

Assessment of Seed Storability Attributes of Selected Nigerian Rice Varieties Under Ambient Conditions in Guinea Savannah Ecology

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ABSTRACT

Temperature and seed moisture content are the two most important factors which influence longevity of seeds in storage. Freshly harvested seeds of the 22 varieties of Nigerian cultivated rice varieties grown during 2017 cropping year at the National Agricultural Seeds Council, Abuja, a guinea savannah environment of Nigeria. Seed lot of each variety were stored under ambient humid conditions of the Seed Processing and Storage complex in NASC, Abuja Nigeria. Two factors were evaluated i.e. 22 cultivars and six storage durations (0, 60,120,180,240 and 300 days). Harvested and cleaned seeds were stored under ambient storage conditions (28 - 31°C ± 1; 70 – 72% RH) for 300 days using CRD in three replicates. The stored seeds were drawn every 60 days and tested for seed quality and longevity attributes. Data obtained were subjected to Analysis of Variance and means were separated using Tukey's HSD at 5% probability level. Pearson's correlation coefficient and principal component analyses were also used. PROBIT analysis was done on seed longevity. PROBIT modeling showed that seeds retained its viability, irrespective of storage time, and had very low varietal deterioration. PROBIT modeling predicted that FARO 22 and FARO 57 can be stored with good seed storage conditions for an average of 51 and 45 months, respectively, before they start deteriorating.

Keywords: seed deterioration, storage, probit, rice seed, seed quality.

INTRODUCTION

Seed storage is the preservation of seed under controlled environmental condition that maintains seed viability for long period (Kameswara, 2006). High temperature, ambient relative humidity and seed moisture content are main factors influencing seed storage capacity (Abdul-Baki, 1980).

Temperature and seed moisture content are the two most important factors which influence longevity of seeds in storage. The two factors are, however, inter-related, the higher the value of either the faster the rate of deterioration and consequently loss of seed viability. The two rules based on temperature and moisture applies independently. Seed deterioration is also described as an unavoidable process, though it is possible to retard the process of ageing through optimum seed storage (Delouche, 1973). High quality seeds should be stored since seed storage does not improve seed quality but maintains it. When seeds deteriorate, they tend to lose vigour and become more sensitive to stress upon germination and eventually lose the ability to germinate.

Storability of seeds is mainly a genetically regulated character and is influenced by quality of the seed at the time of storage, pre-storage history of seed (environmental factors during pre- and post-harvest stages), moisture content of seed or ambient relative humidity, temperature of storage environment, duration of storage and biotic agents (Khatun *et al.*, 2009; Biabani *et al.*, 2011). Damage of seed during storage is inevitable (Balesevic-Tubic *et al.*, 2005). These environmental conditions are very difficult to maintain during storage. The seed storage environment highly influences the period of seed survival. After planting of deteriorated seeds, seedling emergence may be poor and transmission of pathogens to the new crop may occur. Lower temperature and humidity result in delayed seed deteriorative process and thereby leads to prolonged viability period (Mohammadi *et al.*, 2011). Hence this study was conducted: 1) to investigate the storability potential of these rice varieties under ambient humid condition of guinea savannah ecology, and 2). to estimate seed storage life of these rice varieties stored under ambient humid conditions after 300 days of storage using PROBIT modeling.

MATERIALS AND METHODS

Seed Materials and Sources

Freshly harvested seeds of the 22 varieties of Nigerian cultivated rice varieties grown during 2017 cropping year at the National Agricultural Seeds Council, Abuja, a guinea savannah environment of Nigeria.

Seed Preparation Before Storage

Clean seeds of these varieties were tested for moisture content and moisture content was regulated to 10.5 -11% using halogen moisture tester (model). Seed of the 22 varieties were tested for the following attributes as initial quality attributes; Seed germination, Seedling Length (shoot + root), Seedling Vigour Index Each trait was determined following the procedures outlined by ISTA (1995).

Experimental Site and Storage Conditions

Seed lot of each variety were stored under ambient humid conditions of the Seed Processing and Storage complex in National Agricultural Seeds Council, Abuja Nigeria. The temperature and relative humidity of the storage conditions were monitored during the storage period.

Experimental Design and Treatments

The study was arranged in a completely randomized design with three replicates. Two factors were evaluated i.e. 22 cultivars and six storage durations (0, 60,120,180,240 and 300 days).

Seed Packaging, Storage and Duration

A 200 gramme seed of each variety was placed inside moisture proof polyethylene bags of 20 by 15 cm dimension and then sealed and arranged on a pallet in the seed store with protective wire net against store rodents. Packaged seed lots were stored for 360 days and seed samples were taken every 60 days for physiological quality determination.

Seed Quality Determination

Seed samples were drawn at 60 days interval (0, 60, 120, 180, 240 and 300 days) for a period of 300 days and were subjected to the following quality tests:

Seed Viability (%):

Germination test was used to determine this trait according to ISTA (1995) procedure. Fifty seeds of each cultivar in three replicates were placed in a Petri dish moistened with filter paper and then arranged in an incubator regulated to 20-25°C. Germinated (viable seeds) count was determined at 3 and 8 days after sowing. Percentage of viable seeds was computed thus;

$$\text{Seed Viability (\%)} = \frac{\text{Number of Viable Seeds}}{\text{Number of Seeds Sown}} \times 100$$

Seedling Shoot Length (cm):

Ten normal seedlings were randomly selected and their root length were measured in centimeter.

Coleoptile Length (cm):

Length of ten randomly selected seedlings were used to determine the coleoptiles length.

Number of Roots Per Seedling:

Average number of roots from ten randomly selected seedling were counted and recorded.

Seed Storage Life (longevity):

Mean percentage values derived from seed viability test was used to estimate seed storage life according to the procedure of Roberts (1973) as reported by Adebisi *et al.* 2008).

Statistical Analysis

Data obtained for each character were subjected to 2-way Analysis of Variance and significant treatments means were separated at 5% probability level using SPSS Statistical package (version 25). Seed storage life (Seed longevity estimation) was carried out using PROBIT modeling as outlined by Roberts using SAS™ PROC. PROBIT parameters sorted the data by cultivars and storage time (month). Seed longevity parameters were estimated from the procedure based on seed viability test data. PROBIT estimates of rate of extermination (δ) and time taken for seed ageing to decline to 50% (P_{50}) was estimated by the PROBIT Procedure for each seed lot. Seed storage life was estimated as half-life (P_{50}) value multiplied by 2 then divided by 30 days of a month (Robert, 1973).

RESULTS

The mean square values for the effect of storage time on seed quality parameters of 22 Nigerian cultivated rice varieties under ambient conditions in guinea savannah ecology is presented in Table 1. From the Table, variety effect was highly significant ($p < 0.01$) for 100 seed weight, seedling shoot length and number of roots but significant ($p < 0.05$) for seed viability. Storage time effect also showed highly significant effect for all the seed storability attributes evaluated. However, the interaction of variety $\times$ storage time was highly significant ($p < 0.01$) on 100 seed weight, seedling shoot length and number of root but significant ($p < 0.05$) on seed viability.

Table 1: Mean square values for seed quality parameters of Nigerian cultivated rice varieties stored under ambient conditions guinea savanna ecology

Source of variation	Df	100 seed weight	Seed viability	Seedling root Length	Seedling shoot length	Coleoptile length	Number of roots
Replicate	2	0.02ns	54.93ns	1.03ns	1.13ns	0.07ns	0.02ns
Variety	21	0.59**	448.83*	4.42ns	7.78**	0.15ns	0.37**
Storage time	5	1.54**	4594.25**	476.48**	180.45**	18.75**	60.62**
Variety $\times$ storage time	105	0.36**	454.11*	2.29ns	13.00ns	0.10ns	1.87**
Error	262	0.12	250.9	3.86	3.28	0.11	0.15

** Significant at 1% probability level. *significant at 5% probability level, ns not significant.

In Table 2, the data reveal that variability existed amongst the 22 cultivated varieties for seed quality parameters across the storage period. A careful look of the data shows that there were significant differences amongst the varieties during the storage period for 100 seed weight. The highest 100 seed weight of 2.85 – 2.99g was observed in FARO 60, FARO 80, FARO 63 and FARO 59, while the lowest 100 seed weight (2.25g) was observed in FARO 61. Seed viability showed statistical differences among varieties with the highest value (85.44%) in PAC 832 and FARO 21 (80.52%), but this was not significantly different from the 80.32% observed in FARO 61, WAB 189 and FARO 47 with values of 79.85 to 80.52%. Other varieties recorded viability values of between 78.64% in FARO 45 and 69.40% in FARO 27. The lowest viability values were observed in FARO 44, FARO 64, FARO 22, FARO 61 and FARO 52 with values of between 64.37 and 69.40%. With regards to seedling root length, the highest value was noticed in FARO 27 (11.33 cm) as well as the values recorded in FARO 60, FARO 41, FARO 64, FARO 48, and FARO 31 while FARO 58 with a seedling root length of 9.99 cm had the lowest value over the storage periods. In the case of seedling shoot length, the highest seedling shoot length was noticed in PAC 832 (15.64 mm) as well as in FARO 47, FARO 48, FARO 57, FARO 21, WAB 189, FARO 22, FARO 52 and FARO 62 with statistically similar values. The varieties with lower seedling shoot length over the storage period included FARO 27 (13.33 cm), FARO 63 (13.43 cm), FARO 41 (13.70cm) and FARO 21 (13.69 cm). Coleoptile length was highest in FARO 62, FARO 52, FARO 58, FARO 21, FARO 61, FARO 64, FARO 50 and FARO 47(1.66 to 1.50 cm). Lowest coleoptile length values were recorded in FARO 31, FARO 27, FARO 41, FARO 60, FARO 57, FARO 27, FARO 45 and FARO 63 with statistically similar values ranging from 1.35 to 1.41 cm. The number of roots was highest in WAB 189 (3.17) though statistically similar values were obtained in other varieties except FARO 64 with lowest value of 2.40. Other varieties had similar number of roots with values ranging from 2.64 in FARO 44 to 2.96 in FARO 41.

Table 2: Mean performance of Nigerian cultivated rice varieties for seed quality attributes across storage periods under ambient conditions guinea savannah environment

Genotype	100 seed weight (g)	Seed viability (cm)	Seedling root length (cm)	Seedling shoot length(cm)	Coleoptile length (cm)	Number of roots
FARO 62	2.85a	79.85ab	10.18ab	14.67a	1.66a	2.68ab
FARO 60	2.99a	74.65bc	11.24a	14.35ab	1.41b	2.77ab
FARO 52	2.58c	66.27c	9.75ab	14.81a	1.64a	2.70ab
FARO 61	2.25d	69.90c	9.64ab	13.69b	1.55a	2.89ab
FARO 41	2.77b	72.54bc	11.04a	13.69b	1.36b	2.96ab
FARO 22	2.63c	66.65c	10.30ab	15.53a	1.48ab	2.94ab
WAB 189	2.59c	78.79ab	10.13ab	14.87a	1.46ab	3.17a
FARO 21	2.69b	80.52a	10.03ab	14.73a	1.58a	2.81ab
FARO 63	2.97a	73.79b	10.75ab	13.43b	1.41b	2.73ab
FARO 64	2.69b	64.37c	11.13a	13.79ab	1.536a	2.41b
FARO 50	2.49c	74.43b	10.43ab	13.95ab	1.51a	2.72ab
FARO 27	2.49c	69.40bc	11.33a	13.33b	1.35b	2.69ab
FARO 57	2.64b	70.54b	10.73ab	14.99a	1.38b	2.74ab
FARO 48	2.69b	71.96b	11.19a	15.29a	1.40b	2.71ab
FARO 47	2.66b	80.32ab	10.73ab	14.96a	1.49a	2.81ab
FARO 59	2.97a	77.19b	10.58ab	14.25ab	1.55a	2.73ab
FARO 44	2.73b	67.84c	10.76ab	14.26ab	1.47ab	2.64ab
FARO 58	2.49c	72.81bc	9.99b	14.15ab	1.59a	2.65ab
FARO 65	2.46c	70.27bc	10.33ab	13.96ab	1.45ab	2.82ab
FARO31	2.80ab	74.10b	11.22a	14.71ab	1.35b	2.84ab
PAC 832	2.65b	85.44a	10.48ab	15.64a	1.46ab	2.86ab
FARO 45	2.59c	78.64b	10.81ab	14.97ab	1.39b	2.99ab

Means followed by the same alphabet along the column are not different from another at 5% probability level.

In Table 3, the storage period effect shows that 100 seed weight values were highest at 0 and 60 days after storage (DAS) with 2.86g each and thereafter declined significant from 120 to 300 days with values of between 2.61 to 2.56g. For seed viability, values were statistically highest and similar at 0, 60 and 120 DAS with values of 81.21 to 82. 82% and thereafter steadily declined to 74.14% at 180 DAS which was greater than values obtained at 240 and 300 days. Also, seedling root length values were highest at 0 and 120 DAS with values of 13.91 and 13.92 cm and thereafter declined to 9.55cm and further statistically declined to 8.22 and 7.86 cm at 240 and 300 DAS, respectively. For seedling shoot length, there was significant increase in the values with advance in storage time and highest value was obtained at 180 DAS with 17.39cm, followed by 15.25cm recorded at 240days and further declined to 14.12cm at 300 DAS while the least values were obtained at 0 DAS. Coleoptile length varied within the storage periods with highest value of 2.34cm at 180 DAS, followed by 1.94cm at 240 DAS while the values recorded in other storage periods were statistically similar. In respect of the number of roots, highest values were obtained at early storage period 0 and 60 DAS and thereafter recorded statistically similar values of between 2.11 to 2.18 during the remaining storage period.

Table 3: Effect of storage period on seed quality attributes of Nigerian rice across varieties under ambient conditions of guinea savanna environment

Storage Time (days)	100 seed weight (g)	Seed viability (%)	Seedling root length (cm)	Seedling shoot length(cm)	Coleoptile length (cm)	Number of roots
0	2.86a	82.82a	13.91a	12.88e	1.21c	4.03a
60	2.86a	81.48a	13.92a	13.31d	1.21c	4.03a
120	2.61b	81.21a	10.02b	13.78d	1.34c	2.11b
180	2.61b	74.14b	9.55c	17.39a	2.34a	2.17b
240	2.56b	66.15c	8.22c	15.25b	1.74b	2.18b
300	2.56b	61.59c	7.86c	14.12c	1.04c	2.17b

Means followed by the same alphabet along the column are not different from another at 5% probability level.

The effect of storage time on 100 seed weight of the 22 Nigerian cultivated rice varieties stored under ambient conditions in guinea savannah environment for 300 days. Table 4 reveals that at 0 month of storage, FARO 63 had the highest 100 seed weight of 3.28g and the value was statistically similar to the weights observed in FARO 59, FARO 60, FARO 62 and FARO 41. Other varieties exhibited seed weight values that were statistically similar ranging from 2.41 to 2.97g. At 60 days of storage, the varieties exhibited a similar trend with FARO 63 still with the highest weight of 100 seed of 3.20g, followed by FARO 60, FARO 59, FARO 31 FARO 41, FARO 62, FARO 44 and FARO 57 with 100 seed weight values of 3.17, 3.16, 3.03, 3.02, 3.00, 2.99 and 2.98g, respectively while other varieties exhibited similar 100 seed weight values of between 2.52 in FARO 61 and 2.96g in PAC 832. After 120days of storage, 100 seed weight was highest in FARO 60 with 2.86g but this was not statistically different from the weights recorded in FARO64, FARO 59, FARO 44, FARO 31, FARO 63, FARO 62, FARO 52, FARO 41, FARO 22, WAB 189, FARO 21, FARO 57, FARO 47, FARO 48 and PAC 832 with values ranging from 2.45 to 2.82g. The 100 seed weights at 120 DAS was lowest in FARO 61 with a value of 1.96g which was statistically similar to the one in the other remaining varieties. At 180 DAS of storage, weights of 100 seeds were statistically highest and similar in FARO 63, FARO 59, FARO 60, FARO 62, FARO 48, FARO 31, FARO 64, FARO 41, FARO 47, FARO 50, FARO 21, WAB 189, FARO 44, FARO 58 and FARO 45, with values ranging from 3.13 to 2.50g. Lowest seed weight of 2.27g was observed in FARO 27 but this weight was not significantly different from the values in the remaining varieties. After 240 DAS, the 100 seed weight values were not statistically different among the 22 varieties but with values of 2.36 to 2.79g. Also, 300 days of storage, the seed weight differed among the varieties with FARO 62 (2.93g) and FARO 60 (2.96g) showing highest values, though not different from 2.88g recorded in FARO 59 while FARO 61 and FARO 65 had lowest values of 1.94 – 2.35g. The effect of storage time on seed viability of the 22 cultivated rice varieties is presented in Table 5. At 0 month of storage, WAB 189 had the highest value of 89.16% and the value was statistically similar to the values observed in FARO 50, FARO 44, FARO 58 and FARO 45 (above 86.00%). The lowest seed viability values were noticeable in FARO 62, FARO 63 and FARO 59 with 61.49, 63.25 and 62.93%, respectively. After 60 DAS, the highest viability of 76.92% was obtained in FARO 62, followed by FARO 21, FARO 59, FARO 47, FARO 45, WAB 189 and FARO 60 with values ranging from 70.26% to 74.26%, which was not statistically different from the value recorded for FARO 62. Seed viability was however, lowest in FARO 41 and FARO 52 with 46.59 and 44.26% respectively.

Table 4: Effect of storage time on 100 seed weight (g) of 22 Nigerian cultivated rice varieties stored under ambient conditions of guinea savanna environment

Variety	0 DAS	60 DAS	120 DAS	180 DAS	240 DAS	300 DAS
FARO 62	3.11a	3.00a	2.64a	2.83a	2.59a	2.93a
FARO 60	3.23a	3.17a	2.86a	2.99a	2.75a	2.96a
FARO 52	2.70ab	2.79ab	2.54a	2.42h	2.59a	2.46b
FARO 61	2.41ab	2.52ab	1.96b	2.29h	2.35a	1.94c
FARO 41	3.03a	3.02a	2.59a	2.64a	2.64a	2.70bc
FARO 22	2.80ab	2.78ab	2.69a	2.40h	2.52a	2.67bc
WAB 189	2.69ab	2.68ab	2.46a	2.59a	2.56a	2.57bc
FARO 21	2.89ab	2.85a	2.58a	2.59a	2.57a	2.67bc
FARO 63	3.28a	3.20a	2.68a	3.13a	2.73a	2.82b
FARO 64	2.93ab	2.81a	2.82a	2.60a	2.36a	2.64bc
FARO 50	2.62ab	2.73ab	2.17b	2.57a	2.68a	2.23c
FARO 27	2.68ab	2.66ab	2.38b	2.27b	2.48a	2.46b
FARO 57	2.86ab	2.98a	2.48a	2.42b	2.52a	2.53b
FARO 48	2.79ab	2.83ab	2.52a	2.79a	2.80a	2.61b
FARO 47	2.84ab	2.84ab	2.45a	2.64a	2.51a	2.70b
FARO 59	3.24a	3.16a	2.74a	3.02a	2.79a	2.88ab
FARO 44	2.97ab	2.99a	2.70a	2.59a	2.41a	2.68b
FARO 58	2.57ab	2.61ab	2.33b	2.50a	2.54a	2.35c
FARO 65	2.70ab	2.65ab	2.27b	2.45b	2.47a	2.27c
FARO31	2.97ab	3.03a	2.69a	2.69a	2.72a	2.71b
PAC 832	2.94ab	2.96ab	2.49a	2.43b	2.57a	2.49b
FARO 45	2.70ab	2.68ab	2.41b	2.57a	2.42a	2.76b

DAS – Days after storage

Means followed by the same alphabet along the column are not different from another at 5% probability level.

Also, in Table 5, at 120 DAS, highest viability was observed in FARO 48 with 86.00% but this was not different from the values in FARO 21, FARO 31, FARO 22, FARO 41 and FARO 62 (71.67 to 76.67%). Whereas the lowest seed viability of 56.33% was observed in FARO 63 as well as in WAB 189, FARO 61, FARO 60 and FARO 50. With increase in storage time to 180 DAS, seed viability was highest in FARO 44 and FARO 50 with 80.83% and 79.33% respectively. (FARO 60, FARO 22, FARO 64, FARO 48 and PAC 832) had lowest seed viability within the range of 41.33 to 49.66%. After 240 DAS, the highest viability values were observed in seed of FARO 62, FARO 50 and FARO 59 (78.33, 74.66 and 74.60% respectively), while lowest values were obtained in FARO 64 with 28.00%. At the end of 300 DAS, highest seed viability values were noticed in FARO 45 and FARO 47 with 85.83 and 81.33%, respectively while the lowest values were recorded in FARO 61 (41.00%).

Table 5: Effect of storage time on seed viability (%) of 22 Nigerian cultivated varieties stored under ambient conditions of guinea savanna environment

Variety	0 DAS	60 DAS	120 DAS	180 DAS	240 DAS	300 DAS
FARO 62	61.49c	76.93a	74.67b	72.33ab	72.33a	72.00b
FARO 60	80.16ab	70.26a	57.00c	48.33d	47.67d	45.67e

FARO 52	81.83ab	44.26e	68.67b	52.33c	58.63d	48.63e
FARO 61	80.49ab	56.26d	58.67c	63.00b	61.67b	41.00e
FARO 41	77.16b	46.59e	71.67b	64.00b	62.67b	57.00cd
FARO 22	74.16bc	58.26d	75.67a	49.67d	47.33d	46.67bc
WAB 189	89.16a	73.93a	71.00b	65.00b	64.33b	68.33de
FARO 21	79.33b	74.26a	76.67a	67.33b	67.33b	61.33b
FARO 63	63.25c	63.00b	56.33c	63.00c	60.33b	58.33cd
FARO 64	86.25a	55.00c	66.33b	61.67d	58.00c	46.33e
FARO 50	88.08a	78.00a	78.00a	75.33a	74.67a	49.67de
FARO 27	78.58b	70.67a	68.00bc	52.33c	46.33d	42.00e
FARO 57	77.91b	72.67a	71.33b	66.00b	64.67b	59.67cd
FARO 48	80.91ab	75.33a	76.00a	48.33d	46.67d	45.00de
FARO 47	76.26b	71.33a	70.00b	67.00b	66.67b	61.33c
FARO 59	62.93c	71.67a	70.17b	69.17b	68.60a	67.50c
FARO 44	87.93a	80.00a	71.50b	67.33a	64.03b	60.33c
FARO 58	86.28a	70.33b	66.33bc	65.00b	65.00b	57.33d
FARO 65	79.26b	66.00b	61.83bc	60.83b	56.33c	46.67de
FARO31	79.93b	76.90a	76.50a	65.67d	60.67b	57.67d
PAC 832	77.59b	70.00a	66.33bc	64.83b	44.50d	41.53e
FARO 45	86.26a	78.83a	63.33bc	57.17c	56.17c	55.83cd

DAS – Days after storage

Means followed by the same alphabet along the column are not different from another at 5% probability level.

The effect of storage time on average number of roots for the 22 cultivated rice varieties is presented in Table 6. At 0 DAS, number of roots was highest in FARO 62 with 5.66 followed by WAB 189 with 5.13. All remaining varieties except FARO 64 (3.26) and FARO 21 (3.46) were with the lowest number of roots, (3.66 to 4.62). At 60 DAS, number of roots was highest in WAB 189 (4.95) as well as in FARO 41, FARO 47, FARO 21, FARO 22, FARO 61, FARO 60, FARO 62, FARO 59, FARO 31, PAC 832, FARO 65, FARO 63 and FARO 57, with values ranging from 4.00 to 4.48cm. Number of roots was, however, lowest in FARO 64 with 2.73. At 120, 180, 240 and 300 DAS, values of number of roots among the 22 varieties were not significantly different.

Table 6: Effect of storage time on average number of roots of Nigerian cultivated rice varieties stored under ambient conditions of guinea savanna environment

Variety	0 DAS	60 DAS	120 DAS	180 DAS	240 DAS	300 DAS
FARO 62	8.66a	4.27a	2.21a	2.14a	2.07a	2.00a
FARO 60	3.66c	4.28a	2.27a	2.27a	2.13a	2.10a
FARO 52	4.323c	3.42a	2.20a	2.15a	2.13a	2.10a
FARO 61	4.13c	4.31a	2.27a	2.27a	2.20a	2.33a
FARO 41	4.39c	4.48a	2.35a	2.30a	2.27a	2.27a
FARO 22	4.39c	4.35a	2.45a	2.40a	2.13a	2.27a
WAB 189	5.13b	4.95a	2.28a	2.27a	2.27a	2.20a
FARO 21	3.46d	4.47a	2.33a	2.27a	2.07a	2.00a
FARO 63	4.06c	4.07a	2.25a	2.13a	2.07a	2.07a
FARO 64	3.26d	2.73c	2.27a	2.17a	2.13a	2.12a

FARO 50	3.99c	3.67b	2.23a	2.10a	2.10a	2.20a
FARO 27	3.66c	3.67b	2.27a	2.27a	2.13a	2.27a
FARO 57	4.13c	4.00a	2.27a	2.00a	2.00a	2.00a
FARO 48	3.79c	3.73b	2.33a	2.21a	2.10a	2.07a
FARO 47	3.89c	4.33a	2.20a	2.13a	2.10a	2.10a
FARO 59	3.78c	4.23a	2.30a	2.13a	2.03a	2.03a
FARO 44	3.72c	3.57b	2.20a	2.17a	2.17a	2.20a
FARO 58	3.98c	3.41b	2.27a	2.03a	2.09a	2.20a
FARO 65	3.88c	4.07a	2.35a	2.33a	2.17a	2.10a
FARO 31	4.25c	4.17a	2.17a	2.07a	2.30a	2.10a
PAC 832	4.45c	4.13a	2.25a	2.27a	2.27a	2.23a
FARO 45	4.62c	4.43a	2.27a	2.27a	2.23a	2.13a

DAS – Days after storage

Means followed by the same alphabet along the column are not different from another at 5% probability level.

Table 7 presents the values of PROBIT analysis of seed viability data of the 22 Nigerian cultivated rice varieties over 300 days of storage. The values recorded by all varieties indicates that the seeds maintained its viability, irrespective of the storage period. All varieties recorded relatively low rate of deterioration, ranging from 0.06 – 0.22 for FARO 47 and FARO 27, respectively. FARO 22 showed the highest time taken (62.96 days) to lose 1 PROBIT viability, followed by FARO 50 (48.05 days), FARO 63 (44.66 days), FARO 47(26.74 days) and FARO 58 (22.31 days) while FARO 27 (5.02 days), FARO 31 (6.51 days), FARO 64 (6.58 days) and FARO 41 (6.82 days) recorded the lowest time taken to lose 1 PROBIT viability. FARO 22 showed the highest value in days to seed half- life (P_{50}) (765.53 days), followed by FARO 50 (671.94 days), FARO 63 (512.75 days), FARO 47(356.14 days), FARO 58 (332.43 days), FARO 62 (282.05 days), FARO 52 (249.58 days), FARO 21 (206.95 days) and FARO 45 (204.64 days) while FARO 27 (90.96 days) and FARO 64 (92.13 days) were with the lowest value of seed half –life(P_{50}). However, the highest seed storage life (shelf life) of 51.04 months was obtained in FARO 22, followed by FARO 50 (44.79 months), FARO 63 (34.18 months), FARO 47 (23.74 months) and FARO 58 (22.16 months) while FARO 27 (6.06 months), FARO 64 (6.14 months) and FARO 57(6.89 months) had the lowest seed storage life.

Table 7: Values of PROBIT modeling of seed longevity in 22 Nigerian cultivated rice varieties stored under ambient conditions of guinea savanna environment for 300 days.

Variety	Intercept	Slope	Sigma	P_{50}(days)	Storagelife(months)
FARO 62	1.365	-0.087	14.527	282.053	18.804
FARO 60	1.063	-0.107	13.420	192.155	12.810
FARO 52	0.913	-0.131	17.471	249.580	16.639
FARO 61	0.853	-0.180	12.618	159.370	10.625
FARO 41	1.150	-0.157	6.821	112.433	7.496
FARO 22	0.780	-0.090	62.959	765.530	51.035
WAB 189	1.283	-0.126	8.803	159.920	10.661
FARO 21	1.290	-0.105	12.481	206.955	13.797
FARO 63	0.965	-0.070	44.656	512.753	34.184

FARO 64	0.940	-0.159	6.575	92.130	6.142
FARO 50	0.973	-0.078	48.051	671.935	44.796
FARO 27	1.290	-0.223	5.020	90.960	6.064
FARO 57	0.880	-0.123	8.832	103.463	6.898
FARO 48	1.047	-0.123	12.121	172.944	11.530
FARO 47	1.077	-0.056	26.742	356.135	23.742
FARO 59	1.405	-0.135	7.689	155.963	10.398
FARO 44	0.963	-0.136	14.342	185.335	12.356
FARO 58	1.043	-0.115	22.312	332.425	22.162
FARO 65	1.148	-0.178	15.217	178.230	11.882
FARO 31	1.149	-0.157	6.505	110.280	7.352
PAC 832	0.795	-0.109	11.263	132.085	8.806
FARO 45	1.187	-0.104	13.686	204.640	13.643

Intercept is PROBIT estimate of initial seed viability, Slope is the rate of seed deterioration, Sigma is time taken for seed lot to lose 1 PROBIT viability value. P_{50} is seed half- life in days, Seed storage life estimated as P_{50} value multiplied by 2 then divided by the 30 days of a month

DISCUSSION

Seed storage period is an important stage in the seed production process, that is, from harvest time to the time of its use is an essential aspect to be considered in the seed production process, because the effort spent in the production phase may not be effective, if the seed quality is not maintained (Olivera *et al.*, 2013).

The study showed that the variability observed among the entries for 100 seed weight, seed viability, seedling shoot length and number of seedling roots were due to differences in the genetic make-up of the varieties and variation in the conditions of storage period. This implies that there is good opportunity for selecting varieties with superior seed quality (seed longevity) in the rice varieties considered. Adebisi *et al.*, (2019) had earlier reported that the variations observed in all the seed quality parameters among pigeon pea genotypes revealed that the 20 genotypes significantly differed in their genetic make-up, which led to variation in their responses to different storage periods.

The study revealed that significant differences among the seed quality attribute in response to increased storage periods. Seed viability, 100 seed weight, seedling root length, seedling shoot length and number of roots attributes decreased as storage period increased. Relatively, differences in genetic constitution were observed to affect the storage performance of different crops (Adebisi *et al.*, 2008 in sesame; Daniel *et al.*, 2012 in maize and Adebisi *et al.*, 2012 and 2013 in watermelon and kenaf). Their findings corroborated the result of this study that differences in genetic make-up varieties could influence storage performance under different storage periods in different crop species under ambient humid tropical conditions.

On the storability performance among the 22 varieties, PAC 832, FARO 21, FARO 61, WAB 189 and FARO 47 were identified with superior performance in seed viability (80 to 85%) and in most of the seed quality attributes studied across the storage periods. The superior performance could be due to the strong genetic make-up of the varieties combined with other

seed physical characteristics of their seeds. These other genotypes (FARO 44, FARO 64, FARO 22, FARO 61 and FARO 52) were the least storable in seed viability but with moderate to high seedling growth characteristics which could be attributable to their genetic weakness and weak physical characteristics (coat and size) of their seeds.

The highest seed viability percentages were recorded at the earlier storage period 0 to 60 days of storage while a great fall in seed viability was after 120 days of storage while seed stored for 300 days of storage had the lowest seed viability and other seedling vigour attributes. This decline in seed quality aspects could be due to deterioration process which occurs in all biological organisms. The ageing gradually set in and advanced with length of storage and was further aggravated by high temperature (27°C) and high relative humidity (65%) of the ambient conditions of the guinea savanna environment which enhanced higher respiration and led to higher degradation of the assimilates leading to the death of many of the stored seeds.

Earlier reports by Adebisi *et al.* (2008), Esuruoso (2016), Abdul Rafiu (2015); Adebisi *et al.* (2012), Kehinde (2018), Adebisi *et al.* (2019) have utilized PROBIT modelling to predict seed storage life of sesame, eggplant, cayenne pepper, watermelon, kenaf and pigeon pea, respectively under ambient humid storage conditions. In this study, the observations of PROBIT modelling result showed that the seeds maintained their viability, irrespective of the storage time for a period of 300 days. The seeds had very low rate of deterioration in all the 22 rice varieties used in this study, implying that seed longevity was prolonged and FARO 22 and FARO 50 had the highest days of 766 and 672 of seed half-life (P_{50}), implying high storability potential of such seeds while FARO 27 (90 days) and FARO 64 (92 days) had the lowest values in days to seed half-life, implying that these varieties were least storable under ambient humid conditions of guinea savanna environment.

Nevertheless, the PROBIT modelling predicted that FARO 22 and FARO 50 can be stored for an average of 51 and 45 months, respectively before they start deteriorating, if the seeds are put under good storage conditions. This finding corroborates the observations of Jyati and Malik (2013) that the rate of deterioration fluctuates critically from one species to another and also among varieties of the same species. The decline in seed quality parameters could be due to the intrinsic factors in the seeds, irrespective of genotype, as well as other factors such as endosperm size, seed coat, the normal profile of the seed, the type of assimilate (minerals, vitamins and other seed chemicals) that is predominant in the seed among others. The study therefore concluded that storage periods under ambient humid tropical conditions should be given due consideration when storing seeds of cultivated Nigeria rice, irrespective of genotypes available for storage.

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