EFFECT OF STORAGE ENVIRONMENT AND PACKAGE MATERIAL ON STORABILITY, YIELD AND ITS QUALITY OF FLAX SEEDS

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ABSTRACT

Change in germination, viability parameters yield and some chemical composition of five seed flax cultivars (Belinka, Giza 7, Sakha 1, Sakha 2 and Strain 6. Experiments were carried out at seed test lab and at the farm of Sakha Agric. Res. Station, ARC, Egypt, during the period 2000-2004. Treatments included storage under controlled (20°C) and uncontrolled temperature (warehouse) and package (in high density polyethylene 143 g/m^2, and paper) for periods 6, 18, 30 and 42 months. The stored seeds were sown simultaneously after each storage period at the field. Data concerned with germination, moisture, oil percentage, free fatty acid percentage, acid value, acidity percentage, crude protein percentage, technical stem length, fruiting zone length, no. of capsules /plant, no. of seeds /plant, straw yield /fed. and seed yield /fed. were recorded.

The results indicates that, increasing storage period significantly reduced germination percentage, oil content, oil characters (by increased free fatty acid and acid value), crude protein, technical stem length, straw yield /fed. whereas increasing fruiting zone length, no. of capsules /plant, no. of seeds /plant, seed yield /fed and acidity. The storage conditions 20°C gave the highest values for germination percentage, protein percentage, oil percentage, the best oil characters (by decline free fatty acid and acid value), technical stem length, straw yield /fed. On the other hand, acidity, fruiting zone length, no. of capsules /plant, no. of seeds /plant and seed yield /fed. were achieved when flax seeds incubated uncontrolled (warehouse). The highest values of germination percentage, oil percentage, the best oil characters,

technical stem length, straw yield /fed. were recorded by seeds stored in high density polyethylene, whereas seeds stored in paper package gave bad oil characters (by increasing free fatty acid and acid value), the highest values for acidity, fruiting zone length, no. of capsules /plant, no. of seeds /plant, seed yield /fed. Sakha 1 ranked first and was superior to other cultivars in technical stem length and straw yield /fed, while Sakha 2 gave the highest values for germination percentage, oil percentage, no. of capsules /plant, no. of seeds /plant, seed yield/ fed. and strain 6 was recorded the highest value for protein percentage. On the other hand, Belinka cultivar gave the highest value for free fatty acid percentage, acid value and acidity percentage.

Key word: flax genotype, storage period, temperature, package material, warehouse

INTRODUCTION

The production of maximum flax yields required adequate supplies of high quality seed of improved cultivars. In general, we stored seed to maintain it in a viable condition from the time of collection until the time of sowing. Storage time varies according to the purpose for which you stored the seed. The longer you need to store it, the more expensive it becomes. Careful storage may help alleviate problems of seed availability and large seed crops may be used for several years of revegetation activity, avoiding the need to rely on the current crop alone. Seeds of most species may be safely stored for several years by careful control of temperature and relative humidity. In some parts of the world especially in the tropics, conditioned storage is necessary in order to maintain high viability of some seeds from harvest to planting (Harrington 1973). The general principle is that low-moisture, high-quality seeds stored under cool, dry conditions maintain seed quality better than high-moisture, low quality under humid conditions, (Roberts 1986). Factors such as temperature, moisture, variety, and nutrient status influence seed maturity, which, in turn, influence seed storability. The greatest potentials are attained at the time of physiological maturity, or maximum dry weight of the seed. (Copeland and McDonald 1995).

Reducing rate of germination decline would not only provide for longer preservation, but also reduce the demand for germination testing and regrowing. Therefore, optimum conditions must be provided to insure maximum seed preservation. Decline in seed germination was directly related to seed moisture content and storage temperature (Bass and Stanwood 1977). germination decline 2.7 % per degree C storage temperature rise. Low temperature was the most effective means of preserving seed germination. Most observations indicate that starchy seeds above 12 % and oily seeds above 9 % deteriorate faster in sealed storage than in nonsealed storage (Harrington 1973) Seeds in packages that are not completely impervious to moisture may gain or loss moisture with time. Such change are controlled by the surrounding atmosphere, moisture–vapor transmission rate of the packaging material, equilibrium moisture content of the seeds for the surrounding atmosphere, and the ratio of surface area of the packages. Seeds in small packages gain or lose moisture faster than seeds in large packages . Therefore, small packages require better moisture –barrier materials than do large for equal moisture protection (Bass 1971). The use of high vigor planting seed for all crops in justified, however, to help ensure adequate plant population across wide range of field conditions encountered during emergence. In recent years, packing seeds in moisture barrier containers to prevent loss of viability and resistant or hermetically sealed containers for storage and marketing has explored. The purpose of such containers is to maintain seeds at safe storage moisture levels (Copeland and Mc Donald, 1995). Acid value of linseed Giza 7 and Giza 8 oils extracted from stored seeds were increased by prolonging storage period (El-Kady 1995). The hydrolysis of phospholipids leads to the release of glycerol and fatty acids, and this reaction accelerates with increasing seed moisture content (Harrington 1973).

MATERIALS AND METHODS

The present investigation was carried out in the laboratory of seed Technology and field experimental of Sakha Research Station, ARC. Egypt in four successive growing seasons 2000-2004 to

study the effect of four storage periods (6, 8, 30 and 42 months). storage temperature [controlled (20°C) and uncontrolled (warehouse)] and package materials (paper and high density polyethylene 143 g/m^2, each package was field with 1 kg of seeds) on seed viability, seed oil characters, acidity, yields and some chemical characters for seeds of five flax cultivars. The seeds of the mentioned treatments were sown simultaneously at the field after each storing period. Plot size 6 m^2 (1.5 × 4), seeding rate used was 60 kg /fed. Other agricultural practices were applied as usually done in the ordinary flax fields. Plant material included five cultivars of flax (Belinka, Giza 7, Sakha 1, Sakha 2 and Strain 6). Collected date were analyzed according to the factorial completely randomized block design with three replicates .

1- Seed testing parameters:-

Standard Germination:- Test was carried out under optimum conditions according to international rules Testing (ISTA, 1999).

Chemical composition characters:- Seed sample were taken at random from each plot and grounded to fine powder to pass through 2 mm mesh for chemical analysis; i.e., moisture content, oil %, crude protein %, free fatty acids (F.F.A) and acid value (A.V) and acidity % were determined according to procedures outline in AOAC (1990).

At the beginning of storage viability, moisture content, seed oil characters and chemical composition of the seed were measured on an original weight basis as follows:

Table (1): Means of chemical characters of some flax genotypes from combined analysis over seasons.

Genotype	Germination %	Moisture %	Oil %	Crude protein %	F.F.F. %	Crude fiber %	Ash %	A.V
Giza 7	97	8.76	41.36	23.04	0.0540	15.26	3.81	0.1110
Sakha 1	99	8.03	42.47	21.33	0.0552	13.98	3.57	0.0940
Sakha 2	100	8.26	41.79	23.14	0.0570	13.27	3.61	0.1109
Belinka	95	8.76	37.29	22.90	0.0542	14.06	3.68	0.1110
Strain 6	97	8.50	41.24	24.90	0.0561	12.84	3.88	0.1109

2- Yield and its components characters:-

At maturity, guarded plants were hand pulled at random from each plot to be used in recording the yield components. Flax yields for straw and seed per fed. were recorded on the whole plot area basis. Data collected included:- Technical stem length (cm.), straw yield per fed. (ton), fruiting zone length (cm.), no. of capsules per plant, no. of seeds per plant, seed yield per fed., (kg.)

Analysis of variance computed according to Snedecor and Cochran (1982) and treatment means compared by Duncan's multiple range test, (Duncan, 1955). Correlations performed according to Singh and Chaudhary (1979).

RESULTS AND DESCUSSION

1- Seed testing characters:-

The effect of storage periods on studied viability parameters of flax seed lots are given in Table (2). Increasing storage period from 6 to 42 months significantly decreased the mean germination percent from 98.27 % to 79.32 % respectively. However, it can be concluded that there was a general trend towards decrease in seed germination by increasing storage time under the conditions of this study. Similar results were reported by El-kholy 1975; Abdelmagid and Osman 1977; Bass and Stanwood 1977; Odiemah 1987; El-Borai et al. 1993; Soad (1997) and El-Aidy et al. (2001).

The decline in germination percentage with time was associated with a decrease in oil and protein content of seeds, however, the different oil quality indices were significantly affected. Increasing storage period from 6 up to 42 months significantly affected acidity percentage, F.F.A percentage and A.V. These findings are in agreement with those obtained by El-Borai et al. (1993), El-Aidy et al. (2001). Also Wilson and Mc Donalled (1986) who proposed that, during storage, seed lipids are subjected to continuous slow oxidation resulting in the formation of hydroperoxides, oxygenated fatty acid. These is debate as to weather the increase in free fatty acids is due to production of lipases by microflora or by the seed itself (Hummel et al. 1954). Increasing storage from 6 to 42 months significantly increased the

mean acidity, free fatty acid (F.F.A) and acid value (A.V). while decreased oil and protein percentage, and no significant for moisture content. Mean germination percentage of flax seeds as affected by different storage temperature [controlled (incubated) and uncontrolled (warehouse)] are given in Table (2). Data indicated that the highest germination percentage was obtained in flax seeds incubated at 20°C compared with storage in warehouse. The results obtained were similar at those reported by other investigators such as Delouch and Baskin 1973; Harrington 1973; Bass and Stanwood 1977; Ellis and Roberts 1980; Pomeranz 1992; Chhetri et al 1993; Sandhu et al. 1993; Robert 1981; Copeland and Mc Donald 1995; Chimtembo 1996; and Soad 1997. Reported that the germination decline more rapidly at higher temperature and less rapidly at lower temperature. Meantime storage at warehouse recorded the lowest value of crude protein percentage and oil percentage (21.93 and 29.68 respectively), highest value of F.F.A percentage, A.V and acidity (0.1232 %, 0.2466 and 6.24 %) respectively at warehouse storage. Also data show no significant effect for moisture content.

Table (2) indicates that the germination percentage of flax seeds was significantly affected by cultivars; Sakha 2 was significantly higher in germination percentage and oil percentage and lower in F.F.A, A.V and acidity. On the other hand, Belinka was significantly lower in germination percentage and oil percentage and higher in acidity, F.F.A and A.V within a period of 42 months of storage.

There were highly significantly differences among germination percentage of flax seed within various packaging materials. Germination percentage for flax seeds within high density polyethylene (H.D.P) was significantly higher than paper package (92.63 % and 89.07 %) respectively. Meantime storage with H.D.P. recorded high value of oil percentage and protein percentage. On the other hand gave lower value of F.F.A. % A.V. and acidity percentage.

Table (2): Effect of seed storage periods, temperature, genotypes and package materials on seed germination percentage, chemical composition, acidity and oil characters

Item	Germination %	Moisture %	Oil %	F.F.A %	A.V	Acidity %	Protein %
Storage Periods							
6 month	98.27 a	7.76	39.68 a	0.0715 d	0.1431 d	4.20 d	22.98 a
18 month	95.27 b	7.39	37.16 b	0.0888 c	0.1779 c	5.28 c	22.55 b
30 month	90.55 c	7.15	32.40 c	0.1122 b	0.2248 b	6.31 b	21.89 c
42 month	79.32 d	7.65	20.63 d	0.1347 a	0.2696 a	7.12 a	21.34 d
Storage temperature							
20oC	96.53 a	7.49	35.26 a	0.0804 b	0.1611 b	5.22 b	22.45 a
Warehouse	85.17 b	7.48	29.68 b	0.1232 a	0.2466 a	6.24 a	21.93 b
Genotypes							
Belinka	83.65 e	7.75	29.67 e	0.1111 a	0.2223 a	6.40 a	21.84 d
Giza 7	92.79 c	7.40	33.35 b	0.1002 c	0.2007 c	5.57 c	22.28 c
Sakha 1	93.46 b	7.38	33.12 c	0.0994 c	0.1993 d	5.58 c	20.55 e
Sakha 2	95.69 a	7.38	33.64 a	0.0925 d	0.1851 e	5.09 d	22.65 b
Strain 6	88.67 d	7.52	32.57 d	0.1058 b	0.2118 b	6.01 b	23.63 a
Package materials							
Paper	89.07 b	7.50	31.57 b	0.1052 a	0.2106 a	6.01 a	22.10 b
Polyethylene	92.63 a	7.47	33.37 a	0.0984 b	0.1971 b	5.44 b	22.28 a

Means designated by different letters in the same column are significantly different at 5 % according to Duncan s multiple range test.

The interaction between storage temperature and storage period (Fig.1) and (Table 3) indicates that germination percentage declined to 92.73 % and 65.90 % at 20°C and warehouse respectively after 42 months of storage. It is also observed that decline in oil percentage and protein percentage after 42 months with prolonged storage period up to 42 months. The lowest oil percentage 25.71 and 15.55 percentage were recorded at 20°C temperature and warehouse respectively. Rapid decline in oil percentage after 30 months of storage at warehouse storage was compared with 20°C (27.46 % and 37.35 %). Low temperature (20°C) showed little remarkable changes in protein percentage up to 42 months compared with warehouse (21.66 % and 21.06 %) respectively.

F.F.A, A.V. and acidity of flax seeds affected by the interaction between storage temperature and storage period showed

in Table (3). Results show rapid increase in this characters when stored in warehouse after 42 months storage. (0.1655 %, 0.3314 and 6.04 % respectively). While it was slowly increased at 20°C. 0.1038 %, 0.2079, and 6.04 % (F.F.A, A.V. and acidity respectively). Similar results were reported by El-Aidy (1988); El-Borai et al (1993), Soad (1997) and El-Aidy et al. (2001).

Table (3): Effect of interaction between period and storage temperature, cultivar and storage temperature and period and package material on chemical composition, acidity and oil characters

Interaction	Moisture %	Oil %	F.F.A %	A.V %	Acidity %	Protein %
Period × storage temperature						
6 months × 20°C	7.69	39.89	0.0611	0.1227	3.97	23.02
6 months × warehouse	7.82	39.47	0.0818	0.1635	4.43	22.93
18 months × 20°C	7.58	38.08	0.0694	0.1389	5.16	22.94
18 months × warehouse	7.19	36.25	0.1082	0.2168	5.41	22.17
30 months × 20°C	6.87	37.35	0.0874	0.1751	5.70	22.18
30 months × warehouse	7.43	27.46	0.1371	0.2745	6.93	21.61
42 months × 20°C	7.83	25.71	0.1038	0.2079	6.04	21.66
42 months × warehouse	7.47	15.55	0.1655	0.3314	8.20	21.02
LSD	0.114	0.2188	0.001613	0.001613	0.0756	0.03225
cultivar × storage temperature						
20°C ×Belinka	7.54	32.08	0.0834	0.1671	5.69	22.06
20°C × Giza 7	7.32	36.15	0.0816	0.1635	5.11	22.58
20°C × Sakha 1	7.51	36.17	0.0820	0.1643	5.10	20.97
20°C × Sakha 2	7.47	36.48	0.0727	0.1457	4.86	22.86
20°C × Strain 6	7.62	35.42	0.0824	0.1651	5.32	23.78
Warehouse × Belinka	7.95	27.26	0.1388	0.2776	7.11	21.63
Warehouse × Giza 7	7.49	30.54	0.1188	0.2379	6.02	21.97
Warehouse × Sakha 1	7.26	30.07	0.1168	0.2342	6.05	20.14
Warehouse × Sakha 2	7.29	30.81	0.1122	0.2245	5.32	22.44
Warehouse × Strain 6	7.42	29.72	0.1291	0.2585	6.70	23.47
LSD	-	0.2446	0.001803	0.00180	0.0846	0.0361
Period × package material						
6 months × paper	7.70	39.44	0.0725	0.1449	4.35	22.95
6 months ×polyethylene	7.82	39.92	0.0705	0.1413	4.05	23.00
18 months × paper	7.55	36.28	0.0903	0.1809	5.59	22.50
18 months ×polyethylene	7.22	38.05	0.0873	0.1749	4.98	22.61
30 months × paper	7.05	31.64	0.1163	0.2329	6.69	21.77
30 months × polyethylene	7.25	33.17	0.1081	0.2166	5.94	22.02
40 months × paper	7.71	18.91	0.1417	0.2838	7.43	21.20
40 months ×polyethylene	7.59	22.35	0.1276	0.2555	6.80	21.48
LSD	0.1140	0.2188	0.001613	0.001613	0.0756	0.0323

The interaction effects between cultivars and storage temperature according to data collected in Fig.(1) and Table (3) show significant increase in germination percentage, oil percentage and protein percentage with seeds stored at 20°C for the five cultivars compared with warehouse storage. On the other hand, the lowest values of F.F.A., A.V and acidity were recorded with seeds stored at 20°C for the five cultivars compared with warehouse.

The interaction between package material and storage periods (Fig. 2) revealed that the highest germination percentage was recorded from seeds stored inside high density polyethylene. Also oil percentage and protein percentage up to months storage were observed compared with seeds stored inside paper package. On the other hand, data showed that the lowest value of F.F.A, A.V and acidity obtained from seeds stored inside high density polyethylene packages up to 42 months compared with seeds stored in paper packages.

Data concerned with the effect of the interaction between cultivars and packages material on germination and viability parameter are presented in (Fig.2 and Table 4). Significant effects were obtained for germination, oil, protein, acidity, F.F.A and A.V. The highest means of germination percentage and oil percentage were recorded with Sakha 2 cultivar with polyethylene package, also protein percentage except for strain 6 with two packages. In spit of the lowest values of F.F.A., A.V and acidity were recorded for Sakha 2 inside polyethylene package. On the other hand the lowest germination percentage and oil percentage were obtained for Belinka especially with paper package. In general, the highest % of germination, oil and protein were obtained with polyethylene package within the same cultivar. Also, the lowest value of F.F.A %, A.V and acidity % were recorded with polyethylene package within the same cultivar. The effect of the interaction between cultivars and package material on moisture content was no significant.

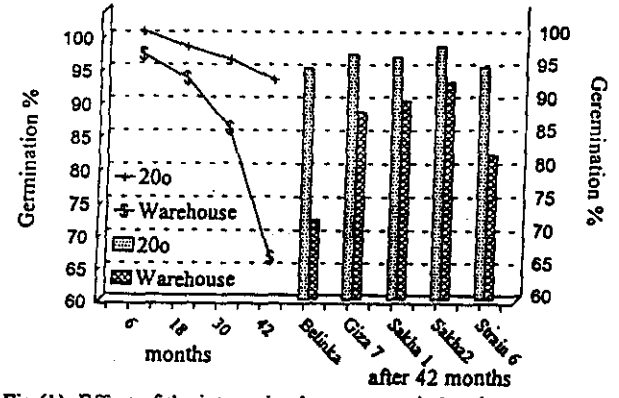

Fig (1): Effect of the interaction between period and storage temperature,cultivars and storage temperature on germination %

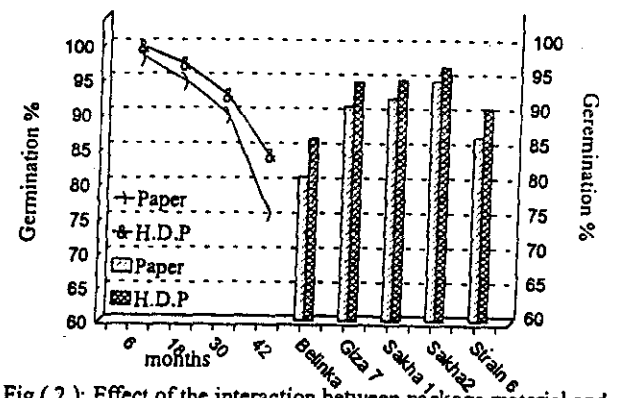

Fig (2): Effect of the interaction between package material and storing period, package material and cultivars on germination %

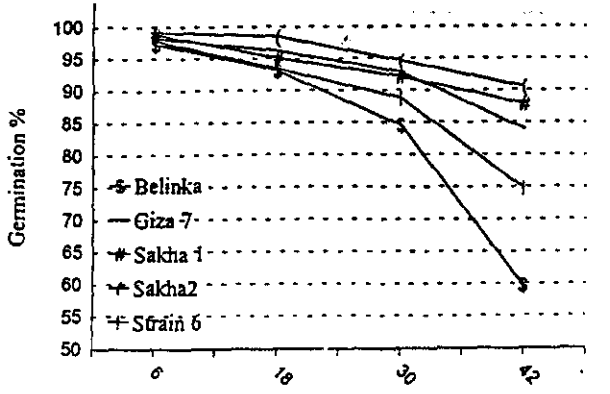

Fig (3): Effect of the interaction between storing period and cultivars on germination %

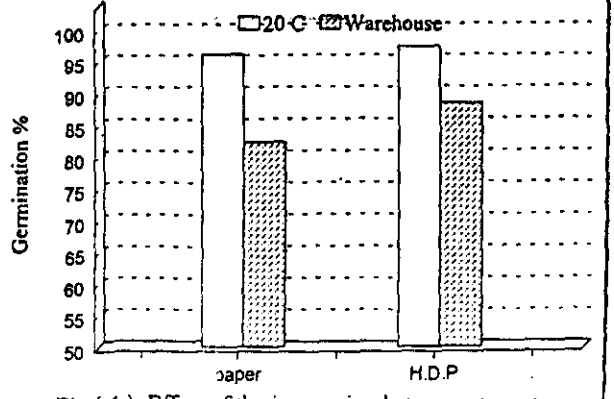

Fig (4): Effect of the interaction between storage temperature and package material on germination %

Table (4): Effect of interaction between cultivars and package materials, cultivars and storing period of seeds and storage temperatures and package material on chemical composition, acidity and oil characters.

Interaction	Moisture %	Oil %	F.F.A %	A.V %	Acidity %	Protein %
Cultivar × package material						
Belinka × paper	7.70	28.63	0.1134	0.2267	6.65	21.83
Belinka × polyethylene	7.79	30.71	0.1088	0.2180	6.15	21.86
Giza 7 × paper	7.37	32.49	0.1035	0.2074	5.79	22.11
Giza 7 × polyethylene	7.43	34.20	0.0969	0.1940	5.34	22.44
Sakha 1 × paper	7.50	32.40	0.1039	0.2081	5.84	20.45
Sakha 1 × polyethylene	7.27	33.84	0.0949	0.1904	5.31	20.66
Sakha 2 × paper	7.49	32.40	0.0958	0.1920	5.41	22.59
Sakha 2 × polyethylene	7.26	34.89	0.0891	0.1782	4.77	22.72
Strain 6 × paper	7.44	31.91	0.1094	0.2191	6.38	23.54
Strain 6 × polyethylene	7.60	33.23	0.1022	0.2046	5.64	23.71
LSD	-	0.2446	0.001803	0.001803	0.0846	0.0361
Storing Period × cultivars						
6 months × Belinka	7.85	36.93	0.0726	0.1446	4.36	22.86
6 months × Giza 7	7.83	40.81	0.0715	0.1433	4.22	22.99
6 months × Sakha 1	7.64	40.44	0.0708	0.1420	4.22	21.21
6 months × Sakha 2	7.71	40.63	0.0699	0.1401	3.91	23.03
6 months × Strain 6	7.77	39.58	0.0726	0.1455	4.30	24.79
18 months × Belinka	7.58	33.40	0.0904	0.1812	5.63	22.55
18 months × Giza 7	7.25	38.76	0.0898	0.1799	5.24	22.39
18 months × Sakha 1	7.31	38.14	0.0869	0.1746	5.25	20.83
18 months × Sakha 2	7.32	37.71	0.0860	0.1718	4.94	22.86
18 months × Strain 6	7.48	37.81	0.0908	0.1819	5.36	24.14
30 months × Belinka	7.38	29.25	0.1240	0.2483	7.26	21.31
30 months × Giza 7	7.12	33.33	0.1100	0.2202	6.17	22.06
30 months × Sakha 1	7.09	33.01	0.1100	0.2204	6.02	20.37
30 months × Sakha 2	7.01	33.12	0.1000	0.2005	5.73	22.49
30 months × Strain 6	7.15	33.33	0.1170	0.2345	6.38	23.23
42 months × Belinka	8.18	19.09	0.1574	0.3151	8.36	20.65
42 months × Giza 7	7.40	20.49	0.1295	0.2593	6.64	21.67
42 months × Sakha 1	7.50	20.89	0.1299	0.2601	6.82	19.80
42 months × Sakha 2	7.47	23.11	0.1139	0.2281	5.78	22.22
42 months × Strain 6	7.69	19.57	0.1427	0.2856	8.00	22.35
LSD	0.1803	0.3459	0.00255	0.00255	0.1196	0.051
Storage temperature × package material						
20°C × paper	7.55	34.48	0.0814	0.1630	5.53	22.38
20°C × polyethylene	7.43	36.04	0.0795	0.1592	4.90	22.52
Warehouse × paper	7.45	28.65	0.1291	0.2583	6.50	21.82
Warehouse× polyethylene	7.51	30.71	0.1173	0.2349	5.98	22.03
LSD	-	0.1547	0.00114	0.00114	0.0535	0.0228

Regarding the interaction effect between cultivars and storage periods, (Fig. and Table 4) significant effect was found on germination percentage. The highest germination percentage were noted with Sakha 2 cultivar, at 6, 18, 30 and 42 months (99.17, 98.50, 94.58 and 90.50 %) respectively. On the other hand, the lowest percent values were noted with Belinka cultivar at same the periods (97.33, 93.08, 84.50 and 59.67 %) respectively. The five flax cultivars varied in germination percentage, moisture content and viability parameters, especially after 42 months storage. Oil and protein percentage were decreased significantly by increasing storage period. In spit of F.F.A, A.V. and acidity were increased significant by increasing the same period. After 42 months, Sakha 2 gave the highest value of oil , protein percentage except Strain 6 compared with other cultivars. In spit of, after 42 months, Belinka gave the lowest value of oil percentage and protein percentage except Sakha 1 compared with other cultivars. On the other hand, after 42 months Sakha 2 gave the lowest value of F.F.A., A.V. and acidity compared with other cultivars, while Belinka gave the highest value of F.F.A. percentage, A.V. and acidity compared with other cultivars.

With respect to the first order interaction (storage conditions × package materials (Fig. 4 and Table 4). The results show that the permeable materials (paper type) under warehouse caused a great decline in germination percentage compared with polyethylene package. The results show that the impermeable package (polyethylene type) at low temperature (20°C) gave the highest value of germination percentage, oil percentage and protein percentage. On the other hand, gave the lowest value of moisture content, F.F.A., A.V. and acidity.

2- Yield and its components:

Analysis of variance showed significant differences between storage periods, storage temperature, cultivars and package material. Results showed that increasing period storage from 6 months to 42 months significantly reduced technical stem length and straw yield/fed (Table 5). On contrary to that, increasing storage period from 6 to 42 months significantly increased the mean values fruiting zone length, no. of capsules/ plant, no of seeds /plant and seed yield /fed. There was a general trend towards decrease in flax germination by increasing storage period from six months to 42 months.

Concerning the effect of controlled (incubated) and uncontrolled (warehouse)] the highest values for technical stem length and straw yield /fed. were obtained in flax seeds incubated at 20°C compared with uncontrolled (warehouse) (Table 5). While the highest values for fruiting zone length, no. of capsules/ plant, no. of seeds /plant and seed yield /fed. were achieved when flax seeds incubated uncontrolled (warehouse) compared with controlled (20°C). For the genotypes, Sakha 1 gave the highest values for technical stem length and straw yield /fed., whereas Sakha 2 cultivar gave the highest values for no. of capsules /plant. No. of seeds /plant and seed yield /fed. Such results are in harmony with those obtained by many investigators. Kineber (1994), Kineber and El- Kady (1996) and (1998) and Kineber and Eman El- Kady (2002) showed that there were large differences in yield and its components among genotypes.

Table (5): Effect of storing periods, storing treatment, genotypes and package material on technical length, fruiting length, no. of capsules, Straw yield and seed yield/fed

Variables	Technical length	Fruiting length	no.of capsules	no.of seeds	Straw yield/fed	Seed yield/fed
Storing period						
6 month	92.56 a	9.09 c	18.55 d	148.70 d	3.57 a	574.15 d
18 month	88.12 b	9.55 c	19.46 c	154.01 c	3.41 b	597.26 c
30 month	82.73 c	10.21 b	21.61 b	168.51 b	3.11 c	650.38 d
42 month	74.67 d	15.66 a	29.72 a	230.15 a	2.76 d	767.84 a
Storage temperature						
20C	90.18 a	9.50 b	20.40 b	162.79 b	3.52 a	608.49 b
Warehouse	78.86 b	12.75 a	24.27 a	187.89 a	2.91 b	686.33 a
Genotypes						
Belinka	85.01 b	7.83 d	15.21 e	116.25 e	3.03 c	341.37 e
Giza 7	82.54 c	13.47 a	20.32 d	160.71 d	3.01 c	650.28 d
Sakha 1	93.05 a	9.55 c	22.83 c	179.76 c	3.74 a	713.30 c
Sakha 2	83.17 c	12.27 b	28.05 a	233.13 a	3.27 b	792.14 a
Strain 6	78.84 d	12.52 b	25.26 b	186.86 b	3.02 c	739.96 b
Package material						
Paper	83.37 b	11.07 b	22.91 a	176.30 a	3.14 b	659.44 a
H.D.P	85.67 a	11.19 a	21.76 b	174.38 b	3.29 a	635.38 b

Means designated by different letters in the same column are significantly different at 5 % according to Duncan's multiple range test.

Regarding, the effect of package materials on technical stem length, fruiting zone length and straw yield per fed. For flax seed

incubated within H.D.P was significantly higher than incubated within paper package. On contrary, no. of capsules /plant, no. of seeds /plant and seed yield /fed. For flax seed incubated within paper package was significantly higher than polyethylene package.

Table (6): Effect of interaction between period, temperature, variety and package on technical length, fruiting length, no. of capsules, Straw yield and seed yield/fed

Interactions	Technical length	Fruiting length	no.of capsules	no.of seeds	Straw yield/fed	Seed yield/fed
Storing period × treatment						
6 months × 20°C	95.64	8.96	19.07	153.99	3.72	579.54
6 months × warehouse	89.49	9.22	18.03	143.40	3.43	568.77
18 months × 20°C	93.11	9.17	19.50	157.47	3.64	592.14
18 months × warehouse	83.13	9.93	19.43	150.55	3.19	602.38
30 months × 20°C	89.30	9.57	20.79	163.82	3.46	608.60
30 months × warehouse	76.16	10.85	22.43	173.20	2.76	692.17
42 months × 20°C	82.69	10.32	22.26	175.88	3.25	653.68
42 months × warehouse	66.66	21.01	37.17	284.42	2.27	881.99
LSD	1.0830	0.7873	0.7968	4.1940	0.0484	16.0400
Storing period × cultivars						
6 months × Belinka	97.10	6.24	9.16	70.06	3.63	240.77
6 months × Giza 7	89.17	11.41	18.04	142.13	3.29	593.34
6 months × Sakha 1	97.67	7.86	21.32	169.08	3.95	675.14
6 months × Sakha 2	90.87	9.94	24.74	208.57	3.56	729.27
6 months × Strain 6	88.02	10.00	19.48	153.65	3.45	632.24
18 months × Belinka	90.59	6.72	9.82	75.11	3.41	257.31
18 months × Giza 7	85.90	11.85	18.81	146.97	3.17	613.70
18 months × Sakha 1	96.07	7.90	21.70	170.92	3.88	685.69
18 months × Sakha 2	85.79	10.54	26.01	217.58	3.39	764.08
18 months × Strain 6	82.24	10.72	20.98	159.48	3.22	665.52
30 months × Belinka	80.94	7.62	11.75	89.96	2.98	300.17
30 months × Giza 7	81.19	12.67	19.96	158.70	2.92	660.50
30 months × Sakha 1	92.35	8.22	22.88	179.81	3.64	724.64
30 months × Sakha 2	81.90	11.06	28.63	235.66	3.12	825.00
30 months × Strain 6	77.28	11.50	24.83	178.42	2.89	741.61
42 months × Belinka	71.41	10.74	30.11	229.86	2.09	567.24
42 months × Giza 7	73.90	17.95	24.48	195.06	2.68	733.57
42 months × Sakha 1	86.14	14.22	25.42	199.21	3.49	767.71
42 months × Sakha 2	74.11	17.56	32.82	270.72	3.02	850.21
42 months × Strain 6	67.81	17.86	35.76	255.91	2.53	920.45
LSD	1.71200	1.24500	1.26000	6.63100	0.07649	25.36000
Storing period × package material						
6 months × paper	92.59	8.87	18.09	142.14	3.54	568.14
6 months ×polyethylene	92.54	9.32	19.01	155.25	3.61	580.17
18 months × paper	87.03	9.41	19.22	148.67	3.38	595.71
18 months ×polyethylene	89.21	9.68	19.71	159.36	3.45	598.81
30 months × paper	81.24	10.17	21.53	165.09	3.02	660.32
30 months × polyethylene	84.22	10.26	21.69	171.93	3.20	640.45
40 months × paper	72.64	15.85	32.79	249.31	2.63	813.59
40 months ×polyethylene	76.71	15.48	26.64	210.99	2.89	722.09
LSD	1.083	0.7873	0.7968	4.194	0.04838	16.04

The effects of the interaction between storage period and storage temperature (Table 6) indicates the highest values for agronomic traits (technical stem length, fruiting zone length, no. of capsules /plant, no. of seeds /plant and seed yield /fed., the highest values of technical stem length and straw yield /fed. were produced, when it received the storage period (6 months) and storage temperature. On the other hand for fruiting zone length, no. of capsules /plant, no. of seeds / plant and seed yield / fed. were affected by this interaction. The highest values were achieved at the storage period (42 months) and flax seeds incubated under warehouse conditions.

Concerning, the interaction between storage period and genotypes is presented in Table (6) showing the highest values for technical stem length and straw yield /fed, when achieved at the storage period (6 months) and Sakha 1 cultivar. While the highest value for fruiting zone length, no. of capsules /plant, no. of seeds/plant and seed yield /fed. Were produced by the interaction between at the storage period (42 months) and strain 6.

For the interaction between storage period and package types, the interaction between storage period (6 months)with H.D.P package produced the highest values for technical stem length and straw yield /fed. while, fruiting zone length, no. of capsules /plant, no. of seeds /plant and seed yield /fed. were achieved by the interaction between storage period (42 months) with paper types.

Regarding, the interaction between storage temperature and genotypes (Table 7), the highest value for technical stem length and straw yield /fed. were produced by the interaction between flax seeds incubated at 20°C with Giza 7 variety. Whereas, for fruiting zone length, no. of capsules /plant, no. of seeds /plant and seed yield / fed. were produced by the interaction between flax seeds incubated at warehouse with strain 6.

Concerning, the interaction between storage temperature and package types is presented in Table (7), showing the highest values for technical stem length and straw yield /fed. were produced by the interaction between flax seeds incubated at 20°C and H.D.P package. On the other hand, the interaction between flax seeds incubated warehouse with paper package was produced the highest

values for fruiting zone length, no. of capsules /plant, no. of seeds /plant and seed yield /fed.

Table (7): Effect of interaction between temperature, cultivars and package, between cultivars and package on technical length, fruiting length, no. of capsules, Straw yield and seed yield/fed.

Interaction	Technical length	Fruiting length	no.of capsules	no.of seeds	Straw yield/fed	Seed yield/fed
Storage temperature× cultivar						
20°C × Belinka	93.77	6.60	10.41	79.48	3.53	268.12
Warehouse × Belinka	88.70	11.41	18.94	150.66	3.20	624.21
20°C × Giza 7	97.34	8.23	22.51	182.05	4.01	713.18
Warehouse × Giza 7	86.88	10.49	27.37	225.94	3.49	782.28
20°C × Sakha 1	84.23	10.80	22.78	175.84	3.35	654.65
Warehouse × Sakha 1	76.25	9.06	20.01	153.02	2.52	414.62
20°C × Sakha 2	76.38	15.53	21.70	170.77	2.82	676.34
Warehouse × Sakha 2	88.76	10.87	23.15	177.46	3.47	713.41
20°C × Strain 6	79.46	14.06	28.73	240.32	3.05	802.00
Warehouse × Strain 6	73.45	14.24	27.74	197.89	2.69	825.27
LSD	1.2110	0.8803	0.8909	4.6890	0.0541	17.9300
Storage temperature× package materials						
20°C × paper	88.66	9.22	20.00	156.66	3.49	607.63
20°C × polyethylene	91.71	9.79	20.81	168.93	3.54	609.35
Warehouse × paper	78.09	12.93	25.82	195.94	2.79	711.24
Warehouse× polyethylene	79.63	12.58	22.71	179.84	3.04	661.41
LSD	0.7656	0.5567	0.5635	2.9650	0.0342	11.3400
Cultivar × package materials						
Belinka × paper	82.88	7.84	17.48	130.85	2.91	354.21
Belinka × polyethylene	87.14	7.82	12.94	101.65	3.14	328.54
Giza 7 × paper	81.24	13.66	20.37	156.11	2.96	654.42
Giza 7 × polyethylene	83.84	13.28	20.28	165.32	3.07	646.14
Sakha 1 × paper	91.60	9.12	22.69	173.36	3.71	713.54
Sakha 1 × polyethylene	94.50	9.99	22.97	186.16	3.78	713.05
Sakha 2 × paper	82.15	12.51	28.39	233.55	3.18	800.30
Sakha 2 × polyethylene	84.18	12.04	27.71	232.71	3.36	783.98
Strain 6 × paper	79.00	12.25	25.61	187.64	2.94	774.72
Strain 6 × polyethylene	78.68	12.80	24.91	186.09	3.11	705.19
LSD	1.211	0.8803	0.8909	4.689	0.05408	17.93

For the interaction between genotypes and package type, the highest value for technical stem length and straw yield /fed. were produced by Sakha 1 with H.D.P package, whereas the interaction between Sakha 2 with paper package was produced the highest

values for fruiting zone length, no. of capsules/plant, no. of seeds / plant and seed yield /fed.

3- Correlations among yield and other characters:

The correlation studies between yield and other characters may help the plant breeder in selection for high fiber and seed yields in flax. The simple correlation coefficient (r) values presented in Table (8) indicate positive correlation between germination percentage and each of oil percentage (r= 0.7607); protein percentage (r=0.3780); technical stem length (r= 0.7927) and straw yield (r= 0.9032). In addition, negative correlation between germination % and each of F.F.A percentage (-0.8768); A.V (r=-0.8767); acidity percentage (r= -0.8505); fruiting zone length (r=-0.5929) and seed yield /fed. (r=-0.3430). The data represented in Table (8) revealed that oil percentage was highly significantly and positively associated with protein percentage (0.5130), technical stem length (0.7841) and straw yield /fed. (0.7233), while it showed significant negative association with F.F.A percentage (-0.8699). A.V (-0.8698); acidity percentage (-0.8530); fruiting zone length (-0.6668); no. of capsules /plant (-0.5156); no. of seeds /plant (-0.4714) and seed yield /fed. (-0.3230). Furthermore, F.F.A percentage showed highly significant and strong positive correlation with acidity percentage (0.9030); A.V (1.00); fruiting zone length (0.6340); no. of capsules /plant (0.5784); no. of seeds /plant (0.5181) and seed yield /fed. (0.3873), while it was significantly and negatively correlated with protein percentage, technical stem length and straw yield /fed. Meanwhile, A.V showed highly significant and positive correlated with acidity percentage; fruiting zone length; no. of capsules /plant; no. of seeds /plant and seed yield /fed., while it showed significant negative association with protein percentage; technical stem length and straw yield /fed. For acidity percentage was positive and strongly correlated with fruiting zone length; no. of capsules /plant; no. of seeds /plant and seed yield /fed., while it showed negative association with protein percentage; technical stem length and straw yield /fed. Positive correlation was observed between protein percentage and each of technical stem length and straw yield /fed. In addition, negative

Table (8): Correlation coefficients for germination, yield and its components, oil characters, acidity and some chemical composition characters of five flax cultivars under effect of storage period, storage condition and package materials

	Cultivars	2	3	4	5	6	7	8	9	10	11	12	13
1	Germination %	-0.1448	0.7607**	-0.8768**	-0.8767**	-0.8505**	0.3780**	0.7927**	-0.5228**	-0.6569**	-0.5929**	0.9032**	0.3430**
2	Moisture %	1.00	-0.0957	-0.0151	-0.0161	-0.0136	0.0598	-0.0525	-0.1359	-0.0424	-0.0496	-0.0889	-0.1871
3	Oil %		1.00	-0.8699**	-0.8698**	-0.8530**	0.5130**	0.7841**	-0.6668**	-0.5156**	-0.4714**	0.7233**	-0.3230**
4	F.F.A %			1.00	1.00**	0.9030**	-0.5023**	-0.9002**	0.6340**	0.5784**	0.5181**	-0.8930**	0.3873**
5	A.V				100	0.9032**	-0.5031**	-0.9008**	0.6347**	0.5794**	0.5192**	-0.8932**	0.3887**
6	Acidity %					1.00	-0.4797**	-0.8440**	0.5662**	0.5142**	0.4503**	-0.8322**	0.2964**
7	Protein %						1.00	0.4274**	-0.3242**	-0.3637**	-0.4213**	0.3955**	-0.2183**
8	Technical length							1.00	-0.7258**	-0.5856**	-0.5327**	0.9126**	-0.4438**
9	Fruiting zone length								1.00	0.6495**	0.6317**	-0.5928**	0.6321**
10	No. of capsules/ plant									1.00	0.9855**	-0.5669**	0.8740**
11	No. of seeds /plant										1.00	-0.5053**	0.8787**
12	Straw yield /fed											1.00	-0.3383**
13	Seed yield / fed.												1.00

* = significant ** = highly significant. r at 5% = 0.217 r at 1% = 0.283

correlation between protein percentage and each of fruiting zone length, no. of capsules /plant, no. of seeds /plant ands seed yield /fed. The correlation between technical stem length and straw yield /fed. was highly significantly and positive, meanwhile, it was highly significantly and negative with fruiting zone length; no. of capsules /plant; no. of seeds /plant and seed yield /fed. The data represented in Table (8) revealed that fruiting, no. of capsules /plant; no. of seeds /plant and seeds yield /fed., while it showed significant negative association with straw yield /fed.

The results generally, indicate that the flax breeder must give priority to selection for increased technical stem length to increase straw yield /fed. and for the no. of capsules /plant as well as fruiting zone length to improve seed yield and its quality in flax.

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الملخص العربي

تأثير ظروف التخزين ونوع العبوة على القدرة التخزينية ومحصول وجودة بذور الكتان

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** قسم بحوث محاصيل الألياف – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

درست التغيرات في الحيوية والمحصول والتركيب الكيماوي لبذور خمسة أصناف للكتان (بلينكا, جيزه ٧ , سخا ١, سخا ٢, سلالة ٦) منزرعة بمحطة البحوث الزراعية بسخا خلال فترات تخزين (٦, ١٨, ٣٠, ٤٢شهر) تحت ظروف تخزين درجة حرارة (٢٠م) وظروف درجة حرارة غير متحكم فيها (الشونة) وباستخدام نوعين من مواد العبوات (الورق–البولى إثيلين ذو الكثافة العالية)

وقد أوضحت الدراسة ما يلي:

١- أدت زيادة فترة التخزين إلى نقص في حيوية البذور ونسبة البروتين والزيت وتدهور في صفات الزيت (بارتفاع الأحماض الدهنية الحرة ورقم الحموضة) ونقص في صفات الطول الفعال للساق ومحصول القش للفدان بينما أدت إلى ارتفاع الحموضة الكلية للبذور, أيضا زيادة صفات طول المنطقة الثمرية وعدد كبسولات النبات وعدد بذور النبات ووزن محصول البذور/ الفدان.

٢- أدى التخزين تحت ظروف الحرارة المنخفضة (٢٠م) لمدة ٤٢ شهر إلى الحفاظ على حيوية البذور , أيضا نسبة البروتين والزيت و صفات الزيت الجيدة, أيضا تسجيل أعلى قيمة للطول الفعال للساق ووزن القش للفدان عند زراعة هذه البذور المخزنة مقارنة بالتخزين في الشونة الذي أدى إلى التدهور السريع في الحيوية وانخفاض نسبة البروتين والزيت بالبذور بالإضافة إلى الحصول على صفات زيت رديئة كما أعطى أعلى القيم لصفات طول المنطقة الثمرية وعدد كبسولات النبات وعدد بذور النبات ووزن محصول البذور/ الفدان عند زراعة البذور المخزنة تحت ظروف الشونة .

٣- سجلت بذور الكتان المخزنة في عبوات من البولي إيثلين ذو الكثافة العالية أعلى القيم لنسبة الإنبات والبروتين والزيت وأيضا الحفاظ على صفات الزيت الجيدة (بانخفاض الأحماض الدهنية الحرة ورقم الحموضة) أيضا أعطت أعلى القيم لصفات الطول الفعال للساق ووزن القش للفدان مقارنة بالتخزين في عبوات الورق التي أعطت أعلى قيمة للحموضة الكلية و طول المنطقة الثمرية وعدد كبسولات النبات وعدد بذور النبات ووزن محصول البذور/ الفدان.

٤- سجل الصنف سخا ٢ أعلى نسبة إنبات و نسبة زيت وأيضا صفات زيت جيده (بانخفاض الأحماض الدهنية الحرة و رقم الحموضة) كما سجل أعلى القيم في صفات طول المنطقة الثمرية وعدد كبسولات النبات وعدد بذور النبات ووزن البذور للفدان بينما سلاله ٦ أعطت أعلى نسبة بروتين, على النحو الآخر سجل الصنف بلينكا صفات رديئة بالنسبة للزيت (بارتفاع الأحماض الدهنية الحرة ورقم الحموضة) وأيضا ارتفاع الحموضة الكلية, كما سجل الصنف سخا ١ أعلى القيم في صفات الطول الفعال للساق ووزن القش للفدان.

ومن النتائج المتحصل عليها يمكن استنتاج أن الظروف المثلى لتخزين بذور الكتان لفترة تصل إلى أكثر من ٤٢ شهر من تاريخ حصادها هي تخزينها تحت درجات حرارة منخفضة نسبيا تصل إلى ٢٠ م وتحت هذه الظروف لا تختلف أنواع العبوات كثيرا في تأثيرها على حيوية التقاوي داخلها أيضا على التركيب الكيماوي للبذرة وصفات الزيت الناتج. وتجدر الإشارة إلى تخزين التقاوي لفترات طويلة نسبيا تحت ظروف غير متحكم فيها مثل المخازن المفتوحة فان اختيار العبوات غير المسامية يصبح ضروريا للمحافظة أو الإبطاء من معدل تدهور التقاوي لأقل حد ممكن.