Asian Research Journal of Agriculture

10(4): 1-14, 2018; Article no.ARJA.47554
ISSN: 2456-561X

Effect of Packaging Materials and Storage Periods on the Vigor Parameters of Some Selected Varieties of Soybeans in Makurdi, Benue State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARJA/2018/v10i430044
Editor(s):
(1) Dr. Marco Aurelio Cristanchos, National Center for Coffee Research, Chinchiná, Caldas, Colombia.
Reviewers:
(1) Aba-Toumnou Lucie, University of Bangui, Central African Republic.
(2) R. Mahalakshmi, India.
Complete Peer review History: http://www.sdiarticle3.com/review-history/47554

Original Research Article

Received 07 December 2018
Accepted 21 February 2019
Published 13 March 2019

ABSTRACT

This study was carried out in 2017 at the Federal University of Agriculture, Makurdi Nigeria. The study was aimed at evaluating the effect of packaging materials and storage period on the vigor parameters of some selected varieties of soybeans in Makurdi. The experimental design was 3x5x6 factorial CRD comprising 3 varieties, 5 storage periods and 6 packaging materials by 3 replicates. Samples were collected from National Cereal Research Institute, Yandev sub-station. The soybeans were cleaned, dried and the moisture content noted. Five hundred grams was measured into the various packaging material stored and at Strategic Grains Reserve, Federal Ministry of Agriculture Makurdi. The seeds in storage was sampled periodically (2, 4, 6 and 8 months) to determine quality by conducting standard germination test with 100 seeds (100 seeds/rep). The investigation revealed that V_3 (TGx 1448-2E) stored for 2 months had the highest Shoot seedling length while V_1 (TGx 923-3F) stored for 8 months had the least shoot seedling length. Soybeans stored in cloth had a very high Shoot seedling length at 2 months but dropped thereafter and turned out to be the lowest at the end of the storage period. V_2 (TGx 1904-6F) stored in laminate paper produced the longest Shoot seedling length and also produced the shortest with V_1. The seedling

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root length was longest in V_3 stored for 2 months and least in V_1 stored for 8months.Soybeans stored in cloth for 2 months produced very high SRL 2 months but dropped to 0.00 at the end of the storage period. V_2 did better in LDPE than all the packaging materials. V_1 had the shortest SRL in soybeans stored in bottle. The highest seedling vigor was recorded in V_3 stored for 2 months while the lowest seedling vigor was recorded in V_1 stored for 8 months. V_2 in plastic container had the highest seedling vigor whileV_1 in plastic had the lowest. However, significant differences were observed at ($P< 0.05$) in the interaction effect. In the present study, LDPE proved to be the best packaging material and the variety that had more resistance to deterioration was V_2 (TGx 1904-6F). Soybeans that are stored at ambient should be in storage material that are impervious to air and moisture otherwise the seeds will lose viability and vigor. In addition, varieties that are prone to fast deterioration should not be stored longer.

Keywords: Soybean; packaging material; storage period; variety; seedling vigor.

1. INTRODUCTION

Soybeans are leguminous vegetable of the pea family that grow in tropical, subtropical and temperate climate [1]. Soybeans are often called the "Miracle crop". They are the world's foremost provider of vegetable protein and oil. The bushy, green soybean plant is a legume related to peas, groundnut (peanuts) and alfalfa [2]. One of the major constraints in soybean cultivation is the non-availability of high vigor seeds at the time of sowing. Rising demand for oil and protein has stimulated soya bean production mainly by increasing land use. Nowadays area and production of the crop is increasing gradually but productivity remains almost constant [3]. Soybean cultivation is hindered due to lack of good quality seed [4]. Soybean producers in the developing world, including Nigeria, still store their produce including seed under the ambient environment. The storage under ambient conditions has been observed to affect seed quality in general particularly germination. Storage can however be improved under ambient conditions if seeds are properly packaged. Preservation of seed viability depends on storage condition and duration. Different periods of seed storage as well as ageing condition adversely affect seed vigor. Changes associated with seed deterioration are depletion in food reserve, increased enzyme activity, increased fat acidity and membrane permeability. As the catabolic changes continue with increasing age, the ability of the seed to germinate is reduced [5].

The most important factor in crop production is high quality seed. Seed vigor is also the key components of seed quality. Seed aging is recognized by some parameters like delay in germination and emergence, slow growth and increasing of susceptibility to environmental stresses in various duration of storage. Seed quality (viability and vigor) decreases under long storage conditions due to aging. Aging is manifested as reduction in germination percentage and those seeds that do germinate produce weak seedling [6]. Seed of different species lose viability to a various degree even when kept under the same storage condition. Accelerated aging of seed i.e seed lot exposure to high temperature and high relative humidity leads to loss of vigor and finally to a loss of viability which is an outstanding method for determination of changes in vigor during seed storage [7].

Different periods of seed ageing and storage conditions adversely affected the seed vigor [8]. The sstorability of seeds is also influenced by the type of packaging material [9]. The seed storability is considerably determined by the variety or cultivar of seeds. Some seeds are naturally short-lived, e.g., onion, soybeans, peanuts, etc., whereas some seeds like, tall fescue and annual rye grass, appear very similar but differ in storability [10]. The objectives of this Research is to study seedling parameter of some soybeans varieties under ambient condition in different packaging materials, different storage period and their interactions.

2. MATERIALS AND METHODS

2.1 Study Area

Newly harvested soybeans was purchased from National Cereal Research Institute, Yandev sub station. The beans was cleaned and dried and the moisture content was taken .It was then stored in various packaging materials at the Strategic Grain Reserve, Federal Ministry of Agriculture Makurdi for the period of 8 months (March 2017 –November 2017). The laboratory

work was carried out at the seed science lab in the Federal University of Agriculture, Makurdi. Makurdi, the capital of Benue state lies between latitude 7˚15-70 N and longitude 8˚40'E in the Guinea savanna vegetation of Nigeria. Five hundred grams (500 g) each of the varieties of soybeans were measured into the various packaging materials. They were then stored for 2 months, 4 months, 6 months and 8 months. The varieties under consideration were TGx 932-3F, TGx 1904- 6F and TGx 1448-2E. The packaging materials were: Cloth bag, laminate paper bag. Glass bottle, low density polyethene bag and plastic container.

2.2 Measuring the Environmental Variables

Data were collected weekly. The Relative humidity was measured using digital psychrometer of the model 5105 JENWAY. The moisture content and temperature of the grain was taken with use of FARMEX MT – PRO. 081125 moisture meter and thermometer.

2.3 Experimental Design and Procedure

The experimental design was factorial in 3x5x6x comprising 3 varieties, 5 storage periods and 6 packaging materials by 3 replicates. Least significant (LSD) at 5% was used to compare the treatment means. The seeds in storage were sampled periodically (2, 4, 6 and 8 months) to determine quality by conducting standard germination test with 100 seeds (100 seeds/rep).

Twenty five healthy (25) seeds were placed on double layered filter paper and moistened [11]. Analysis of variance of all parameters were computed using statistics version 21.

2.4 Study Variables

Variables investigated during the study were the Seedling length, Seedling shoot length, Seedling root length and the seedling vigor of seed stored for 2 months, 4 months, 6 months and 8 months in 5 packaging materials.

2.5 Seedling Vigor Test

Seedling vigor is the sum of those properties that determine the activity and performance of seed lots of acceptable germination in a wide range of environment [11]. Thus a vigorous seed lot should perform well even if the environmental conditions are not optimal for growth of the specific species. Twenty-five seeds from each replication of the sixty samples were taken from the seed lots and placed in petri dish with two layered filter paper. The filter paper was moistened daily and the seeds were allowed to germinate. The seedling vigor was determined using seedling length. The recorded length was multiplied by the percentage germination of each replication to give the seedling vigor as seen in the formulae below.

Vigor index = Germination (%) x Seedling length [37].

2.6 Seedling Root Length (cm)

Ten normal seedlings were randomly selected in each petri dish from final count and the root length was determined from the collar region to the tip of the primary root. The average root length of ten seedlings was computed and expressed in centimeter.

2.7 Seedling Shoot Length (cm)

Ten seedlings used for root length were used for shoot length measurement. The length between the collar region and the tip of the primary shoot was considered as shoot length and it was measured. The mean value of shoot length calculated and expressed in centimeter [12].

2.8 Statistical Analysis

Data collected were subjected to statistical analysis using analysis of variance to compute variances of all parameters (seedling shoot length, seedling root length, and seedling length and seedling vigor) and least significant difference (5%) to separate the means.

3. RESULTS AND DISCUSSION

3.1 Seedling Parameters

3.1.1 Effect of variety, packaging material and storage period on the seedling shoot length, seedling root length, seedling length, and seedling vigor of soybeans

3.1.1.1 Seedling shoot length

The effect of variety, packaging materials and storage period on SSL of soybeans is presented on Table 1. The result showed that the seedling

shoot length was more in V_2 than V_3 and V_1. V_2 had seedling shoot length of 6.15 while V1 had the lowest of 3.73. The difference between the seedling shoot length of V_1 and V_2 was 2.42 and the difference between V_2 and V_3 was 0.86. The result showed that there was significant difference ($P<0.05$) in SSL of soybean among different varieties as seen on Table 1.

The seedling shoot length, had higher mean values as a result of the genetic composition of the seed. Tatić et al. [8] in his work reported that there was significant difference between soybean genotypes. These differences between genotypes might be due to the genetic factors and seed chemical composition influence the expression of seed deterioration and vigor decline. The present findings is in agreement with El-Abady et al. [13] who asserted that assessment of some soybean cultivars seed quality during storage by monitoring germination and germination after storage, in addition to seed and seedling vigor measurement may be reliable indicators for damages occurred after mechanical threshing method. The effect of packaging materials also varies. The highest value of SSL was in control (7.98) while the lowest (3.94) was in cloth. LDPE showed a higher (4.92) SSL than all the packaging materials, then plastic container (4.63). Glass bottle and laminate paper had SSL of 4.46 and 4.42 respectively. However, there was significant difference ($P<0.05$) in SSL of soybeans among different packaging materials. (Table 1)

The significant effect of packaging materials on the means of SSL might be due to the air-tight nature of some of the packaging materials while others were very porous. In the present study Cloth had the lowest SSL mean due to its moisture absorption which increased the respiratory activities. This work is in conformity with the work of Akter et al. [14] who stated that the deterioration of seed due to high moisture absorption in cloth bags, which is a progressive process accompanied by accumulation of metabolites, and which progressively depresses germination and growth of seedling with increased age, ultimately reduces the dry matter and vigor of soybean seeds during storage.

The main effect of storage period on the SSL of soybeans showed that as the storage period increased, the SSL decreased. The longest SSL was at 0 month (control) with 7.98 and the shortest SSL was at 8 month with a value of 3.03. Soybeans stored for 2 months had a higher SSL than all the other storage periods (6.50). The effect of the storage period showed that there was a significant difference ($P<0.05$) in SSL of soybeans among different storage period. (Table 1). This could be caused by the deleterious effect of fluctuating temperature and relative humidity and the prolong storage. This present study is in line with the work of Manomani, et al. [15] who reported that the decline in root length, shoot length, seedling dry and fresh weight and seedling vigor index with increase of storage periods might be due to their genetic differences age induced deterioration, inherent differences in seed structure and composition.

3.2 Seedling Root Length

3.2.1 The effect of variety on seedling root length is presented on Table 1.

The investigation showed that V_2 recorded the longest root length while V_1 recorded the shortest root length. V_2 recorded 5.78 while V_1 recorded 3.06 as seen on Table 3. The difference between V_1 and V_2 was 2.72 while the difference between V_2 and V_3 was 0.61. Significant difference ($P<0.05$) was observed in SRL of soybeans among varieties (Table 1).

The significant difference might be due to the physical I and chemical composition of seed. This study is in consonance with the findings of Doijoide et al. [16] who stated that the storability of different soybean cultivars is also regulated by initial seed quality, physical and chemical composition of seed as different cultivars possess different physical structure and chemical composition which determine the viability of seed in storage.

3.2.2 The effect of packaging material on SRL is also presented on Table 1

The result showed that control had the longest root length while the shortest root length was recorded in soybeans stored in laminate paper followed by cloth (4.08 and 4.13) respectively. Soybeans stored in plastic container recorded a longer (4.49) SRL than all the packaging materials. There was significant difference ($P<0.05$) in SRL on stored soybean among different storage period. (Table 1).The significant difference could be as a result of alterations in carbohydrate during storage. This study is in line with the work of Panobianco et al. [17] who found that alterations in carbohydrates during

storage could affect the cell membrane permeability, thus contributing to the reduction in the physiological quality and germination of seeds.

3.2.3 The effect of storage period on the SRL of soybean is presented on Table 1

The SRL of soybeans decrease with increase in storage period. The investigation revealed that 2 months had the longest (7.21) seedling root length and the shortest was in 8 months (1.91). This was followed by control (6.65). However, significant difference (0.05) was observed in SRL among storage period.

This work is in line with the findings of Fu et al. [18] who reported that as seed quality deteriorates during storage, vigor declines before loss in standard germination. Akter et al. [14] also reported that seedling characters like shoot length, root length varied over storage containers and storage period.

3.3 Seedling Length

The effect of variety on seedling length of stored soybean is presented on Table 1. The result showed that V_2 recorded the longest (11.93) seedling length while the shortest was recorded in variety V_1 (6.7). The difference between V_2 and V_1 was 5.14 while the difference in SL between V_2 and V_3 was 1.47. However, significant difference ($P<0.05$) was observed in SL among varieties of soybeans.

The significant difference between varieties could be due to the amount of food reserves in the seeds as expressed in seedling establishment at 8 DAP. Kandil et al. [12] reported differences in root and shoot length and root/shoot ratio in soybean.

3.3.1 The effect of packaging material on the SL of stored soybeans is presented on Table 1

The result showed that the SL before storage (Control) had the longest SL while length cloth had the shortest SL (14.63 and 8.07 respectively). LDPE had longer (9.38) SL than the other packaging materials. The result of the effect showed that there was a significant difference ($P<0.05$) in SL on soybeans among different packaging materials. This could be as a result of the high moisture and fungal activities. The present study conforms with the work of Monira et al. [19] who reported that the maximum abnormal seedlings and dead seeds were recorded in cloth bag and the minimum in tin container. Increasing rate of abnormal seedling and dead seed was observed higher in cloth bag, due to high moisture and fungal activities in soybean.

3.3.2 The effect of storage periods on the SL of soybeans is presented on Table 1

The investigation revealed that SL decreased with increase in storage periods. The SL decreased with increase in storage periods. The longest SL was recorded at control (14.63) and the shortest SL was recorded at 8 month (4.94). Month 2 recorded longer SL than all other storage period as seen on Table 2. Significant difference ($P<0.05$) was observed in SL among storage periods.

The significant difference could be as a result quick deterioration due to auto oxidation of lipids and the increase of free fatty acid during period. The present study agrees with the findings of Akter et al. [14] who reported that the decline in seedling length at the end of the storage period were due to reduced seed germination and damage caused by insect, pests during storage which might have hindered the seedling growth.

3.4 Seedling Vigor

3.4.1 The effect of variety on seedling vigor is presented on Table 1

The result showed that V_2 had the highest seedling vigor of 1052.77 while V_1 had the lowest seedling vigor of 501.22. V_3 had a SV of 895.20. The difference in SV between V_1 and V_2 was 551.55 while the difference between V_2 and V_3 was 157.57. However, significant difference ($P<0.05$) was observed in seedling vigor of soybeans among varieties. The significant difference could be due to the chemical composition of the different varieties which determine the viability and vigor of the seeds in storage. This findings is in agreement with Tatic et al. [8] who asserted that differences between genotypes might be due to the genetic factors and seed chemical composition influence the expression of seed deterioration and vigor decline. Doijoide et al. [16] made a similar statement that the storability of different soybean cultivars is also regulated by initial seed quality, physical and chemical composition of seed as different cultivars possess different physical

structure and chemical composition which determine the viability of seed in storage.

3.4.2 The effect of packaging materials on the seedling vigor of stored soybeans is presented on Table 1

The result showed that control recorded the highest (1279.72) SV while glass bottle recorded the lowest (676.10) SV. Among those in packaging materials, LDPE recorded the highest SV of 775.27, followed by laminate paper (753.36). Significant difference (P<0.05) was observed in SV among different packaging materials. The significant difference could be due to the vapor resistance of the packaging materials. The packaging materials vary in their ability to resist moisture from the surrounding. Packaging materials that are moisture resistant are better than those that have poor resistance. Those with poor moisture resistance hastened respiratory activities which consequently utilized the food reserve meant for the viability and seedling vigor. The present study conforms with the work of Tripathi and Lawande [20] and Rao et al. [21] both in onions that significant differences exist in seed germination and seedling vigor among various packaging materials.

3.4.3 The effect of storage period on SV is presented on Table 1

Seedling vigor generally decrease with increase in storage periods. The highest SV was obtained at 2 months (1329.28) while the lowest was obtained at 8 months with a value of 284.08. The control had the next high value of 1272.93, followed by 4 months, 6 months and 8 months. However, significant difference (P<0.05) was observed in SV of soybeans among different storage periods. The significant difference could be due to the respiratory effect on the soybeans. As the storage period increased, the metabolic activity increased and the food reserve declined. This led to the decrease in seedling vigor This finding is in line with the assertion of Nkang et al. [22] that one of the major constraints to the production of soybean in the tropics is the rapid loss of seed viability and vigour during storage under ambient conditions.

Table 1. Effect of Variety, Packaging material and storage period on the seedling shoot length, seedling root length, seedling length, and seedling vigor of soybeans

	SSL	SRL	SL	SV
Variety				
V1	3.73	3.064	6.79	501.22
V2	6.15	5.78	11.93	1052.77
V3	5.29	5.17	10.46	895.20
LSD	0.46	0.59	0.94	84.00
P.M.				
Control	7.98	6.65	14.63	1279.72
Cloth	3.94	4.13	8.07	681.95
G. bottle	4.46	4.21	8.67	676.10
L. density	4.92	4.47	9.38	775.27
L. paper	4.42	4.08	8.50	753.36
P. container	4.63	4.49	9.1b	731.98
LSD	0.64	0.84	1.33	118.79
Storage period				
0	7.98	6.65	14.63	1272.93
2	6.50	7.21	13.71	1329.28
4	3.91	4.04	7.91	698.93
6	3.87	3.54	7.45	496.76
LSD	**0.59**	**0.77**	**1.22**	**108.44**

SSL= seedling shoot length, SRL= seedling root length, SL= seedling length, SV= seedling vigor

3.5 Interaction Effects

3.5.1 Seedling shoot length

3.5.1.1 The Interaction Effect of Variety and Storage Period on the Shoot Seedling Length of Soybeans

The interaction effect of variety and storage period on the seedling shoot length of soybeans is presented on Table 2.

The result showed that V_2 recorded the highest SSL while V_1 recorded the lowest SSL. The result also showed that soybeans stored for 0months (control) recorded the highest followed by 2 months of storage. It was observed that irrespective of the variety, the SSL decreased with increase in storage period except in variety 1 at 6 months that there was a slight difference of 0.327.There was a deviation from this trend in V_2 at 6 months which there was a difference of 0.61. The investigation showed that V_2 x 0months recorded the highest SSL while V_1 x 8months showed the lowest SSL. There were significant differences ($P<0.05$) among variety and storage period on SSL of soybeans.

The present study is in conformity with the findings of Kandil et al. [12] who reported that the decline in seedling shoot length with increase in storage periods might be due to their genetic differences, age induced deterioration, inherent differences in seed structure and composition. Vange et al. [23] also reported that significant difference between varieties could be due to the amount of food reserves in the seeds as expressed in seedling establishment at 8 DAP. Kandil et al. [12]. Reported differences in root and shoot length and root/shoot ratio in soybean.

3.5.1.2 Interaction effect of packaging material and storage period on the SSL of soybeans

The result of the interaction is presented on Table 3. The result showed that the SSL for cloth is higher (7.787) than all the packaging materials apart from control which was 7.979. The lowest was still cloth (0.50) but at a different storage period followed by LDPE (3.33). The result showed that 2 months recorded the highest SSL of 7.787 and the lowest recorded was at 8 months (0.0). The result of the interaction between packaging material and storage period (Table 10b) showed cloth to have recorded the highest SSL after 2 months of storage. After 2 months, there is a rapid deterioration of the soybeans and cloth turned out to record the lowest SSL at 8 months. There were significant differences ($P<0.05$) among p.m. and storage period on SSL of soybeans. This present study is in line the work of Mohmmedi et al. [24] who reported that seed deterioration resulted in decreased percentage and rate of germination and decreased percentage of normal seedlings. These findings are in conformity with those of Kandil et al. [14], Sharma et al. [28], Tactic et al. [8] and Khaliliaqdam et al. [25]. Akter et al. [14] reported that Seedling characters like shoot length, root length (seedling length) varied over storage containers and storage period. Storage container showed significant effect on root length and shoot length which decreased with the increase in storage period.

3.5.1.3 Effect of variety and packaging material on SSL of soybeans

The effect of variety and storage period is presented on Table 4.

The result showed that V_2 had higher SSL while V_1 had the lowest SSL (5.628 and 2.816 respectively). Investigation also showed that laminate paper recorded the lowest SSL of 2.816. The interaction result showed that V_2 x laminate paper recorded the highest SSL (5.628) while V_1 x laminate paper recorded the lowest SSL (2.816). There were significant differences ($P<0.05$) among variety and packaging material on SSL of soybeans.

The present findings is in consonance with the report of Sadeghi et al. [26] who reported that Williams (a variety) has more resistance to seed deterioration that could be related to genetically or structural characteristic such as seed coat, seed stored matters and so on.

Table 2. Interaction effect of variety and storage period on the seedling shoot length of soybean

	0 month	2 months	4 months	6 months	8 months
V1	4.907	4.676	3.00	3.327	2.744
V2	11.023	6.712	4.533	5.143	3.362
V3	8.007	8.127	4.07	3.25	2.996

*LSD variety*month=1.01*

Table 3. Effect of packaging material and storage period on the seedling shoot length of soybean

	Control	2 months	4 months	6 months	8 months
Cloth	7.979	7.787	2.423	1.507	0.00
Control	7.979	7.979	7.979	7.979	7.979
G. Bottle	7.979	5.696	2.139	3.096	3.399
LDPE	7.979	5.931	3.291	4.069	3.33
L. Paper	7.979	6.411	3.913	2.78	1.037
P. container	7.979	5.224	3.46	4.009	2.458

*LSD pm*month=1.44*

Table 4. Effect of variety and packaging material on the seedling shoot length of soybeans

	Control	Cloth	Bottle	Density	Paper
V1	4.907	3.055	3.558	4.036	2.816
V2	11.023	4.373	5.057	5.393	5.628
V3	8.007	4.389	4.769	5.331	4.828

*LSD variety*pm=1.25*

3.6 Seedling Root Length

3.6.1 Effect of variety and storage period on seedling root length of soybeans

The effect of variety and storage period on the seedling root length of soybeans is presented on Table 5.

The result showed that the SRL ranges between 8.739-1.327. V_3 recorded the maximum (8.739) SRL while V_1 recorded the minimum (1.327) SRL. It was observed that SRL decrease with increase in storage months. The highest SRL was recorded at 2 months (8.739) while the lowest was recorded at 8 months (1.327). The interaction result showed that V_3 x 2 months (8.739) gave the highest SRL while the lowest SRL was V_1 x 8 months (1.327). There were significant differences ($P<0.05$) among variety x storage period on SRL of soybeans as seen on Table 15.

This findings is in line with the report of Balesevic et al. [27]. It is also in line with the findings of Tactic et al. [8], Sharma et al. [28] and Khaliliagdam et al. [25].

3.6.2 Interaction effect of packaging material and storage period on the seedling root length of soybeans

The effect of packaging material and storage period on the SRL of soybeans is presented on Table 6. The result showed that cloth recorded the highest SRL (10.258) while the lowest was also cloth at a different storage period. The next highest was plastic container (7.022), then glass bottle (6.693). The investigation showed that the highest SRL was recorded at 2 moths (10.258). It was observed that generally, the SRL decrease with increase in storage period irrespective of the packaging material. The result of the interaction showed that cloth x 2 months gave the highest (10.258) while cloth x 8 months gave the lowest (0.00) SRL. There were significant differences ($P<0.05$) among packaging material and storage period on SRL of soybeans.

The significant difference observed could be due to the alteration in the carbohydrate quality while in storage which could have affected the cell membrane permeability .This study confirms the work of Kandil et al. [12] who reported differences in root and shoot length and root/shoot ratio in soybean. Panobianco et al. [17] also found that alterations in carbohydrates during storage could affect the cell membrane permeability, thus contributing to the reduction in the physiological quality and germination of seeds.

3.6.3 Interaction effect of variety and packaging material on the seedling root length of soybeans

The effect of variety and packaging material on the SRL of soybeans is presented 0n Table 7. The SRL varied with variety. The result showed that V_2 recorded the maximum (4.788) SRL while the minimum was V_1 (2.55). The result also showed that glass bottle recorded the highest and the lowest SRL but with different variety. However, the soybeans that were not stored (control) recorded higher SRL values than all of them (Table 17). The interaction showed that V_2 x bottle gave the highest value of SRL while V_1 x bottle gave the lowest value of SRL. There were

significant differences (P<0.05) among variety and packaging material on SRL of soybeans.

Though the mean values across the packaging materials and down the varieties vary, they are statistically not different this might be due to inconsistent measuring technique. The present study is in line with Mohammadi et al. [24] who reported that seed deterioration resulted in decreased percentage and rate of germination and decreased percentage of normal seedlings. Vange et al. [23], Tatic et al. [8], Sharma et al. [28] gave similar reports.

3.6.4 Interaction effect of variety and storage on the seedling length of soybeans

The effect of variety and storage period on the seedling length of soybeans is presented on Table 8. The result showed that V_3 had the highest (16.866) seedling length and the lowest was V_1 (4.071). It was also observed that as the storage period increased, the SL decreased. The maximum SL was recorded at 2 months (16.866) while the minimum was recorded at 8 months (4.071). The result of the interaction showed that V_3 x 2months had the highest SL while V_1 x 8months had the lowest SL on soybeans. There were significant differences (P<0.05) among variety and storage period on seedling length of soybeans as seen on Table 8.

The interaction showed a significant difference due to low germination caused by the varietal difference and ageing effect leading to depletion of food reserves, seed deterioration, fluctuating temperature, relative humidity and seed moisture content The present study is in conformity with the work of Akter et al. [14] who reported that the decline in seedling length at the end of the storage period were due to reduced seed germination and damage caused by insect, pests during storage which might have hindered the seedling growth. Similar reports were given by [29].

Table 5. Effect of variety and storage period on the seedling root length of soybean

	Control	2 months	4 months	6 months	8 months
V1	4.373	4.348	2.436	2.838	1.327
V2	8.337	8.551	5.403	4.317	2.278
V3	7.233	8.739	4.29	3.48	2.117

*LSD variety*month=1.33*

Table 6. Interaction effect of packaging material and storage period on the seedling root length of soybean

	Control	2 months	4 months	6 months	8 months
Cloth	6.648	10.258	2.501	1.232	0
Control	6.648	6.648	6.648	6.648	6.648
G. Bottle	6.648	6.693	2.60	3.096	2.012
LDPE	6.648	6.633	3.563	4.051	1.438
L. Paper	6.648	6.02	4.404	2.718	0.613
P. container	6.648	7.022	4.542	3.524	0.732

*LSD pm*month=1.88*

Table 7. Interaction effect of variety and packaging material on the SRL of soybean

	Control	Cloth	Bottle	LDPE	Paper
V1	4.373	2.993	2.55	2.897	2.856
V2	8.337	4.747	4.788	5.591	4.979
V3	7.233	4.643	5.291	4.912	4.407

LSD Variety packaging material = NS*

Table 8. Effect of variety and Storage period on the Seedling length of soybean

	0 month	2 months	4 months	6 months	8 months
V1	9.28	9.008	5.436	6.164	4.071
V2	19.36	15.262	9.936	9.459	5.639
V3	15.24	16.866	8.36	6.73	5.113

*LSD Variety *S. period= 2.11*

3.6.5 Effect of packaging materials and storage period on the seedling length of soybeans

The interaction effect between packaging material and storage period is presented on Table 9. The result showed that the SL ranges between 18.044(cloth) – 0.0 (cloth). The highest SL was recorded for soybeans stored in cloth while the lowest was also recorded in cloth but at different storage period. It was observed that at the early stage of the storage, SL was very high for cloth and dropped sharply before the end of the storage period. Generally, the SL dropped as the storage period increased irrespective of the variety. The result of the interaction showed that cloth x 2 months had a better SL (18.044) while cloth x 8 months had a very poor SL (0.00). There were significant differences ($P<0.05$) among packaging materials and storage period on SL of soybeans.

The significant interaction was due to the moisture resistance of some of the packaging materials. Although cloth had the highest seedling length at 2 months that is not to say that cloth is moisture resistant. The seedling length of the soybeans stored in cloth dropped to 0.0 at the end of the storage period. Akter et al. [14] reported that Seedling characters like shoot length, root length (seedling length) varied over storage containers and storage period. Storage container showed significant effect on root length and shoot length which decreased with the increase in storage period. Monira et al. [19] also asserted that increasing rate of abnormal seedling and dead seed was observed higher in cloth bag, due to high moisture and fungal activities in soybean.

3.6.6 Interaction effect of variety and packaging materials on the sl of soybeans

The effect of variety and packaging materials on the seedling length of soybeans is presented on Table 10. The results of the SL values for varieties vary. The SL for varieties ranges between 10.984-5.672 (V_2 and V_1 respectively).The packaging material too varies in terms of their SL. The highest SL was recorded for plastic (11.672) while the lowest was recorded for laminate paper (5.672). The result of the interaction showed that V_2 x plastic recorded the highest (11.672) while V_1 x Laminate paper recorded the lowest. There were significant differences.

The significant difference might be due to their genetic differences inherent in seed structure and composition and the vapor-proof nature of some the packaging materials. The present study is in consonance with the findings of Kandil et al. [12] who reported differences in root and shoot length and root/shoot ratio in soybean. Vange et al. [23] and Ambika et al. [30] gave si1ilar reports.

3.7 Seedling Vigor

3.7.1 Interaction effect of variety and storage period on seedling vigor of soybeans

The interaction effect of variety and storage period is presented on Table 11.

Table 9. Interaction effect of packaging material and storage period on the seedling length of soybean

	0 month	2 months	4 months	6 months	8 months
Cloth	14.627	18.044	4.924	2.739	0
Control	14.627	14.627	14.627	14.627	14.627
G. Bottle	14.627	12.389	4.739	6.191	5.411
LDPE	14.627	12.533	6.854	8.12	4.768
L. Paper	14.627	12.431	8.318	5.498	1.65
P. container	14.627	12.247	8.002	7.533	3.19

*LSD p. material * S. period = 2.99*

Table 10. Interaction effect of variety and packaging material on the SL of soybeans

	Control	Cloth	Bottle	Density	Paper	Plastic
V1	9.28	6.048	6.108	6.915	5.672	6.728
V2	19.36	9.121	9.845	10.984	10.607	11.672
V3	15.24	9.03	10.061	10.243	9.235	8.959

*LSD variety * p. material =2.59*

The seedling vigor varies among varieties. The seedling vigor in this study ranges between 1648.46 -185.58 (cm). The result showed that V_3 had the highest seedling vigor while V_1 has the lowest seedling vigor. The effect of storage period showed that as the storage period increased the Seedling vigor decreased. The highest seedling vigor was recorded at 2month and the least was recorded at 8 months (1648.46 and 185.58 respectively). The interaction effect between variety and storage period showed that V_3 stored for 2 months recorded the highest seedling vigor (1648.457) while V_1 at 8 months recorded the lowest seedling vigor (Table 11). There were significant differences ($P<0.05$) observed among variety and storage period. The variety and storage period interaction had significant effect on the seedling vigor which might be due to their age induced deterioration and inherent differences in seed structure and composition. The seedling vigor decreased with increase in storage period as a result of reduced seed germination and damage caused by insect, pests during storage which might have hindered the seedling growth. The present study is in line with the work of Ambika et al. [30] who reported that the seedling vigor index decrease by increase of the storage period. Similar findings were also reported by Patel et al. [33], Vange et al. [25], Nithya et al. [34].

3.7.2 Interaction effect of p.m. and storage period on seedling vigor of soybean

The effect of P.M. and storage period on the seedling vigor is presented as seen on Table 12. Seedlings were very vigorous initially but declined with storage period. The result showed that the highest seedling vigor was at 2 months (1755.56) while the lowest was at 8 months (0.0).The seedling was even higher at 2 months than the initial (1755.56 and 1238.800 respectively). The effect of packaging material on seedling vigor on soybean showed that cloth had the highest seedling vigor at 2 months and the lowest (275) at 8 months (0.00). The next vigorous seed is the seeds stored in laminate paper (1375.2). The result of interaction between p.m. and storage period showed that cloth at 2 months recorded the highest (1755.56) seedling vigor followed by laminate paper (1375.2), then LDPE (1300.2), glass bottle (1235.32) plastic container is the least at 2months (1070.6) as the storage period increased, the seedling vigor dropped. The beans stored in cloth had high seedling vigor initially but dropped to 0.00 at the end of the storage period. LDPE maintained constant seedling vigor up to 8 months (157.99). There were significant differences ($P<0.05$) among p.m. and storage period on the seedling vigor of soya beans. The packaging material and storage period interaction was significant as result of the pervious nature of some of the packaging material and the effect of the length of time. The more pervious the packaging material is, the faster the deteriorative effect and vice versa. The longer the storage time, the more the soybean is exposed to agents such as air, moisture, temperature, fungi which hastened the respiratory activity and consequently deterioration. The present findings is in line with the report of Patel et al. [31] who asserted that Packaging container and storage duration significantly affected viability and seedling vigor.

Table 11. Interaction effect of variety and S period on the seedling vigor of soybeans

	0months	2 months	4 months	6 months	8 months
V1	796.33	758.391	461.66	304.12	185.58
V2	178.583	1580.977	931.757	661.259	381.283
V3	1313.887	1648.457	703.364	524.915	285.391

*LSD variety*month=208.84*

Table 12. Effect of packaging material and storage period on the seedling vigor of soybeans

	0months	2 months	4 months	6 months	8 months
Control	1443.607	1238.743	1238.743	1238.743	1238.743
Cloth	1238.800	1755.56	375.58	39.827	0.00
G.Bottle	1238.800	1235.32	468.951	286.043	151.389
LDPE	1238.800	1300.222	730.551	448.787	157.992
L. Paper	1238.800	1375.2	666.124	413.402	73.258
P. container	1238.800	1070.604	713.613	553.773	83.126

*lsd PM*month=295.34*

Table 13. Interaction effect of variety and packaging material on the seedling vigor

	Control	Cloth	G. bottle	LDPE	L. paper	Plastic container
V1	798.52	551.639	393.141	462.893	409.972	391.136
V2	1720.665	752.019	780.388	1021.472	1013.312	1028.768
V3	1319.963	742.203	854.773	841.446	836.787	775.046

*LSD variety*PM=255.78*

3.7.3 Effect of variety and p.m. on the seedling vigor of soybean variety

The interaction effect between variety and packaging material on seedling vigor is presented on Table 13.

The result showed that V_2 (TGX1904-6F) had higher seedling vigor while V_1 (TGX 923-3F) had the lowest (391.136) seedling vigor. The effect of packaging material on seedling vigor showed that plastic container recorded the highest seedling vigor (1028.768) and also recorded the lowest at V1 (391.136).The result showed that V_2 x plastic container had the highest (1028.768) seedling vigor while V_1 x plastic container had the least (391.136). The interaction effect of variety x packaging material on seedling vigor showed significant differences ($P<0.05$). The significant difference could be due to genetic variability and effect of packaging material. The rate of deterioration varied from variety to variety and from packaging materials to packaging materials depending on the vapor resistance. The present findings is in line with the reports of Akter et al. [14], Bortey et al. [33], Kamara et al. [34] and Obute et al. [36].

4. CONCLUSION AND RECOMMENDATION

Soybeans can be stored at ambient and still maintain its viability and vigor if stored at suitable temperature and airtight packaging materials. The effect of variety, packaging material and storage period were determined in this study. The individual interaction effect were evaluated. The three varieties were TGx 932-3F, TGx 1904-6F and TGx 1448-2E. Storage period considered were 2 months, 4 months, 6 months and 8 months. The treatment individually and collectively affected each variable. The packaging material, variety, storage environment the moisture content at the time of storage all determine the storability of soybeans. Investigation revealed that TGx 1448-2E proved to do better in terms of shoot seedling length while TGx 932-3F had the least shoot seedling length. The highest seedling vigor was recorded in V2 (TGx 1904 – 3F) stored for 2 months while the lowest was recorded in V_1 (TGx 932 -3F) On the whole, LDPE proved to be the best packaging material and the variety that had more resistance to deterioration was TGx 1904- 6F (V2).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle3.com/review-history/47554