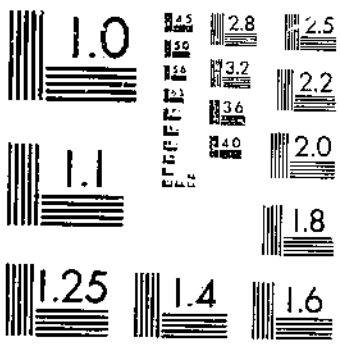
IB 1215 (1959) -- USDA TECHNICAL BULLETINS UPDATA

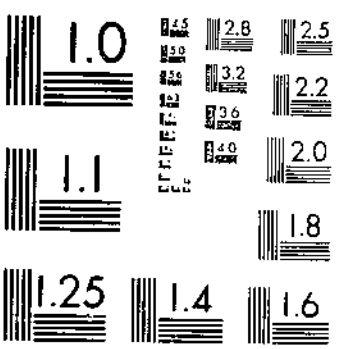
PRESERVATION OF HEMP AND KENAF SEED

TOOLE, E H ; TOOLE, V K ; NELSON, E G 1 OF 1

START



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Preservation of HEMP and KENAF SEED

By E. H. Toole,[1] *principal physiologist*, Vivian K. Toole, *plant physiologist*, and E. G. Nelson, *agronomist, Crops Research Division, Agricultural Research Service*

In several tests since 1948, the behavior of hemp seed (*Cannabis sativa*) and kenaf seed (*Hibiscus cannabinus*) in storage was studied and a method for longtime preservation of the seed was sought. In an emergency, seed may be needed for the production of these crops in the United States; at the present time no hemp or kenaf is grown commercially in this country.

Work with other crop seeds has shown that seed-moisture content and temperature determine longevity. Seed-moisture content is controlled by the relative humidity of the surrounding air. The seed-moisture content at a given relative humidity varies with the kind of seed. Also, at a given moisture content and temperature the longevity varies somewhat for different kinds of seed. In addition, the original viability of the seed, as determined by its previous history, affects longevity.

Koehler [2] in seed-treatment studies found rapid loss of viability of hemp seed when the seed moisture and the temperature were high. Crocioni [3] showed that hemp seed held at a few degrees above freezing with not more than 8.6-percent moisture did not decrease in viability in 3½ years. Sengbusch [4] found that hemp seed stored at 20° C. lost viability after 3 years, but seed stored at −20° retained viability for 5 years; the moisture content of the seed was not mentioned. Kondo et al.[5] reported that hemp seed retained full viability for 14 years when stored with calcium chloride.

No references have been found in the literature to the specific behavior of kenaf seed to conditions of storage.

---

[1] Retired January 1959.

[2] Koehler, Benjamin. Hemp seed treatments in relation to different dosages and conditions of storage. Phytopathology 36: 937–942, illus. 1946.

[3] Crocioni, Angiolo. Durata del potere germinativo del seme di canapa. [Duration of viability of hemp seed in relation to storage conditions.] Bologna Univ. Cent. di Studi per le Ricerche Sulla Lavorazione Coltiv. ed Econ. Della Canapa Quaderni 9, 30 pp. 1950.

[4] Sengbusch, R. von. Die erhaltung der keimfähigkeit von samen bei tiefen temperaturen. [Preserving the germination of seeds by low temperatures.] Züchter 25: 168–169. 1955.

[5] Kondo, M., Kasahara, Y., and Akita, S. [Germination of hemp seeds stored for 19 years and their growth.] Nōgaku Kenkyū, Rpt. Ohara Inst. Agr. Res., 39: 37–39, illus. 1950. [In Japanese.]

This study was undertaken to determine the effects of relative humidity or various seed-moisture contents and temperatures on the preservation of hemp and kenaf seed stored under controlled and uncontrolled conditions.

MATERIALS AND METHODS

Hemp seed grown in Kentucky in 1947 was received at Beltsville, Md., on December 18, 1947 (lot 1). It was kept in a room at 10° C. and 50-percent relative humidity until it was stored on May 28, 1948. A part of the seed was dried at 47° to a moisture of 5.7 percent. The undried seed contained 8.3-percent moisture. Both dried seed and undried seed were placed in cloth bags and in sealed glass jars at (1) 10° and 50-percent relative humidity, 2) −10° and uncontrolled high humidity, and in (3) an unheated building at Beltsville, Md. Dried seed and undried seed in sealed glass jars were also stored at 21°.

Hemp seed grown in Kentucky in 1950 was received at Beltsville in January 1951 (lots 2 and 3), and hemp seed grown in Beltsville in 1950 was received at the laboratory in March 1951 (lot 4). All lots were kept in a room at 10° C. and 50-percent relative humidity until stored. A part of each seed lot was reduced in moisture to 6.2 percent by drying at 47°, and a part was conditioned to 9.5-percent moisture by keeping the seed at 21° and about 70-percent relative humidity until the seed reached equilibrium. After it was conditioned to the two moisture contents, it was sealed in glass jars to maintain a uniform moisture level. On May 11, 1951, seed of each moisture content from each of the three lots was stored at −10°, 0°, 10°, and 21°.

In addition, seed from each of the three lots that had been kept at 10° C. and 50-percent relative humidity was sent on May 25, 1951, to the Western Kentucky Substation, Princeton, Ky., for storage in an unheated attic and to the Dry Land Experiment Station at Lind, Wash., for storage in an unheated building.

Kenaf seed grown in Cuba in 1950 was received at Beltsville in May 1950 (lot 1) and in April 1951 (lot 2). It was placed in a room at 10° C. and 50-percent relative humidity until stored. A part of each seed lot was conditioned to approximately 8-percent and another part to approximately 12-percent moisture. On May 11, 1951, the conditioned seed was sealed in glass jars and stored at the same temperatures as the hemp seed.

The nonconditioned seed from the two lots of kenaf seed that had been kept at 10° C. and 50-percent relative humidity was placed in cloth bags and on May 25 sent for storage to the same places as the hemp seed. In addition, seed from these same two lots was sent to Havana, Cuba, and Quito and Pichilingue, Ecuador. In order to protect the seed from excess moisture in shipment to the Tropics, each bag of seed was enclosed in an aluminum foil-backed sealed envelope and then placed inside a heavy canvas bag.

Kenaf seed grown in Cuba in 1952 was received at Beltsville on April 1, 1953 (lot 3). Part of it (lot 3*a*) was placed in an unheated frame building, and the remainder (lot 3*b*) was kept at 10° C. and 50-percent relative humidity to condition the seed for storage. Lot 3*a* had 9.2-percent moisture and lot 3*b* had 10.4-percent moisture when sealed and stored on July 31, 1953. Seed from each lot was sealed in glass jars and stored with seed from the 1950 crop at −18°, 0°, 10°, and 21°.

In addition, seed from lot 3*a* was shipped to Havana, Cuba, on August 3, 1953, where part of it was stored in a dehumidified room and part of it in an office under conditions similar to those of a warehouse. Seed from lots 3*a* and 3*b* was also sent to San Salvador, El Salvador, where it was kept in an office.

At intervals, usually about 6 months, the stored seed was thoroughly mixed and tested for moisture and germination. Seed moisture was determined by heating the seed at 103° C. for 24 hours.

Viability of the hemp and kenaf seed was determined by germination tests. The seed was placed between folds of moist paper toweling—the hemp seed at a daily alternation of 20° to 30° C. and the kenaf seed at a constant 30°. The kenaf seed was surface dusted with 75-percent thiram before testing in order to prevent the spread of saprophytic fungi, which destroy the seedlings. Four replicates of 100 seeds each were tested.

A basic germination value was obtained for each seed lot from the average germination for all tests where the seed clearly showed no evidence of decreased germination. A value for the least significant difference (L.S.D.) was determined from these germination values. Statements as to when the seed showed a significant fall in germination are based on the L.S.D. and basic germination for each seed lot.

RESULTS

Hemp Seed, 1947 Crop

As would be expected, the moisture content of the seed stored in sealed jars did not change appreciably during storage. The average of 42 moisture tests during storage of the seed dried to 5.7-percent moisture before storage was 6.0 percent, with a standard deviation of ±0.35 percent. The average of 56 moisture tests during storage of the seed conditioned to 8.3-percent moisture before storage was 8.3 percent, with a standard deviation of ±0.19 percent.

The moisture content of the seed stored in cloth bags quickly adjusted to equilibrium with the storage environment. Table 1 shows that at each test period the moisture content of the dried seed was slightly lower than that of the undried seed. This difference was least marked for the seed stored in the unheated building.

TABLE 1.—*Moisture content of dried and undried hemp seed (lot 1, 1947 crop) stored in cloth bags under various conditions when tested at intervals, Beltsville, Md.*

Months in storage	Seed dried to 5.7-percent moisture and stored at—			Undried seed conditioned to 8.3-percent moisture and stored at—		
	10° C. and 50-percent relative humidity	−10° C. and high humidity	Unheated building	10° C. and 50-percent relative humidity	−10° C. and high humidity	Unheated building
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
11	7.1	11.8	8.2	7.9	12.3	8.7
17	7.3	11.8	8.2	7.9	12.3	8.7
24	6.8	11.6	8.0	7.8	12.1	8.2
31	7.3	11.4	9.2	7.7	12.0	9.4
40	7.2	11.2	7.9	7.5	11.7	8.1
53	7.3	11.1	7.3	7.7	11.8	7.5
66	6.8	9.4	8.6	7.0	9.4	8.7
75	6.6	10.7	7.8	7.1	11.0	7.5
85	6.6	10.3		6.8	10.8	
93	7.4	10.5		7.5	10.9	
99	6.8	11.5		7.2	11.8	
Average	7.0	11.0	8.1	7.5	11.5	8.3

Table 2 shows no loss of germination in 99 months for the seed stored at 10° or −10° C., whether dried or undried or whether stored in cloth bags or in sealed jars. The seed in cloth bags at −10° did not fall in germination, even though the moisture of the seed increased to above 11 percent (table 1). The germination of the dried seed in cloth bags originally stored at −10° was appreciably lower the first time the seed was tested after it was moved to −18°. No further change was evident in four subsequent tests. We have no explanation for these aberrant results, especially since three other lots moved at the same time showed no change.

When the seed was stored in sealed jars to maintain the original moisture, seed dried to 5.7-percent moisture kept for a much longer time than the undried seed conditioned to 8.3-percent moisture, whether held at 21° C. or in an unheated frame building. At 21° the dried seed first showed a significant decrease in germination at 75 months, but the undried seed showed a significant loss in 24 months and only 45 percent germinated after 40 months. The seed sealed in jars kept very much the same in the unheated building as at 21°.

The dried and undried seed stored in cloth bags in the unheated building soon reached about the same moisture content (table 1) and showed an identical response when tested for germination (table 2). They both showed a significant decrease in germination at 11 months and were soon worthless.

TABLE 2.—*Germination of dried and undried hemp seed (lot 1, 1947 crop) stored in cloth bags and sealed jars under various conditions when tested at intervals, Beltsville, Md.*[1]

CLOTH BAGS

Months in storage	Seed dried to 5.7-percent moisture and stored at—				Undried seed conditioned to 8.3-percent moisture and stored at—			
	10° C. and 50-percent relative humidity	−10° C. and high humidity	21° C.	Unheated building	10° C. and 50-percent relative humidity	−10° C. and high humidity	21° C.	Unheated building
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0	98	98	98	98	100	100	100	100
3	99	98	------	97	98	98	------	96
11	98	99	------	87	97	98	------	88
17	97	99	------	48	99	98	------	48
24	99	98	------	7	98	99	------	8
31	99	98	------	2	99	99	------	4
40	96	97	------	1	99	97	------	1
53	97	[2] 96	------	0	99	[2] 97	------	0
66	98	92	------	0	99	99	------	0
75	99	91	------	0	99	96	------	0
85	97	90	------	--------	97	94	------	--------
93	97	93	------	--------	99	96	------	--------
99	97	93	------	--------	97	97	------	--------

SEALED JARS

0	98	98	98	98	100	100	100	100
3	98	98	99	98	99	99	98	98
11	99	98	100	97	99	99	99	98
17	98	99	99	98	99	96	97	87
24	98	99	99	99	98	98	87	80
31	99	99	99	99	98	99	72	48
40	98	98	99	99	98	98	45	13
53	98	[2] 98	97	98	98	[2] 99	5	0
66	99	99	96	98	99	98	0	0
75	98	98	92	96	99	99	0	0
85	97	99	88	94	99	99	------	--------
93	98	99	[3] 71	87	98	99	------	--------
99	98	99	[4]	[4]	98	99	------	--------

[1] Basic germination was 98 percent, based on all tests at 10° C. and all tests except those of seed dried to 5.7-percent moisture and stored at −10° in cloth bags. The least significant difference at 1 percent was 2.6 percent.

[2] Seed moved to −18° 1 month prior to this test.

[3] Temperature changed to 24° 7 months prior to this test.

[4] No more seed.

Hemp Seed, 1950 Crop

Controlled Conditions of Storage.—The moisture content when the seed was tested for germination during storage in sealed jars checked closely with the two moisture levels—6.2 and 9.5 percent—at which the seed was conditioned before being stored.

Table 3 shows that the germination of lots 2 and 3, which were of high viability, was very similar. Both lots conditioned to 6.2-percent moisture and stored at all four temperatures did not decrease in viability during 66 months. Both lots conditioned to 9.5-percent moisture and stored at −10° and 0° C. also did not decrease in viability during this period. When stored at 10°, they showed a significant loss after 36 and 42 months, respectively. When stored at 21°, they did not decrease in viability during 6 months but decreased very rapidly after that.

TABLE 3.—*Germination of hemp seed (1950 crop) stored in sealed jars at two moisture contents and four temperatures (° C.) when tested at intervals, Beltsville, Md.*

LOT 2

Months in storage	Seed conditioned to 6.2-percent moisture and stored at—				Seed conditioned to 9.5-percent moisture and stored at—			
	−10°	0°	10°	21°	−10°	0°	10°	21°
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0	98	98	98	98	98	98	98	98
5	94	98	98	98	96	97	94	97
6	98	96	97	98	99	98	98	97
13	96	99	97	98	98	95	94	64
18	[1] 97	99	98	97	[1] 97	99	97	22
24	96	96	97	97	98	97	95	5
31	97	98	95	99	98	98	95	0
36	93	97	98	95	98	95	93	0
42	94	97	93	94	95	98	90	0
48	97	98	98	97	98	98	91	0
54	98	94	95	[2] 97	97	97	86	.....
60	98	96	97	93	98	99	84	.....
66	93	96	98	98	97	96	65	.....

LOT 3

0	99	99	99	99	97	97	97	97
5	97	98	99	98	97	97	98	95
6	99	97	98	99	98	98	98	97
13	99	98	97	97	95	97	97	70
18	[1] 97	98	98	98	[1] 98	97	96	26
24	97	96	99	98	98	98	94	5
31	95	97	97	97	97	98	95	0
36	99	97	96	96	96	95	90	0
42	93	96	93	98	95	91	90	0
48	97	98	95	97	90	97	86	0
54	97	97	96	[2] 98	83	94	85	.....
60	98	97	96	98	94	97	78	.....
66	97	95	95	95	92	98	64	.....

TABLE 3.—Continued

LOT 4

Months in storage	Seed conditioned to 6.2-percent moisture and stored at—				Seed conditioned to 9.5-percent moisture and stored at—			
	−10°	0°	10°	21°	−10°	0°	10°	21°
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0	87	87	87	87	89	89	89	89
5	87	87	88	88	87	88	91	89
6	87	80	87	85	84	87	92	85
13	83	80	92	93	78	87	92	85
18	[1] 87	89	86	87	[1] 80	86	92	54
24	85	79	90	87	87	82	91	10
31	83	82	86	89	74	90	81	1
36	88	85	85	86	76	83	76	0
42	85	85	88	84	87	82	75	0
48	84	88	93	86	90	89	77	0
54	85	89	84	[2] 83	85	85	66	0
60	84	82	86	86	87	78	60	
66	80	84	73	75	86	80	42	

Lot	Basic germination [3]	L.S.D. at 1 percent [3]
	Percent	*Percent*
2	97	5.0
3	96	7.6
4	84	14.3

[1] Seed moved to −18° 1½ months prior to this test.
[2] Temperature changed to 24° 4 months prior to this test.
[3] Based on all tests at −10° and 0° for both moisture levels.

Lot 4 was of lower viability when stored. As is characteristic of such seed, the germination values obtained at successive test periods showed much greater variation than those for lots 2 and 3; consequently, it was more difficult to establish the time of loss of germination. Lot 4 deteriorated at about the same rate as lots 2 and 3.

Uncontrolled Conditions of Storage.—The moisture content of the hemp seed stored under uncontrolled conditions at Princeton, Ky., and Lind, Wash., showed about the same variations for each of the three lots. Therefore, in table 4 the average moisture content of these lots is shown for each period. It was not very different at these localities, although slightly higher at Princeton.

The changes in germination during storage at these two places differed greatly, as shown in table 5. At Princeton all three lots showed a significant decrease in germination after storage for 18 months and the decrease was rapid thereafter. On the other hand, at Lind none of the lots showed a consistently significant decrease in germination in 73 months. As under controlled conditions of storage, lot 4 was erratic in germination.

TABLE 4.—*Moisture content of hemp seed* [1] *stored in an unheated building at Princeton, Ky., and at Lind, Wash., when tested at intervals*

Months in storage	Princeton, Ky.	Lind, Wash.
	Percent	*Percent*
0 [2]	7.5	7.2
6	8.8	7.4
12	7.7	7.1
18	6.4	6.3
24	8.2	7.5
30	7.1	7.1
36	7.1	7.0
42	7.5	6.9
48	7.7	6.8
54	....	7.0
60	....	7.0
66	....	6.8
73	....	6.3

[1] Average values for lots 2, 3, and 4, 1950 crop.
[2] On arrival at place of storage.

TABLE 5.—*Germination of hemp seed (1950 crop) stored in an unheated building at Princeton, Ky., and at Lind, Wash., when tested at intervals*

LOT 2

Months in storage	Princeton, Ky.	Lind, Wash.
	Percent	*Percent*
0 [1]	98	98
6	97	99
12	94	97
18	84	96
24	77	96
30	38	98
36	34	94
42	8	96
48	3	95
54	....	98
60	....	95
66	....	96
73	....	93

LOT 3

0 [1]	98	99
6	95	98
12	92	98
18	86	95
24	84	97
30	46	98
36	44	95
42	11	96
48	5	94
54	....	96
60	....	91
66	....	93
73	....	91

TABLE 5.—Continued

LOT 4

Months in storage	Princeton, Ky.	Lind, Wash.
	Percent	*Percent*
0 [1]	92	80
6	85	89
12	73	81
18	57	72
24	55	74
30	28	88
36	16	81
42	2	80
48	0	72
54		79
60		65
66		73
73		74

Lot	Basic germination [2]	L.S.D. at 1 percent [2]
	Percent	*Percent*
2	97	5.0
3	96	7.6
4	84	14.3

[1] On arrival at place of storage.

[2] Based on all tests at −10° and 0° C. for both moisture levels.

Kenaf Seed, 1950 Crop

Controlled Conditions of Storage.—The moisture content of the two lots of kenaf seed stored in sealed jars at four temperatures showed the usual variation from test to test. The average moisture content of each lot was as follows:

Lot	*Seed conditioned to 8-percent moisture*	*Seed conditioned to 12-percent moisture*
	Percent	*Percent*
1	8.3	12.1
2	7.5	12.4

The germination of the two lots of kenaf seed stored in sealed jars at two moisture contents and four temperatures is shown in table 6.

Lot 1 carried much saprophytic fungi. Although the seeds were treated with 75-percent thiram before testing, the fungi sometimes caused erratic germination of this low-quality lot. One must depend on a succession of low germination values to indicate definite loss of viability. Both lots when conditioned to 8-percent moisture and stored at −10°, 0°, and 10° C. and when conditioned to 12-percent moisture and stored at −10° and 0° showed no definite fall in germination during 66 months. Lot 1 with 8-percent moisture stored at 21° began to lose viability at 48 months and lot 2 was deteriorating at 66 months. Lot 1 with 12-percent moisture stored at 10° first showed decreased germination at 48 months and lot 2 at 54 months. Lot 1 with 12-percent moisture stored at 21° definitely had deteriorated when tested at

TABLE 6.—*Germination of kenaf seed (1950 crop) stored in sealed jars at two moisture contents and four temperatures (° C.) when tested at intervals, Beltsville, Md.*

LOT 1

Months in storage	Seed conditioned to 8-percent moisture and stored at—				Seed conditioned to 12-percent moisture and stored at—			
	−10°	0°	10°	21°	−10°	0°	10°	21°
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0	66	66	66	66	73	73	73	73
5	72	64	73	65	72	78	72	73
6	78	74	83	77	73	78	76	60
13	76	75	75	76	74	76	66	65
18	[1] 69	66	65	67	[1] 71	69	59	46
24	72	75	73	70	71	67	72	24
31	77	71	77	62	72	67	55	11
36	76	75	76	67	72	72	64	2
42	73	69	79	58	76	71	58	2
48	70	66	72	55	72	68	44	0
54	63	56	65	[2] 32	60	49	35	0
60	75	76	65	42	76	61	42	-------
66	77	71	68	26	70	70	33	-------

LOT 2

0	95	95	95	95	91	91	91	91
5	91	85	86	82	90	89	86	91
6	92	90	89	90	90	93	91	80
13	88	91	91	93	88	92	92	92
18	[1] 78	86	89	85	[1] 80	86	85	84
24	88	89	90	82	89	90	87	−61
31	94	92	92	87	90	93	89	34
36	86	89	88	89	90	88	87	10
42	86	85	87	90	88	88	83	1
48	79	86	88	87	86	84	80	0
54	83	89	87	[2] 85	88	88	76	0
60	87	88	89	83	86	90	78	-------
66	86	87	88	75	86	87	71	-------

Lot	Basic germination [3]	L.S.D. at 1 percent [3]
	Percent	*Percent*
1	72	14.6
2	89	9.2

[1] Seed moved to −18° 1½ months prior to this test.
[2] Temperature changed to 24° 4 months prior to this test.
[3] Based on all tests for first 36 months of storage, except tests of seed conditioned to 12-percent moisture and stored at 21°.

18 months, whereas lot 2 showed a significant loss in 24 months. Thereafter both lots rapidly became worthless.

Storage in Different Localities.—Princeton, Ky., Lind, Wash., Havana, Cuba, and Quito and Pichilingue, Ecuador, have a wide range of temperature and humidity. Table 7 shows the average moisture content of two lots of kenaf seed (1950 crop) stored at each locality.

TABLE 7.—*Moisture content of kenaf seed (1950 crop)*[1] *stored at various places*

Lot	Princeton, Ky.	Lind, Wash.	Havana, Cuba	Quito, Ecuador	Pichilingue, Ecuador
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
1	9.3	8.4	7.4	10.7	13.4
2	9.4	8.3	7.4	10.6	13.3

[1] Average values for intervals of storage.

The seed at Pichilingue remained viable for such a short time that the value given represents a single moisture test. The moisture recorded for the seed at Havana is lower than would be expected for that climate, and it is low for the rapid loss of viability.

The germination of the kenaf seed was very different at these five locations, as shown in table 8. The seed kept best at Lind, where it remained dry and the temperature was not excessively high. It lost viability most rapidly at Pichilingue on the coast, where it absorbed much moisture and the temperature was very high. The germination at each place varied inversely with the prevailing temperature and humidity.

Kenaf Seed, 1952 Crop

Controlled Conditions of Storage.—The moisture content of lots 3*a* and 3*b* of kenaf seed stored in sealed jars at four temperatures did not change appreciably during storage from the original values of 9.2 percent for lot 3*a* and 10.4 percent for lot 3*b*.

Table 9 shows that lot 3*a* did not decrease in germination at any of the temperatures during 36 months. Lot 3*b* with a somewhat higher moisture content lost viability after storage at 21° C. for 36 months.

TABLE 8.—*Germination of kenaf seed (1950 crop) stored at five locations when tested at intervals*

LOT 1

Months in storage	Princeton, Ky.	Lind, Wash.	Havana, Cuba	Quito, Ecuador	Pichilingue, Ecuador
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
0 [1]	82	82	82	82	82
0 [2]	76	78	69	76	71
6	65	77	66	78	0
12	65	73	39	65	0
18	49	70	8	65	
24	39	60	3	50	
30	35	67	[3]	38	
36	30	63		37	
42	23	65		21	
48	20	64		14	
54	8	62		12	
60	6	66		7	
66	2	60		7	
73	0	55		1	

LOT 2

0 [1]	91	91	91	91	91
0 [2]	89	90	90	93	91
6	91	95	86	90	5
12	87	91	75	90	0
18	84	87	53	84	
24	80	82	26	83	
30	74	87	[3]	81	
36	77	87		80	
42	70	87		69	
48	68	88		62	
54	61	87		58	
60	49	88		56	
66	31	88		56	
73	15	87		44	

Lot	Basic germination [4]	L.S.D. at 1 percent [4]
	Percent	*Percent*
1	72	14.6
2	89	9.2

[1] Before shipment.
[2] On arrival at place of storage.
[3] Seed destroyed Feb. 9, 1954.
[4] Based on all tests for first 36 months of storage at −10°, 0°, 10°, and 21° C., except tests of seed conditioned to 12-percent moisture and stored at 21°.

TABLE 9.—*Germination of kenaf seed (1952 crop) stored in sealed jars at four temperatures (° C.) when tested at intervals, Beltsville, Md.*

Months in storage	−18°	0°	10°	21°
	LOT 3a			
	Percent	*Percent*	*Percent*	*Percent*
0	91	91	91	91
7	95	92	92	93
13	95	92	89	93
19	84	89	93	90
24	92	93	92	[1] 92
30	92	94	91	90
36	92	91	91	89
	LOT 3b			
0	88	88	88	88
7	87	86	88	86
13	86	87	86	81
19	84	85	83	82
24	90	87	88	[1] 80
30	87	85	83	77
36	84	87	87	75

Lot	Basic germination [2]	L.S.D. at 1 percent [2]
	Percent	*Percent*
3a	92	8.36
3b	81	4.86

[1] Temperature changed to 24° 1 week before this test.
[2] Based on all tests at −18°, 0°, and 10°.

Storage in the Tropics.—The moisture content of lot 3*a* of kenaf seed shipped on August 3, 1953, to Havana, Cuba, part of which was stored in a dehumidified room, averaged 9.3 percent. The moisture content of the other part of this lot that was stored in an office, under conditions similar to those of a warehouse, averaged 11.4 percent. Both lots of seed sent to San Salvador, El Savador, had an average moisture content of about 11.0 percent during storage.

As shown in table 10, the germination of the seed stored in the office in Havana decreased to 48 percent in 6 months, but that stored in a dehumidified room did not show a significant decreased germination until 17 months. At San Salvador lot 3*b* deteriorated slightly more rapidly than lot 3*a*.

TABLE 10.—*Germination of kenaf seed (1952 crop) stored at Havana, Cuba, and San Salvador, El Salvador, when tested at intervals*

Months in storage	Lot 3a seed stored at Havana in—		Seed stored at San Salvador in office	
	Dehumidified room	Office	Lot 3a	Lot 3b
	Percent	*Percent*	*Percent*	*Percent*
0 [1]	91	91	91	88
0 [2]	93	94	93	80
6	92	48		
7	90	63	88	79
8	89	55		
9	91	36		
10	91	29		
11	85	10		
12	88	3	74	61
13	85	0		
14	86	2		
15	86	2		
16	85	1		
17	79	0		
18			62	42
36	34		(3)	(3)

Lot	Basic germination [4]	L.S.D. at 1 percent [4]
	Percent	*Percent*
3a	92	8.36
3b	81	4.86

[1] Before shipment.
[2] On arrival at place of storage.
[3] All seed decayed.
[4] Based on all tests at −18°, 0°, and 10° C.

SUMMARY AND CONCLUSION

This study was undertaken to determine the effects of relative humidity or various seed-moisture contents and temperatures on the preservation of hemp seed (*Cannabis sativa*) and kenaf seed (*Hibiscus cannabinus*) stored under controlled and uncontrolled conditions.

Four lots of hemp seed and three lots of kenaf seed were stored at several temperatures in cloth bags at a given relative humidity or in sealed glass jars with an adjusted seed-moisture content. Seed was also stored under uncontrolled conditions at localities with various climates. The tests were conducted for 5½ to 8 years.

Viability of one lot of hemp seed conditioned to a moisture content of 5.7 and 8.3 percent was maintained for more than 8 years at 10° and −10° C. Hemp seed with a moisture content of 5.7 percent did not decrease in germination in 6 years when stored in sealed jars at 21°. Two other lots with 9.5-percent moisture maintained full viability for 5½ years at −10° and 0°. Seed of both

high and low viability when stored seemed to deteriorate under unfavorable storage conditions at about the same rate.

Hemp seed stored under uncontrolled conditions maintained original viability for 6 years at Lind, Wash., where its moisture did not exceed 7.5 percent. However, at Princeton, Ky., and at Beltsville, Md., hemp seed lost viability rapidly.

Kenaf seed conditioned to a moisture content of 8 percent maintained viability for 5½ years when stored at −10°, 0°, and 10° C. At 12 percent, full viability was maintained for 5½ years at −10° and 0°, but the seed showed a significant loss in viability in 4 to 4½ years when stored at 10°.

The germination of kenaf seed stored at Princeton and at Lind was much like that of the hemp seed stored at these places. Kenaf seed sent to Havana, Cuba, and to Pichilingue, Ecuador, deteriorated rapidly in the humid tropical climate, but at Quito, Ecuador, at a high elevation, the seed kept for 1 year.

One lot of kenaf seed stored under natural atmospheric conditions in Cuba deteriorated markedly in one-half year, but seed of the same lot kept in a dehumidified room in Cuba maintained full viability for 1⅓ years. Seed of the same lot kept under natural conditions in El Salvador deteriorated appreciably in 1 year.

Hemp and kenaf seed, as with other crop seeds, will remain viable for a long time if the seed is kept dry and is stored at a low temperature, but viability decreases rapidly under natural conditions in some areas where the crops are grown.

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1960

Washington, D.C. Issued April 1960

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C. - Price 10 cents

END