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Effect of Variety, Packaging Materials and Storage Period on Three Varieties of Soybeans in Makurdi, Benue State, Nigeria

J. O. Obute[1*], S. V. Irtwange[2] and T. Vange[2]

[1]Department of Biological Sciences, CEFTER, Benue State University, Makurdi, Nigeria.
[2]Center for Food Technology and Research, CEFTER, Benue State University, Makurdi, Nigeria.

Authors' contributions

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

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ABSTRACT

This work was carried out at the seed science laboratory in the Federal University of Agriculture Makurdi, Nigeria. It was aimed at assessing the germination parameters of soybeans stored under ambient condition. The experimental design was factorial in 3x5x6x comprising 3 varieties, 5 storage periods and 5 packaging materials by 3 replicates. The varieties investigated were TGx 932- 3F, TGx1904- 6F and TGx1448- 2E stored in cloth, glass bottle, plastic container, low density polyethene and laminate paper. The storage periods were 0, 2, 4, 6 and 8months Least significant (LSD) at 5% was used to compare the treatment means. The seeds in storage was sampled periodically (2, 4, 6 and 8 months) to determine quality by conducting a standard germination test with 100 seeds (100 seeds/rep). The germination percentage, germination index and germination rate index were evaluated. TGx 1904- 6F (V2) proved to do well in all the germination parameters. Low density polyethene proved to be the best packaging material in terms of the germination percentage and germination index. Laminate paper seemed to be the best for germination rate index. There was no significant difference in the interaction effect of all parameters. The present study revealed that soybeans stored for 4months at ambient could still do well in terms of the germination percentage, germination index and germination rate index.

**Corresponding author: E-mail: justinaobuteoma50@gmail.com;*

Keywords: Soybeans; germination; storage period; packaging material.

1. INTRODUCTION

Soybeans are leguminous vegetable of the pea family that grow in tropical, subtropical and temperate climate [1] soyabeans are often called the "Miracle crop". They are the world's foremost provider of vegetable protein and oil. The bushy, green soya bean plant is a legume related to peas, groundnut (peanuts) and alfalfa, soya beans are included in the category of oilseed which is a generic reference to crops with seed that can produce edible and or non-edible oil in economic quantities [2]. Nigeria presently produces about 500,000 MT of soya beans annually making it the largest producer of the product on the African content. Soybeans is a legume which is produced most in the middle belt of the country with Benue State accounting for about 45% of the total production in the country. Soybeans is an important source of high and inexpensive protein and oil. With an average protein content of 40% and oil content of 20%. Soybeans has the highest protein content of all food crops and second only to groundnut in terms of oil content among food legumes. Soybeans are used in the production of milk, edible oil and animal feeds. Its high protein content and price makes it the best option in terms of treating malnutrition which currently is estimated at US $40 billion [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].

Poor seed germination is a major constraint for increasing the productivity of soybeans. Seed longevity is greatly influenced by the relative humidity and storage temperature, storage condition and duration are important factors affecting germination. Seed vigor is used as a measure of accumulated damage in seed as viability declines. Preservation of seed viability depends on storage condition and duration. The decline of germination is much more acute under tropical conditions [3]. Seed deterioration during storage is one of the basic reason for low productivity in soybeans. Changes that occur in seed during ageing are significant in terms of seed quality among other thing also implies seed longevity [3]. Different periods of seed storage, as well as ageing condition adversely, affect seed vigour. Seeds deteriorate and lose their germinability during periods of prolonged storage [4].

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]. Seed production rate and for to plant production researches is needed. The availability of high quality seeds is a crucial factor in development of sustainable agriculture. The storage is one of the important factors affecting the seed quality. At physiological maturity stage the seed vigour of crops is the highest, but after harvesting and during storage it changes. Also, seed vigour is the first component of seed decreases and will also reduce. Therefore in order the weak emergence, reduction in a stored with a certain moisture and storage till planting season is necessary [6]. Good storage is a basic requirement in seed production program as the maintenance of high seed viability and vigor from the harvest to planting is of utmost importance in a seed production program [3]. Viable seeds had, and still have, to be maintained from one growing season to the next and the necessity of seed conservation (*in-situ* or *ex-situ*) is one of the best strategies for the protection of plant diversity [7]. The study is aimed at investigating the effect of variety, packaging material and storage period on germination percentage of three (3) varieties of soybeans.

2. MATERIALS AND METHODS

2.1 Study Area

Newly harvested soybeans were purchased from National cereal research institute, Yandev sub station. The beans were cleaned and moisture content was taken. It was then stored in various packaging material at the Strategic Grain Reserve, Federal Ministry of Agriculture Makurd 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, Benue State Nigeria. Five hundred grams (500g) of each varieties of soybeans was measured into the various packaging materials and their initial moisture content noted. They were then arranged in 3 replicates and stored for 2 months,

4 months, 6 months and 8 months. The varieties under consideration are TGx 932- 3F, TGx 1904-6F and TGx 1448-2E.

The packaging materials are: Cloth bag, laminate paper bag. Glass bottle, low density polyethene bag and plastic container.

2.2 Measuring the Variables

Germination test was carried out at the beginning of the experiment to ascertain the value of the germination percentage, germination index and the germination rate index. Subsequently, germination test carried out at 2months, 4months, 6months and 8months.

2.3 Germination Test and Procedure

Twenty five healthy (25) seeds were placed on double layered filter paper and moistened [8]. Analysis of variance of all parameters (germination percent, germination index and germination rate index) was computed using statistics version 21. To evaluate the effect of the various variable on the quality of soybean seeds after storage, germination test was conducted. Germination percentage and germination index were calculated using these formulae [9].

Germination %

$$= \frac{No\ of\ seedlinggs\ germinated\ \ x}{Total\ no\ of\ seed\ planted} \times 100$$

Germination rate index

$$= \frac{germination\ \ index}{Total\ germination\ \%}(\text{decimal})$$

Germination index was calculated using the formula adopted by AOSA, 1983

$$GI = \frac{No.\ of germinated\ seeds}{days\ of\ \ first\ count} + \text{------} + \frac{no.of\ \ germinated\ seeds}{days\ of\ \ final\ count}$$

3. RESULTS AND DISCUSSION

3.1 Germination Parameters

Table 1: Germination percentage

The effect of variety on the germination percentage is presented on Table 1.

The germination percentage varies with variety. The highest germination percentage was recorded for V_2 while the lowest was recorded for V_1. The difference in germination percentages between V_1 and V_2 is 18.34% while the difference between V_1 and V_3 is 8.35% The result showed that there was a significant difference ($P<0.05$) observed in germination percentage of soybeans seed among different varieties. The present study revealed that germination percent of soybeans in storage varies among varieties.The significant difference could be due to the quantity of food reserve in the seeds as expressed in the seedling establishment of different varieties. Vange et al. [10] reported that 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. Ghahfarokhi et al. [4] reported that seeds deteriorate and lose their germinability during periods of prolonged storage. This work is also in conformity with the work of Julio Marcos-Filho [11]. Where he asserted that seed viability in storage is a genetic character and is influenced by species and varieties. The present findings is similar with Jitendra et al. [12].

3.2 Germination Index

The effect of variety on the germination index of stored soybean seeds is presented on Table 1. The influence varies with variety. The result showed that V_2 had the highest germination index of 7.12 while the lowest was V1 with a value of 5.11. The difference in the germination index of V_1 and V_2 was 2.01 while the difference between V_2 and V_3 was 0.78. The difference between V_3 and V_1 was 1.23. Significant difference was observed in germination index of soybeans among varieties. The difference could be due to variation in the genetic make-up and chemical composition which influence the expression of seed deterioration. El-Abady et al. [13] asserted that assessment of some soybean cultivars seed quality during storage by monitoring germination and germination after storage, in addition to seed and seedling vigour measurement may be reliable indicators for damages occurred after mechanical threshing method.

3.3 Germination Rate Index

3.3.1 The effect of variety on germination rate index of soybeans is presented on Table 1

The effect of variety on germination rate index varies with variety. The result showed that V_2 had the highest germination rate index of 645.82 while V_1 had the lowest germination rate index of 378.80. The difference between V_2 and V_1 in

terms of their germination rate index is 267.02 and the difference between V_2 and V_3 is 134.37. The result showed that there was a significant difference ($P<0.05$) in germination rate index of soybeans among varieties as shown on Table 1. The difference in the germination rate index could be as result of the genetic make-up of the various varieties. The thickness of the seed coat varies from variety to variety. This finding is in line with Jyoti and Malik, [14] who reported that genetic make-up of varieties also influences storability.

Table 1. Effect of variety on the G%, GI and GRI of soybean

Variety	G%	GI	GRI
V1	60.51c	5.11c	378.80c
V2	78.85a	7.12a	645.82a
V3	69.36b	6.34b	511.45b
LSD	2.66	0.337	34.767

Treatment means not followed by the same letters are different. Otherwise they are the same at 5% level of significance.
G% - germination percent, GI – Germination Index, GRI – Germination Rate Index

3.3.2 Effect of packaging material on the germination percentage of soybeans

The effect of packaging materials on the germination percentage of soybeans is presented on Table 2. The effect of packaging materials on the germination percentage of soybean seeds showed that control had the highest (88.00) while the lowest germination percentage was recorded in soybeans seeds stored in cloth (53.38) Control had the highest mean value as the soybeans had not undergone deterioration and so the food reserve was intact. LDPE recorded a higher (73.56) germination percentage than all the packaging materials. There was significant difference ($P<0.05$) in germination percentage of soybeans among different packaging materials as seen in Table 2. The significant difference could be as a result of the pervious nature of some packaging material. Cloth has proved to be more pervious to moisture than all the packaging materials in this study .With the absorption of moisture from the surrounding, catabolic reaction was hastened and consequently the food reserve used up. The reduction in food reserve affect the germination percentage. This work is in consonance with the work of Sucheta Sharma et al. [15] who reported that high germination percentage can be maintained for 14 months in seeds packed in 700 guage polythene bags whereas, it fell to 3 per cent and 1 per cent, respectively in seeds packed in cloth bags by 8 months.

3.3.3 Effect of packaging materials on the germination index of soybean

The effect of packaging materials on the germination index of soybean is presented on Table 2. The results of the effect of packaging materials on the germination index showed that LDPE had the highest (6.22) germination index while cloth recorded the lowest germination index of 5.12. Though control had the highest mean value of 8.06 because the soybeans had not undergone deterioration and so the food reserve was intact. LDPE had a higher germination index than all the packaging materials. Laminate paper and plastic container had the germination index value of 6.15 and 5.90 respectively. The difference in the germination index was as a result of the pervious nature of some of the packaging materials. There was significant difference ($P<0.05$) in germination index of soybeans seeds among different packaging materials as seen on Table 2. This work is in consonance with the findings of Tripathi and Lawande [16] and Jyotindra et al. [17] both in onions that significant differences exist in seed germination and seedling vigor among different packaging materials. Vange et al. [10] asserted that prolonged storage life of soybean seed without the use of chemical could be achieved by the use of different kinds of packaging materials.

3.3.4 The effect of packaging materials on the germination rate index of soybeans

The main effect of packaging materials on germination rate index of soybeans is presented on Table 2. The result showed that control had the highest germination rate index of 715.53 while the lowest was cloth (414.23). Control had the highest mean value as the soybeans had not undergone deterioration and so the food reserve was intact. The packaging material that had a higher germination rate index is Laminate paper with a value of 533.22 (Table 2). The main effect showed that there was a strong significant difference ($P<0.05$) in germination rate index of soybeans seeds among different packaging materials.

3.3.5 Effect of storage period on the germination percentage of soybean

The effect of storage period on the germination percentage of soybean seeds is presented on

Table 2. Effect of packaging material on the G%, GI and GRI of soybeans

P.M.	G%	GI	GRI
Control	88.00a	8.06a	715.53a
Cloth	53.38e	5.12d	414.23c
Glass bottle	64.76d	5.70c	423.72c
Low density polyethene	73.56b	6.22b	487.33b
Laminate paper	69.49c	6.15bc	533.22b
Plastic container	68.23cd	5.90bc	498.11b
LSD	3.76	0.478	49.17

Treatment means not followed by the same letters are different. Otherwise they are the same at 5% level of significance.
G% - germination percent, GI – Germination Index, GRI – Germination Rate Index

Table 3. The study showed that soybean seeds stored for 2 months had the highest germination percentage and the least was in 8 months (89.80 and 33.80 respectively). It was observed that the germination decreased with increase in storage period as seen in Table 3. However, there was significant difference in the germination percentage of soybeans among the storage periods. The longer the storage time, the more the catabolic reaction. The difference could be as a result of continuous catabolic reaction resulting in depletion of food reserve. The result of the present study is in line with the work of Tatipata [18]. Gbolami et al. [19] also reported that by increasing the storage period of soybean and rice seeds, germination rate coefficient is decreased.

3.3.6 Effect of storage period on the germination index of soybeans

The effect of storage period on the germination index of soybeans is presented on Table 3. The result showed that as the storage period increased, the germination index decreased. The highest germination index was recorded at 2 months while the lowest was recorded at 8 months (8.47 and 2.98 respectively). The germination index of soybeans stored for 4 months and 6 months had the germination index value of 6.31 and 5.12 respectively as seen in Table 3. Significant difference ($P<0.05$) was observed in germination index of soybeans seeds among different storage periods. With increase in storage period there was a decline in the alpha amylase activity and sugar content. This present study agrees with the work of Mitra et al. [20] who reported that decrease in germination of aged seeds might be due to either decline of alpha amylase activity and sugar content.

3.3.7 Effect of storage period on the germination rate index of soybeans

The effect of storage period on the germination rate index of soybeans is presented on Table 3. The effect of storage period on the germination rate index (GRI) showed that the GRI decreased with increase in storage period. The highest GRI was recorded at 2 months (766.59) while the lowest (178.13) was at 8 months. At 4 months, the GRI was 515.26 and at 6 months, it was 384.61. The effect showed that there was a significant difference ($P<0.05$) in GRI of soybeans among different storage period (Table 3).

Table 3. Effect of storage period on the G%, GI and GRI of soybeans

Storage period	G%	GI	GRI
0	87.17a	8.06a	715.53b
2	89.80a	8.47a	766.59a
4	77.63b	6.31b	515.26c
6	59.37c	5.12c	384.61d
8	33.89d	2.98d	178.13e
LSD	3.44	0.436	44.89

Treatment means not followed by the same letters are different. Otherwise they are the same at 5% level of significance.
G% - germination percent, GI – Germination Index, GRI – Germination Rate Index

3.4 Interaction Effects

3.4.1 Germination percent

3.4.1.1 Effect of variety and storage period on germination percentage on soybean

The interaction effect of variety and storage period on the germination percentage of soybean is presented on Table 4a. The germination

percentage varied with the different varieties. The result showed that V_1 had the lowest germination percentage with 29.89 and V_2 had the highest germination percentage with 97.78. The effect of storage period on germination percentage varies with months. It was observed that as the storage period increased, the germination% (viability) of the seed decreased. The highest germination was observed at 2 months (97.78) apart from the initial which was 98.72. The lowest germination percentage recorded was at 8 months (29.89) as seen 0n Table 4a. The interaction effect between variety and storage period showed that V_2 at 2months recorded the highest germination percentage (97.79). The lowest germination percentage recorded was at 8months (29.89). There were significant difference ($P<0.05$) observed in the interaction between variety x storage period.

The significant difference could be due to the varietal differences and the decline in food reserve. The present study is in line with the findings of Shelar [21], who stated that irrespective of genotypes, the germination potential of soybean seeds decreased during storage. It also confirms the work of Nagel [22] who maintained that Millard product are in naturally aged soybean seeds and were associated with the loss of seed viability under long term storage conditions.

3.4.1.2 Effect of packaging material and Storage period on germination percentage of soybean

The interaction effect of packaging material and storage periods on germination percentage is presented on Table 4b. The result showed that different packaging materials have different effect on germination percentage of soybean. The highest (97.3) germination percentage was recorded in soybeans stored in cloth and the least was also in cloth (0.0) followed by plastic container (21.78). The investigation showed that soybeans stored for 2 months had the highest (97.3) g% 0f all the storage periods while 8 months recorded the lowest(0.0). The interaction effect between packaging material and storage period showed that soya beans stored in cloth for 2 months (97.3) has better germination percentage and the poorest is in cloth stored for 8 months (0.0%). It was also observed that LDPE is the next Packaging material that has a high germination percentage initially and maintained some reasonable germination percentage to the end of the storage period. The interaction effect showed significant difference ($P<0.05$) between packaging materials and storage period as seen on Table 4b. The significant difference could be as a result of depleting food reserve, seed deterioration, fluctuating temperature, relative humidity. This work is in line with the findings of Sharma et al. [23] who stated that seed viability gradually decreased from 64.5 to 39.2% as the time in storage increased from 2 to 12 months. Jitendra et al. [24] and Vijay et al. [25] had similar findings.

3.4.1.3 Effect of variety and Packaging material on germination percentage of soybean

The interaction effect of variety and P.M on germination percentage showed variation or differences in the germination. The highest germination percentage was recorded for V_2 while the lowest was recorded in V_1 (81.61 and 50.27 respectively). The result also showed that soybean stored in different packaging material varies in their viability (germination %). In this study, cloth showed the lowest (50.27%) germination percentage while LDPE recorded the highest (81.61). The interaction effect between variety and packaging material showed that V_2 x packaging material recorded a high value of 81.61% and V_1 x cloth recorded the lowest (50.27) as shown on Table 4c. There were significant differences observed among variety and packaging material on the germination percentage of soybeans. The significant difference could as a result of catabolic activity due the porous nature of some of the packaging materials .It could also be genetic. This work is in agreement with the findings of Haque et al. [26] 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

Table 4a. Effect of variety and storage period on the germination % of soybean

	0 months	2 months	4 months	6 months	8 months
V1	78.583	78.722	68.111	47.222	29.889
V2	98.917	97.778	86.222	72.667	38.667
V3	84.000	92.889	78.556	58.222	33.111

*LSD variety*month=5.96*

Table 4b. Effect of packaging material and storage period on the germination % of soybean

	0 months	2 months	4 months	6 months	8 months
Control	90.667	87.333	87.333	87.333	87.333
Cloth	86.467	97.333	64.444	18.667	0
G.Bottle	86.467	85.778	67.556	50.222	33.778
L Density	86.467	90.667	84	69.778	36.889
L.Paper	86.467	89.222	82	66.222	23.556
P. container	86.467	88.444	80.444	64	21.778

*LSD pm*month=8.42*

Table 4c. Effect of variety and packaging material on the germination % of soybean

	Control	Cloth	bottle	LDPE	Paper	Plastic container
V1	81.067	50.273	54.54	66.273	56.34	54.54
V2	98.933	59.207	73.873	81.607	78.94	80.54
V3	84	50.667	65.867	72.8	73.2	69.6

*LSD variety*pm=7.29*

physical structure and chemical composition which determine the viability of seed in storage. Bortey et al. [27] reported that seed stored in cotton bag under ambient temperature and humidity recorded the lowest vigour and germination percentage after 60 and 90 day period irrespective of variety. Tripathi and Lawande [28] and Patel et al. [29] both in onions reported that significant differences exist in seed germination and seedling vigour among various packaging materials.

3.5 Germination Index

3.5.1 The interaction effect of variety and storage period on Germination index of soybean

The effect of variety and storage period is presented on Fig. 1a. The result showed that V_2 recorded the highest (9.408) germination index while the lowest value was recorded for V_1 (2.498). The effect of storage period showed that 2month recorded the highest G.I. while 8 months recorded the lowest. The result of the interaction between variety and storage period on GI (Fig. 1a) showed that V_2 x 2 months recorded the highest while V_1 x 8months recorded the lowest Germination index. There were significant differences ($P<0.05$) observed among soybean variety and storage period on germination index.

The difference could be due to variation in the genetic make-up and chemical composition which influence the expression of seed deterioration and lipid changes of seed during storage and decrease in phospholipids and polyunsaturated fatty acids which led to marked decline in seed vigour and germination index. El-Abady et al. [30] asserted that assessment of some soybean cultivars seed quality during storage by monitoring germination and germination after storage, in addition to seed and seedling vigour measurement may be reliable indicators for damages occurred after mechanical threshing method. This present study also confirms the findings of Balesevic-Tubic et al. [31] who reported that differences in germination index due to storage periods might be due to lipid changes of seed during storage and decline in phospholipids and polyunsaturated fatty acids leading to marked decline in seed vigour and germination index.

3.5.2 The interaction effect of packaging material and storage period on the germination index of soybeans

The effect of p.m. and storage period is presented below (Fig.1b). The result showed that cloth had the highest (10.027) germination index and it still had the lowest at a different storage period (0.00). The highest G.I. was recorded at 2 months and the lowest (0.00) was recorded at 8months of storage. There were significant differences ($P<0.05$) among packaging material and storage period on germination index of soybeans as seen on Fig.1b. The significantly difference could be due to a decline in alpha amylase activity. Bortey et al. [27] stated that decrease in in germination of aged seeds might be due to either decline of alpha amylase activity and sugar content. This work is in line with the findings of Panobianco et al. [32], Sharma et al. Nithya [23].

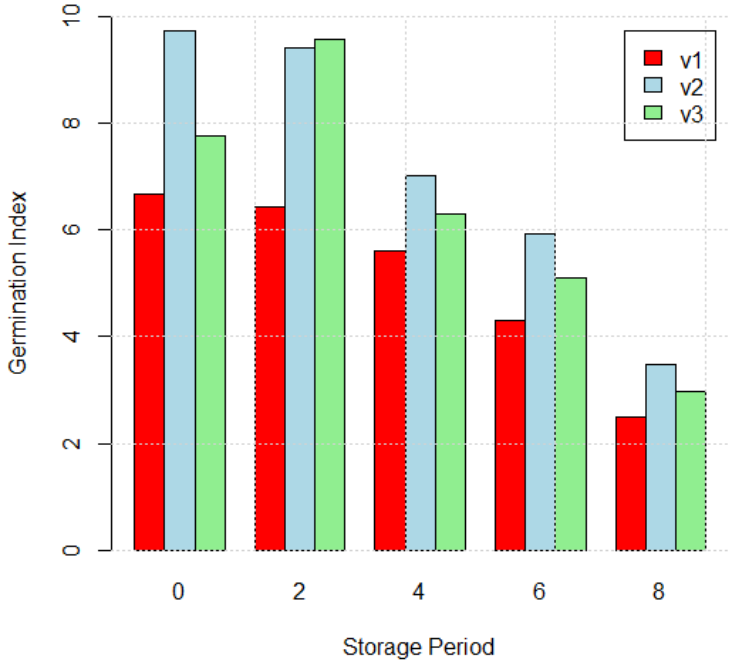

Fig. 1a. Effect of variety and storage period on germination index of stored soybeans

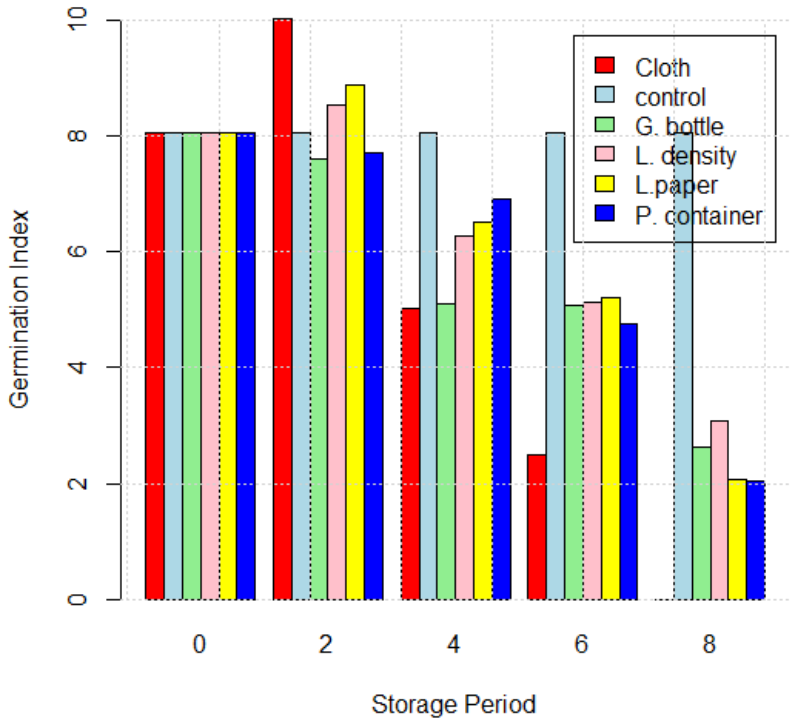

Fig. 1b. Effect of packaging material and storage period on germination index of stored soybean

3.5.3 Effect of variety and packaging material on the germination index of soybeans

The interaction effect of variety and p.m. is presented below (Fig.1c). The result showed that V_2 recorded the highest G.I. of 7.265 while the lowest G.I. was recorded for V_1 (4.342).The packaging material that recorded the maximum G.I. was plastic container (7.265) while the minimum was recorded for cloth (4.342).The result of interaction between variety and packaging material showed that V_2 (TGX-1904-6F) and plastic container recorded the highest G.I.((7.265) while V_1 (TGX-923-3F) stored in cloth recorded the lowest G.I.(4.342) on soybeans. There were significant differences ($P<0.05$) among variety and p.m. on the germination index of soybeans as seen on Fig.1c. Significant differences occur due to the varietal differences in soybean seeds. This could be as result of the deleterious effect of temperature, relative humidity and moisture from the surrounding depending on the packaging materials. This findings is line with the work of Panobianco et al. [32] who reported 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. This work also agree with the finding of Tame et al. [34] who stated that the storage life of seeds varies and environmental conditions in which the seeds are stored.

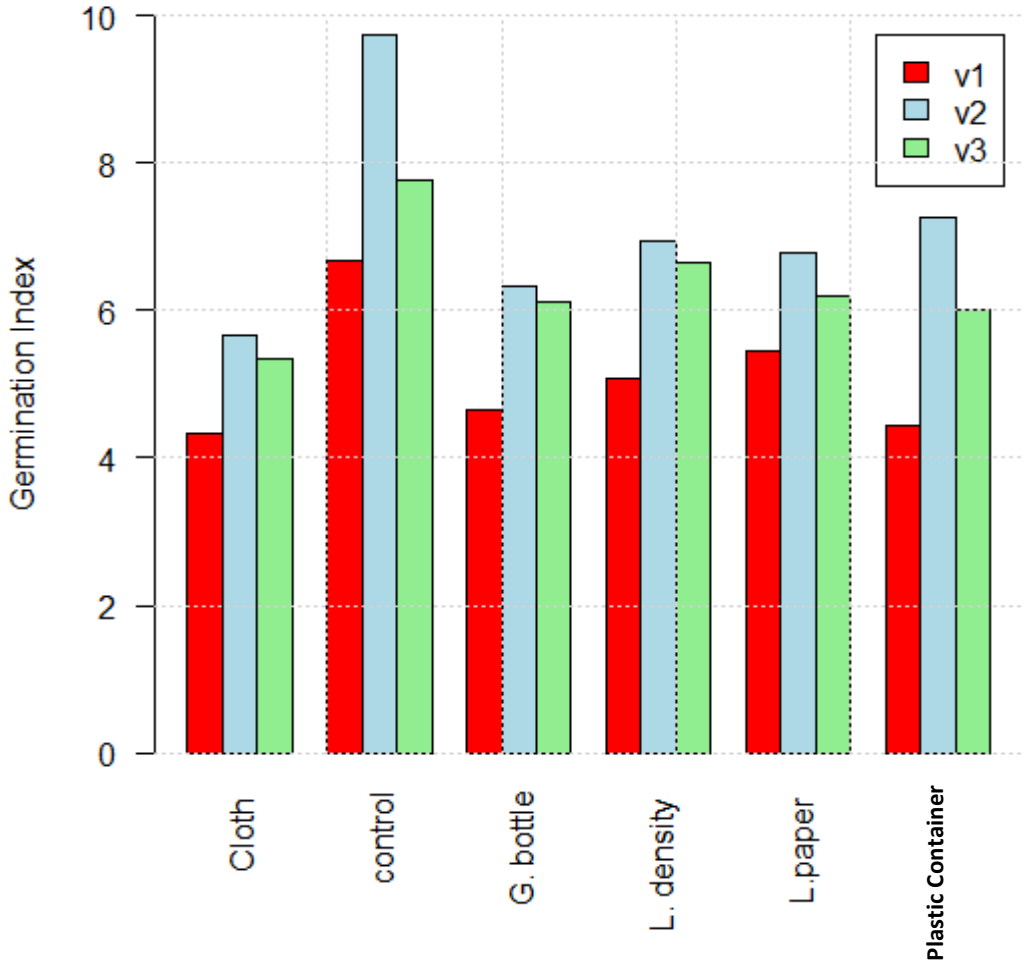

Fig. 1c. Effect of variety and packaging material on the germination index of soybeans

3.6 Germination Rate Index

3.6.1 The interaction effect of variety and storage period on the germination rate index of soybeans

The interaction effect of variety and storage period is presented on Table 5a. The result showed that V_2 (TGX-1924-6F) recorded the highest GRI of 911.514 whileV_1 (TGX-923-3F) recoded the lowest GRI of 137.365. The result of the storage period showed that the GRI control was the highest (959.120) followed by storage at 2months and the lowest GRI was at 8 months 137.365). The result of the interaction showed that V_2 that x control recorded the highest GRI (959.120). The lowest GRI was recorded for V_1 stored for 8 months. It has been observed that GRI decreased with increase in storage period in all varieties. The interaction effect showed that there were significant differences ($P<0.05$) among variety and storage period on germination rate index of soybean (Table .5a). The significant difference was due to the fact that the soybeans varieties have difference genetic make-up and generally the more the storage period, the less the germination parameters. Haque et al. [26] 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. Narayan et al. [35], also reported that physical, chemical and biochemical alterations may occur in soybeans, depending on conditions and storage duration.

3.6.2 The interaction effect of packaging materials and storage period on the GRI of soybeans

The investigation showed that cloth had the highest GRI of 976.943 and also had the lowest of 0.00. The result also showed that soybeans stored for 2months recorded the highest GRI while 8 months recorded the lowest GRI. The interaction effect showed that soybeans stored in cloth for 2 months recorded the highest GRI (976.943). Soybeans also stored in cloth for 8 months had the lowest GRI. There was decrease in GRI in all p.m. with an increase in storage period. There were significant differences ($P<0.05$) among p.m. and storage period on germination rate index of soybeans seen on the table below (Table 5b). There was a significant difference in their interaction which might be as result of the air-tight nature of some of the packaging materials. LDPE stored better than cloth due to the moisture and air proof nature of it. The present findings is consonance with the report of Tripathi and Lawande [28] who stated that storability of soybean cultivars could be enhanced by four months after storing seed in polythene bag compared to cloth bag.

Table 5a. Effect of variety and storage period on the germination rate index of soybean

	Control	2 months	4 months	6 months	8months
V1	535.133	501.478	412.679	307.334	137.365
V2	959.120	911.514	626.722	498.083	233.679
V3	652.323	886.775	506.375	348.415	163.346

*LSD variety*month=77.74*

Table 5b. Effect of packaging material and storage period on the GRI of soybean

	Control	2 months	4 months	6 months	8months
Cloth	715.526	976.943	348.674	30.013	0
Control	715.526	715.526	715.526	715.526	715.526
G. Bottle	715.526	660.391	349.372	294.88	98.427
L Density	715.526	748.514	515.263	339.77	117.584
L. Paper	715.526	748.514	515.263	339.77	117.584
P. container	715.526	698.739	609.989	403.418	62.863

*LSD pm*month=109.94*

Table 5c. Effect of variety and packaging material on the GRI of soybeans

	Control	Cloth	Bottle	Density	Paper	Plastic
V1	535.133	352.783	293.594	353.625	418.168	319.485
V2	959.12	480.929	503.023	610.623	629.819	691.427
V3	652.323	408.983	474.54	497.747	551.679	483.409

*LSD VARIETY * P M= 95.21*

3.6.3 The interaction effect of variety and p.m. on germination rate index of soybeans

The effect of variety and p.m. on germination rate index of soybean is as presented on table 5c. The result showed that V_2 had the highest GRI while V_1 had the lowest GRI. It also showed plastic container to have recorded the highest GRI (691.427) while bottle recorded the lowest GRI on soybeans. The interaction effect showed that V_2 x plastic container recorded the highest GRI while V_1 x bottle recorded the lowest GRI on soybeans. There were significant differences ($P<0.05$) among variety and p.m. on the GRI of soybeans (Table 5c). The significant difference was as a result of the decline in the food reserve due to the deteriorative effect of the air, fluctuating temperature and relative humidity of the packaging materials. Panobianco et al. [32] 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. These results are in conformity with those reported by Khaliliaqdam et al. [36], Sharma et al. [23], Tatic et al. [37].

4. CONCLUSION

Soybeans can be stored at ambient and still have its quality parameters intact only for a short while. The packaging materials, the variety, the storage environment and the moisture at the time of storage all determine the storability of soybeans. TGx 1904- 6F (V_2) proved to do well in all the germination parameters. Low density polyethene proved to be the best packaging material in terms of the germination percentage and germination index. The poorest storage material was cloth due to its pervious nature. Laminate paper seemed to be the best for germination rate index. The interaction effect between V2 x 2.months, cloth x 2months, V2 x plastic proved to be the best in terms of germination percentage. Soybeans stored for 4months at ambient could still do well in terms of the germination percentage, germination index and germination rate index. The longer the storage time, the more catabolic process which eventually affect the germination of soybean seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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