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Storage life of African yam bean (*Sphenostylis stenocarpa,* Hochst. ex. a Rich) seeds as affected by storage containers

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Abstract

Seed longevity of crop can be affected by storage devices and there is a knowledge gap in this aspect for African Yam Bean (AYB). An experiment was conducted to determine the storage life of African Yam Bean (*Sphenostylis stenocarpa*) seeds stored under different storage containers at the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria in 2014 using Completely Randomized Design in three replications in the laboratory. The effect of six storage containers (glass bottles, plastic bottles, earthen pot, polyethylene bag, galvanized tin and paper envelope (control) was determined on seed physiological quality and longevity of 10 AYB genotypes stored for 12 months under ambient conditions (30.0°C, 75.23% Relative Humidity). Data collected were subjected to analysis of variance. Mean separation was carried out by Duncan's Multiple Range Test and PROBIT analysis of seed longevity data. On storability performance, seed viability was high in all storage containers except paper envelope. The AYB seeds stored for up to ten months under ambient conditions inside air-tight plastic bottle containers and retained viability of 75 %. Seed of the genotypes TSs86, TSs50, TSs331, TSs83 and TSs311 seeds were superior in storability in all storage containers except paper envelope. The PROBIT modelling estimated significantly **($p<0.05$)** higher storage life of 20 months in seeds of TSs48, TSs83, TSs209, TSs331, TSs349 and TSs370 stored in plastic and polyethylene containers.

Keywords: Storage life, physiological quality, probit modelling, storability and seedling vigour index

Introduction

African yam bean (*Sphenostylis stenocarpa*) Hochst ex. A Rich, family leguminosae, sub-family papilionacaea, is one of the most valuable legumes in the family Fabaceae. Storage of seed has continued to pose a major threat to seed men in humid tropical regions where ambient temperature and relative humidity could be more than 33°C and 75°C, respectively. Under such conditions, it is difficult to dry seed moisture levels below 12 %. Seed may be stored in cold rooms to prolong their lifespan, but this may add extra cost to seed production (Oyekale, 2010). Seeds are stored for few days, weeks, months or year during which it deteriorates, moving inexorably towards death (Grey *et al*., 1994).

Seeds stored in humid and warm environments tend to absorb moisture from surroundings, leading to increased seed moisture content until equilibrium is established. As seed moisture increases, the rate of deterioration increases (Roberts, 1972), and high temperature plus high relative humidity makes seed storage much more difficult. Serious famines can occur in locations where little or no seeds are stored under favourable conditions of temperature and humidity (Harrington, 1972). Oyekale (2010) reported that one of the major factors influencing seed longevity is seed moisture content. Along with improved methods of testing has come the necessity for proper storage facilities so as to maintain viability and vigour.

There are different ways of maintaining the viability and vigour of seeds. The cheapest, easiest and commonest way is by storing seeds (Harrington, 1970; Bonner, 1990). Maximizing the longevity of seeds requires a good seed store and knowledge of the principles of seed preservation (Ng, 1996). Grain must be protected from weather, insects and growth of micro- organisms to maintain high grain quality during storage.

However, monitoring viability of seeds under storage is important. Appert (1987) observed that the storage of large quantities of seed such as rice, groundnut and soybean for relatively long periods of time under different often precarious conditions is no easy matter, since many factors of deterioration are responsible for losses which are important to be kept at a minimum.

Seed storage environment cannot thus be isolated from initial quality of seed; for both interact to determine the trend of seed testing or quality parameters and subsequent use of the seed lot (Powell and Matthews, 1985).

Maintaining seed germplasm in cold storage is still problematic even for many gene banks in the developing countries. Lack of proper refrigeration equipment, unreliable electricity supply, poor maintenance practices and high operating costs are some of the key constraints (Abdul-Rafiu, 2015). Many farmers and gene banks, especially those in developing countries, lack the resources and facilities to carry out their tasks effectively. A simple and adoptable method of seed storage, which involves the maintenance of very dry seeds under ambient or partly cooled conditions, may provide a cost-effective alternative for such resources-constrained farmers and gene banks. The proper drying of seeds is essential to ensure longevity and healthy plants. Moisture also encourages mould, diseases and fungal infections which might be passed on to the next generation of plants if seeds are not dried sufficiently. Control measures to prevent infestation and post-harvest losses include the control of environmental factors such as temperature, moisture, relative humidity among others and treatment with insecticides (Kossou and Bosque-Perez, 1998). Seed treatment cannot improve the seed quality but can only protect and preserve them from infestation and damage by pest. Hence, seed meant for storage should be of good physical and genetic quality (Abdul-Rafiu, 2007).

The longevity of seeds in storage is a good indicator of seed quality (germination) and vigour in many crops (Ellis and Roberts, 1980). In the humid tropical countries, the high relative humidity of the storage environment leads to an increase in moisture content which in combination with high ambient temperature results in rapid deterioration leading to decline in seed vigour and ultimate loss of viability. Poor storage conditions have been reported to cause 10% loss in seed quality in the tropics (Genchev, 1995).

However, between seed harvest and planting of the succeeding crop, there is always an interval of few months (depending on the cropping system and on the kind of seed) during which seed must be stored. During this interval, the physiological quality of the seed must be maintained by minimizing the rate of seed deterioration.

Roberts (1983) has developed probit analysis method to quantify the initial quality of seed lots. Seed longevity has been described as a function of temperature, seed moisture content and storage (Harington, 1972; Roberts, 1983), genetic constitution and pest and pathogen damages in storage (Kulik, 1995; Abdul-Rafiu, 2007).

A primary objective of the AYB seed production program is to provide farmers with seeds of high physiological quality which guarantee the establishment of a uniform stand of healthy seedlings even under less favorable field conditions and to store the seeds in affordable storage materials for the use of local farmers and at the same time maintain quality. On the other hand, Claassen (1995) reported that proper storage slows down deterioration in all seed species, preserving the viability and vigour of seed and protecting farmer's investment, profit and reputation. Available genetic resources of AYB for research materials are the few accessions/landraces in the hands of market women and rural farmers.

However, such genetic materials lack sufficient information on influence of storage containers on physiological quality attributes of AYB seeds grown in Nigeria. Except for the International Institute of Tropical Agriculture (IITA), Ibadan, where some accessions of the crop are kept under normal cooling conditions, the conservation/storage of such crop is very poor in Nigeria (Adewale, 2011). However, there is lack of information on the best storage container for storing such genetic materials under ambient humid tropical conditions in Nigeria. It is known that AYB genotypes differ in respect of degree of seed quality loss during storage (Alegiledoye, 2016). The storage environments of agricultural seeds are key factors that determine the physiological and longevity of the seeds. This study is, therefore, necessary to overcome the above challenges, such that genotypes of high seed yield with superior seed quality and high potential longevity are guaranteed for the farmers and for seeds are going to be stored or put into immediate use. This is particularly important for seeds of AYB. The objective of the study, therefore, is to estimate seed storage life of AYB genotypes stored under ambient conditions using PROBIT modelling.

Materials and Methods

Clean seeds of 10 AYB genotypes TSs42, TSs48, TSs50, TSs83, TSs86, TSs209, TSs311, TSs331, TSs349 and TSs370 harvested in 2013 cropping year were selected for this experiment based on their high seed yield performance and potential seed quality (germination and seedling vigour level) and the moisture content of the seed lots determined following procedures (ISTA, 1985). Briefly, 2g (initial weight) of seeds of each genotype was weighed out into a crucible and placed in the oven at 103°C for 17 hours after which the samples were brought out and allowed to cool in a dessicator (for 5 minutes). The samples were then reweighed (final weight) to determine the per cent MC of the seeds. The MC was then computed thus;

$$\text{M.C. (\%)} = \frac{\text{Initial weight of the seed} - \text{final weight of seed samples}}{\text{Initial weight of seed samples}} \times 100$$

Six storage containers commonly used by local farmers in southwestern Nigeria; galvanized iron tin, plastic bottles, glass bottles, polyethylene bag, earthen pot and paper envelopes as control, were used as storage containers. Two hundred gramme seeds from each genotype were placed in each storage containers with temperature of 30.1°C and relative humidity 75 % for a period of 360 days. Seed samples were taken from each storage container and control for seed quality evaluation at 120-day interval.

The experiment was a factorial in completely randomized design with three replicates. Two factors were examined (10 AYB genotypes and six storage containers). Seed samples were drawn from each experimental unit at 0, 120, 240, and 360 days and evaluated for the following seed quality traits:

Seed viability

From each treatment, 100 seeds were placed on three moist towels inside 11 cm diameter petri dishes, and kept in an incubator at a temperature of 25°C. Germination count was taken on the nineth day after sowing using the Bekendem and Grob (1979) procedures. Germination was taken as clear emergence of seedlings.

$$\text{Seed viability (\%)} = \frac{\text{Number of viable seeds}}{\text{Number of seeds tested}} \times 100$$

Seedling vigour index:

Seedling vigour levels of each genotype was calculated by multiplying percent normal germination by the average of plumule length of each genotype after nine days of germination (Kim *et al*., 1994) and divided by 100 (Adebisi, 2004).

Seed storage life (seed longevity):

Mean percentage value of seed viability data were used to estimate seed longevity (storage life of the stored seed (Roberts, 1973; Daniel, 2007; Adebisi *et al.,* 2008)

Data Analysis

Analysis of variance was used to determine significant differences for each and between experimental factors. Means of the treatment were separated statistically using Tukey's HSD at 5% probability test. Data on seed viability were subjected to PROBIT modeling according to Robert (1973) to predict the storage life of the seeds. The PROBIT analysis of mean percentage seed viability (longevity) was done with SAS™ PROC PROBIT statements that first sorted the data by genotype and storage container. Seed longevity parameters were estimated from the procedure based on seed viability test data point for each container. Estimates of intercept (time = 0) of the seed survival line, slope i.e. rate of seed deterioration ($^1/\sigma$) and time taken for seed aging to decline to 50% viability (P_{50}) were estimated by the PROBIT procedure for each seed lots. Seed storage life was estimated as half-life (P_{50}) value multiplied by 2 then divided by the 30 days of a month.

Results and Discussion

Results

Table 1 shows the summary of analysis of variance (ANOVA) of the PROBIT parameters evaluated in 10 AYB genotypes stored in different storage containers. From the result, the genotype effect, container effect and genotype x container interaction were found to be highly significant for intercept (K_i) which is the PROBIT value of the initial seed viability, sigma (α) which is the standard deviation of seed death in time during storage, slope ($^1/_\alpha$) which is the rate of seed deterioration, (P_{50}) which is the seed half-life and seed storage life.

The PROBIT parameters and seed storage life evaluated in 10 AYB genotypes stored for 12 months across storage containers are presented in Table 2. Highest value of the intercept was observed in TSs370 with 1.84 × 10^{-3} followed by TSs209 with 1.68 × 10^{-3} whereas TSs331 and TSs349 had highest values of 245.20 and 234.30 followed by TSs331, TSs42, TSs83, TSs50, TSs86 with values of 217.20, 211.30, 208.70 and 201.50 respectively whereas TSs311, TSs209 and TSs370 gave the lowest sigma values of 188.70, 188.10 and 173.60, respectively. However, in terms of slope, TSs370 had highest value of slope of 6.31 × 10^{-3}, followed by TSs209 with 5.78 × 10^{-3} while TSs349 recorded the lowest slope of 4.58 × 10^{-3}. The data further reveal that TSs48 recorded highest seed half-life of 10.05 followed by TSs349 with seed half-life of 9.94. However, TSs331 gave the least seed half-life of 9.37. The estimate of seed storage life was highest in TSs48 with (20.10 months) though was not statistically different from value obtained in TSs349 (19.88 months) whereas TSs331 still recorded the lowest storage life of 18.75 months which shows the estimates of time taken for viability to fall to 50 %.

Figure 1 presents the PROBIT parameters and storage life evaluated across AYB genotypes seed stored in six different storage containers. The data show that the values of the intercept was significantly highest in seeds stored inside glass bottle plastic bottle, polyethylene bag, earthen pot and galvanized iron tin with values of between 1.52 × 10^{-3} and 1.68 × 10^{-3} compared to paper envelope container with 1.13×10^{-3}. However, sigma which is the standard deviation of seed death in time during storage was highest in paper envelope with 235.80, followed by polyethylene bag, earthen pot and galvanized tin with 214.40, 209.70 and 208.10, respectively while glass and plastic bottles showed the lowest sigma with 182.80 and 197.10, respectively. The highest values of slope in seeds stored in glass, plastic, polyethylene bag, earthen pot and galvanized iron tin were highest with values of 5.85 × 10^{-3}, 5.52 × 10^{-3}, 5.44 × 10^{-3}, 5.12 × $10^{-3}$and 5.21 × 10^{-3}, respectively. Lowest value of slope was, however, observed in seeds stored in paper envelope with 4.39 × 10^{-3}. Highest extended seed half-life was exhibited by seeds stored in plastic bottle and polyethylene bags with 10.15 months (10 months and 5 days) and 10.12 months (10 months and 4 days), followed by 9.96 months (9 months, 29 days) in earthen pot and 9.87 months (9 months and 26 days) in galvanized iron tin. However, the lowest seed half-life of 8.52 months (8 months and 16 days) was recorded in paper envelope. Highest storage life values were recorded in seeds stored inside plastic bottle and polyethylene bags with 20.31months (20 months and 9 days) and 20.24 months (20 months and 7 days), respectively, followed by 19.92 months (19 months and 28 days) and 19.74 months (19 months and 22 days) observed in earthen pot and galvanized tin, respectively. Conversely, the lowest storage life value of seed was observed in seed stored in paper envelope with 17.04 months (17 months and 1 day).

The initial seed viability values (represented by the intercept) of 10 AYB seeds stored for 12 months in six different storage containers are presented in Table 3. In the glass bottle, seeds of TSs209 had the highest intercept of 2.15×10^{-3}, closely followed by seeds of TSs370 with intercept of 2.13×10^{-3} whereas TSs50 had the least intercept values of 1.30×10^{-3}. Also, under the paper envelope container, seeds of TSs50, TSs209, TSs 331 and TSs370 recorded the highest values of intercept of between 1.18×10^{-3} and 1.25×10^{-3}, followed by TSs86, TSs83, TSs48, TSs311 and TSs349 with values of between $1.05 \times 10^{-3}$and 1.17×10^{-3} while TSs42 gave the lowest intercept value of 0.94×10^{-3}. The value of intercept in plastic bottle was highest with seeds of TSs370 with 2.14 $\times 10^{-3}$ and this was not significantly different from values obtained in TSs311 (1.96×10^{-3}) and TSs83 (1.71×10^{-3}) while the lowest value of intercept was obtained in TSs48 with 1.51×10^{-3}. In seeds stored in earthen pot container, intercept value was highest in TSs370 with 1.91×10^{-3}, though was not statistically different from 1.72 $\times 10^{-3}$ recorded in TSs311 whereas seeds of TSs42 showed the least intercept of 1.30×10^{-3}. Significant highest value of intercept in polyethylene bag container was observed in seeds of TSs86 with 2.19×10^{-3} whereas the least value was recorded in TSs349 and TSs331 with 1.17×10^{-3} and 1.20×10^{-3}, respectively. The value of intercept in seeds stored in galvanized tin container was highest in TSs209 with 1.95×10^{-3} followed by TSs370, TSs311, TSs42 and TSs50 with values of between 1.62×10^{-3} and 1.82×10^{-3} while the least of 0.98×10^{-3} was recorded in TSs331.

Table 4 presents the PROBIT sigma value of seeds of AYB stored for 12 months in six different storage containers. Seeds stored in glass bottles had highest value of sigma (standard deviation) in TSs42 with 235.00, followed by 221.70 in TSs 50 whereas the least sigma value was obtained in TSs370 with 139.20. Seeds stored in paper envelope showed the highest value in TSs370, TSs48 and TSs42 with 265.70, 265.30 and 263.20, respectively followed by TSs349 and TSs311 with values of 237.00 and 233.70, respectively, while the lowest values were observed in TSs86, TSs83 and TSs50 with 221.30, 219.50 and 214.40, respectively. Seeds stored in plastic bottle container had the highest sigma values in TSs349 (256.20) and TSs48 (253.30) while the lowest value was exhibited by TSs370 (143.50). However, seeds stored in earthen pot container showed highest value in TSs86 (281.90), followed by TSs349 with 249.90 whereas TSs370 showed the least value of 147.90. The sigma value in seeds stored in polyethylene bag showed that TSs48 had the highest of 317.20 though was not statistically different from TSs86, TSs370, TSs42, TSs83, TSs50, TSs311, TSs209, TSs331, and TSs349 with values between 134.30 and 287.60. Furthermore, seeds stored in galvanized iron tin container recorded highest value in TSs83 with 276.90, though not significantly different from 262.70 shown by TSs331 while TSs209, TSs370, TSs50 and TSs311 exhibited the least values of between 162.50 and 188.10.

Data on rate of seed deterioration as determined by PROBIT slope in seeds of AYB genotypes stored for 12 months in six different storage containers are presented in Table 5. The highest values of slope in seeds stored in glass bottle was recorded in TSs370 and TSs209 with 7.37×10^{-3} and 7.33×10^{-3}, though not significantly different from all the other genotypes except TSs42 which recorded the lowest slope of 4.30×10^{-3}. Also, the highest value of slope in seeds stored in paper envelope container was observed in TSs209 with 5.10×10^{-3} while TSs42 had the lowest (4.30×10^{-3}). However, highest slope under plastic bottle was exhibited by seeds of TSs370 with 7.10 $\times 10^{-3}$ followed by TSs311 (6.47×10^{-3}) whereas TSs349 gave lowest value of (3.97×10^{-3}). Similarly, highest slope value under earthen pot container was observed in seeds of TSs370 (6.93×10^{-3}), which was not statistically different from TSs311 (5.97×10^{-3}) while TSs86 showed lowest value (4.17×10^{-3}). For seeds stored in polyethylene bag, the slope value was highest in TSs86 (7.67×10^{-3}) and this was followed by TSs48 (6.90×10^{-3}) while TSs349 showed the lowest slope (3.57×10^{-3}). The highest values of slope of seeds stored in galvanized iron tin were observed in TSs209 (6.50×10^{-3}) and TSs370 (6.23×10^{-3}) while TSs83 gave the least slope (3.77×10^{-3}). A cursory look at the data shows that seeds stored in paper envelope (control) had highest values of slope compared to other storage containers.

Table 6 shows the PROBIT half-life of seeds of 10 AYB stored for 12 months in six different storage containers. Highest seed half- life was exhibited by seeds stored under glass bottle with TSs42 (10.53 months), followed by TSs83, TSs349, TSs86 and TSs209 with values of between 9.88 and 9.98 months whereas TSs311 had a half- life of 8.78 months. Seed of TSs370 stored in paper envelope was identified with highest value of 9.60, followed by TSs48 (9.25 months) and TSs331 (9.17 months) but the lowest was observed in TSs83 (7.74 months). However, with plastic bottle storage container, TSs209, TSs48, TSs83, TSs349 and TSs331 had highest values of 10.78, 10.71, 10.60, 10.51 and 10.49 months, respectively though not significantly different from values obtained in TSs311, TSs370, TSs50 and TSs86 whereas seed of TSs42 had the least half- life of 9.05 months. Furthermore, seeds stored in earthen pot had significantly highest half- life in TSs48 (11.39 months) but lowest in TSs48 (8.95 months). Similarly, highest seed half- life in polyethylene bag was observed in TSs349, TSs48 and TSs50 with 10.97, 10.67 and 10.62 months, which were not significantly different from 10.45 months obtained in TSs83 while TSs331 recorded the least seed half- life of 9.20 months. Seeds stored in galvanized tin had the highest values in TSs42 and TSs311 with 10.86 and 10.79 months, respectively whereas the lowest value was observed in TSs331 with 8.57 months. A cursory look into the data shows that the lowest seed half- life was recorded in seeds stored in paper envelope while four genotypes (TSs48, TSs83, TSs349 and TSs370) had highest seed half-life when stored in most of the storage containers investigated.

The values of seed storage life of 10 AYB genotypes stored for 12 months in six different storage containers are shown in Table 7. The estimate of seed storage life under glass bottle was highest in TSs42 with 21.07 (21 months and 2 days) which was not significantly different from values obtained in TSs83, TSs349 and TSs86 (19.96 (19 months 29 days) and 19.76 (19 months 23 days) whereas the least value was obtained in TSs311 with 17.55 (17 months 17 days). In addition, seed storage life in paper envelope was highest in TSs370 with 19.21 (19 months and 6 days) which was not significantly different from values recorded in TSs48 with 18.50 months (18 months and 15 days) and TSs331 with 18.35 (18 months and 11 days) while TSs83 had the lowest seed storage life of 15.49 months (15months and 15 days). Also, seed storage life under the plastic bottle was highest in TSs209, TSs48 and TSs83 with values of between 21.56 months (21 months and 17 days) and 21.20 months (20 months and 6 days), respectively followed by TSs349 with 21.03 months (21 months and 1 day) and TSs331 with 21.98 months (20 months and 29 days) while TSs42 recorded the least value (18.10 months (18 months and 3 days). Seed storage life in earthen pot was significantly highest in TSs48 (22.76 months (22 months and 23 days) but lowest in TSs42 (17.90 months (17 months and 27days). However, under polyethylene bag, three genotypes (TSs349, TSs48 and TSs50) had highest values of between 21.23 months (21 months and 7 days) and 21.94 months (21 months and 28 days) but was not significantly different from 20.89 months (20 months and 27days) obtained in TSs83 while TSs331 recorded the lowest (18.40 months (18 months and 12 days). However, seed storage life in galvanized iron tin was highest in TSs42 (21.73 (21 months and 22 days) which was not significantly different from TSs311 (21.57 months (21 months and 17 days) whereas TSs331 gave least value of 17 14 months (17 months and 4 days).

Discussion

The result of the PROBIT analysis of seed longevity of 10 AYB genotypes seeds stored in different storage containers showed differences in estimates of intercepts and slopes, revealing significant reduction in longevity of AYB, irrespective of genotypes and storage period observed. Findings on variety and seed lot differences in potential seed longevity among varieties of different species were reported by Adebisi *et al*. (2008), Adebisi *et al*. (2012), Adebisi (2012). This observation may not connect or signify superiority in seed longevity among the varieties since seed intercept character is a seed lot parameter as reported by Ellis and Roberts (1980) but confirmed that seed deterioration rate and eventual seed storage life are dependent on the initial viability of seed put into storage.

Adebisi *et al*. (2008) have reported in their work that the higher the quality of a seed put into storage, the longer the expected seed storage life. In this study, genotype TSs48 stored under ambient conditions recorded significant longest storage life than other seeds. Storage life of seeds had been predicted using PROBIT modeling under various environmental conditions. (Daniel and Ajala, 2004; Demir *et al.,* 2009; Adebisi *et al*., 2012 and Abdul-Rafiu, 2015). In this study, the PROBIT parameters of seed of African yam bean genotypes under different storage containers revealed differences in the value of estimates observed under the six storage container for the slope and intercept. This shows that the initial viability of the seed lot and the rates of seed deterioration under the different storage containers among the genotypes were not constant.

The result of the PROBIT modeling in this study reveals that six genotypes (TSs48, TSs83, TSs209, TSs311, TSs349 and TSs370) gave half- life of above 10 months and storage life of above 20 months in plastic bottles and polyethylene bags. This result was in agreement with the works of Adebisi, (2012) in okra, Daniel, (2007) in maize and Abdul-Rafiu, (2015) in cayenne pepper stored under ambient conditions.

PROBIT modeling had been widely used in the evaluation of seed quality such as potential seed longevity and seed deterioration (Daniel *et al.,* 1999, Tang *et al.*, 1999) and predicting seed viability in storage under constant conditions for different species under different storage environments (Daniel *et al*., 2003, Daniel and Ajala, 2004 and Oyekale, 2010). Observations made on AYB seed genotypes stored in different storage containers indicated progressive seed deterioration and systematic decline in seed longevity over the periods of storage. Seed deterioration is a physical mechanism (Parish and Leopold, 1978) aggravated by the adverse storage conditions which are attributes of warm and humid conditions of unconditioned tropical stores.

Conclusion

In order to maintain maximum physiological quality in AYB seeds under ambient storage conditions, the storage period should not exceed eight months as seed viability and seedling vigour index progressively decline with length of storage. When seeds of AYB are to be stored, either of plastic bottle, earthen pot, glass bottle or galvanized tin containers could be used for maintenance of superior seed quality. Genotypes TSs370, TSs209, TSs311, TSs86 and TSs50 were identified with relatively higher seed viability and seedling vigour index across the storage containers. The result of the Probit modelling in this study reveals that seeds of six genotypes (TSs48, TSs83, TSs209, TSs311, TSs349 and TSs370) had half- life of above 10 months and storage life of above 20 months when stored in plastic bottles and polythene bag containers.

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Conflict of Interests

None

Tables, Figures and Charts

Table 1**:** Analysis of variance of the PROBIT parameters evaluated in seeds of ten of AYB genotypes stored in six different storage containers

Source of variation	Df	Intercept	Sigma	Slope (x 10^{-6})	Mu P_{50}	Storage life
Rep	2	4.73	77624.00	54.45	12.10	48.39
Genotype (G)	9	0.46**	8357.00**	4.98**	0.72**	2.88**
Container (C)	5	1.19**	9422.00**	7.28**	11.21**	44.85**
G x C	45	0.14**	3482.00*	2.09**	1.28**	5.10**
Error	118	0.06	2272.00	1.00	0.19	0.738

** Highly significant at1 % probability level***,** Significant at 5 % probability level Intercept- is the PROBIT estimate of initial seed viability. P_{50} – is the seed half- life (estimate of time taken for viability to fall to 50 %
Slope – is the rate of seed deterioration. Seed storage life-estimate of time taken for viability to fall to 0 %
Sigma: standard deviation of seed death in time during storage G-genotypes, C-container.

Table 2**:** PROBIT parameters and storage life evaluated in seeds of ten genotypes of AYB stored for 12 months across storage containers

Genotypes	Intercept	Sigma	Slope (x 10^{-3})	Mu P_{50}	Storage life (months)
TSs42	1.42^{bc}	211.30^{ab}	5.02^{bc}	9.50^{bc}	19.01^{bc}
TSs48	1.40^{bc}	245.20^{a}	5.11^{bc}	10.05^{a}	20.10^{a}
TSs50	1.43^{bc}	208.70^{ab}	4.87^{bc}	9.68^{abc}	19.36^{abc}
TSs83	1.49^{bc}	211.30^{ab}	5.08^{bc}	9.74^{abc}	19.50^{abc}
TSs86	1.58^{abc}	201.50^{ab}	5.52^{abc}	9.59^{abc}	19.18^{abc}
TSs209	1.68^{ab}	188.10^{b}	5.78^{ab}	9.80^{abc}	19.60^{abc}
TSs311	1.63^{abc}	188.70^{b}	5.63^{abc}	9.64^{abc}	19.29^{abc}
TSs331	1.35^{c}	217.20^{ab}	4.81^{bc}	9.37^{c}	18.75^{c}
TSs349	1.36^{c}	234.30^{a}	4.58^{c}	9.94^{ab}	19.88^{ab}
TSs370	1.84^{a}	173.60^{b}	6.31^{a}	9.79^{abc}	19.58^{abc}

Means followed by the same letter along the column are not significantly different from one another according to DMRT at 5 % probability level. Intercept- is the PROBIT estimate of initial seed viability. P_{50} – is the seed half- life (estimate of time taken for viability to fall to 50 % Slope – is the rate of seed deterioration. Seed storage life-estimate of time taken for viability to fall to 0 % Sigma: standard deviation of seed death in time during storage.

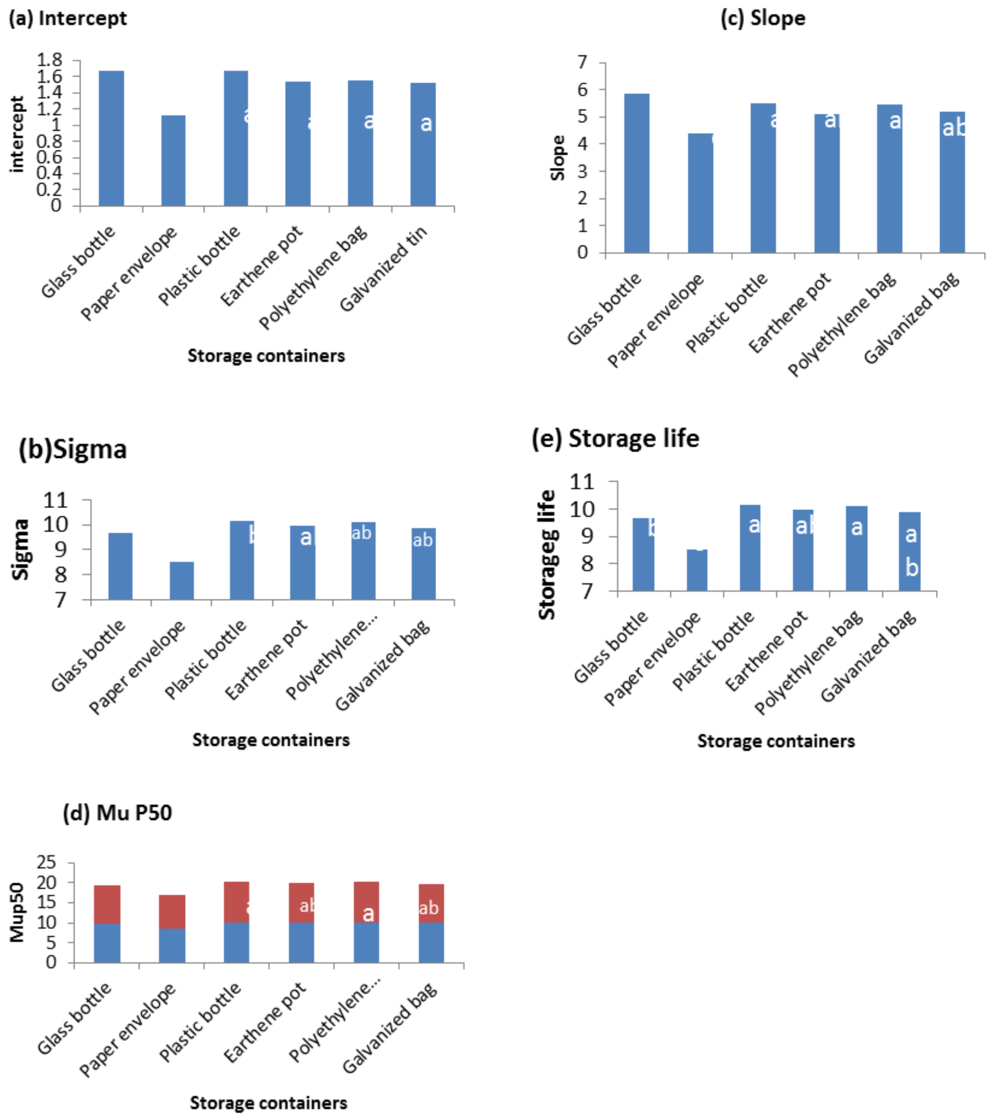

Figure 1: PROBIT parameters and storage life of seed evaluated across AYB genotypes stored in six different storage containers

Table 3**:** PROBIT Intercept values of seeds of AYB genotypes stored for 12 months in six different storage containers

Genotypes	Intercept ($\times10^{-3}$)					
	Glass bottle	Paper envelope	Plastic bottle	Earthen pot	Polyethylene bag	Galvanized iron tin
TSs42	1.36^{bc}	0.94^{c}	1.60^{bc}	1.30^{c}	1.72^{bc}	1.63^{ab}
TSs48	1.40^{abc}	1.11^{ab}	1.51^{c}	1.62^{abc}	1.39^{cd}	1.36^{bcd}
TSs50	1.30^{c}	1.18^{a}	1.44^{cd}	1.42^{bc}	1.64^{bc}	1.62^{ab}
TSs83	1.70^{abc}	1.13^{ab}	1.71^{ab}	1.58^{abc}	1.66^{bc}	1.13^{cd}
TSs86	1.65^{abc}	1.17^{ab}	1.62^{bc}	1.35^{bc}	2.19^{a}	1.51^{abcd}
TSs209	2.15^{a}	1.25^{a}	1.82^{b}	1.57^{abc}	1.33^{cd}	1.95^{a}
TSs311	1.75^{abc}	1.10^{ab}	1.96^{ab}	1.72^{ab}	1.51^{bcd}	1.74^{ab}
TSs331	1.55^{abc}	1.23^{a}	1.59^{bc}	1.55^{abc}	1.20^{d}	0.98^{d}
TSs349	1.82^{abc}	1.05^{ab}	1.25^{cd}	1.37^{bc}	1.17^{d}	1.49^{abc}
TSs370	2.13^{ab}	1.20^{a}	2.14^{a}	1.91^{a}	1.82^{b}	1.83^{ab}

Means followed by the same letter along the column are not significantly different from one another according to DMRT at 5 % probability level
Intercept- is the PROBIT estimate of initial seed viability.

Table 4**:** PROBIT sigma value of seeds of AYB stored for 12 months in six different storage containers

Genotypes	Sigma					
	Glass bottle	Paper envelope	Plastic bottle	Earthen pot	Polyethylene Bag	Galvanized iron tin
TSs42	235.00^{a}	263.20^{a}	173.10^{bc}	209.50^{bcd}	171.80^{ab}	215.20^{abc}
TSs48	199.00^{abc}	265.30^{a}	253.30^{a}	217.70^{abcd}	317.20^{a}	218.90^{abc}
TSs50	221.70^{ab}	219.40^{c}	209.60^{b}	226.70^{abc}	198.70^{ab}	176.20^{c}
TSs83	180.20^{abc}	219.50^{c}	202.20^{b}	194.70^{bcd}	194.20^{ab}	276.90^{a}
TSs86	195.70^{abc}	221.30^{c}	178.80^{bc}	281.90^{a}	134.30^{ab}	197.00^{bc}
TSs209	146.80^{bc}	204.50^{c}	184.80^{bc}	199.50^{bcd}	230.30^{ab}	162.50^{c}
TSs311	161.40^{abc}	233.70^{ab}	167.90^{c}	174.70^{cd}	206.50^{ab}	188.10^{c}
TSs331	182.60^{abc}	228.30^{abc}	201.50^{b}	194.80^{bcd}	233.10^{ab}	262.70^{ab}
TSs349	166.50^{abc}	237.00^{ab}	256.20^{a}	249.90^{ab}	287.60^{ab}	208.80^{abc}
TSs370	139.20^{c}	265.70^{a}	143.50^{cd}	147.90^{d}	170.80^{ab}	174.70^{c}

Means followed by the same letter along the column are not significantly different from one another according to DMRT at 5 % probability level.
Sigma: standard deviation.

Table 5: Rate of seed deterioration as determined by PROBIT slope in seeds of AYB stored for 12 months in six different storage containers

Genotype	Slope (x 10^{-3})					
	Glass bottle	Paper envelope	Plastic bottle	Earthen pot	Polyethylene bag	Galvanized iron tin
TSs42	4.30^{b}	3.83^{c}	5.90^{abc}	4.87^{bc}	6.13^{bc}	5.10^{ab}
TSs48	5.20^{ab}	4.03^{abc}	4.90^{cd}	4.80^{bc}	6.90^{ab}	4.83^{ab}
TSs50	4.50^{ab}	4.37^{ab}	4.93^{cd}	4.47^{bc}	5.13^{cd}	5.83^{ab}
TSs83	5.70^{ab}	4.77^{ab}	5.43^{c}	5.50^{abc}	5.30^{cd}	3.77^{b}
TSs86	5.63^{ab}	4.63^{ab}	5.70^{bc}	4.17^{c}	7.67^{a}	5.33^{ab}
TSs209	7.33^{a}	5.10^{a}	5.73^{bc}	5.27^{abc}	4.43^{de}	6.50^{a}
TSs311	6.67^{ab}	4.30^{ab}	6.47^{ab}	5.97^{ab}	4.93^{cde}	5.43^{ab}
TSs331	5.67^{ab}	4.43^{ab}	5.10^{c}	5.43^{abc}	4.33^{de}	3.87^{b}
TSs349	6.13^{ab}	4.27^{abc}	3.97^{d}	4.70^{bc}	3.57^{e}	4.87^{ab}
TSs370	7.37^{a}	4.17^{abc}	7.10^{a}	6.93^{a}	6.03^{bc}	6.23^{a}

Means followed by the same letter along the column are not significantly different from one another according to DMRT at 5 % probability.
Slope: is the rate of seed deterioration.

Table 6**:** The PROBIT half-life of seeds of 10 AYB genotypes stored for 12 months in six different storage containers

Genotype	Mu (P_{50}) in months					
	Glass bottle	Paper envelope	Plastic bottle	Earthen pot	Polyethylene bag	Galvanized iron tin
TSs42	10.53^{a}	8.17^{bc}	9.05^{c}	8.95^{e}	9.44^{bc}	10.86^{a}
TSs48	8.96^{bc}	9.25^{ab}	10.71^{a}	11.39^{a}	10.67^{a}	9.35^{cd}
TSs50	9.62^{abc}	8.36^{b}	9.63^{ab}	10.55^{de}	10.62^{a}	9.31^{cd}
TSs83	9.98^{ab}	7.74^{c}	10.60^{a}	9.59^{cd}	10.45^{ab}	10.13^{abc}
TSs86	9.90^{ab}	8.32^{b}	9.53^{ab}	10.76^{b}	9.51^{bc}	9.52^{cd}
TSs209	9.88^{ab}	8.12^{bc}	10.78^{a}	9.97^{c}	10.01^{abc}	10.04^{bc}
TSs311	8.78^{c}	8.27^{b}	10.17^{ab}	9.66^{cd}	10.21^{abc}	10.79^{a}
TSs331	9.12^{bc}	9.17^{ab}	10.49^{a}	9.68^{cd}	9.20^{c}	8.57^{d}
TSs349	9.95^{ab}	8.20^{bc}	10.51^{a}	9.82^{cd}	10.97^{a}	10.18^{abc}
TSs370	9.75^{abc}	9.60^{a}	20.06^{ab}	9.22^{de}	10.13^{abc}	9.96^{bc}

Means followed by the same letter along the column are not significantly different from one another according to DMRT at 5 % probability level.
Mu P_{50} : the half-life (estimate of time taken for viability to fall to 50 %)

Table 7: Seed storage life of 10 AYB genotypes stored for 12 months in six different storage containers

Genotypes	Seed storage life (Months)					
	Glass bottle	Paper envelope	Plastic bottle	Earthen pot	Polyethylene bag	Galvanized iron tin
TSs42	21.07^{a}	16.35^{bc}	18.10^{c}	17.90^{e}	18.89^{bc}	21.73^{a}
TSs48	17.92^{bc}	18.50^{ab}	21.42^{a}	22.76^{a}	21.3^{a}	18.69^{cd}
TSs50	19.23^{abc}	16.72^{b}	19.25^{bc}	21.09^{b}	21.23^{a}	18.63^{cd}
TSs83	19.96^{ab}	15.49^{cd}	21.20^{a}	19.19^{cd}	20.89^{ab}	20.26^{abc}
TSs86	19.81^{ab}	16.64^{bc}	19.06^{bc}	21.53^{b}	19.03^{bc}	19.04^{cd}
TSs209	19.76^{ab}	16.23^{bc}	21.56^{a}	19.95^{c}	20.02^{abc}	19.95^{bc}
TSs311	17.55^{c}	16.53^{bc}	20.33^{b}	19.31^{cd}	20.42^{abc}	21.57^{ab}
TSs331	18.25^{bc}	18.35^{ab}	20.98^{ab}	19.37^{cd}	18.40^{c}	17.14^{d}
TSs349	19.91^{ab}	16.40^{bc}	21.03^{ab}	19.63^{cd}	21.94^{a}	20.36^{abc}
TSs370	19.51^{abc}	19.21^{a}	20.12^{abc}	18.44^{de}	20.27^{abc}	19.92^{bc}

Means followed by the same letter along the column are not significantly different from one another according to DMRT at 5 % probability level.
Storage life: estimate of time taken for viability to fall to 0 %

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