. Plot size was 6 m^2 (3 x2m). Seeding rate used was 60 kg/feddan. Other cultural practices were carried out as usual. The central six rows in each plot were harvested determine seed and straw yields per plot and then adjusted to seed and straw yields per feddan. The outer two rows adjacent to the border ones in each plot were used to collect samples to study yield per plant and its components at full maturity.

A- Yield and its component.

The following parameters were recorded:

1- Technical stem length (cm).
2- Upper branching zone length (cm).
3- Main stem diameter (mm).
4- Straw yield per plant (g).
5- Number of capsules per plant
6- Number of seeds per plant.
7- Seed yield per plant (g)
8- Seed index (g).
9- Straw yield per feddan (ton).
10-Seed yield per feddan (ton).

B- Technological characters of seeds:-

1- Oil seed percentage. 2- Oil yield per feddan (ton). 3- Iodine value.

C- Anatomical study:

The anatomical studies were carried out only in the second season. For preparing sections, the stem, root and leaf specimens were taken after 95 days from sowing (at blooming stage), while the seed samples were taken at the end of growth season. Stem and root pieces 4-5 mm in length were taken from 10^{th} internode and about 2 cm from the tip of the main roots, respectively. Concerning the leaves pieces 5 mm in length were taken from fourth leaf from the tip of the main stems including the midrib. Specimens were killed and fixed in formalin Alcohol Acetic acid mixture (FAA, 1:18:1 v/v) and washed and dehydrated in ethanol 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). The sections were examined microscopically.

Measurement of stem transverse sections of four fibrous flax genotypes i. e. stem diameter, vascular bundle and fiberous layer thickness, and diameter of fiber. Measurement of transverse sections of root of studied flax genotypes i. e. root and vascular cylinder diameters were measured. Measurement of transverse sections of leaves i. e. lamina, palisade, spongy tissues thickness and vascular bundle wideness were recoded. Measurement of transverse sections of seeds included length and width of seeds as well as thickness of testa, endosperm and cotyledons.

Statistical analysis:

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

RESULTS AND DISCUSSION

Characters studied for yield and its components:-

Tables (1 and 2) showed that the means of straw, seed yields and its components differ as affected by flax genotypes during the both seasons. Results indicated significant differences between means of four tested genotypes for all characters. It is clear that, promising strain 22 recorded the highest mean values of upper branching zone length, number of capsules per plant, number of seeds per plant as well as seed yield per plant and seed yield per feddan followed by Sakha 2. In opposite, Giza 6 ranked the latest position in seed characters. In general, the descending arrangement of the flax genotypes for all characters under study was as follows: Strain 22, Sakha 2, Sakha 1 and Giza6 for seed characters except for seed index, while straw characters the arrangement as follow: Sakha 2, Sakha 1, Giza 6 and Strain 22.

The above mentioned results indicated that, the genotypes differed in genetic potential for straw and seed yields as well as its related characters. Such variability existed among the tested genotypes in seed and straw yields was also indicated by Kineber (1994); Kineber and El-Kady (1996 and 1998), Kineber and El-Kady (2002) and El-Kady and Kineber (2004).

Table (1): Means of technological characters as affected by genotypes of flax during 2004/2005 season.

Gnotypes / Characters	Sakha 1	Strain 22	Sakha 2	Giza 6	Means
Technical stem length (cm)	85.41 a	58.31 c	83.61 a	81.18 b	77.10
Upper branching zone length (cm)	11.96 b	19.62 a	17.38 a	13.71 ab	15.67
Stem diameters (mm)	1.90 c	2.01 b	2.01 b	2.12 a	2.01
Straw yield/plant (g)	1.38 b	0.898 c	1.182 a	1.098 a	1.14
Number of capsules/plant	11.56 c	19.98 a	16.78 ab	13.67 b	15.50
Number of seeds/plant	86.70 d	173.18 a	125.96 b	98.78 c	121.16
Seed yield/plant (g)	0.78 b	1.304 a	1.176 ab	0.854 b	1.03
Straw yield/fed. (ton)	4.818 ab	3.809 c	5.012 a	4.656 b	4.57
Seed yield/fed. (kg)	0.730 c	0.974 a	0.878 b	0.638 d	0.81

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

Table (2): Means of technological characters as affected by genotypes of flax during 2005/2006 season.

Characters \ genotype	Sakha 1	Strain 22	Sakha 2	Giza 6	Means
Technical stem length (cm)	86.36 a	51.67 c	84.18 a	80.19 b	**75.60**
Upper branching zone length (cm)	12.67 c	21.78 a	18.78 a	14.21 b	**16.86**
Stem diameters (mm)	1.82 c	2.01 b	2.11 a	2.12 a	**2.02**
Straw yield/plant (g)	1.067 b	0.916 c	1.178 a	1.102 a	**1.07**
Number of capsules/plant	12.67 c	20.78 a	18.87 a	14.72 b	**16.76**
Number of seeds/plant	95.03 d	180.11 a	131.81 b	106.37 c	**128.33**
Seed yield/plant (g)	0.862 b	1.356 a	1.232 a	0.920 b	**1.093**
Straw yield/fed. (ton)	4.953 a	3.884 b	4.995 a	4.673 a	**4.521**
Seed yield/fed. (kg)	0.801 c	1.014 a	0.920 d	0.687 d	**0.856**

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

Technological characters:

Mean values of technological characters of four flax genotypes of the two successive seasons are presented in Tables (3). Analysis of variance showed significant differences among flax genotypes with regard to the two technological characters i. e., oil seed percentage and Iodine value. Concerning oil seed percentage, data in two categories, the first group included the relatively higher mean values such as strain 22 46.72%. The second one included the lower estimates such as Sakha 2 (41.36%), Sakha 1 (40.12%) and Giza 6 (39.98%). This results showed similar trend with seed yield per feddan. Regarding Iodine value, this trait ranged from 181.67 (Giza 6) to 189.78 (Strain 22) with superiority ratio of 4.46%. This results are in harmony with those obtained by Mostafa (1994), Kineber (1994), Kineber and El-Kady (1996 and 1998), Mostafa *et al.* (1998), Kineber and El-Kady (2002), El-Kady and Kineber (2004), Kineber and El-Saayed (2004) and Kineber *et al.* (2006). Generally, the promising strain 22 achived high seed technology and relatively great seed yield per feddan.

Table (3): Means of technological characters of four double purpose genotypes of flax during 2004/2005 and 2005/2006 seasons.

Characters / Genotypes	2003/2004			2004/2005		
	Oil seed %	Oil yield/fed. (kg)	Iodine value	Oil seed %	Oil yield/fed. (kg)	Iodine value
Sakha 1	40.12 b	292.88 c	184.00 b	40.26 b	322.48 c	183.87 b
Strain 22	46.72 a	455.05 a	189.78 a	45.23 a	458.63 a	191.78 a
Sakha 2	41.36 b	363.14 b	183.71 c	41.70 b	383.64 b	182.88 c
Giza 6	39.98 c	255.07 d	181.67d	39.88 c	273.98 d	183.78 b
Means	**42.05**	**341.54**	**184.79**	**41.77**	**359.68**	**185.58**

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

Anatomical studies:

Anatomically, stem, root, leaf and seeds of four double purpose flax genotypes (Sakha 1, Strain 22, Sakha 2 and Giza 6) were studied. Measurement of cross sections of these plant organs of flax genotypes differ significantly mainly in the most anatomical parameters. Data illustrating in Fig (1) and presented in Table (4) showed that, the highest values of phloem fiber layer thickness, fiber diameter, xylem and phloem tissues thickness of stem were recorded by Sakha 2 and Giza 6. Fiber in Giza 6 seem to be elongated in the cross section compared with the other genotypes. The lowest values were obtained by the other two genotypes in this respect except Sakha 1 gave the highest value of phloem tissue thickness. These results are in harmony with those obtained by Kineber *et. al.* (2006), who studied the anatomical differences of stem of five fibrous flax genotypes.

Regarding the measurements of transverse sections of root of the tested flax genotypes, the highest values of root, vascular cylinder and xylem vessel diameter were determined in Sakha 2 genotype (Fig. 2 and Table 5). On the other hand, the lowest values of root and vascular cylinder diameters were obtained in strain 22, while the lowest value of xylem vessel diameter were recorded in Sakha 1 genotype

Concerning anatomical parameters of flax leaf of the studied genotypes, data illustrating in Fig (3) and presented in Table (6) showed that, Sakha 2 genotypes gave the highest values of leaf lamina, palisade, spongy tissues thickness as well as length and width of midrib vascular bundle compared with the other flax genotypes under study. On the other side, the lowest values of leaf lamina, palisade and spongy tissues thickness were produced by Giza6 It should be noted that there are relationship between anatomical parameters of stem and root and the anatomical parameters of the leaf

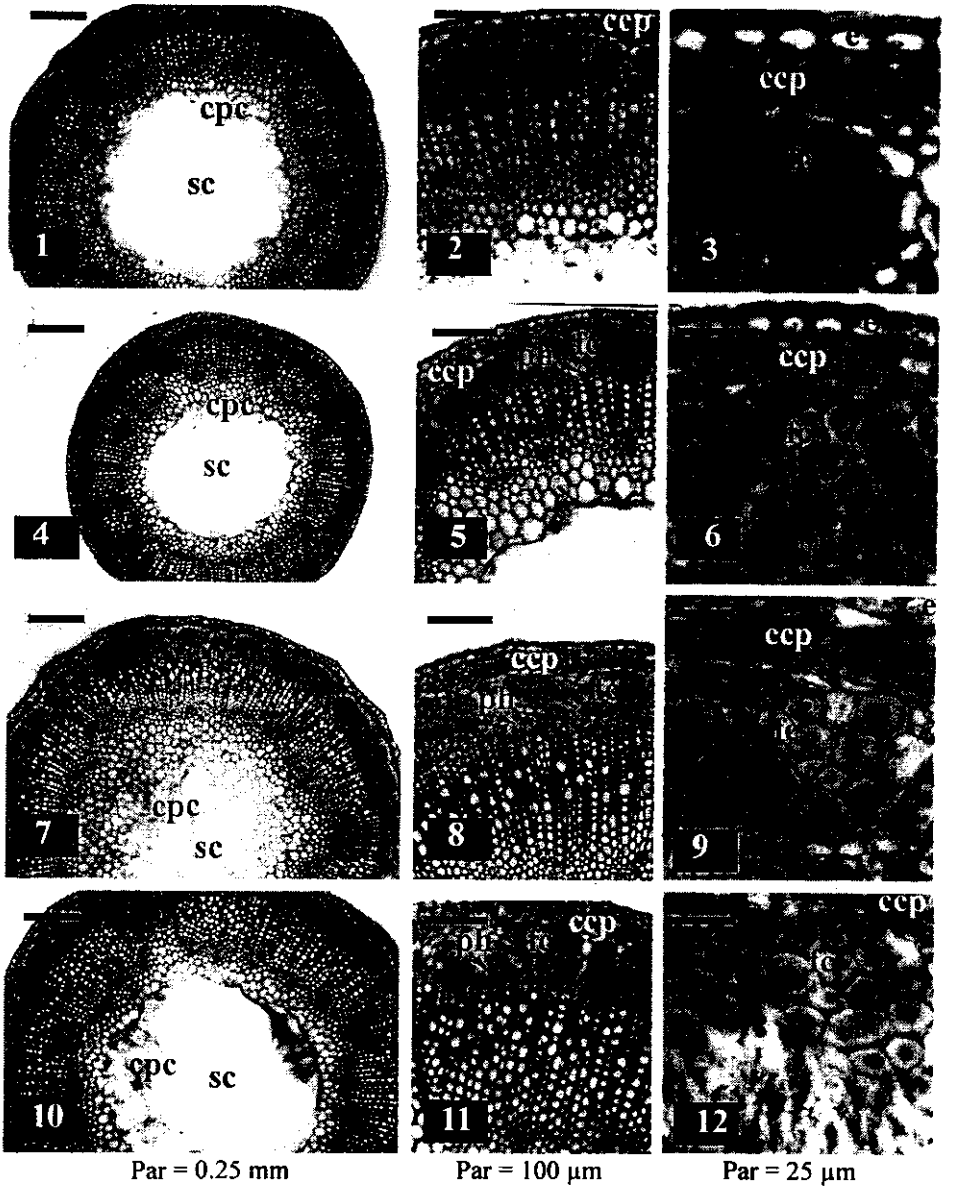

Fig. (1): Stem cross sections of four flax genotypes; 1-3: Sakha 1, 4-6: Strain 22, 7-9: Sakha 2, 10-12: Giza 6, e = epidermis, ccp = crushed cortical parenchyma, fc = fibereous cells, ph = phloem, x = xylem, cpc = crushed pith cells, sc = stem cavity.

Table (4): Anatomical parameters of ster . of four oily flax genotypes.

Parameters / Genotypes	Fiber layer thick. (µm)	Fiber diameter (µm)	Xylem t. thickness (µm)	Phloem t. thickness (µm)
Sakha 1	70 c	18 b	160 b	45 a
Strain 22	78 b	18 b	135 c	20 b
Sakha 2	87 a	22 a	325 a	40 a
Giza 6	86 a	20 a	330 a	32 a
Means	79.75	19.5	237.75	36

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

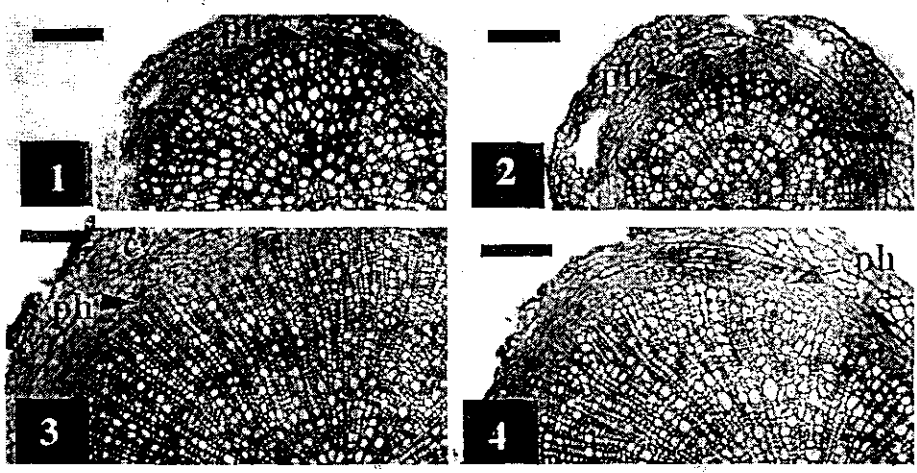

Fig. (2): Root cross sections of four oily flax genotypes. 1: Sakha 1, 2: Strain 22, 3: Sakha 2, 4: Giza 6. ph: phloem, x = xylem (Par = 0.25mm).

Table (5): Anatomical parameters of root of four oily flax genotypes.

Characters / Genotypes	Root diameter (mm)	Vascular cylinder diameter (µm)	Xylem vessel diameter (µm)
Sakha 1	1.4 c	1225 c	20 c
Strain 22	1.3 c	875 d	28 b
Sakha 2	2.5 a	2075 a	38 a
Giza 6	2.0 b	1650 b	25 c
Means	1.8	1456.25	27.75

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

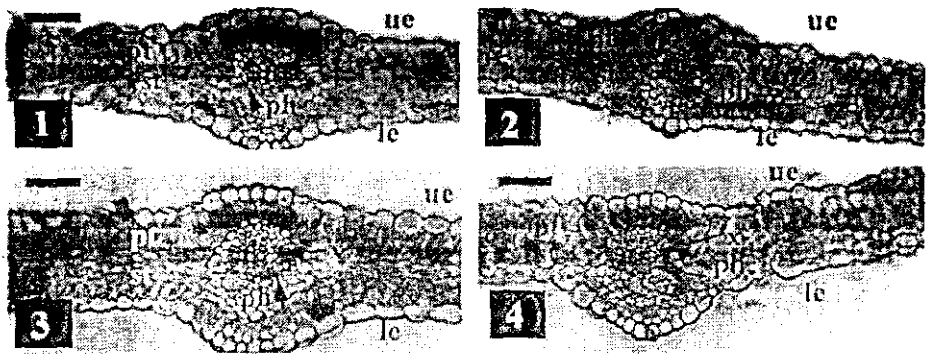

Fig. (3): Leaf cross sections of four oily flax. 1: Sakha 1, 2: Strain 22, 3: Sakha 2, 4: Giza 6. ph: phloem, x = xylem, ue = upper epidermis, le = lower epidermis, pt = palisade tissue, st = spongy tissue, mrz = midrib zone, (Par = 100µm).

Table (6): Histological structure parameters of leaf of four oily flax genotypes.

Characters / Genotypes	Lamina thickness (µm)	Palisade t. thickness (µm)	Spongy t. thickness (µm)	V.B. length (µm)	V.B. width (µm)
Sakha 1	180 b	56 c	65 b	125 b	150 b
Strain 22	170 c	60 b	65 b	115 c	150 b
Sakha 2	190 a	69 a	70 a	180 a	200a
Giza 6	160 d	55 c	55 c	125 b	125 c
Means	175	60	655	136.25	156.25

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

Fig. (4) and Table (7) indicated that, the tested anatomical properties of seeds of four flax genotypes differ significantly. Seed color ranged from yellow in Strain 22 to dark-brown in Giza 6. The highest values of seed length were recorded in Sakha 2 and Giza 6 (5.07 mm), while Sakha 1 gave the lowest value in this respect. Seed width ranged from 2.63 mm in strain 22 to 3.15 mm in Giza 6 with a mean 3.01 mm. For endosperm thickness, Sakha 1 ranked in the first position (260µm), while Strain 22 gave the lowest value (130µm) in this respect. Sakha 2 achieved the highest thickness of cotyledon and testa (outer and inner integuments), while Strain 22 gave the lowest values in this respect. These results can explain the increasing of oil seed % and oil yield/fed. in Sakha 2, which had the highest value of cotyledons thickness. On the other hand, Strain 22 achieved the highest values of oil seed % and oil yield/fed. Endosperm and cotyledon cells appear to be more cytoplasmic desity. Yield, and its components as well as anatomical differences among the four tested flax genotypes could mainly be attributed to both the differences in their genetical constitution and their response to environmental conditions Kineber, *et al.* (2006). No available literature was found concerning the anatomical differences between seeds of flax genotypes under the study.

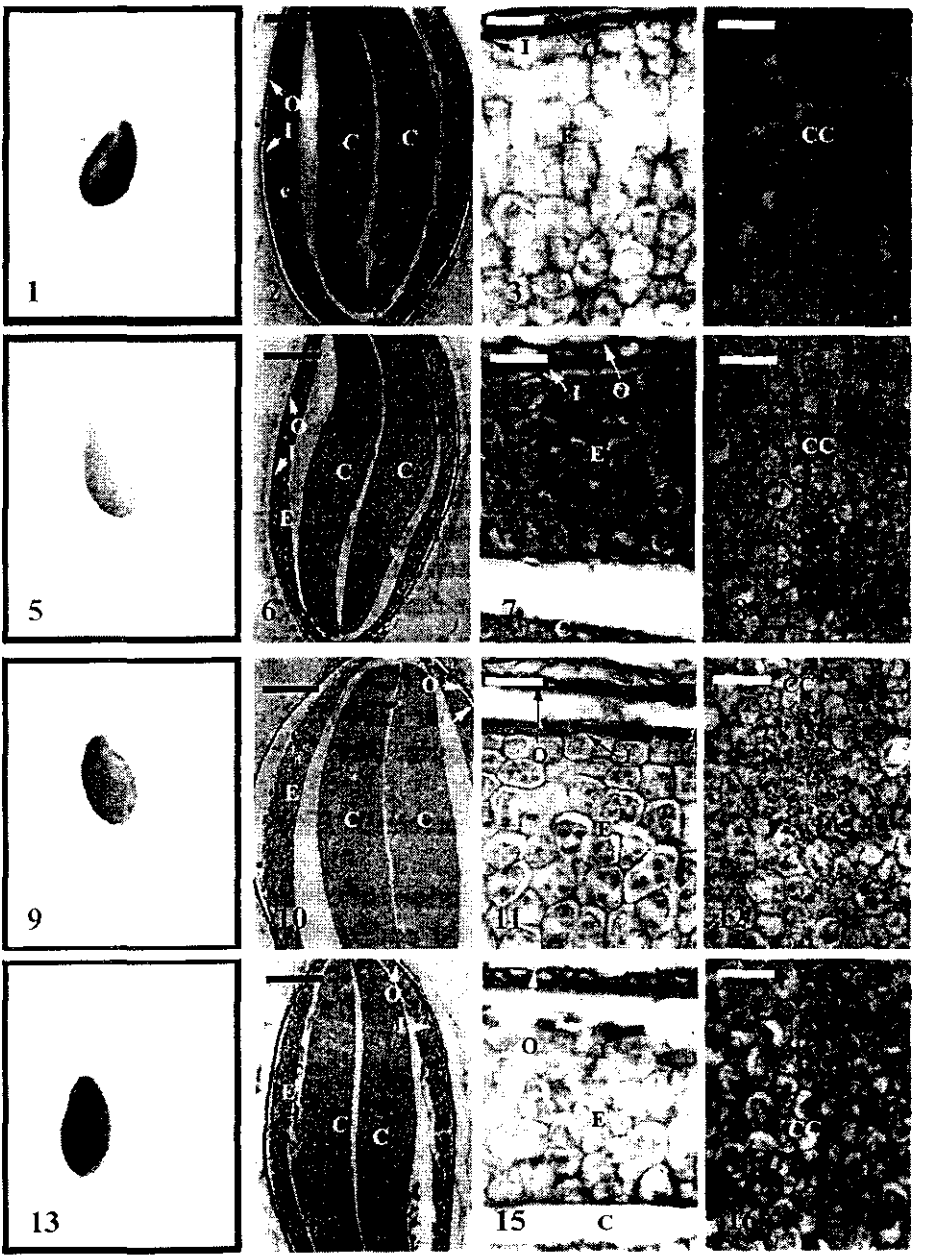

Fig. (4): Seeds and its cross sections of four flax genotypes, 1-4: Sakha 1, 5-8: Strain 22, 9-12: Sakha 2, 13-16: Giza 6. C: Cotyladon, CC: Cotyladonary cells, E: Endosperm, I: Inner integument, O: Outer integument

Table (7): Histological structure parameters of seeds of four oily flax genotypes.

Characters / Genotypes	Seed length (mm)	Seed width (mm)	Thickness of Endosperm (µm)	Thickness of cotyledon (µm)	Thickness of Testa (µm)
Sakha 1	4.40 b	3.13 ab	260 a	420 b	25 c
Strain 22	4.97 ab	2.63 c	130 d	400 d	20 d
Sakha 2	5.07 a	3.13 ab	240 b	470 a	50 a
Giza 6	5.07 a	3.15 a	160 c	410 c	45 b
Means	**4.88**	**3.01**	**197.5**	**425**	**35**

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

According to the obtained results, it's obvious that the promising strain 22 achieved high seed technology and relatively great seed yield per feddan. Therefore, we recommend that the promising strain 22 and Sakha 2 can be uses as parents in flax breeding programs, since they are high yielding in both seasons in oil percentage and oil yield/fed.

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الملخص العربي

دراســـــات علـــي بعـــض التراكيب الوراثية للكتـــــان ثنـــــــائيـــــــة الـــــغرض المنزرعة تحت ظروف دلتا مصر

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بسخا موسمي ٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦م حيث اشتملت كل تجربة على أربعة تراكيب وراثية ثنائية الغرض (ثلاثة أصناف تجارية هي: سخا١ وسخا ٢ وجيزة ٦ وسلالة ٢٢) وذلك لتقييمها من حيث محصولي القش والبذور ومكوناتهما بالإضافة إلى الصفات التشريحية والنباتية الأخرى لأجزاء النبات المختلفة وهي الساق والجذور والأوراق والبذور وكانت أهم النتائج المتحصل عليها كالآتي:-

١- اختلفت التراكيب الوراثية فيما بينها معنوياً في كل الصفات المدروسة مثل طول وقطر الساق ومنطقة التفريع ومحصول القش وعدد الثمار والبذور لكل نبات كذا ومحصول القش والبذور والزيت للفدان وأيضاً نسبة الزيت والرقم اليودي.

٢- تفوقت السلالة المبشرة س٢٢ على باقي التراكيب الوراثية في كل الصفات البذور المختلفة وكذا الصفات التكنولوجية المدروسة وتبع ذلك التراكيب الوراثية الآتية: سخا ٢ وسخا ١ وجيزة ٦ على الترتيب.

٣- أظهر الصنف سخا ٢ تفوقاً في معظم الصفات التشريحية تحت الدراسة ، حيث أعطى أعلى القيم في سمك طبقة الألياف وقطر كلاً من الألياف والجذور وكذا كل قياسات الأوراق تحت الدراسة وأيضاً سمك الفلقات الجنينية.