THE EFFECTS OF STORAGE AND DURATION ON DORMANCY AND EARLY GERMINATION PERIOD OF *Chrysophyllum albidum* G. DON. SEEDS

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Abstract
This study investigated the effect of storage and duration on the dormancy period and early germination of Chrysophyllum albidum. The experiment was laid out in4 x 5 Factorial experiment in Completely Randomized Design. Factor A consisted of the 4 storage conditions and Factor B is five storage durations. Each storage duration was replicated three times. The four storage conditions are as follows; SC1 =Air tight container (AC) 14.6^{0}C to 16.2^{0}C, SC2 = Air tight container in refrigerator (ACR) -5.1^{0}C to 3.2^{0}C, SC3 = Open container (OC) 23^{0}C to 26.5^{0}C and SC4 = Open container with every day moisture application (OCW) 23^{0}C to 25^{0}C while the 5 storage duration comprised of; SD1 = 2 weeks, SD2 = 4 weeks, SD3 = 6 weeks, SD4 = 8 weeks and SD5 = 10 weeks. A total of one thousand, eight hundred and ninety seeds of C. albidum were used for this experiment. Before seed storage, 90 seeds were selected and sown immediately after extraction to test for the germination potential of freshly collected seeds of C. albidum. The remaining 1800 seeds were used for storage. A total of 450 seeds were stored in each storage condition. Three replicates of 30 seeds for each storage duration. Data collected were subjected to analysis of variance. The mean germination for storage ranged from 0.00 % to 49.33 % while it ranged from 11.67 % to 43.33 % respectively. There was significant difference ($p<0.05$) in the effect of storage, duration and the interaction of storage and duration on germination of C. albidum seeds. Complete dormancy period ranged from 10 days to 17 days. This study revealed that Chrysophyllum albidum seeds are recalcitrant. They lose moisture easily to the environment, thereby losing their viability easily. They cannot survive low temperatures. This research work has been able to increase the viability period of C. albidum seeds from 2 weeks to 10 weeks.

Keywords: *African Star Apple, Seed, Storage Duration, Viability, Germination.*

Introduction

Natural forest in Nigeria is in fact diminishing and declining in the area due to extensive human activities and population growth, these activities range for uncontrollable and indiscriminate felling of the trees, bush burning conversion, of forest land and agro-forest to other uses such as agriculture, road, building of factories, (Orwa*et al*, 2009). Most of the economically important indigenous fruit tree species in Nigeria are exploited in the wild. Recently, attention has been given to the domestication of these fruit tree species (Onyekwelu *et al.,* 2015). One of these indigenous tree species is *Chrysophyllum albidum*.

African star apple (*Chrysophyllum albidum*), an indigenous plant is an edible tropical fruit known by various tribal names in Nigeria as agbalumo (Yoruba), Udara (Ibo, Efik and Ibibio), ehya (Igala) and agwalumo (Hausa) (Dandare, 2017). It is from the family Sapotaceaeand classified as a wild plant. The fleshy edible pulp is consumed by people (CENRAD, 1999) and for the purpose of stopping irritation, loss of appetite and salivation. Studies have shown the fruit to be an excellent source of vitamins, iron, flavours to diet and raw materials to some manufacturing industries (Okafor and Fernandes, 1987; Bada, 1997; Umelo, 1997; Adisa 2000).

The seeds are used for local games (Bada, 1997). Fruiting season of the plant is usually in the months of December to April during which it is found both in rural and urban cities (Amusa*et al*., 2003). The fruits are not usually harvested, but left to naturally fall to the forest floor from where they are picked.

For germination to be initiated, three conditions must be fulfilled. Firstly, the seed must be viable; that is, the embryo must be alive and capable of germinating. Secondly, the seed must be subjected to the appropriate environmental condition: available water (moisture), proper temperature regimes, a supply of oxygen and sometimes, light. Thirdly, any primary dormancy condition present within the seed must be overcome. (Hartmann *and* Kester, 1990).

Chrysophyllum albidum is employed for the treatment of stomachache and diarrhea. The fruit can serve as raw material for the manufacturing industries. It can also be used in the preparation of wine, spirits and soft drinks, jam and jellies (Umelo, 1997). The oil is extracted and used in making soap and other products. The leaves are used as emollient for the treatment of skin eruptions (Idowu*et al.*, 2003). The bark is used in the preparation of medicine for the treatment of fever and black –coated tongues called '*efududu*in'in Yoruba language (Olapade, 1997). It is used as a remedy for yellow fever and malaria (Idowu*et al.*, 2003).

Despite the importance of *C. albidum*, it has beengreatly neglected and under-utilized, especially withrespect to their regeneration and improvement due to lack of knowledge of their silvicultural requirements coupled withpoor documentation of most of the researches carried out on them (Bolanle-Ojo and Onyekwelu, 2014).

Chrysophyllum albidum seeds are said to be recalcitrant and the endangered standing of *C. albidum* further necessitates its propagation and mass multiplication, for which protocol targeting an appropriate and relatively longer period of storage of seeds would be vital. This will strengthen both in-situ and ex-situ conservation of the species. In spite of it numerous important values in the area of medicine, fuel wood, construction work, etc. *C. albidum* seeds have a short viability period which needs to be addressed. Deriving a means of storing the seeds of this species will help in the availability of genetic material for regeneration and reduction of genetic erosion.

Materials and Methods

Experimental Site

The screen house experiment was carried out at the Department of Sustainable Forest Management, Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State, located on the longitude 07^{0}23'18"N to 07^{0}23'43"N and latitude 03^{0}51'20"E to 03^{0}51'43"E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry harmattan wind. The wet season on the other hand usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is approximately 1548.9 mm, falling within 90 days. The mean maximum and minimum temperature are 31.9^{0}C and 24.2^{0}C respectively while the mean daily relative humidity is about 71.9% (FRIN 2015).

Fruit Collection

Chrysophyllum albidum fruits were collected from the mother tree at around Baptist Secondary School, Gbekuba, Ibadan, Oyo State, Nigeria. Oyo State is located in the South Western Region of Nigeria.

Seed Extraction/Processing

C. albidum fruits were cut opened with knife, seeds were separated from the fleshy sheaths that enclose the seeds. The thin, slimy coating around the seed (perianth lobe) was removed and the seeds thoroughly rinsed in water to remove any remaining pulp juice or sugary residue. Seeds were air-dried for about an hour for ease of handling.

Seed Viability Test

Floatation method was used for seed viability test. The seeds were poured into a bucket of water for 1 minute, seeds that floated were discarded while seeds that were at the base of the bucket were used for this experiment.

Experimental Design and Layout

The Experimental Design used for this experiment was 4 x 5 Factorial experiment in Completely Randomized Design (CRD). Factor A is 4 storage condition and Factor B is 5 storage duration which constituted the treatments. Each storage duration was replicated 3 times. The 4 storage conditions are as follows; SC1 =Air tight container (AC) 14.6^{0}C to 16.2^{0}C, SC2 = Air tight container in refrigerator (ACR) -5.1^{0}C to 3.2^{0}C, SC3 = Open container (OC) 23^{0}C to 26.5^{0}C and SC4 = Open container with every day moisture application (OCW) 23^{0}C to 25^{0}C while the 5 storage duration comprised; SD1 = 2 weeks, SD2 = 4 weeks, SD3 = 6 weeks, SD4 = 8 weeks and SD5 = 10 weeks.

Experimental Procedure

A total of one thousand, eight hundred and ninety seeds of *C. albidum* were used for this experiment. Before seed storage, 90 seeds were selected and sown immediately after extraction to test for the germination potential of freshly collected seeds of *C. albidum*. The remaining 1800 seeds were used for storage. A total of 450 seeds were stored in each storage condition. Three replicates of 30 seeds for each storage duration. The temperature of each storage condition was taken with the aid of a digital thermometer. The temperature was taken twice in a week throughout the duration of storage. Mean temperature range for each storage condition was determined with the aid of a thermometer. Electricity supply for 10 hours was ensured for seeds stored in refrigerator. Mean temperature in SC1 ranged from 14.6^{0}C to 20.1^{0}C, SC2 ranged from -5.1^{0}C to 3.2^{0}C, SC3 ranged from 23^{0}C to

26.5^{0}C while S4 ranged from 23^{0}C to 25^{0}C. Sterilized river sand was used as the sowing medium for this experiment. The sown seeds were placed inside a propagator. Watering of the seeds was done once daily.

Data Collection

In this experiment, the criterion for germination is the emergence of the plumule from the surface of the river sand. Germination was recorded daily until no further germination was observed for two consecutive weeks. Data on germination percentage and Complete dormancy period (number of days from sowing to start of germination) CDP were collected.

Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA). Treatment means were separated by the use of Duncan Multiple Range Test (DMRT). Results were presented in tables and figures.

Results and Discussion

Freshly collected seeds of *C. albidum* gave 99.33 % germination with 10 days complete dormancy period. ANOVA result revealed that there was significant difference in the effect of storage condition, storage duration and interaction of storage condition and storage duration (Table 1). Considering storage condition, seeds stored in air tight container (AC) gave the highest germination percentage of 43.33 %, followed by seeds stored in open container with application of every day moisture (OCW) having 28.67 %, followed by seeds stored in open container without application of every day moisture (OC) having 16 % germination while seeds stored in air tight container inside refrigerator (ACR) gave the least germination percentage with no germination (Table 2). Mean separation result showed that germination percentage of seeds stored in the different storage conditions are significantly different from each other (Table 2).

Relating to storage duration, seeds stored for 2 weeks gave the highest germination percentage of 43.33 %, seeds stored for 4 weeks gave 27.50 % germination, seeds stored for 6 weeks gave 19.17 % germination, seeds stored for 8 weeks gave 15.83 % germination while seeds stored for 10 weeks gave 11.67 % germination (Table 3). Mean separation result revealed that the germination percentage of seeds stored for the different storage durations are significantly different from each other (Table 3).

Table 1 : ANOVA Result for Effect of Storage Condition and Storage Duration on the Germination Percentage of *C. albidum* Seeds

Source of Variation	df	Sig.
Storage Condition (SC)	3	0.00*
Storage Duration (SD)	4	0.00*
SC * SD	12	0.00*
Error	40	
Total	59	

- significant (p<0.05)

Table 2 : Mean Result for Effect of Storage Condition on the Germination Percentage of *C. albidum* Seeds

Storage Condition	Mean Germination %
AC	49.33±14.70^a
ACR	0.00±0.00^d
OC	16.00±24.14^c
OCW	28.67±9.15^b

Mean ± standard error with different alphabet are significantly different (p<0.05)

Table 3 : Mean Result for Effect of Storage Duration on the Germination Percentage of *C. albidum* Seeds

Storage Duration	Mean Germination %
2weeks	43.33±27.96^a
4weeks	27.50±22.61^b
6weeks	19.17±20.94^c
8weeks	15.83±17.65^d
10weeks	11.67±13.14^e

Mean ± standard error with different alphabet are significantly different (p<0.05)

Considering the interaction of storage condition and storage duration, seeds stored in AC for 2 weeks gave the highest germination percentage of 70 % followed by seeds stored in AC for 4 weeks and OC for 2 weeks with 60 % germination, seeds stored in AC for 6 weeks gave 46.67 % germination, seeds stored in OCW for 2 weeks gave 43.33 % germination, seeds stored in AC for 8 weeks gave 40 % germination, seeds stored in AC for 10 weeks, OCW for 4 and 6 weeks gave 30 % germination, seeds store in OCW for 8 weeks gave 23.33 % germination, seeds stored in OC for 4 weeks gave 20 % germination, seeds stored in OCW gave 16.67 % germination while seeds stored in ACR for all storage durations, OC for 6, 8, and 10 weeks gave no germination (Figure 1). The result showed that the longer the storage duration the lower the germination percentage. The germination percentage reduced with storage duration (Fig. 1).

Result for Complete Dormancy Period (CDP) showed that germination commenced after 10 days for seeds stored for 2 weeks. Seeds stored for 4 weeks gave germination after 13 days of sowing, seeds stored for 6 weeks gave germination after 15 days of sowing, seeds stored for 8 weeks gave germination after 17 days of sowing while seeds stored for 10 weeks gave germination after 17 days (Fig. 2). CDP obtained in this study ranged from 10 to 17 days (Fig. 2).

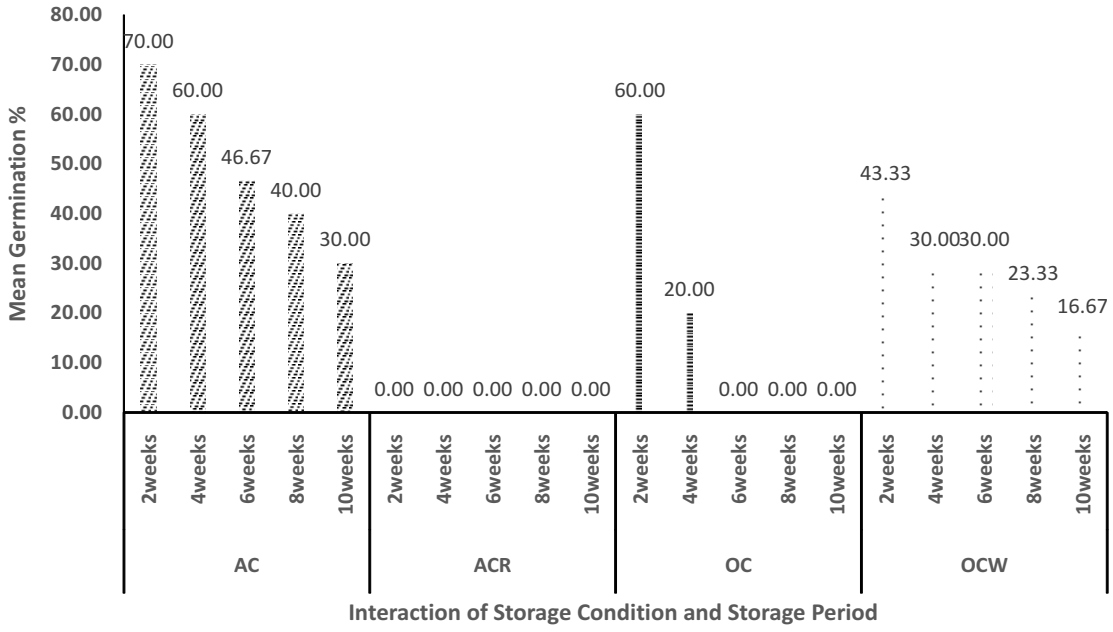

Figure 1: Interaction Effect of Storage Condition and Storage Duration on the Germination % of *C. albidum* Seeds

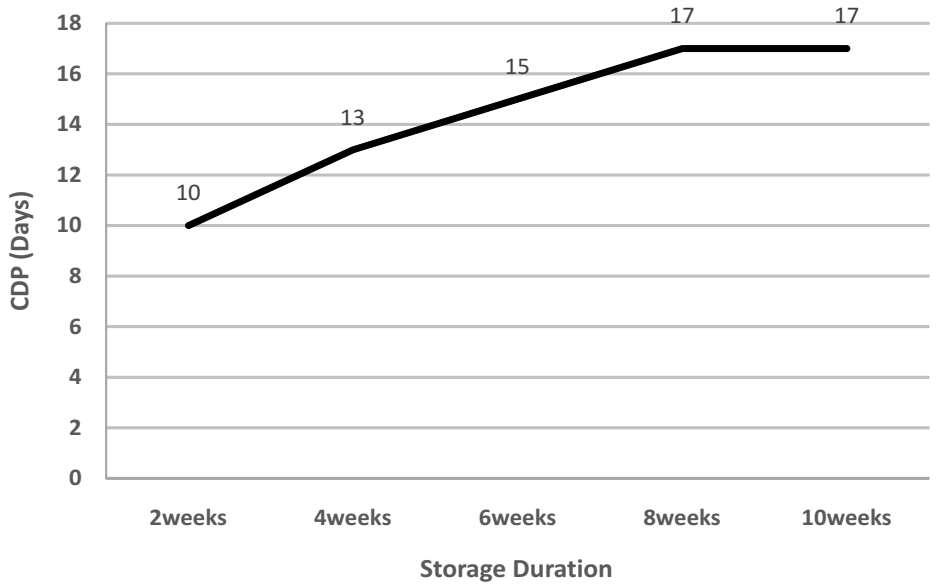

Figure 2: Effect of Storage Duration on the Complete Dormancy Period (CPD) of *C. albidum* Seeds

The different treatment methods used for the storage of *Chrysophyllum albidum* seeds had significant effect on the viability of the seeds. The seeds in the airtight container had the highest germination percentage throughout the duration of the experiment followed by seeds stored in an open container with everyday moisture application which had a lower germination compared to the ones in an airtight container. The result gotten from seeds stored in airtight container might be due to the fact that the container prevented the easy loss of moisture from the seeds thereby prolonging the viability period of the seeds. The result gotten from seeds stored in open container with everyday application of moisture shows that part of the moisture given off from the seeds due to the recalcitrant nature was added back by the moisture applied there leading to the prolonged viability period but germination potential was not as high as the seeds stored in the airtight container.

Seeds stored in an open container had germination from only the 2nd and 4th week and no further germination was recorded after the 4th week of storage. This implies that the entire moisture in the seeds was completely given off after 4 weeks revealing that the seeds of *C. albidum* cannot stay viable more than 4 weeks in room temperature. Seeds stored in an airtight container in a refrigerator had no germination recorded at all. This shows that *C. albidum* seeds are freezing sensitive and there might be disruption of the cell membrane due to freezing there by leading to no germination after storage.

Storage duration had effect on the complete dormancy period. The longer the storage duration the longer the complete dormancy period. This might be due to the moisture given off by the seeds for the storage duration as the time needed to absorb moisture and the amount of moisture required for germination will increase. Required moisture must get to the embryo of a seed for germination to be triggered. Result for complete dormancy period shows the recalcitrant nature of the seeds of *C. albidum*.

The decrease in the germination of seeds of *C. albidum* with increase in storage period is in correlation with the findings of Adelani*et al.* (2017) who stated that the highest germination percentage was observed in seeds of *C. albidum* stored for 1 week. Temel*et al.* (2011) also reported decrease in germination of *Pinusnigra* with increase in storage periods and Missanjo and Kapira(2015) who reported that germination percentage and germination energy of *Pinuskesiya* seeds decreased with an increase of storage period. However, contrary report by Kamotho*et al.* (2013) stated a significant increase in germination percentage of *Cleome gynandra* after 6 months of storage.

The effect of increasing period of storage on the germination percentage *C.albidum* seeds shows it is recalcitrant (Adelani*et al.,* 2017). Recalcitrant seeds are reported to have a relativelyhigh moisture contents and are sensitiveto desiccation (Anandalakshmi*et al.,*2005). Recalcitrant seeds germinate rapidly whensown fresh, but are sensitive to desiccationand freezing (Berjak and Pammenter, 2004; McDonald, 2004). This is in line with thereports of Liang and Sun (2000).

Conclusion and Recommendation

Conclusion

This study revealed that *Chrysophyllum albidum* seeds are recalcitrant. They lose moisture easily to the environment, thereby losing their viability easily. They cannot survive low temperatures (i.e. inside a refrigerator). They cannot be stored more than two weeks in room temperature. Storing the seeds in room temperature with application of daily moisture can prolong the viability period but germination potential will be low. *C. albidum* seeds can be stored in a condition with temperature ranging from 14.6^{0}C to 16.2^{0}C as derived from this study. This temperature will prolong the viability period of the seeds giving germination that is higher than seeds stored in room temperature with everyday application of moisture. This study has been able to increase the viability period of *C. albidum* seeds from 2 weeks to 10 weeks.

Recommendation

- *C. albidum* seeds can be stored in a condition with temperature ranging from 14.6^{0}C to 16.2^{0}C for the duration of 10 weeks.
- More research should be carried out on a better storage medium that can help in the storing of *C. albidum* seeds for longer period of time.
- Federal government should assist in the development of seed store banks in Nigeria for better storage of seeds in order to prevent genetic erosion.

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