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Assessment of Germination and Vigour of Sesame Seeds from Four Storage Environments at Different Periods

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Authors' contributions

This work was carried out in collaboration between all authors. Author O. Adam designed the study, wrote the protocol and first draft of the manuscript. Authors AO, O. Anthony and AG managed the analyses of the study, literature searches and over all planning and supervision of the experiment. Authors O. Ayooluwa and AT performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Sesame (*Sesamum indicum* L.) is an important oil-crop, however, its seeds deteriorate rapidly after harvest from the field. The objective of this study was to assess the germination and vigour of sesame seeds from different storage environments at different periods. The experiment was arranged in 2 x 3 x 4 factorial using completely randomized design (CRD) in three replication. The laboratory experiment was carried out at The National Centre for Genetic Resources and Biotechnology (NACGRAB) Ibadan, Nigeria starting from April to October 2015. The stored seed samples were drawn at three-month intervals and evaluated for germination and germination index. Analysis of variance (ANOVA) revealed that effects of accession and accession by storage environment interaction were significant (*P*=.05) while effects of storage environments, storage periods, storage periods by environments and storage periods by accessions interactions were

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highly significant (*P*<.01) on germination of sesame seeds. Similarly, effects of the storage environment and storage period by environment interactions were significant (*P*=.05) while effects of storage period and accession by storage environment interactions were highly significant (*P*<.01) on germination index. Seeds stored under ambient conditions gave the lowest germination percentage (65%), while seeds stored in freezer gave the highest germination percentage (81.2%). The germination percentages of seeds stored under short (73.8%) and medium (72.1%) term conditions were not significantly different. Moreover, germination index for seeds stored under ambient conditions was highest (5.6 days) and significantly higher than germination index for seeds stored under short-term (5.4 days) conditions. The germination index for the seeds stored under medium (5.2 days) and freezer (5.2 days) conditions were not significantly different. The study concludes that freezer compartment at -4 to -2°C temperature was the best storage environment and could retain germination and vigour of sesame seeds for longer period than other storage environments.

Keywords: Accession; temperature; period; storage; germination index.

1. INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oil-seed crop usually grown in tropical and temperate regions around the world. The crop is very important in human nutrition and medicine [1,2]. It is cultivated for its edible seeds which grow in pods or buns. Its seed contains edible oil with a good source of protein for man. However, storage of its seeds for subsequent planting or conservation is a major challenge, especially in developing countries. Longevity of seed during storage could be influenced by several factors such as temperature and relative humidity of the storage environment, nature of the seeds, seed moisture content and storage periods [3,4]. Seed quality is a multiple concepts encompassing genetic quality, seed health, physical aspects, germination and vigor. Seed germination and vigour are regarded as the two crucial components of seed quality. The Association of Official Seed Analysts [5] defines seed germination as 'the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favourable conditions. Since germination capacity forms a crucial aspect of seed quality, germination tests are therefore used worldwide to determine the maximum germination potential of a seed batch under optimum conditions. The International Seed Testing Association (ISTA) [6] defined seed vigour as "the sum total of those properties of the seed that determine the level of activity and performance during germination and seedling emergence". The aspect of performance associated with seed vigour include (i) rate and uniformity of seed germination and seedling growth, (ii) field performance, including the extent, rate and uniformity of seedling emergence, and (iii) performance after storage and transport particularly the retention of germination capacity. The concept of seed vigour implies that two seed lots having similar germination level may perform differently due to differences in vigour potential when subjected to poor field conditions. Speed of emergence of seedlings is one of the oldest seed vigour concepts. Vigorous seeds have been shown to germinate rapidly. Speed of germination can be measured through various techniques and given different names such as: emergence rate index, germination rate, germination index and speed of germination.

The objective of seed storage is to maintain seed quality for the longest duration possible. However, seeds deteriorate and lose viability during periods of prolonged storage [7]. Some of the characteristics of seed ageing include a delay in germination and emergence, slow growth and increase of susceptibility to environmental stresses in the various duration of storage. The fundamental objective of seed testing therefore is to establish the quality level of seed. Sesame seeds like other oil-seeds deteriorates rapidly immediately after physiological maturity or harvest from the field. This is as a result of the high oil content of the seed [8]. Besides, the predominant hot and humid tropical and subtropical conditions with great variation in relative humidity and temperature throughout the year in tropical countries like Nigeria makes storage problem a big challenge. Suma et al. [9] reported that frequent fluctuation in temperature, moisture content and storage time make the processing and storage of seeds difficult. In order to minimize the loss of viability of sesame seeds in storage, there is need to assess seed germination from different storage environments at different storage time. The findings would furnish information on appropriate storage environment that would retain germination and vigour of sesame seeds for as long as possible. This study was undertaken to assess seed germination and vigour of sesame seeds stored in different storage environments at different periods.

2. MATERIALS AND METHODS

2.1 Plant Materials

Seeds of two accessions of sesame: NGB 00420 and NGB 00967 with initial germination percentages of 94 and 96% respectively and dried to about 12% moisture content were sourced from the genebank of The National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan, Nigeria. The materials were randomly selected among the accessions regenerated and processed during the late season of 2014. The materials were kept in the short-term cold room of the centre prior to the commencement of the experiment. The laboratory experiment was conducted at the seed testing laboratory of NACGRAB between April and October 2015.

2.2 Experimental Design

The experiment was arranged in 2 x 3 x 4 factorial using completely randomized design (CRD) in three replications. The three factors were two sesame accessions, three storage periods and four storage environments. The stored seed samples were tested at quarterly intervals starting from April to October 2015.

2.3 Seed Storage

Two hundred grams of each accession were partitioned into four parts. Samples from each accession were kept separately in four storage environments. The first environment was ambient which represents normal room conditions. The second storage environment was a short-term cold room where genetic materials are kept for purpose of distribution and regeneration and the third storage environment was medium-term cold room where genetic materials are kept as safety duplicate while the fourth storage environment was freezer compartment which serves as a backup for medium term. The materials were kept in the environments in February 2015 using aluminium cans as packaging materials. The stored seed samples were drawn at three-month intervals starting from April to October 2015 which constituted three storage periods.

2.4 Temperature and Relative Humidity Measurement of the Storage Environments

Temperature and relative humidity of the four storage environments were taken daily using sensors. Power supply was ensured for a minimum of ten hours daily in all three cold storage environments. The stored seed samples were tested for germination and germination index at quarterly intervals.

2.5 Standard Germination Test

One hundred seeds of each treatment combination were drawn and evaluated for standard germination test in three replications. The test was assayed by placing the seeds in germination plastic containers lined with four layers of tissue paper moistened with 15ml of distilled water. The containers were covered and placed in a germinating chamber at 25 ± 2°C. The seeds were kept moist every day for seven days. Germination percentages were calculated by expressing the number of seedlings in a replicate that emerged 7 days after planting as a percentage of the number of seeds planted according to ISTA rules [10]. Germination Index (GI) was calculated by taking the germination counts at 5 and 7 days after planting and the data were substituted into the following formulae:

$$GI = \frac{\text{Seedlings germinated on day 5}}{\text{Days of first count}} + \frac{\text{Seedlings germinated on day 7}}{\text{Days of final count}}$$

2.6 Data Analysis

Data on germination percentage were subjected to analysis of variance (ANOVA) using Statistical Analysis Software, SAS Version 9.1[11]. Data on percentages do not conform to normal distribution, the germination data were therefore log transformed before subjecting them to the ANOVA. However, since ANOVA did not detect any significant difference between transformed and untransformed values, untransformed values are hereby presented. Pertinent means were thereafter separated by the use of the least significant difference (LSD) at 0.05 level of probability.

3. RESULTS AND DISCUSSION

3.1 Conditions of the Storage Environments

The mean temperature and relative humidity ranges of the four storage environments used during the study were presented in Table 1. Temperature values under ambient, short, medium and freezer environments ranged from 28.5 to 32.3°C, 15.1 to 20.3°C, -4.1 to 3.1°C and -4 to -2°C respectively while the relative humidity values ranged from 20.2 to 30.1, 26.9 to 50.7, 42.7 to 72.1 and 51.0 to 54.0% respectively (Table 1).

Table 1. Mean temperature (°C) and relative humidity (%) ranges in the four storage environments used during the study

Storage environment	Temperature (°C)	Relative humidity (%)
Ambient	28.5 to 32.3	20.2 to 30.1
Short term	15.1 to 20.3	26.9 to 50.7
Medium	-4.2 to 3.1	42.7 to 72.1
Freezer	-4.0 to -2.0	51.0 to 54.0

3.2 Germination Performance of Sesame Seeds in the Storage Environments across the Periods

Analysis of variance (ANOVA) revealed that effects of accession (ACC) and accession by storage environment (ACC × ENV) interaction were significant (P=.05) while effects of storage environments (ENV), storage periods (STP), storage periods by environments (STP × ENV) and storage periods by accessions (STP × ACC) interactions were highly significant (P<.01) on germination of sesame seeds (Table 2). Similarly, effects of storage environment and storage period by environment interactions were significant (P=.05) while effects of storage period and accession by storage environment (ACC × ENV) interaction were highly significant (P<.01) on emergence index (Table 2). Similar results were reported by Omal et al. [12] where they observed significant effect of varieties, storage environments and periods on germination of wheat seeds.

3.3 Germination Performance of sesame seeds as influenced by Accessions, Storage Environments and Storage Periods

There was differential response of accessions of sesame to germination. Germination percentage of accession NGB 00967 was significantly higher (75.7%) than that of accession NGB 00420 with germination percentage of 70.3% (Table 3). Kumar et al. [13] had similar observation when they observed variation in storage pattern of four different seed coat colors (white, black, dark brown and light yellow) of sesame. This finding also agrees with that of Tame and Elam [14] who reported significant difference in germination of soybean varieties. Effect of storage environments was significant on germination and emergence index of sesame seeds. Seeds stored under ambient conditions had the lowest germination percentage (65%), while seeds stored in freezer had the highest germination percentage (81.2%). The germination percentages of seeds stored under short (73.8%) and medium (72.1%) term conditions were not significantly different (Table 3). Adriana et al. [15] stated that seeds stored in ambient conditions lose their viability and vigour very fast due to changes in storage conditions (temperature and relative humidity). Chauhan and Nautiyal [16] also reported much faster loss of seed viability at room temperature (10-35°C) and retaining of seed viability for more than two years in refrigerator (Storage at 0 to -5°C) in *Nardostachys jatamansi*. However, in this present study, a non-significant difference was observed between the germination percentages of sesame seeds stored in the short and medium term storage chambers could be attributed to the fluctuation in power supply, which could have masked the anticipated differences between the two cold rooms used in this study. Olosunde et al. [17] had earlier arrived at the same conclusion when investigating the influence of storage environments on cowpea varieties under similar conditions. This findings supported the report of Yakubu, 2009 [18] that fluctuation of temperature and relative humidity in tropical countries accelerates rapid multiplication of molds and insects, which facilitate further spoilage of grain. Moreover, germination index for seeds stored under ambient conditions was highest (5.6 days) and significantly higher the than germination index for seeds stored under short term (5.4 days) conditions. The germination index for the seeds stored under medium (5.2 days) and freezer (5.2 days) conditions were not significantly different. This results indicate that seeds stored under medium term and freezer conditions have tendency to germinate faster compared with other environments. The results corroborated with findings of Ravi et al. [19] who reported that high seed germination and minimum time taken for germination were recorded for seeds stored at 0 to -5°C compared with room temperature.

Seed germination of sesame was significantly decreased with increase in storage periods. Germination percentage at ninth month (64.4%) in storage was significantly lower compared to germination percentages at third (77.7%) and sixth (77.0%) month in storage. This result agrees with that of Yilmaz and Aksoy [20] who reported decrease in germination of *Rumex scutatus* with increase in storage period irrespective of storage conditions. Also, Olosunde et al. [17] also concluded that germination percentage of the cowpea seeds decreased with increase in duration of storage. Also, effect of storage period was significant on germination index with lowest number of days (5.0 days) recorded for first period which was third month in storage. The number of days for sixth (5.5 days) and ninth (5.5 days) month in storage were not significantly different (Table 3). This shows that as the storage period increases, germination percentage decreases due to ageing or deterioration and consequently leads to increase in time taken for seed to germinate.

Table 2. Mean squares from the analysis of variance for the germination test and emergence index on sesame seeds at NACGRAB, Ibadan

Source of variation	df	Germination (%)	Emergence index (days)
Rep	2	4.06	0.03
Accession (ACC)	1	522.72*	0.16
Storage Environment (ENV)	3	797.98**	0.65*
Storage Period (STP)	2	1337.38**	1.74**
ACC x ENV	3	303.91*	0.28**
STP x ENV	6	1046.87**	0.33*
STP x ACC	2	411.72**	0.05
ACC x ENV x STP	6	65.80	0.11
Error	46	82.90	0.08
Total	71	251.04	0.18
R^2 (%)		0.79	0.70
CV		12.47	5.40
Mean		73.03	5.31

**, **, Significant at probability level of .05 and .01, respectively*

Table 3. Effect of accession, storage environment and period on seed germination and vigour of sesame seed at NACGRAB, Ibadan

Factors	Seed germination (%)	Emergence Index (days)
A. Accession		
ACC1	70.3b	5.3a
ACC2	75.7a	5.4a
LSD	**4.3**	**0.1**
B. Storage Environment		
ENV1	65.0c	5.6a
ENV2	73.8b	5.4b
ENV3	72.1b	5.2c
ENV4	81.2a	5.2c
LSD	**6.1**	**0.2**
C. Storage Period		
STP1	77.7a	5.0b
STP2	77.0a	5.5a
STP3	64.4b	5.5a
LSD	**5.3**	**0.2**

Means with different letters within the column of the same factor are significantly different at P=0.05
ACC1= NGB00420, ACC2= NGB00967; ENV1=Ambient conditions, ENV2= Short term conditions, ENV3 =Medium term conditions, ENV4 =Freezer conditions; STP1=First storage period, STP2= Second storage period, STP3= Third storage period

3.4 Germination and Vigour Performance of Sesame Seeds as Influenced by the Interaction between Accession and Storage Environments

Germination of sesame accessions varied from one storage environment to another. Accession NGB 00967 had highest germination percentage (87.1%) under freezer storage conditions whereas accession NGB 00420 had highest germination of 77.1% under short term storage conditions (Table 4). Similarly, accession NGB 00420 had maximum mean germination time of 5.7 days under ambient environment whereas accession NGB 00967 had maximum mean germination time of 5.5 days under short term storage environment (Table 4). This findings supported the report of Olosunde et al. [17] where they concluded that germination of cowpea varieties varied from one storage environment to another.

3.5 Germination and Vigour Performance of Sesame Seeds as Influenced by the Interaction between Storage Environments and Periods

Similarly, germination of sesame seeds observed at each quarter varied with storage environment, for instance, at the second quarter, the highest germination percentage (91%) was observed under short (ENV2) conditions (Table 5), but for the third quarter, the highest germination percentage was observed under freezer (ENV4) conditions with value of 86.7% (Table 5). This result also agrees with that of Olosunde [17] where highest germination percentage (94.33%) of cowpea was observed under ambient conditions at first quarter, and highest germination percentage (70.0%) was observed under medium term storage conditions at the third quarter.

Table 4. Effect of interaction between accessions and storage environments on germination and seedling vigour of sesame seeds

Accession (ACC)	Storage Environment (ENV)	Germination (%)	Emergence index (days)
ACC1	ENV1	61.1	5.7
ACC1	ENV2	77.1	5.2
ACC1	ENV3	67.8	5.0
ACC1	ENV4	75.3	5.1
ACC2	ENV1	68.9	5.4
ACC2	ENV2	70.4	5.5
ACC2	ENV3	76.4	5.3
ACC2	ENV4	87.1	5.2
LSD		**14.2**	**0.4**

ACC1= NGB00420, ACC2= NGB00967; ENV1=Ambient conditions, ENV2= Short term conditions, ENV3 =Medium term conditions, ENV4 =Freezer conditions

Table 5. Effect of interaction between storage environments and periods on germination and seedling vigour of sesame seeds

Storage environment (ENV)	Storage period (STP)	Germination (%)	Emergence index (days)
ENV1	STP1	76.7	5.0
ENV1	STP2	84.3	5.9
ENV1	STP3	63.0	5.8
ENV2	STP1	78.0	5.0
ENV2	STP2	91.0	5.3
ENV2	STP3	52.3	5.8
ENV3	STP1	76.3	5.0
ENV3	STP2	55.3	5.3
ENV3	STP3	55.7	5.2
ENV4	STP1	79.7	5.0
ENV4	STP2	77.3	5.3
ENV4	STP3	86.7	5.1
LSD		**12.2**	**0.4**

ENV1=Ambient conditions, ENV2= Short term conditions, ENV3 =Medium term conditions, ENV4 = Freezer conditions; STP1=First storage period, STP2= Second storage period, STP3= Third storage period

Table 6. Effect of interaction between accessions and periods on germination and seedling vigour of sesame seeds

Accession (ACC)	Storage period (STP)	Germination (%)	Emergence index (days)
ACC1	STP1	79.7	5.0
ACC1	STP2	71.1	5.4
ACC1	STP3	60.2	5.4
ACC2	STP1	75.7	5.0
ACC2	STP2	82.8	5.5
ACC2	STP3	68.7	5.6
LSD		**12.0**	**0.3**

ACC1= NGB00420, ACC2= NGB00967; STP1=First storage period, STP2= Second storage period, STP3= Third storage period

3.6 Germination and Vigour Performance of Sesame seeds as Influenced by the Interaction between Accession and Storage Periods

The significant effect of accession by storage environment interaction (ACC × ENV) implies that germination of accession sesame seeds varied from one storage period to another. Acession NGB00967 had highest germination percentage of 82.8% at the second storage period whereas accession NGB00420 had its highest germination percentage (79.7%) observed at the first storage period (Table 6). Moreover, germination percentage of accession NGB00420 at the third storage period was significantly lower (68.7%) than that of the first (79.7%) and second (71.1%) storage periods (Table 6). Similarly, germination percentage of accession NGB00967 at the third storage period was significantly lower (60.2%) than that of the first (75.7%) and second (82.8%) storage periods (Table 6).This implies that at early stage of storage of sesame seeds, the extent of deterioration may not severe however as the duration in storage prolongs the impact of deterioration becomes severe. This suggests that viability tests of should be carried on sesame seeds as the storage prolongs especially after six months in cold environments so as th ascertain the viability status. Nevertheless, results corroborated with the report of Omar et al. [12] where they reported highly significant interaction storage periods and cultivars in wheat germination.

4. CONCLUSION

The storage conditions highly influenced the seed germination percentage of *Sesamum indicum* which declines with increase storage duration irrespective of storage environments. The extent of deterioration was significant as the storage duration increased beyond six months. The study concludes that freezer compartment at -4 to -2°C temperature was the best storage environment and could retain germination and vigour of sesame seeds for a longer period than other storage environments. The study further showed that storage sesame seeds inside the freezer compartment with a minimum of 10 hours power supply can at least retain seed viability (>85%) up to nine months in storage. However, the medium term (-4.2 to 3.1°C) or short-term (15.1 to 20.3°C) conditions can at least retain seed viability (>85%) up to six months in storage. Furthermore, the seeds must be stored in moisture-prove packaging materials.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Mochizuki M, Tsuchie Y, Yamada N, Miyake Y, Osawa T. Effect of sesame lignans on TNF-alpha-induced expression of adhesion molecules in endothelial cells. Biosci Biotechnicol Biochem. 2011;74: 1539-1544.
2. Jan KC, Chu YH, Hwang LS. Intestinal distribution and excretion of Sesaminol andits tetrahydrofuranoid metabolites in rats. J. Agric Food Chem. 2011;59:3078-3086.
3. Onyekwelua JC, Fayose OJ. Effect of storage methods on the germination and proximate composition of *Treculia africana* seeds; in Proceedings of the International Conference on Agricultural Research for Development, University of Kassel-Witzenhausen and University of Göttingen, Tropentag; 2007.

4. Association of Official Seed Analysts. Rules for testing seeds. AOSA, Ithaca, NY; 2009.
5. Pradhan BK, Badola HK. Seed germination response of populations of *Swertia chirayita* following periodical storage. Seed Technology. 2008;30(1):63–69.
6. ISTA (International Seed Testing Association). International rules for seed testing. Seed Science Technology. 1993; 21(Suppl.).
7. Ghahfarokhi MG, Ghasemi E, Saeidi M, Kazafi ZH. The effect of accelerated aging on germination characteristics, Seed reserve utilization and malondialdehyde content of two wheat cultivars. J. of Stress. Physiol. and Biochem. 2014;10(2): 15-23.
8. Oyekale KO, Nwangburuka CC, Denton OA, Daramola DS, Adeyeye JA, Akinkuotu AO. Comparative effects of organic and inorganic seed treatments on the viability and vigour of sesame seeds in storage. Journal of Agricultural science (JAS). 2012;4(9):187-195.
9. Suma A, Sreenivasan K, Singh AK, Radhamani J. Role of relative humidity in processing and storage of seeds and assessment of variability in storage behaviour in *Brassica* spp. and Eruca sativa. The Sci. World. J. 2013;9.
10. ISTA (International Seed Testing Association). International rules for seed testing. Seed Science Technology 21 (Suppl.). 1999;27-32.
11. SAS/STAT User's Guide version 6, 4th edition. SAS Institute, Cary, North Carolina; 1990.
12. Omar AM, Sorour FA, El-Sayed SA, Nagwa ES. Effect of storage periods, cultivars, environments and package materials on germination, viability and seedling vigor of wheat grains. J. Plant Production, Mansoura Univ. 2012;3(6): 1075–1087.
13. Prashant KM, Seema P, Ravi PM. Assessment of storage dependent physiological parameters of *Sesamum indicum* seeds. Int. J. Curr. Microbiol. App. Sci. 2016;5(1):641-653.
14. Tame VT, Elam Y. Effect of storage materials and environmental conditions on germination of percentage of soybean (*Glycine max* (L) Merr) seeds, Yola, Nigeria; 2015.
15. Adriana L, Tassi W, Santos JF, Panizzi RD. Seed-born pathogens and electrical conductivity of soyabean seeds. Sci. Agric. 2012;69:19-25.
16. Chauhan RS, Nautiyal MC. Seed germination and seed storage behaviour of *Nardostachys jatamansi* DC, an endangered medicinal herb of high-altitude Himalaya. 2007;92(11):1620–1624.
17. Olosunde AA, Coker DO, Ajiboye TO, Ojo AO. Effect of Storage Environments and Duration on Germination of Cowpea (*Vigna unguiculata* (L.) Walp) Seeds. Ife Journal of Agriculture. 2017;29(2):10-17.
18. Yakubu A. Non-chemical on-farm hermetic maize storage in East Africa. A Master of Science thesis. Iowa State University Ames, Iowa; 2009.
19. Ravi B, Meenu S, Usha T. Effect of storage temperature and period on seed germination of *Rheum australe* D Don: An endangered medicinal herb of high altitude Himalaya. International Journal of Farm Sciences. 2014;4(2):139-147.
20. Yilmaz DD, Aksoy A. Physiological effects of different environmental conditions on the seed germination of *Rumex scutatus* L (Polygonaceae). Erciyes Üniversitesi Fen Bilimleri Enstitüsü Dergisi. 2007; 23(1-2):24-29.

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