



Influence of Micro-Environment of Storage Materials on Kenaf Seed Quality under Ambient Storage Conditions

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Abstract

Kenaf seeds losses viability rapidly because of its oil content. Various modifications to storage environments are exploited by farmers to create conducive environment for seed preservation. The study was conducted to understand the micro-environment in some locally available storage materials under ambient condition to determine the suitability of these materials for short and medium term storage for kenaf seeds. Initial seed quality of kenaf (Cuba 108) was determined before dividing them to ten sample representatives. The samples were stored in three storage containers (covered clay pot, calabash gourd and plastic container) under shade and seed cold room for six months. Experimental design for the trial was Completely Randomized Design replicated three times. Thermo-hygrometer was used to monitor the relative humidity (RH) and temperature within the micro-environment of the storage container, cold room and storage environment. Monthly evaluation of the seed quality was done to determine deterioration rate in each storage container. Data obtained were subjected to analysis of variance and significant treatment means were separated using Duncan Multiple Range Test ($p=5\%$) Estimates of intercept of the seed survival line, rate of deterioration and time taken for seed to decline to 50% seed life was estimated by probit procedure, while predicting equation for seed germination and seedling vigour were generated through regression analysis. Results showed that kenaf seeds are naturally short-lived. None of the storage containers possess conducive environment comparable to the cold room storage. Therefore, storage of kenaf seed for over three months under ambient environment should be avoided, while use of covered plastic bucket containers under shade was recommended only for short term storage not exceeding three months.

Keywords: Kenaf, Seed quality, Storage materials, Storage micro-environment

Introduction

Ideal storage for seeds of many crop types requires cold dry condition, which may be created using air conditioner and dehumidifier that are mostly not affordable by peasant farmers in Sub Sahara Africa. Farmers therefore struggle to prevent losses of seed during storage, which usually impede their ability to meet quality supplies for planting. Consequently, farmers plant low quality seed purchased from the grain/seed market prior to the next sowing season. This has resulted to low productivity of most agricultural

enterprises. Farmers in the tropics have attempted to mitigate seed deterioration during storage, through on-farm hermetic storage which consists of enclosing seed in air-tight containers that prevent or minimize gas exchange (Lane and Woloshuk, 2017) However, relative humidity (RH) and moisture management has been a challenge because the method locks aeration both in and out of the container, thus constituting danger to the survival of the seed. High storage temperatures can cause physiological and enzymatic changes in seeds during storage

(Catão *et al.*, 2018). Such changes affect the embryo of oil seed crop and thus results in rapid loss of viability during storage (Catão *et al.*, 2018).

Kenaf seed has about 23.7%, ranging from 21.4 to 26.4% oil content (Mohamed *et al.* 1995). The oil content is high and could trigger spoilage of the seeds. Therefore, precautions should be taken to preserve the seed viability, especially when contemplating long-term seed storage. Research efforts on kenaf seeds indicated that storage at 8-12% RH and temperature of -10 or 10°C, will fully keep the seeds viable for up to 5 years (Toole *et al.*, 1960). Similarly, Meints and Smith (2003) reported that kenaf seed germination was not affected by storage environment for four years when stored at 10°C. These conditions are however, difficult to attain under tropical condition because facilities for controlled conditions are prohibitive and annual mean ambient temperature ranges between 25.4 to 27.9 °C, (WMO, 2015; Collins, 2011).

Various traditional seed storage techniques have been exploited by farmers to create conducive environment that will preserve seeds. Choice of each technique depends on various factors, among which is, quantity of seeds to be stored, vulnerability of the seeds to insect attack and period of storage. Other dependent factors are technical know-how about the facility available, cost of the storage material and climatic factors at the time of storage. Therefore, this study evaluated some readily available seed storage materials, aiming at (i) understanding the micro-environment created in the storage materials under ambient condition; (ii) determining the suitability of these storage materials for short and medium term

storage of kenaf seed and (iii) recommend the most suitable storage material for reduced seed deterioration under ambient storage to farmers in the rural communities.

Materials and Methods

Preliminary quality assessment of kenaf seed

Two kilograms of freshly processed seed of Cuba-108 variety of Kenaf was obtained from the seed processing and storage unit of Institute of Agricultural Research and Training (IAR&T), Moor Plantation, Ibadan. Initial quality of the seed lot was determined by testing 50 seeds in round transparent plastic bowl filled with sterilized river sand replicated thrice. The river sand was adequately moistened before planting and watered regularly on daily basis. The bowls were arranged in a Completely Randomized Design (CRD) in the seed testing laboratory. The plastic bowls were kept under ambient environment (temperature of 24°C - 27°C and Relative humidity of 62% to 64%). Data were collected on seeds and germinated seedlings as follows:

- i. 100 seed weight: This was evaluated by counting 100 seeds randomly without bias and weighing them using top-loading sensitive balance and recorded in grams
- ii. Germination count: Germinated seeds were counted on daily basis beginning from three to seven days after planting (ISTA, 2003).
- iii. Seedling height: Five randomly selected seedlings were tagged and numbered in each bowl using paper tape without bias. Seedling length was measured from the base of the shoot to the top of the seedling using

transparent ruler at 3 to 7 days after planting and recorded.

The data collected were used to estimate the following seed germination and seedling vigour characters

- i. Final Germination Percentage (FGP) was determined by finding the ratio of normal germinated seed at 7 days after sowing to total number of seeds planted.

$$\text{FGP} = \frac{\text{Number of germinated seedling at final day}}{\text{Number of seed planted}} \times 100$$

- ii. Seedling Vigor Index (SVI) was estimated from the seedling height and germination percentage according to the method of Adebisi *et al* (2004).

$$\text{CVI} = \frac{(\text{Germination \%} \times \text{Seedling length})}{100}$$

- iii. Germination Rate Index (GRI) reflects the percentage of germination on each day of the germination period and was calculated according to the method of Olisa *et al.* (2010).

$$\text{GRI} = \frac{G1}{x} + \frac{G2}{x} + \frac{G3}{x} + \dots + \frac{Gx}{x}$$

Where G1 = Germination percentage at the first day after sowing,

G2 = Germination percentage at the second day after sowing and

x = corresponding day of germination.

- iv. Mean Germination Time (MGT) represents the mean time a seed sample requires to initiate and end germination. It is calculated according to the method of Al-

Ansari and Ksiksi (2016).

$\text{MGT} = \frac{\sum Fx}{\sum F}$ where F is the number of seeds germinated on day x.

Seed preparation and storage

The seed lot was divided into ten sample representatives. Each sample was placed inside tightly fastened water proof polythene bag to prevent pest infestation, water absorption and exchange of gas. Each packaged seed was then placed in a well-covered three indigenous storage containers (Clay pot, Calabash Gourd and Plastic) replicated three times, representing the treatments. Another package of each seed sample was placed in the cold room of the seed store of IAR&T, Ibadan to serve as control. Thermo-hygrometer was placed in each storage container to obtain the temperature and relative humidity of the micro-environment in each storage container. The storage containers were then arranged in Completely Randomized Design under a raised shed constructed with forged poles and palm leaves as the roof (Plate 1).



Plate 1: Arranged ambient micro-environments for kenaf seed storage.

Duration of the experiment.

The experiment was conducted twice. In each experiment, the seeds were stored for six months, starting from August, 2016 to January 2017 and from July to December 2017. Monthly evaluation of the seed quality was carried out to determine deterioration rate under each storage container. During the storage, thermo-hygrometer was placed in each storage container three times a week to monitor the RH and temperature within the micro-environment of the storage container. Also, the Relative Humidity (RH) and temperature of the storage environment and inside the cold room were monitored and recorded.

Monthly seed quality evaluation:

Samples were carefully drawn monthly from each polythene bag in the three replicates for seed quality evaluation in the seed testing laboratory of IAR&T, Ibadan. The procedure was as described for the initial quality assessment.

Data analysis:

Data on the RH and temperature were pooled for each month and their means were used for statistical analysis. All other data collected were subjected to analysis of variance (ANOVA) and significant

treatments means were separated using Duncan's multiple range test at 5% probability level (Duncan 1955). Estimates of intercept of the seed survival line, slope (rate of deterioration) and time taken for seed to decline to 50 % (P50) were estimated by probit procedure. Predicting equations for the final germination percentage and seedling vigour of the seeds and their relationships with storage duration under different storage environment were generated by means of regression analysis.

Results

Atmospheric condition of the storage area

The atmospheric condition during the period of the seed storage revealed that the highest temperature for the two storage seasons was recorded in December. Temperature recorded in December 2016 (29°C) and 2017 (30.1°C) were significantly higher than all other months (Table 1). The temperature recorded in October, 2016 (27.2°C), November, 2016 (27.5°C) and January 2017 (28.2°C) were not significantly different from each other during the first storage but during the second storage season, temperature recorded in the months were significantly different from each other except August and September 2017 (Table 1). In both seasons

Table 1: Mean temperature and relative humidity recorded during the storage seasons

Storage Season 1			Storage Season 2		
Storage Month	Temperature (°C)	RH (%)	Storage month	Temperature (°C)	RH (%)
August. 2016	26.4 ^c	73.0 ^a	July 2017	29.0?	82.0?
September. 2016	26.7 ^c	72.9 ^{ab}	August 2017	28.0?	85.4?
October 2016	27.2 ^{bc}	72.0 ^{bc}	September. 2017	28.0?	84.9?
November 2016	27.5 ^{bc}	71.7 ^c	October 2017	28.1?	83.7?
December 2016	29.8 ^a	61.5 ^d	November. 2017	29.5?	81.2?
January 2017	28.2 ^b	60.6 ^d	December. 2017	30.1?	76.0?

Means followed by same alphabet along each column are not significantly different at 1% probability level

lowest temperature was recorded in the month of August. The driest period during the storage was December and January. The RH obtained in January 2017 (60.6%) and December, 2016 (61.5%) were not significantly different from each other and was the lowest. Similarly, the lowest RH (76%) during the second season was recorded in December, 2017. In both storage seasons, the wettest period was August with significantly highest RH of 73% and 85.4% recorded for 2016 and 2017 respectively.

Atmospheric condition of the micro-environment of the storage container, cold room and the storage area.

The atmospheric condition obtained in the micro-environment of the storage containers varied significantly (Table 2). In both storage seasons, highest significant temperatures (29.1 °C and 29.4 °C for season 1 and 2, respectively) were obtained in the plastic container while the lowest temperatures (24.5°C and 26.3°C for season 1 and 2 respectively) were obtained in the cold room. In the first season, temperature in the calabash (28.1 °C) was not significantly different from temperature in the clay pot (27.7 °C) whereas there was significant difference in the temperature

recorded in the calabash and the clay pot in the second season. Highest RH was obtained in clay pot (87.4 %) for both seasons and the RH was significantly different from that recorded in the other micro-environments. However, lowest RH (48.5% and 64.1% for seasons 1 and 2, respectively) were recorded in the cold room for both years. The temperature (29.2 °C) and RH (70.8 %) recorded in the storage area in the first season was not significantly different from the temperature (29.1°C) and RH (70.8%) in the micro-environment of the plastic container. Similarly, in the second season, the mean temperature in the storage environment (29.3 °C) was not significantly different from the mean temperature recorded in the micro-environment of calabash (Table 2).

Analysis of variance for the seed and seedling quality parameters of Kenaf seeds stored in different indigenous storage media

Mean squares from analysis of variance for seed and seedling quality parameters of kenaf seed stored in the different storage containers for the two seasons revealed that the Germination Rate Index (GRI), Final Germination Percent (FGP) and Seedling Vigour Index (SVI) of the seeds were

Table 2: Mean temperature and relative humidity recorded in the storage area, storage materials and cold room.

Storage Environment	Storage Season 1		Storage Season 2	
	Temperature (°C)	Relative humidity (%)	Temperature (°C)	Relative humidity (%)
Plastic	29.1 ^a	69.0 ^a	29.4 ^a	87.3 ^a
Clay pot	27.7 ^b	87.4 ^a	29.4 ^a	87.4 ^a
Calabash	28.1 ^a	70.5 ^b	29.3 ^a	87.4 ^a
Cold room	24.5 ^c	48.5 ^d	26.3 ^c	64.1 ^c
Storage area	29.2 ^a	70.8 ^a	29.3 ^a	87.3 ^a

Means followed by same alphabet along each column are not significantly different at 1% probability level

Table 3: Mean Square from ANOVA for seed quality characters of Kenaf seed stored in four different micro storage environments for two seasons.

Source	DF	GRI	FGP	MGT	SVI	100 Seed weight
Storage season (SS)	1	212.5*	784.3*	0.6	27.0*	0.000
Storage Environment (SE)	3	387.4*	3693.7*	0.1	156.2*	0.024
Storage Duration (SD)	6	1730.1*	16245.4*	0.5	659.5*	0.016
E x SE	3	19.6*	187.8*	0.6	7.4*	0.000
E x SD	6	24.8*	168.9*	0.2	6.3*	0.001
SE x SD	18	50.0*	609.1*	0.5	20.3*	0.011
E x SE x SD	18	12.1*	63.3*	0.4	2.2	0.000

* Significant at 5% probability level: SS:

Sv: Sources of Variation, Df: Degree of Freedom, GRI: Germination Rate Index, FGP: Final Germination Percentage, MGT: Mean Germination Time, SVI: Seedling Vigour Index; SW – Seed Weight

significantly affected by the storage containers. Also, there were significant difference in the results of experimental season one and two at $P < 0.05$. However, the mean germination time (MGT) and 100 seed weight of kenaf seeds were not significantly affected by the storage containers, storage duration and the two seasons (Table 3). The means of the interactions showed significant responses for GRI, FGP and SVI, while there was no significant interaction effect for MGT and 100 seed weight at $P < 0.05$ (Table 3).

Variation in the germination and seedling quality of kenaf seed stored in two different seasons.

There was seasonal variation in the results obtained from the two storage seasons. GRI (15.30), FGP (51.05%) and SVI (9.63) of seeds in the first storage season were significantly lower than the results obtained in the storage season (Table 4). The MGT and 100 seed weight of the seeds were however, not significantly different from each other in the two storage seasons (Table 4).

Table 4: Means of the seed germination and seedling vigour of kenaf during two storage seasons

Storage season	GRI	FGP	MGT	SVI
1	15.30b	51.05b	3.34a	9.63b
2	17.58a	55.37a	3.21a	10.43a

Means followed by same alphabet along each column are not significantly different at 5% probability level:

GRI: Germination Rate Index, FGP: Final Germination Percentage, MGT: Mean Germination Time, SVI: Seedling Vigour Index.

Germination and seedling quality of kenaf seed as affected by micro-environment of the storage materials and the cold room

The effect of the micro environment in the indigenous storage container on seed germination and seedling quality of kenaf seed showed that seeds stored in the cold room gave significantly higher seed quality in term of GRI, FGP and SVI in the two storage seasons, followed by seeds stored in plastic containers, which recorded 15.0 and 17.7 for GRI; 49.9 and 55.4 for FGP; 9.9 and 10.9 for SVI in season 1 and 2 respectively (Table 5). The GRI of seeds

Table 5: Interaction means of the seed germination and seedling vigour of kenaf as affected by micro-environment of storage containers and cold room.

Storage Environment	GRI		FGP		MGT		SVI		100 Seed weight	
	SS 1	SS 2	SS 1	SS 2	SS 1	SS 2	SS 1	SS 2	SS 1	SS 2
Cold Room	18.9a	22.7a	61.7a	71.4a	3.3a	3.3a	11.6a	13.5a	2.76b	2.75b
Plastic	15.0b	17.7b	49.9b	55.4b	3.3a	3.3a	9.9b	10.9b	2.80a	2.80a
Clay Pot	14.0c	15.3c	47.1c	45.7d	3.4a	3.0a	8.2c	8.2d	2.78ab	2.78ab
Calabash	13.5c	14.6c	45.5c	48.9c	3.3a	3.3a	8.8c	9.1c	2.75b	2.75b

Means followed by same alphabet along each column are not significantly different at 5% probability level:

SS: Storage season 1 and 2; GRI: Germination Rate Index, FGP: Final Germination Percentage, MGT: Mean Germination Time, SVI: Seedling Vigour Index; SW: Seed Weight

stored in the clay pot and calabash were not significantly different from each other in the two seasons. Significant differences existed in the FGP and SVI recorded between seeds stored in the clay pot and calabash in the first storage season, but there was no significant difference in the FGP and SVI recorded in the second season. The MGT and 100 seed weight of the seeds were not significantly different from each other in the two seasons of the study, irrespective of the storage environment.

Germination and seedling quality of kenaf seeds as affected by storage duration

Means of seed germination and seedling quality parameters of kenaf seeds as affected by storage period showed that 100 seed weight and MGT of the seeds recorded at initial storage period were not significantly different from the mean recorded at different storage period (Table 6). However, the result obtained for GRI followed the same trend as for FGP and SVI. The GRI, FGP and SVI of the seed

Table 6: Interactive means of seed germination and seedling vigour of kenaf as affected by storage Duration

Storage Duration	GRI		FGP		MGT		SVI		100 S/W	
	SS1	SS2	SS1	SS2	SS1	SS2	SS1	SS2	SS1	SS2
Initial	24.6 ^a	24.6 ^a	77.0 ^a	77 ^a	3.2 ^{ab}	3.2 ^a	15.6 ^a	15.6 ^a	2.77 ^{ab}	2.77 ^a
30day	22.7 ^a	23.0 ^b	70 ^b	72 ^b	3.1 ^b	3.2 ^a	13.9 ^b	14.1 ^b	2.80 ^a	2.80 ^a
60day	21.6 ^b	22.5 ^b	70 ^b	71 ^b	3.1 ^b	3.2 ^a	13.1 ^{bc}	13.1 ^b	2.77 ^{ab}	2.77 ^{ab}
90day	20.0 ^c	22.3 ^b	70 ^b	70 ^b	3.3 ^{ab}	3.3 ^a	12.9 ^c	13.1 ^b	2.77 ^{ab}	2.77 ^{ab}
120day	12.7 ^d	16.0 ^c	45 ^c	51 ^c	3.4 ^{ab}	3.3 ^a	7.5 ^d	8.8 ^c	2.76 ^{ab}	2.78 ^a
150day	4.3 ^e	10.1 ^d	17 ^d	31 ^d	3.4 ^{ab}	3.3 ^a	3.0 ^e	5.7 ^d	2.80 ^a	2.80 ^a
180day	1.5 ^f	4.5 ^e	8 ^e	16 ^e	3.7 ^a	3.0 ^a	1.4 ^f	2.7 ^e	2.74 ^b	2.71 ^b

Means followed by same alphabet along each column are not significantly different at 1% probability level:

SS: Storage Season 1 and 2; GRI: Germination Rate Index, FGP: Final Germination Percentage, MGT: Mean Germination Time, SVI: Seedling Vigour Index; SW (g).

before storage were mostly significantly different from the mean recorded after 30 days after storage. The significantly lower GRI, FGP and SVI recorded after 30 days of storage continued the trend till the end of the storage duration in both seasons (Table 6).

Estimation of Kenaf seed longevity under varied storage environment

The probit parameters estimates for kenaf seed survival data after six months of storage in different storage environment is presented in Table 7. The values of intercept (estimates of the measure of the seed quality) was higher in the seeds stored in the cold room (3.18), followed by seeds stored in the clay pot (2.96). The lowest intercept estimate (2.41) was from the seed stored in the plastic container. Negative values were recorded in the estimates of slope of the seed survival data for all the storage environments. However, the degree of deterioration (-0.017) was lowest in the cold room while the highest degree of deterioration (-0.028) was recorded in the seeds stored in the clay pot environment. Kenaf seeds stored in the cold room

environment had the highest estimates of seed life (P_{50}) and storage life (185 and 6.1 respectively). This was followed by seeds stored in the plastic ambient environment. Seeds stored in clay pot environment had the lowest estimated storage life of 3.6 months (Table 7).

Monthly changes in quality of kenaf seed as affected by micro-environment of the storage container.

Monthly changes that occurred in the quality of kenaf seed stored in different micro-environments revealed that both the germination (Figure 1) and seedling vigour (Figure 2) decreased with storage duration regardless of the micro-environment. However, rate of deterioration in germination and seedling vigour of kenaf seed stored in the cold room was low until after 120 days (4 months) of storage, before a sharp decline in the seed quality was noticed. The rate of deterioration of germination and seedling vigour of kenaf seed were similar in all the ambient micro-environments till 60 days (2 months) of storage, before the rate of deterioration among the micro-environments started

Table 7: Probit parameters for kenaf seed survival data after six months storage in four storage environments

Storage Container	* Intercept	** Slope	P_{50} (Days)	*** Seed Storage life (Months)
Cold Room	3.18	-0.017 (0.001)	185	6.1
Plastic	2.41	-0.018 (0.001)	130	4.3
Clay Pot	2.96	-0.028 (0.001)	107	3.6
Calabash	2.48	-0.022 (0.001)	110	3.7

* Intercept is probit estimate of initial seed viability

** Slope is the rate of seed deterioration (I/S). Probit viability loss per day

*** Seed storage life: Estimated as half-life (P_{50}) value multiplied by 2 divided by 30 days in month.

Standard Error of means is in parenthesis

showing differences. The highest rate of deterioration in terms of germination and seedling vigour were recorded in the seeds stored in the clay pot micro-environments (Figures 1 and 2). The regression analysis indicated that the relationship between seed quality (final germination and seedling vigour index) and storage duration is polynomial (Quadratics of order-2) in nature for all the storage containers (Figures 1 and 2). The coefficients of predictor (x^2) for all the storage containers were negative resulting to a concave curve. Four models each were generated to predict germination and seedling vigour of the seeds in each of the storage environment at a particular time (Figures 1 and 2). The Coefficient of determination of the models (R^2) ranges from 0.92 to 0.98.

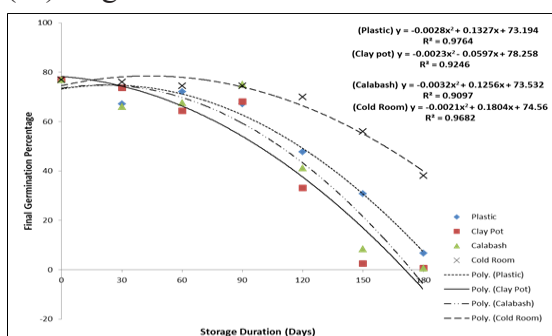


Figure 1: Monthly changes in the Final germination of kenaf seed stored in varied micro-environments for two seasons

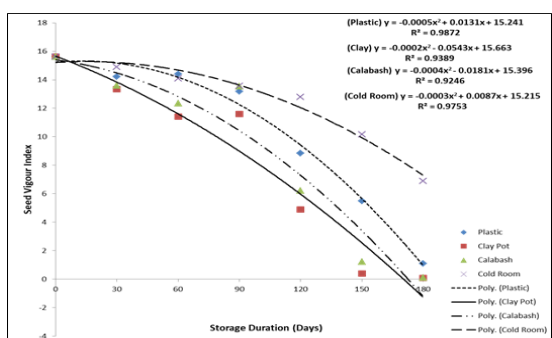


Figure 2: Monthly changes in the seedling vigour index of kenaf seed stored in varied micro-environments for two seasons

Discussions:

Seed ageing and loss of viability are matters of concern in seed conservation, particularly in the tropical and sub-tropical regions. High temperature and RH in this region tend to deteriorate the stored seed; therefore the ability to forecast seed deterioration is enormous for the proper management of seed longevity in stores. The significant differences in the atmospheric condition in the micro-environment of the storage containers indicate ability of the containers to sustain change in temperature. This condition is likely to influence seed deterioration during storage. The significantly higher temperature of the environment than all the storage containers shows influence of the environment temperature on micro environment in each storage container.

The plastic container absorbed heat from the environment more than the other storage containers and retain the heat. This was responsible for the higher temperature recorded in the plastic container. The lowest temperature obtained in the cold room can be attributed to the use of air-conditioner and de-humidifier installed in the cold room. However, high RH in the clay pot is as a result of high density of the clay which makes it possible for moisture to be retained in the clay pot.

Seeds stored in the cold room gave significantly higher seed quality due to low temperature and RH. This is expected because seed storage at lower temperatures results in higher levels of germination (Maroder *et al.*, 2000). Seed quality of kenaf stored in plastic container was next to the seed stored in the cold room in terms of the FGP, SVI and GRI. This can be attributed to dryness recorded in the micro-environment of the plastic container when compared to

other storage containers. Seed deterioration in the plastic micro-environment was also slower than all other containers because the seed germination and seed quality of kenaf seed stored in the plastic container was higher than all other containers. It has been reported that dryness of storage environment enhances reduction of seed moisture and enhances seed longevity (Van Hezewijk, 1993). The condition is in a dry storage environment which will reduce seed imbibition caused by hygroscopic nature of most seed (McDonald, 2007). This fact is corroborated by low seed quality recorded in kenaf seed stored in the clay pot. The micro-environment in the clay pot was characterized with low temperature and high relative humidity. The clay pot seems to retain moisture in its micro-environment and makes the seed vulnerable to high rate of deterioration.

The high coefficient of determination (R^2) of the models (0.92 to 0.98) implies that the models are about 92 - 98% reliable. The negative values (concave curve) recorded in the estimates of slope of the seed survival data, as well as the coefficient of relationship (x^2) in all the storage containers indicated reduction in seed quality as storage days increases for all the storage environments which happens to be more prevalent seed stored on clay pot. This implies that a unit change in storage duration negatively affects the seed quality, regardless of the storage container. This result confirmed the fact that seed ageing and deterioration is inevitable, but the rate can be reduced with adequate attention paid to storage environment. This result is in agreement with the result of Adebisi *et al*, (2004).

Result from probit and regression analysis demonstrated that seed

deterioration rate and seed storage life are dependent on the initial seed quality and the storage environment. Highest estimates of kenaf seed storage life found in the cold room means that the degree of deterioration was lowest in the cold room. On the contrary, the highest degree of deterioration found in the clay pot environment is likely to have been influenced by high RH. This finding is supported by Ellis and Roberts (1981) model which described seed survival curve as reverse sigmoid curve, which means that each seed lot has a particular mean viability period for each set of storage condition.

Conclusion:

This experiment clearly showed that kenaf seeds are naturally short-lived regardless of the storage container. The micro-environment of all the storage containers in this experiment was not comparable to the cold room storage. The atmosphere in the plastic container was dry but could only be suitable to preserve seed quality of kenaf for three months under ambient condition. Therefore, storage of kenaf seed for over three months under ambient environment should not be encouraged. However, use of covered plastic bucket containers under shade could be adopted for short term storage, where cold seed store are not available.

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