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Studies on Shea (*Vitellaria paradoxa*) fruits storage and different preservation technologies for domestication

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In order to prevent a Shea seed from germination when stored, a preservation technology was adopted using different polythene bags which include a white transparent polythene bag of 500 mm gauge, big size perforated brown envelope, and black polythene bags of 500 mm guage. The results revealed that the Shea seeds preserved in the white transparent polythene bags retained their viability for six months which can then be used by experienced/professional domesticators for nursery establishment. With the result obtained from this study, the viable Shea seeds would be available all year round for domesticators. Therefore, the problem of seasonality in Shea seed availability is solved. However, Shea seed domesticators are encouraged to use the successful method of preservation to ensure availability of viable seeds across the yearly seasons.

Key words: Shea seeds, preservation, technology, polythene bag, domestication.

INTRODUCTION

Shea tree is an indigenous woody plant of Savanna Parkland that is scientifically called *Vitellaria paradoxa* which belongs to the family Sapotaceae. It is found in wide belts of Africa, extending from Senegal through the Sahel savanna parkland (Elias and Carney, 2004; Schreckenberg, 2004). Shea butter is processed from Shea nuts, which is also edible fruits and plays significant roles in household consumption and livelihood for rural people. Apart from providing a food supplement, Shea tree has monetary transaction importance in local economic and international trade (Lovett and Haq, 2000; Olosu, 2009).

The main constraints to domestication of karite/Shea tree are their slow growth, long juvenile phase and large yield variability. There is a high degree of variation in fruit and nut production, nut and fruit size, pulp sweetness, oil content and quality has been documented for karate (Maraz et al., 2004). A Shea seed is a ripened ovule. At the time of separation from the parent Shea plant, the plant consists of an embryo and stored food supply, both of which are encased in a protective covering. The activation of the metabolic machinery of the embryo leading to the emergence of a new seedling plant is known as germination.

For germination to be initiated, three conditions must be fulfilled (Ching, 1972; Jann and Amen, 1977). First, the seed must be viable; that is, the embryo must be alive and capable of germination. Second, the seed must be subjected to the appropriate environmental conditions such as available water, proper temperate regimes, a

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supply of oxygen, and sometimes light. Third, any primary dormancy condition present within the seed must be overcome (Crocker, 1916). Internal processes leading to removal of primary dormancy are collectively known as after-ripened and result from the interaction of the environment with the specific primary dormancy condition.

The stage of germination involves activation of seeds, digestion and translocation of seeds and seedling growth (Bewley and Black, 1985). Seed dormancy is a form of biological adaptation that prevents germination on the plant itself (viviparia), as well as germination of seeds at an inconvenient time of year, when the seedlings would not endure adverse environmental conditions (Bewley, 1997). Seed Dormancy and Germination are very critical periods for seeds domestication. Germination is the process by which the embryo wakes up from the state of dormancy and takes to active life. The seed contains only 10 to 15% of water and this low water content is one of the factors responsible for dormancy, when certain external conditions are satisfied the dormant embryo begins to grow. Seed democracy allows seeds to overcome periods that are unfavorable for seedling establishment and is therefore important for plant ecology and agriculture. There are other factors that affect seed germinability such as insufficient and untimely rainfall, sowing in poorly prepared land in combination with low precipitation or deep sowing etc.

Seed development comprises of two major phases, embryo development and seed maturation. Embryogenesis, which is a major photogenesis phase, starts with the formation of a single-cell-zygote and ends in the heart stage when all embryo structure has been formed (Mayer et al., 1991). Seed storage is one of the major factors of seeds domestication. Seeds that falls from a particular plant or harvested usually enters resting period. During this resting period, the seeds do not germinate until proper conditions are attained; however, they are still alive.

During dormancy, the seeds are still alive; they undergo what is referred to as cellular respiration, using up oxygen and stored sugars, while respiring and cleaning carbon dioxide. High temperature can speed respiration, adversely affecting the storage life of seeds. High humidity, especially when combined with high temperature favors the growth of fungal pathogens and subsequent rotting of seeds. Germination of seeds is a complex physiological and biochemical process controlled by many mechanisms (Gu et al., 2016).

Viability is expressed by the germination percentage, which indicates the number of seedlings produced by a given number of seeds. Additional characteristics of high-quality seed are prompt germination, vigorous seedling growth, and normal appearance (Abdul-Baki, 1980). Vigor of seed and seedling is an important attribute of 1986; McDonald, 1980). Low germination percentage, low germination rate, and low vigor are often associated. Low germination can be due to genetic properties of certain cultivars (Dickson, 1980). The objective of storage is to keep the seeds alive in such a way that they use their food reserves slowly, remain viable for a long time and maintain energy for germination at planting time.

Domestication of Shea trees largely depends on their seeds and thereafter followed by vegetative propagation for gestation period reduction. They are constrained by some biological factors such as seasonality of production, ageing of Shea trees and local recalcitrant of shell seeds. The seeds contain high moisture content and about 45-50% oil content which shorten their dormancy and usability period in preservation for germination.

The general objective of this research is to prolong the dormancy period and viability of Shea seeds and to sustain its availability as reliable planting materials for the domesticators from a period of one week to six months as against the dormancy period and viability loss of one to two weeks as cited by Lovett and Haq (2004). The study also proffered solutions to the bottleneck of seasonality of planting of Shea seeds, short dormancy period, short period loss of viability, low effectiveness and efficiency of nursery establishment and managements at a convenient period by the domesticators or growers. The researcher carried out Shea seeds preservation and germination for domestication, using three preservation methods, namely: white transparent polythene bags, perforated brown envelope and black polythene bags for the period of one to six months as enumerated in the work.

MATERIALS AND METHODS

Description of study location

The study was conducted at Nigerian Institute for Oil Palm Research (NIFOR), Shea Tree Research Substation Nursery Site in Bida local Government Area of Niger State, Nigeria. It is located in the Guinea Savanna zone, which falls in the middle belt of Nigeria. The area lies on Latitude 08°0578N and Longitude 006°47.789E. The soil type in this location is sandy loam with annual rainfall ranges between 500 to 1200 mm per annum. Minimum and maximum temperature ranges between 24 and 33°C respectively. Shea seeds/fruits were collected from already identified superior mature trees, according to farmers' criteria, which included good physical and sanitary characteristics (such as vigorous growth and absence of parasites) as well as the quality of the fruits and nuts (tasty pulp and oil-rich kernel). The collected seeds/fruits were processed for seeds by depulping the fruits manually at the substation.

Collection and preparation of Shea seeds

First, 150 Shea seeds were collected from the wild of Shea tree growing areas in Niger state. The seeds were selected and washed under a running tap, then sun dried for 5 min and stored in room temperature differently in the following storage materials with frequent observation: white transparent polythene bags of 500 mm guage; big size perforated brown envelope; and black polythene bags of 500 mm guage. Secondly, 150 Shea seeds were selected, washed, soaked in warm water for 2 min; sun dried and stored in room temperature differently in the same storage materials as itemized above. The first and second year experimental observation

lasted from one to five months, while the third year of the experimental observation lasted from one to six months with 180 Shea seeds for each preservation methods in 2017.

The experiment was carried out for three (3) consecutive years (2015, 2016 and 2017). For each seeds sample, six lots of 50 seeds each were used for germination tests: - Lots one to six: fresh seeds no 180 Stored after harvest (0 month of storage): Lot 1: seeds stored for 1 month after harvest; Lot 2 seeds stored for 2 months after harvest; Lot 3 seeds stored for 3 months after harvest; Lot 4 seeds stored for 4 months after harvest; Lot 5 seeds stored for 5 months after harvest; Lot 6 seeds stored for 6 months after harvest.

Experimental design, treatments and planting of Shea seeds

Treatment 1

150 Shea seeds were selected from the different preservation methods, namely: white transparent polythene bags, perforated brown envelope and black polythene bags, and 50 Shea seeds were used for each method. The seeds were washed under a running tap water, sun-dried for 5 min and stored differently in the preservation materials, planted in the appropriate soil medium of river sand, sandy loamy and cured organic manure of 1:2:1 in 8 by 12 by 500 mm guage polythene bags with adequate manual irrigation at every other day and exposed to natural precipitation. The seeds were planted on sequential months in ascending order from April to August of the year of experimental observation. This was repeated in 2015, 2016 and 2017 as indicated in tables 1-6. While in 2017, 180 Shea seeds were used for three preservation methods as indicated in Table 5 and 6 of the analysis.

Treatment 2

150 Shea seeds were selected from the different preservation methods, namely: white transparent polythene bags, perforated brown envelope and black polythene bags, and 50 Shea seeds were used for each method. The seeds were soaked in warm water for 2 min, washed with ordinary clean water, sun-dried for 5 min and stored differently in the preservation materials, planted in the appropriate soil medium of river sand, sandy loamy and cured organic manure of 1:2:1 in 8 by 12 by 500 mm guage polythene bags with adequate manual irrigation at every other day and also exposed to natural precipitation.

The seeds were planted on sequential months in ascending order from April to August of the year of experimental observation; while in 2017, 180 Shea seeds were used for three preservation methods as indicated in Tables 5 and 6 of the analysis.

Data analysis

The data for this study was collected and analyzed using frequency and percentage to show the differences in the performance of the three preservation methods with particular reference to germination.

Evaluation of seed germination

Germination is measured on two parameters, the germination percentage and the germination rate. Vigor may be indicated by measurement, but seedling growth rate and morphological appearance must also be considered. Sometime abnormal growing seedlings result from low seed quality (Heydecker, 1972). Statement of germination percentage should involve time element, indicating the number of seedlings produced within a specified length of time. Germination rate can be measured by several methods. One determines the number of days required to produce a given germination percentage (Kotowski, 1926; Gordon, 1973; Czabator, 1962).

Germination percentage of Shea seeds was evaluated each month. Seeds are considered germinated when the plumule emerged from the testa/embryo. The percentage of germination (% G) was to:

$$\%G = \frac{NSG}{NST} \times 100$$

Where, NSG is number of seed germinated and NST is total number of seed tested.

After 6 months, the cumulative percentage of germination was determined.

RESULTS AND DISCUSSION

The results in Table 1 show that 80% of the Shea seeds preserved in the white transparent polythene bag in the first, third, and fifth months respectively were still viable and as such germinated after planting. However, 90% of the Shea seeds in the second month were still viable and germinated after planting and 70% of the Shea seeds planted in the fourth month were viable and germinated, while 0% of the Shea seeds preserved in perforated envelope and black polythene bag were recorded death.

Table 2 results indicate that in the whole five months, none of the Shea seeds preserved in white transparent polythene bag, perforated envelope and in the black polythene bag germinated after planting. This reveals that 100% of the Shea seeds were not viable after preservation. This could be attributed to warm water soaking of Shea seeds before planting in the polythene bags, which would have destroyed or damage the embryonic cells of the seeds.

From Table 3, the result reveals that 100% of the Shea seeds preserved in the white transparent polythene bag were still viable and germinated after two months of preservation. 90% of the preserved seeds were also still viable and germinated after one month and five months of preservation respectively. 80% of the seeds were also viable and germinated after four months and 60% were those that were viable and germinated at as after three months of preservation, while 0% of germination was recorded for Shea seeds that were preserved in perforated envelope and black polythene bag, this could be attributed to temperature of the growing seeds or the environmental conditions which might have influenced either positively or negatively to the seeds germination. However, Bass and Clark (1967) in his study found that the loss of viability of freshly harvested Kentucky bluegrass seed was correlated with the moisture content of the seed and length of time held at a given temperature.

The result in Table 4 shows that none of the Shea seeds preserved in the white transparent polythene bag,

Table 1. Variations in percentage germination using the different germination technologies for the year 2015.

Months of experimental observation (April to August, 2015)	White transparent polythene bags/percentage germination (%)		Perforated brown envelope /percentage germination (%)		Black polythene bag/percentage germination (%)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
First month						
Number planted	10		10		10	
Number germinated	8	80	0	-	0	-
Second month						
Number planted	10		10		10	
Number germinated	9	90	0	-	0	-
Third month						
Number planted	10		10		10	
Number germinated	8	80	0	-	0	-
Fourth month						
Number planted	10		10		10	
Number germinated	7	70	0	-	0	-
Fifth month						
Number planted	10		10		10	
Number germinated	8	80	0	-	0	-

Table 2. No viability recorded using the different preservation methods after planting for the year 2015.

Months of experimental observation (April to August, 2015)	White transparent polythene bag/percentage germination (%)		Perforated brown envelope/percentage germination (%)		Black polythene bag/percentage germination (%)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
First month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Second month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Third month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Fourth month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Fifth month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-

perforated envelope and black polythene bag germinated after one month, two months, three months, four months and five months of preservation respectively. This result simply means that 100% of the preserved seeds in the

Table 3. Variations in percentage germination at different months after planting for the year 2016.

Months of experimental observation (April to August, 2016)	White transparent polythene bag/percentage germination (%)		Perforated brown envelope/percentage germination (%)		Black polythene bag/percentage germination (%)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
First month						
No. planted	10		10		10	
No. germinated	9	90%	0	-	0	-
Second month						
No. planted	10		10		10	
No. germinated	10	100%	0	-	0	-
Third month						
No. planted	10		10		10	
No germinated	6	60%	0	-	0	-
Fourth month						
No. planted	10		10		10	
No. germinated	8	80%	0	-	0	-
Fifth month						
No. planted	10		10		10	
No. germinated	9	90%	0	-	0	-

Table 4. No viability recorded using the different preservation methods after planting at different months for the year 2016.

Months of Experimental Observation (April to September, 2016)	White Transparent polythene Bag/Percentage Germination (%)		Perforated Brown Envelope/Percentage Germination (%)		Black Polythene Bag/Percentage Germination (%)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
First Month						
No. Planted	10		10		10	
No Germinated	0	-	0	-	0	-
Second Month						
No. Planted	10		10		10	
No. Germinated	0	-	0	-	0	-
Third Month						
No. Planted	10		10		10	
No. Germinated	0	-	0	-	0	-
Fourth Month						
No. Planted	10		10		10	
No. Germinated	0	-	0	-	0	-
Fifth Month						
No. Planted	10		10		10	
No. Germinated	0	-	0	-	0	-

various preservation materials were not more viable after the various said months.

The result from Table 5 indicates that 90% of the Shea seeds preserved in the white transparent polythene bag

Table 5. Variations in percentage germination at different months after planting for the year 2017.

Months of experimental Observation (April to September, 2017)	White transparent polythene bag/percentage germination (%)		Perforated brown envelope/percentage germination (%)		Black polythene bag/percentage germination (%)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
First month						
No. planted	10		10		10	
No. germinated	8	80%	1	10%	0	-
Second month						
No. planted	10		10		10	
No. germinated	9	90%	0	-	0	-
Third month						
No. planted	10		10		10	
No. germinated	7	70%	0	-	0	-
Fourth month						
No. planted	10		10		10	
No. germinated	9	90%	0	-	0	-
Fifth month						
No. planted	10		10		10	
No. germinated	9	90%	0	-	0	-
Sixth month						
No. planted	10		10		10	
No. germinated	8	80%	0	-	0	-

after two months, four months, five months and six months respectively maintained their viability and as such germinated after planting. 80% of the Shea seeds were also viable and germinated after one month of preservation and 70% proved viable after three months of preservation, while only 10% of the Shea seeds preserved in perforated envelop geminated after one month of preservation and all other ones representing 90% lost their viability right from one month to six months respectively. 100% of the Shea seeds preserved in the black polythene bag lost their viability from the first month up to the last month, this might be attributed to the environmental conditions, or the chemical compositions of the seed might have been deteriorated. The results of this research is in conformity with the report of Pollock (1961) who opined that a seed with an unbalanced chemical composition, or one mechanically damaged, permitting early entry of micro-organisms, would be at a disadvantage in storage.

The result in Table 6 shows that all the Shea seeds, that is 100% of seeds preserved in transparent polythene bag, perforated envelop and black polythene bag lost their viability and as such did not germinate after one, two, three, four, five and six months of preservation respectively. The inability of the seeds to germinate at these periods might be due to environmental conditions which may have triggered the duration of dormancy of the seeds.

Conclusion

The results of the study revealed that Shea seeds preserved in the white transparent polythene bags, washed with ordinary clean water, sun-dried for 5 min, planted in the appropriate soil medium of river sand, sandy loamy and cured organic manure of 1:2:1 in 8 by 12 by 500 mm guage polythene bags with adequate manual irrigation of every other day and exposed to natural precipitation can retained their viability for six months and they can be used by experienced/ professional domesticators for nursery establishment. Shea seeds viability and dormancy period is one of the major constraints affecting Shea tree propagation as well as its plantation establishment. With the result obtained from this study, the viable Shea seeds would be available all the year round for domesticators.

Therefore, the problem of seasonality in Shea seed availability is solved. However, Shea seed domesticators are encouraged to use the successful method of preservation to ensure availability of viable seeds across the yearly seasons.

Table 6. No viability recorded using the different preservation methods after planting at different months for the year 2017.

Months of experimental observation (April to September, 2017)	White transparent polythene bag/percentage germination (%)		Perforated brown envelope/percentage germination (%)		Black polythene bag/percentage germination (%)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
First month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Second month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Third month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Fourth month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Fifth month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-
Sixth month						
No. planted	10		10		10	
No. germinated	0	-	0	-	0	-

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

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