EFFECT OF MOISTURE CONTENT AND TEMPERATURE ON VIABILITY, VIGOUR AND LONGEVITY OF CORDIA SINENSIS Lam. SEEDS IN STORAGE

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Effect of Moisture Content and Temperature on Viability and Longevity of Cordia Sinensis Lam. Seeds

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Abstract
The main objective of this study was to determine the effect of different temperatures and moisture contents on *Cordia simesis* seeds viability on storage. Seeds of *Cordia sinenis* (L) were stored in hermitically corked glass viols for up to 150 days at different constant temperature ranging 6^0C to 35^0 C and moisture contents ranging 6% to 18% (fresh weight basis). Seed with different moisture contents were retrieved at intervals of 30 days from different storage temperature regimes for viability for a period of 150 days. Viability and storage period (longevity) decline during storage was generally lower at lower temperatures and moisture contents but rapid at higher temperatures and moisture contents. The effect of storage conditions on viability was also quantified using seedlings requirements equation. The estimated periods for viability to fall to 50% (P_{50} half-life value) decreased with the increase in seed moisture contents and storage temperatures. The viability results obtained could be used to predict the longevity and expected number of seedlings at different times. The results obtained in the present study could be applied in predicting viability loss and number of seedlings especially under short to medium-term storage conditions.
Keywords: viability, longevity, *cordia, sinensis,* half-life

1. Introduction

The primary essence of long storage of seeds is to maintain the viability and vigour for as long as possible for use when required. This task is challenging due to deterioration of seeds in storage which usually leads to decline in vigour and reduced number of viable seeds. This would assist cold stores managers estimate/predict seedling productions intervals and scheduling of viability and vigour testing on seed in cold stores to retain quality of stored seeds. Seed quality is known to be affected during pre and post-harvest period Walters et al., [1]

Storage is considered as the preservation of viable seeds from the period of collection until they are required for sowing (Holmes and Buszewicz, [2]. The time taken for viability to decline by 50% (P_{50}-half-life) is widely used as a measure of longevity in many wild plant species Probert [3], Muthoka, [4]. Research done of seed viability and the rate of seed deterioration are known Kundu and Kachari, [5]; Walters *et al.,* [1]. Methods and means of preserving and predicting seed quality during seed storage exists Sajo and Tame, [6].

Seeds stored at high temperatures or high seed moisture levels have their germination (viability) percentage declining more rapidly than those stored under cooler and drier conditions Burris[7]. It is known that Seed moisture content and storage temperature are two critical factors for seed storage Thomsen, [8]. Seed deterioration is considered as the increased probability of death of an individual seed as deterioration proceeds Tang *et al.,* [9], whilst, seed death is considered as failure to germinate thus seed longevity is considered as the period until seed death occurs Hay et al., [10]; Mollah et al., [11]; Sacande et al., [12]. Given the intensity of anthropogenic pressure and the importance of rehabilitating disrupted or degraded environments, in-depth research of forest tree seeds storage and longevity is warranted.

2.0 Materials and Methods

2.1 Seed collection and processing

The study was conducted between December 2014 and August 2015 at Kenya Forestry Seed Centre in Muguga, a section of the Kenya Forestry Research Institute (KEFRI). Yellow ripe fruits of *C. sinensis* were collected from both Baringo and Turkana Counties in equal quantities for good sample representation Omondi *et al*., [13]. The collected fruits were carried in sisal, 90kg sacks from the field and transported to the laboratory at Muguga for processing. The fruits, containing seeds were sampled by getting a small representative. The sampled fruits were extracted by squeezing the fruit and rubbing derived seeds with a dry towel. The extracted seeds were tested for moisture content by subjecting a sample weighing 5g to quick monitoring automatic infra-red moisture content machine. The moisture contents obtained were used as the initial moisture contents for the experiment. The remaining fruits were placed on a wire screen/mess and gently rubbed with hand to remove the fresh pulp and reduce sticky mucilage on the seeds. The extracted seeds were washed with water under pressure to remove mucilage Hong and Ellis., [14] before gently rubbing with towel to remove excess water on seed surface. A sub-sample was randomly drawn from each experimental lot for initial moisture contents and viability determination.

2.2 Seed moisture content determination and desiccation process

The high adjustable automatic temperature oven method ISTA, [15] was used to determine moisture content both initially and subsequently during adjustments. Approximately 5 grams were accurately weighed (to 3 decimal places) in two replicates into dry clean, pre-weighed petri dishes and placed into a preheated oven at 107^0C for 17h. At the end of each exposure period, the seeds were cooled for 45 min inside a desiccator and reweighed. Moisture content (MC) was expressed on a fresh weight basis. Combination of cool air and silica gel methods was used to adjust moisture contents from the initial levels to the targeted storage levels. In the silica gel drying methods, sub-samples of seeds in porous cloth bags were placed on blue silica gel, coved and placed in germination chamber set at 15% relative humidity and 20^0C. Five lots of seeds were desiccated in silica gel until the target moisture contents of 6.0%, 8.0%, 10.0%, 12% and 18.0% were attained. During desiccation, moisture contents were checked by frequent weighing and calculating moisture contents using the formula:

Seed weight at desired MC= initial weight of seed X (100-intial MC)/ (100-desired MC) (1)

2.3 Seed storage and germination testing

Twenty subsamples of 2500 seeds for each MC were put in a bottle and tightly closed. All five MC regimes were replicated in four temperature regimes storage at 6^0C, 15^0C, 25^0C and 35^0C in incubators maintained at respective storage temperature regimes. Seeds were removed at intervals of 30 days for a period of 150 days. Two samples for each MC treatment were taken to determine if seed MC changes occurred during storage. Samples were tested for germination by placing seeds on pre-prepared 1% (w/v) agar (plain agar) in distilled water in 9cm Petri dishes and incubated in germination cabinets set at alternating temperatures $20/30^0$C. Light was applied for 8hours/day during the warm temperature phase ISTA, [15]. Germination tests were performed by using four replicates of 25 seeds for each moisture contents for corresponding storage temperature. Germinated seeds were scored daily for up to 7 weeks. A seed was considered as normally germinated when the radicle protruded to 2–3cm. Moisture content was determined periodically to the desired storage levels.

Table 1. Initial and targeted moisture levels of *Cordia sinensis* seeds from Lodwar and Baringo before and after desiccation.

Provenance	Initial moisture content (%)	Adjusted storage moisture contents (%)			
Lodwar	18.5	12.0	10.0	8.0	6.0
Baringo	18.0	12.0	10.0	8.0	6.0

2.4 Measure of longevity

The time taken for germination to drop by 50% (p50) have been commonly used as a measure of longevity by many authors as it have the advantage of this period being the most accurately determined one Probert, [3], Muthoka, [4], Roberts, [15].

Table 2. *Cordia sinensis* seeds longevity assessed by P_{50} for seeds stored at different temperature and different moisture contents (6, 8, 10, 12 and 18 % f.w.b).

Moisture content	**P_{50} viability at 6^0C Celcius**		**P_{50} viability at 15^0C Celcius**		**P_{50} viability at 25^0C Celcius**		**P_{50} viability at 35^0C Celcius**	
	Lodwar P_{50}(days)	Baringo P_{50}(days)	Lodwar P_{50}(days)	Baringo P_{50}(days)	Lodwar P_{50}(days)	Baringo P_{50}(days)	Lodwar P_{50}(days)	Baringo P_{50}(days)
6%	N/A	N/A	N/A	75	40	50	30	32
8%	N/A	N/A	30	70	25	45	20	31
10%	30	60	25	45	17	33	15	28
12%	20	40	17	35	9	30	7	26
18%	15	23	9	15	6	15	5	9

3.0 Results

3.1 Seed viability and longevity

The *C.sinensis* seed longevity and viability in storage gradually increased as the moisture contents decreased at constant storage temperature (figure 1, 2, 3, 4). However, the longevity and viability also decreased as storage temperature increased (figure. 1, 2, 3, 4). Seeds with 6% moisture content had the highest longevity and retained higher viability compared with other seeds with 8%, 10%, 12% and 18% moisture content across all storage temperature (figure.1, 2, 3, 4). The seed longevity and viability declined with increase of both moisture content and storage temperature, thus, the seed longevity and viability was in the order with respect to both MC and storage temperature as 6%>8%>10%>12%>18% and 6^OC>15^0C>25^0C>35^0C respectively (figure. 1, 2, 3, 4). In overall, the two sites in terms of moisture content and storage temperature were not significantly different. There was statistically significant difference ($p<0.001$) in the moisture content (6%, 8%, 10%, 12% and 18%) and also storage temperature (6^0C, 15^0C, 25^0C, 35^0C) for seeds sourced from the two sites.

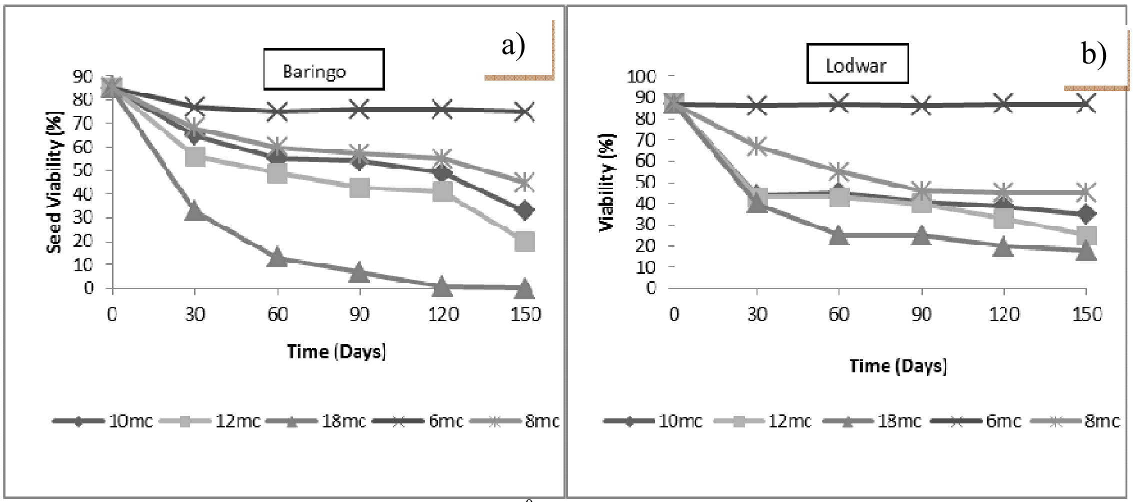

Figure 1: Seed viability and longevity stored at 6^0C for 150 days

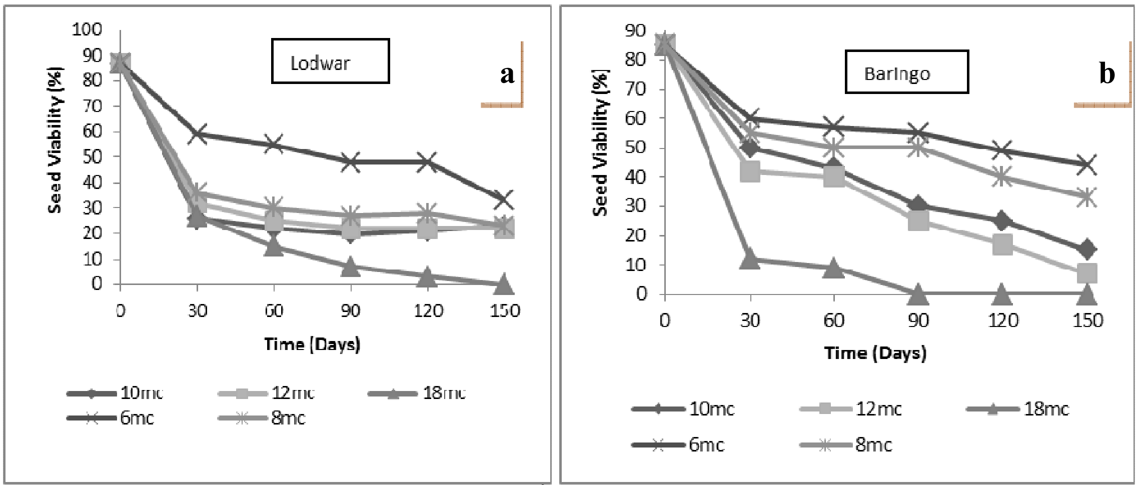

Figure 2: Seed viability and longevity stored at 15^0C for 150 days

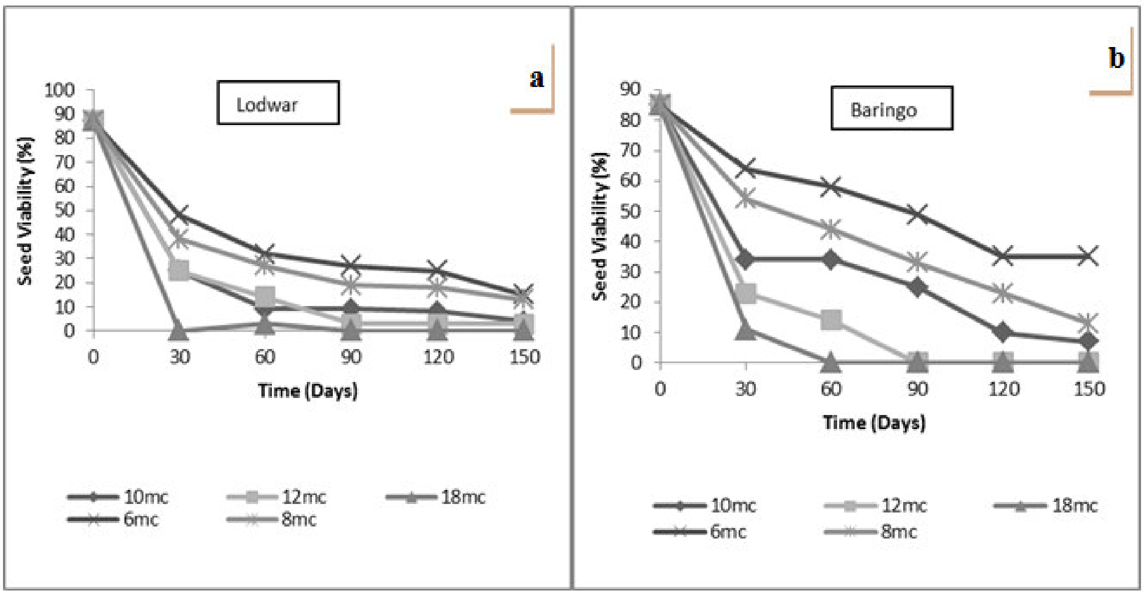

Figure 3: Seed viability and longevity stored at 25^0C for 150 days

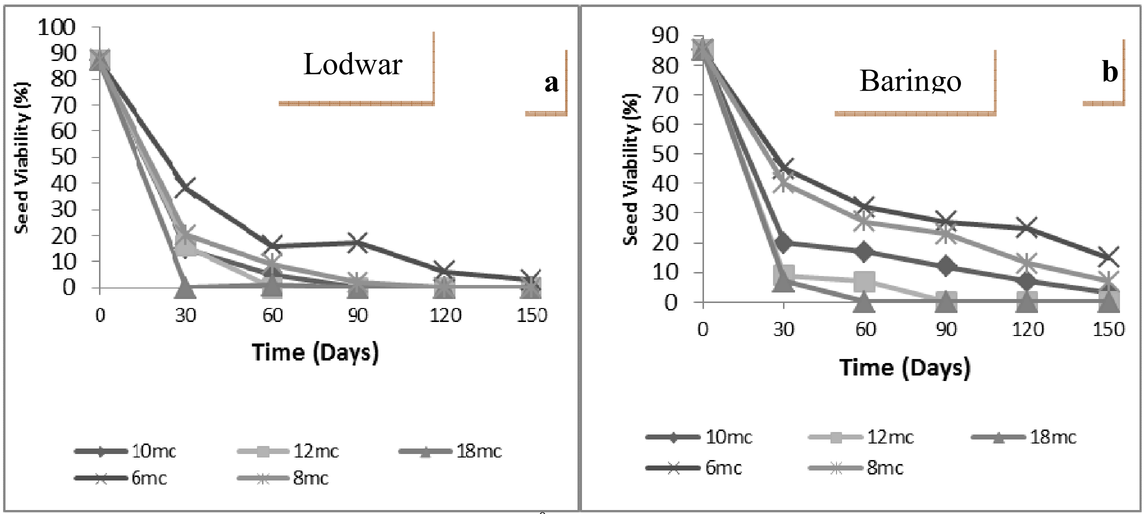

Figure 4: Seed viability and longevity stored at 35^{0}C for 150 days

3.2 Regression of viability against storage temperature, moisture content and site

Table 3: Model summary of regression on viability against time, moisture content, storage temperature and site

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.835[a]	0.697	0.692	16.876	1.613
a. Predictors: (Constant), Time (Days), Moisture content (%), Storage temperature, Site					
b. Dependent Variable: Viability (%)					

Since there are more than one independent variable the adjusted R Square in table 3 was used which shows that the independent variables explain 69.2% of the dependent variable (viability).

3.3 Regression of time verses viability.

In figure 5, the R^2 shows that, 56% of the variation in dependent of viability is reduced by taking into account predictors of time, moisture content and temperature. The initial viability was approximately 86% and not 100% which R^2 would have given 100%. It was difficult to explain this apparent anomaly unless one assumes that a certain percentage of the seed possibly were less mature (Austin, [17] or of different genotype Roberts, [16] and were adversely affected by extraction method or storage temperature while the remainder was not. The graph exhibits a negative relationship where increase of both moisture contents and storage temperature caused decrease in viability over time.

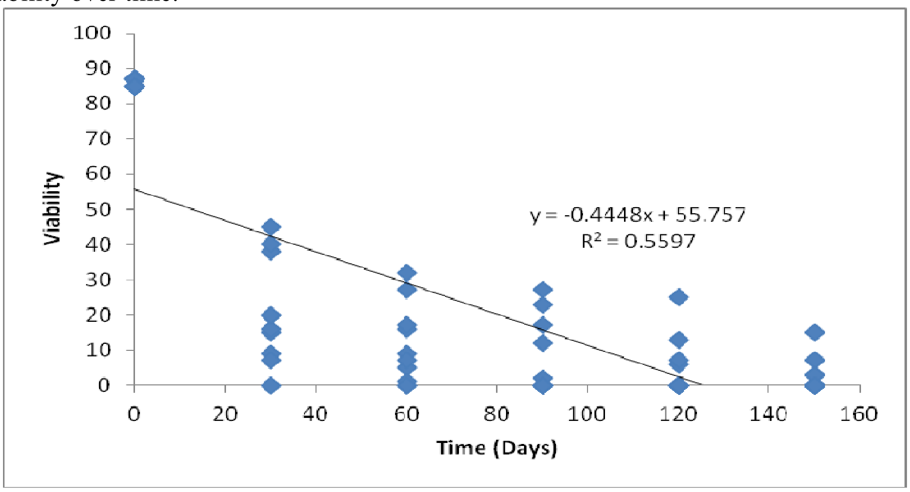

Figure 5: Regession of time verses seed viability

4.0 Discussion

There were short lived and long lived seeds in the results reported in this study. Seeds with low moisture content of 6% had the longest life with high viability compared to seeds with highest moisture content of 18% stored across all temperature regimes of 6^{0}C, 15^{0}C, 25^{0}C and 35^{0}C for 150 days. For example the results for seeds with

18%, 12%, 10%, 8% and 6% moisture content stored at 6^0C temperature revealed that with decrease of seed moisture content seed viability period increased but there was a continuous decrease in viability levels with time. Seed viability was in the order with mc as 6>8>10>12>18% for both study sites (Figure 1, 2, 3, 4). This conforms to Orthodox seeds which conform to certain rules of the thumb that predict well the pattern of loss of viability in relation to storage environment Roberts, [16],: Schmidt, [18].

Again the results for same seeds with 18%, 12%, 10%, 8% and 6% moisture content stored at 35^0C ,25^0C 15^0C and 6^0C revealed that with decrease of storage temperature, seed longevity period increased with time. Seed viability and longevity was in the order in respect to MC as 6>8>10>12>18% for both study sites (Figure 1, 2, 3, 4). This again conforms to Orthodox seeds which conform to certain rules of the thumb that predict well the pattern of loss of viability in relation to storage environment Bewley and Black, [19]

5.0 Conclusion

The *Cordia sinensis* seeds can be classified as orthodox which is exhibited by seed with 6% MC which gave highest longevity (shelf life) and higher viability in all storage temperatures.

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