American Journal of BioScience
2022; 10(4): 137-142
http://www.sciencepublishinggroup.com/j/ajbio
doi: 10.11648/j.ajbio.20221004.12
ISSN: 2330-0159 (Print); ISSN: 2330-0167 (Online)

Science PG
Science Publishing Group

Effect of Type and Storage Period on the Characteristics of (*Acacia senegal*) Seeds on North Kordofan, Sudan

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To cite this article:

Yahia Ibrahim Mohammed Abutaba, Mehad Elbelil Adam, Muneer Elyas Siddig Eltahir. Effect of Type and Storage Period on the Characteristics of (*Acacia senegal*) Seeds on North Kordofan, Sudan. *American Journal of BioScience*. Vol. 10, No. 4, 2022, pp. 137-142. doi: 10.11648/j.ajbio.20221004.12

Received: June 19, 2022; **Accepted**: July 19, 2022; **Published**: August 29, 2022

Abstract: The study aimed to investigate the effect of the storage longevity period and the type of storage on the characteristics and viability of *Acacia senegal* (*Hashab*) seeds, to attain an appropriate method of storage. The experiment was applied at the Regional Tree Seed Centre-Elobied during the year 2016, and seeds were collected from *El-Damoukya.* The tests were applied (purity, number of seeds/kg, moisture content, germination, viability) before seed and after storage in three different stores (normal, cold and deep), where the tests were conducted after 3, 6, 9, 12 months for each sample. The seeds trees were divided into three groups, and each seed group was stored in the stores. Experiment design by Randomized Complete Block Design (RCBD) with three replicates in storages by repeating three samples. The data analyzed by SAS software for ANOVA table, while LSD test used for means separation for the results. The results showed high significant difference (α = 0.0001) in the moisture content of seed in the normal store with high ratio (20%) in the fourth period (12 months), while in the cold stores was (15%). The results showed a decrease in the number of seeds/ kg for the deep store by (9091 seeds) compared to the normal and cold store. The deep and cold stores are suitable for storing seeds for 12 months and the normal store can be considered as unsuitable of which affected directly by surrounding factor and led to an increase in the moisture content of the seeds, resulting in the weight gain of the seeds and the decrease in the number of seeds/kg. This study recommends the use of deep and cold storage of *Hashab* seed.

Keywords: Storage Longevity, Hashab, Acacia Senegal, Germination, Deep and Cold Storage

1. Introduction

The seed constitutes the main vector of plant propagation and it is a critical development stage with many specificities. Seed longevity is a major challenge for the conservation of plant biodiversity and for crop success. Seeds possess a wide range of systems (protection, detoxification, repair) allowing them to survive in the dry state and to preserve a high germination ability. Therefore, the seed system provides an appropriate model to study longevity and aging [11]. Seed storage is the preservation of seeds under controlled environmental conditions to maintain seed viability (germination and vigour) for long periods. The entire storage period comprises several processes and sites. In the broadest sense, storage begins at physiological maturity and ends with germination in the field [7]. Seeds differ in terms of sensitivity to drying and temperature; some seeds lose their viability once they reach a certain level of moisture content. Seed moisture is a critical factor determining the viability and longevity of all seed types. For this reason, it is fundamental to identify the seed type before considering the method of storage. In terms of seed longevity and the effects of drying and storage on germination, there are different seed categories [16]. For restoration, it is fundamental that every single decision and step regarding the activities prior to storage consider the best practices to ensure that seeds of the highest possible quality enter the storage facilities. Then, proper protocols are critical to assess seed longevity and maintain high levels of seed viability under storage, and ultimately to supply native seeds of high quality for seed-based restoration projects. Seeds that are handled and stored improperly result in shorter lifespan and die, and the restoration will fail [11]. Orthodox seeds long-lived can be dried to moisture content of 5% (i.e. lower than they would normally achieve in nature) without damage, and *Acacia senegal* seeds are of this category. Seeds can be preserved for several years in tight storage at 10°C with a moisture content of (4.5 - 9)% [2]. The seed storage behavior is orthodox. 98% purity can be achieved. Seed weight depends on the source and climatic conditions of the maturity year. Properly mature and dried seeds can be stored in airtight containers at room temperature for at least one year, and 10°C for several years. It is recommended to store with insecticides. The average number of seeds is 15,000 seeds/kg [5, 10].

The seeds may sometimes be kept in cool places for storage. Good buildings that do not differ in temperature have a gradual rise and fall with different seasons. The seeds can be kept in such places for a period of one year without much damage or more than a year and to store them for a longer period. The temperature is low [12].

The amount of moisture in the seeds is perhaps the most important factor influencing their viability during storage. Moisture content is the root of many storage problems - increased metabolic activity, higher respiration, fungus attack, heating and weakness - ultimately leads to seed death [6]. If the moisture content of the seeds increases, this may encourage the growth of fungi and attack insect pests; generally, seeds deteriorate quickly when moisture content exceeds 20%. Too low moisture content also harms seed quality, as the seed becomes vulnerable to mechanical damage, resulting in the breakage or cracking of the basic seed parts, rendering the seed vulnerable to damage and fungal attack. Moisture content is the basis of one of Harrington's basic rules: "For everyone low seed moisture content By 1%, the seed doubles life." However, this rule is applicable in the range (5-14)%, because 5% causes physiochemical changes in the seeds, and more than 14% exposes the seeds to insects and fungal attack [6] (Ellis and Roberts, 1980).

It has been proven from these studies that reducing moisture content facilitates the possibility of longer storage and better germination, and temperature was the main factor that played an important role in controlling seed degradation [3].

2. Material and Methods

2.1. Seeds Collection

The seed collected in Kordofan (Central Sudan), namely *El- Demokeya* forest reserve site are situated in the "gum belt" of Sudan.

El-Demokeya forest reserve (North Kordofan State) is located 30 km east of El Obeid town (latitude 13° N, longitude 30° E) The forest reserve covers more than 3150 ha of sandy soils and the mean annual precipitation in this area averages around 365 mm. The site is naturally dominated by *A. senegal* with few scattered trees and shrubs of *Balanites aegyptiaca* (L.) Del., *Boscia senegalensis* (Pers.) Lam, and *Cordia abyssinica* R. Br.

The seeds were collected during the seed collection period from November and December 2015 by the technical group.

2.2. The Seeds Processing

The maturity fruits were collected and placed in the drying and cleaning yard, where seeds were extracted from the capsule and these seeds were placed in bags of burlap, and then some tests were performed on them.

2.3. The Seeds Storage

The tests were applied (purity, number of seeds/kg, moisture content, germination, viability) before seed and after storage in three different stores (normal, cold and deep), where the tests were conducted after 3, 6, 9, 12 months for each sample. The seeds trees were divided into three groups, and each seed group was stored in the stores. Experiment design by Randomized Complete Block Design (RCBD) with three replicates in storages by repeating three samples.

2.4. Storage Types

1) Normal store: It is a room prepared for normal storage conditions and a normal temperature similar to the normal room temperature (25-30)°C. It increases and decreases according to the general air [1].
2) Cool store: It is a temperature-controlled windowed room where it is cooled to (1-12)°C. And with a regulator to adjust the temperature until the required degree is controlled [1].
3) Deep store: A deep freezer is to cool to (10-20)°C below zero.

2.5. The Seeds Characteristics

1) Purity test.
2) Number of seed per kg.
3) Moisture content.
4) Germination test.
5) Viability (seed cutting).

2.6. Data Analysis

The data analyzed by SAS statistical software version 6.12 (SAS Institute Inc., 1996) for ANOVA table, while LSD test used for means separated for the results.

3. Results

Table 1 that shows the analysis of variance for the purity tests of seeds stored in three different stores, which showed that there were no significant differences with a significant level (α = 0.05) for each of the seeds stored in the deep, cold and normal store.

The results also showed by analyzing the variance of the tests of viability of seeds stored in three different stores that there were no significant differences at a significant level (α = 0.05), Table 2.

The germination tests of seeds, which were stored in three different stores, showed the results of no significant differences, Table 3.

From the results of Table 4, which shows the mean percentage of moisture content and the number of seeds/ kg of seeds, which were stored in three different stores (deep, cold and normal), for which moisture tests were conducted in four periods and in which some differences in the moisture content appeared, and it was evident in the deep storage, which was in the first period (7%), while it showed a frequency in the moisture content in the second and third periods, and it appeared at a higher rate in the fourth period (11%).

The cold storage, which appeared at a rate of (7%), which is considered standard for all storage levels of seeds, there is a fluctuation in moisture content, which showed a higher percentage in the fourth period (15%), Table 4 and Figure 2.

Normal storage, for which the moisture content tests were conducted in four periods, which are considered the first standard period (7%) for Seeds and showed a few decrease in the second period and an increase in the third period (13%) and a higher rate in the fourth period (20%), Table 4 and Figure 3.

Table 4, which shows the mean number of seeds/ kg, which showed results in the first period, which are considered standard (10589 seed), deep storage showed a change in the number of seeds in the second, third and fourth periods, which showed a significant decrease in the fourth period (9091 seed), Figure 4.

The cold store for the mean number of seeds/kg, which appeared in the frequency of the number of seeds for the second and third periods, and a few decreases in the fourth (10127 seed), Table 4 and Figure 5.

While the normal store for the mean number of seeds/kg of seeds, which showed results with a frequency of during the second and third periods, and a significant decrease in the fourth (10,000 seed) Table 4 Figure 6.

Table 5. The ANOVA table analysis of the moisture content of seeds in the different stores after 12 months of storage in the presence of high significant differences (p = 0.0001) between the different stores, where the normal store showed a high mean moisture content (20%) compared to the store, where the deep store recorded the lowest average moisture content (11%), Table 6 and Figure 7.

Table 1. *The ANOVA table shows purity testing of Acacia senegal seeds were stored in three different storages.*

Sources	Df	Normal storage			Cold storage			Deep storage		
Period		**Ss**	**Ms**	**F value**	**Ss**	**Ms**	**F value**	**Ss**	**Ms**	**F value**
	3	0	0	1^{n}	0	0	1^{n}	37.5	12.5	0.9^{n}

Table 2. *The ANOVA table shows viability testing of Acacia senegal seeds were stored in three different storages.*

Sources	Df	Normal storage			Cold storage			Deep storage		
Period		**Ss**	**Ms**	**F value**	**Ss**	**Ms**	**F value**	**Ss**	**Ms**	**F value**
	3	0	0	1^{n}	0	0	1^{n}	0	0	1^{n}

Table 3. *The ANOVA table shows germination testing of Acacia senegal seeds were stored in three different storages.*

Sources	Df	Normal storage			Cold storage			Deep storage		
Period		**Ss**	**Ms**	**F value**	**Ss**	**Ms**	**F value**	**Ss**	**Ms**	**F value**
	3	124.92	41.64	0.09^{n}	49.17	16.4	0.03^{n}	167.05	55.68	0.11^{n}

Table 4. *The mean moisture content and the number of seeds/kgof Acacia senegal stored in three different storages.*

Period (Every three months)	The test		
	Normal storage%	**Cool storage%**	**Deep storage%**
The first	7^{C}	7^{C}	7^{B}
The second	5^{C}	10^{B}	7^{B}
The third	13^{B}	5^{C}	5^{B}
Fourth	20^{A}	15^{A}	11^{A}
	The mean number of seeds/kg		
The first	10589^{A}	10589^{A}	10589^{A}
The second	9804^{A}	10020^{A}	10152^{A}
The third	10485^{A}	103902^{A}	10050^{A}
Fourth	10000^{A}	10127^{A}	9091^{A}

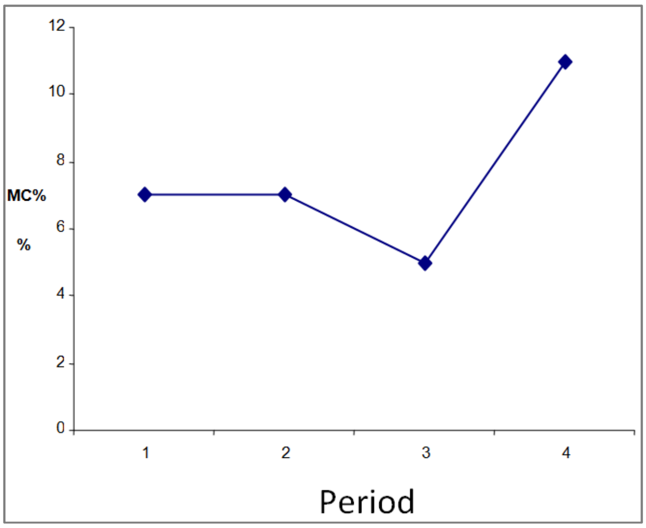

Figure 1. *Mean moisture% in deep storage.*

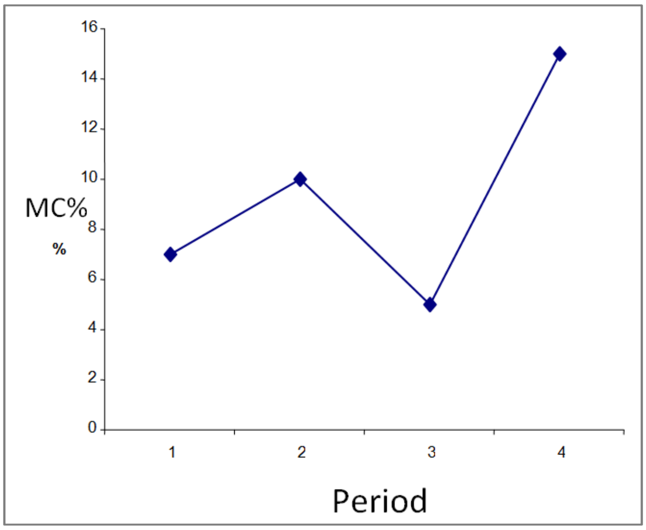

Figure 2. *Mean moisture% in cool storage.*

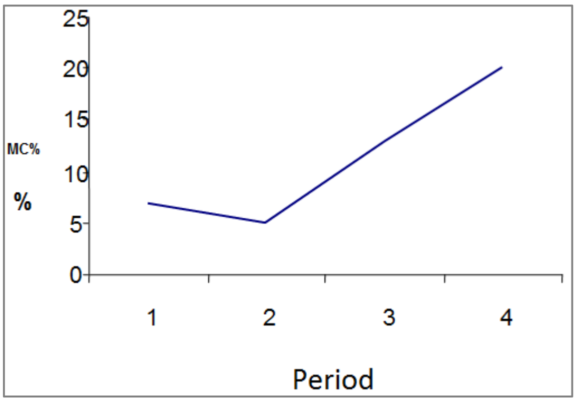

Figure 3. *Mean moisture% in normal storage.*

Table 5. *The ANOVA table shows moisture content of Acacia senegal seeds were stored in three different storages after (12 month).*

Source	DF	SS	MS	F value
Storage	2	122	61	15.3***

Table 6. *The moisture content of Acacia senegal seeds were stored in three different storages after (12 month).*

Storage	Moisture content%
Normal	20^{A}
Cool	15^{B}
Deep	11^{C}

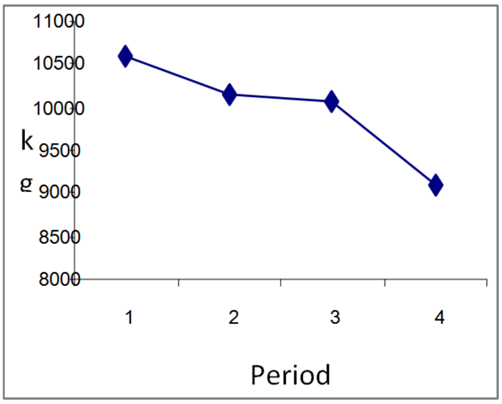

Figure 4. *Mean number of seeds/kg in deep storage.*

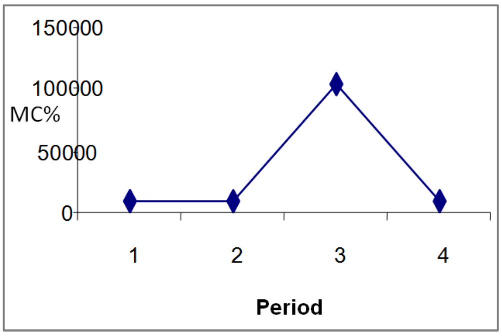

Figure 5. *Mean number of seeds/kg in cool storage.*

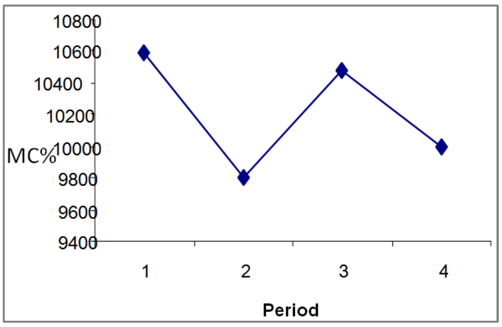

Figure 6. *Mean number of seeds/kg in normal storage.*

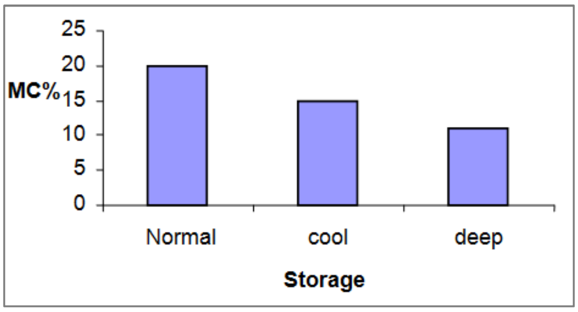

Figure 7. *Moisture content of seeds stored in three different storage.*

4. Discussion

Acacia senegal seeds, which appear to be important in the production of these trees from gums, It has direct contributions to increasing local and national income, and which show their importance in that, While these trees are widely spread in Sudan in different areas within the Gum Arabic zoon, but they are repeatedly produced from seeds in different periods known as (Seed years), which are stored in storages for use in different periods.

The seeds contain different factors and places of storage, some of them are stored in storages with normal temperatures, some are stored in refrigerated storages, and others are known in depth for many years.

Among the results of seeds, which were subjected to different storage conditions (normal, cold, and deep) for a period of 12 months, they were subjected to different tests and showed in each of the stores clear superiority, harmony and unaffectedness in each of the different storages, there were no significant differences for the different tests (purity, viability and germination). While there is an increase in moisture content in both the normal, cold and deep stores, this is due to changes in temperature, and when the moisture percent of seeds increases to more than (20%), germination decreases or lacks its vitality and during these periods, which lasted for a period of 12 months, there is a change in moisture rate, the deep and cold store, despite the increase in moisture percent, but within the permissible limits that do not exceed (15%). From these results, the deep and cold storage is more suitable for storing *Acacia senegal* seeds for a period of 12 months [8, 14]. This was reflected in an increase and decrease in the number of seeds/kg, when a decrease in the number of seeds means an increase in the moisture content.

The normal storage can be considered unsuitable for storing *Acacia senegal* seeds compared to the deep and cool storage, which has a direct effect on the factors surrounding the store, which led to an increase in the moisture content of the seeds, which was reflected in the weight gain of the seeds and the decrease in the number of seeds/kg.

The change of oxygen and removal of toxic gases produced during the metabolism process must be taken into consideration when determining storage conditions, especially long-term storage [13]. This proved that reduced moisture content facilitates the possibility of longer storage and better germination, and temperature was the main factor that played an important role in controlling seed degradation [2]. Some studies proved that primed seeds are known to have low storage longevity [9, 15, 17], generally primed seeds are not used immediately [4]. However, such variations in longevity of primed seeds are greatly influenced by environmental (storage temperature, seed moisture con tent), and genetic factors (such as seed quality) [11]. Recently, it was stated that the reduced longevity can be partially recovered via post-storage treatments such as dehydration, heat shock, or post-storage humidifi cation [18].

5. Conclusion and Recommendation

The study concluded that the seeds of Acacia Senegal could be stored and remain viable in optimal characteristics when deeply cold stored. The normal store conditions were not suitable; therefore, it is recommended that the seeds should be stored under cool conditions.

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