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Influence of Packaging Materials on Seed Germination of Cowpea Varieties during Short Term Storage

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Authors' contributions

This work was carried out in collaboration between all authors. Author OA designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors AO, AT and BA managed literature searches and overall planning and supervision of the experiment. Author OB performed the statistical analysis of the study. All authors read and approved the final manuscript.

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ABSTRACT

A storage experiment was conducted at the seed testing laboratory of the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria to examine the effect of packaging materials and storage periods on seed germination of cowpea. Seeds of two improved varieties of cowpea: Ife Brown and SAMPEA 12 were packed using three packaging materials viz. aluminium bags, plastic containers and envelopes. The seeds were dried to 12% moisture content with initial germination percentages of 90% and 88% respectively. The packaged seeds were stored under short-term storage conditions (temperature of 15.1 to 22.6°C and relative humidity of 26.9 to 50.7%) in Febrary 2015. The stored seed samples were drawn at three-month intervals starting from May 2015 to May 2016 which constituted five storage periods and evaluated for germination. The experiment was arranged in 2 x 3 x 5 factorial using completely randomised design (CRD) in three replications. The three factors were two varieties of cowpea, three packaging

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materials and five storage periods. The results of analysis of variance revealed that effect packaging materials were significant (P=.05) while an effect of storage period was highly significant (P<0.01) on seed germination of cowpea. The seeds packed in plastic containers recorded highest germination percentage of 75.9%. Germination values for seeds packed in envelopes (73.53%) and aluminium bags (70.20%) were not significantly different. Hence, plastic containers appeared to be the best for storage of cowpea seeds. Furthermore, increasing storage periods from 3, 6, 9 12 and 15 months resulted to declining in germination percentage with respective values of 91.4, 84.6, 74.4, 68.1 and 47.6%. Moreover, means for the interactive effect of variety by storage period revealed that cowpea varieties could retain viability values of 70% and above up to 12 months in storage at the present conditions used in the study.

Keywords: Cowpea; storage; germination; packaging materials; periods.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* [L] Walp) is the leguminous crop that is widely produced in Africa. Cowpea grains are an important source of affordable protein, vitamins and minerals in the predominantly carbohydrate-based diet of people in West Africa [1]. In Nigeria, the crop is grown mainly for its edible grains which contain about 23% by weight of protein. The grains can be cooked and made into stews and curries or ground into flour or paste to make delicacies such as bean cake, beanballs just to mention a few. It therefore, plays an important role in the diet of over 180 million Nigerian by providing protein requirements of the population. Due to its importance in Nigerian diet, Cowpea scientists from International Institute of Tropical Agriculture (IITA), Ibadan in collaboration with scientists from National Agricultural Research System (NARS) have made giant strides in developing over 30 improved varieties of cowpea to meet the requirements of major clients, the farmers [2]. However, conservation of this germplasm for immediate and future use in the breeding programme is still a big challenge.

Seed storage is the maintenance of high germination from storage till planting time. Therefore storage of seed and retention of viability form essential aspects in seed genebank management. Longevity or shelf life of seeds solely depends on the nature of the seeds, packaging materials, environmental conditions such as temperature and relative humidity, seed moisture content and storage duration. Seeds are hygroscopic which means they pick up and release moisture from and to the surrounding air until the vapour pressures of seed moisture and air reach equilibrium which can lead to rapid seed deterioration especially where humid conditions prevail. However, irrespective of the initial seed quality, unfavourable storage conditions particularly temperature and relative humidity of the storage environment contribute to accelerating seed deterioration [3]. Efforts must, therefore, be made to optimise the storage conditions to enhance the longevity of these crops in the storage environments. Besides, prolonged storage period can cause a reduction in germination and seedling vigour, accelerate seed ageing, increases germination time, electrical conductivity, insect infestation and finally, loss of seed weight [4].

Seed deterioration is a severe problem in developing countries especially where seeds are stored in places usually without proper control of humidity and temperature. To enhance the longevity of seeds, there is need to store in optimum conditions to maintain its quality. Several studies have been reported on the influence of packaging materials on germination of different species of crops. For instance, Bortey [5] reported low germination percentage in tomato seeds stored in a piece of cloth and tin container. Furthermore, it has also been reported that the storability of seeds in a storage environment varies among plant and within plant species [6,7].

Quality of germination is the most essential attribute of seed quality. The standard germination test is, therefore, used worldwide to determine the maximum germination potential of a seed batch under optimum conditions. According to the Association of Official Seed Analysts [8], seed germination is 'the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favorable conditions. Germination of seed is a function of storage period [9] hence, depending on the duration and method adopted, prolonged storage may lead to considerable reduction in germination or to the eventual death of the seeds. According to Kandil et al. [10], increasing storage periods from 3, 6,

9, and 9 months in storage decreased final germination percentage in soybean cultivars by 3.11, 9.11, 18.67 and 25.8% respectively.

In Nigeria, The National Centre for Genetic Resources and Biotechnology (NACGRAB), Moor Plantation, Ibadan, has the mandate for conservation and maintenance of valuable genetic resources for immediate utilisation and posterity. Over the years, NACGRAB had been distributing cowpea accessions from its working collections (short term storage) to meet the requirements of researchers in the National Agricultural Research System. In the short term storage chamber, different packaging materials are being used over the years in order to protect the seed from moisture absorption. The choice of appropriate packaging material and storage duration may, therefore, enhance germination of cowpea seeds from the storage environment. Moreover, an understanding of how best the seeds can be stored under short term storage temperature and relative humidity at relatively low cost, with minimum deterioration in quality for periods extending over one or more years will be of immense use to seed industry and genetic resources center like NACGRAB. The objective of this study, therefore, was to identify appropriate packaging material for storage of cowpea seeds under short term conditions and storage period for optimum germination.

2. MATERIALS AND METHODS

2.1 Genetic Materials and Location of the Experiment

Seeds of two improved varieties of cowpea: Ife brown and SAMPEA 12 produced during the growing season of 2014 were used for study. The materials were randomly selected among the varieties harvested and processed during the late season of 2014. The seeds were dried to about 12% moisture content with initial germination percentages of 90% and 88% respectively. Two hundred and fifty grams of each variety were packed separately in aluminium bags, plastic containers and envelopes. The laboratory experiment was conducted at NACGRAB between May 2015 and May 2016 at the seed testing laboratory of NACGRAB.

2.2 Seed Storage

The cowpea varieties were kept in the short term storage environments of NACGRAB in February 2015. The stored seed samples were drawn at three-month intervals starting from May 2015 to May 2016 which constituted five storage periods. The temperature of the environment ranged from 15.1 to 22.6°C while relative humidity ranged from 26.9 to 50.7%. Electricity supply was ensured for at least of ten hours daily in the short term storage environment.

2.3 Experimental Design

The experiment was arranged in 2 x 3 x 5 factorial using completely randomized design (CRD) in three replications. The three factors were two varieties of cowpea, three packaging materials and five storage periods. The stored seed samples were drawn at three-month intervals starting from May 2015 to May 2016 which constituted five storage periods and evaluated for germination test.

2.4 Standard Germination Test

One hundred seeds of each variety were drawn and evaluated for standard germination test in three replications. The test was assayed by placing the seeds in germination plastic containers lined with four layers of tissue paper moistened with 15ml of distilled water. The containers were covered and placed in a germinating chamber at 25 ± 2°C. The seeds were kept moist every day for seven days. Germination counts were determined at seven days after planting according to International Seed Testing Association (ISTA) rules [11].

2.5 Data Analysis

Data on germination percentage were subjected to analysis of variance (ANOVA) using Statistical Analysis Software, SAS Version 9.1 [12]. Data on percentages do not conform to normal distribution, the germination data were therefore log transformed before subjecting them to the ANOVA. However, since ANOVA did not detect any significant difference between transformed and untransformed values, untransformed values are hereby presented. Pertinent means were thereafter separated by the use of the least significant difference (LSD) at 0.05 level of probability.

3. RESULTS AND DISCUSSION

3.1 General Germination Performance

Seed deterioration is an inexorable process, which cannot be prevented during storage. However, the process can be slowed down.

Seed viability in storage is determined not only by the period of storage, but also the type of packaging materials used. The present study was an attempt to gather information on the appropriate packaging material and storage duration for the retention of seed viability during storage under short term storage conditions. The analysis of variance showed effect packaging materials was significant (P=.05) while effect of storage period was highly significant (P<0.01) on seed germination of cowpea. Also, interactive effects of variety by packaging material (VAR × PKM), variety by storage period (VAR × STP) and variety by packaging material by storage period (VAR × PKM × STP) were highly significant (P<0.01) on germination of cowpea seeds (Table 1).

Table 1. Mean squares from the analysis of variance for the germination test conducted on two varieties of cowpea seeds at NACGRAB, Ibadan

Source of variation	DF	Mean squares for germination
Replication	2	17.8ns
Variety (VAR)	1	98.2ns
Packaging Material (PKM)	2	248.7*
Storage Period (STP)	4	5161.0**
VAR*PKM	2	1040.2**
PKM*STP	8	72.9ns
VAR*STP	4	413.4**
ACC*PKM*STP	8	403.4**
Error	58	5273.8
Total	89	34093.5
R^2		0.8
CV (%)		13.0
Mean		73.2

**, **, Significant at probability level of 0.05 and 0.01, respectively; ns = not significant*

3.2 Influence of Packaging Materials and Duration in Storage on Seed Germination of Cowpea Seeds

Influence of packaging materials was significant on germination of cowpea seeds. The seeds packed in plastic container recorded highest germination percentage of 75.9%. Germination values for seeds packed in envelopes (73.53%) and aluminium bags (70.20%) were not significantly different (Table 2). Earnest et al. [13] also had similar conclusion who stated that cowpea seeds stored in plastic container had highest vigour and germination percentages of 61.1 and 77.1% respectively. The result was also in agreement with that obtained by Razia et al. [14] who stated that plastic containers appeared to be the best for storage of okra seeds. The results further revealed that germination percentage of cowpea seeds was significantly influenced by storage periods. Increasing storage periods from 3, 6, 9, 12 and 15 months resulted to decline in germination percentage with respective values of 91.4, 84.6, 74.4, 68.1 and 47.6%. These findings corroborated with that of some authors who worked on other species of crops. Arif M. [15] concluded that germination percentage was inversely related to storage duration in soybean as germination gradually decreased from 64.5 to 39.2% as the time in storage increased from 2 to 12 months. Kandil et al. [16, 17,10] also arrived at similar conclusion in their studies on soybean seeds. Furthermore, Tame [18] also reported that germination percentage of onion seeds decreased with increase in storage period.

Table 2. Influence of variety, packaging material and duration in storage on seed germination of cowpea seed at NACGRAB, Ibadan

Factors	Seed germination (%)
Variety	
Ife Brown	72.2a
SAMPEA 12	74.3a
LSD	4.0
Packaging Material	
Aluminum bags	70.2b
Plastic container	75.9a
Envelope	73.5b
LSD	4.9
Storage Period	
Month 3	91.4a
Month 6	84.6b
Month 9	74.4c
Month 12	68.1c
Month 15	47.6d
LSD	6.36

3.3 Interaction between Cowpea Varieties and Package Materials

The significant variety by packaging material interactive effect indicates that germination response of cowpea seeds varied from one packaging material to another. This finding agrees with that of Naguib et al. [19]. However from this study, the germination percentage of SAMPEA 12 stored in aluminium bag was significantly lower (62.4%) when compared with

the performance in plastic container and envelope which were not significantly different but exhibited better storability with the respective values of 77.6 and 76.5% (Table 3) suggesting that aluminium bag should be avoided in storing SAMPEA 12 under short term conditions used in this study. Moreover, germination percentages of Ife Brown stored in the three packaging materials used during the study were not significantly different with respective values of 78.0, 74.3 and 70.5% for aluminium bag, plastic container and envelope (Table 3).

Table 3. Effect of variety and packaging material interaction on seed germination of cowpea seeds at NACGRAB, Ibadan

Variety of cowpea	Packaging materials	Germination (%)
VAR 1	PKM 1	62.4
VAR 1	PKM 2	77.6
VAR 1	PKM 3	76.5
VAR2	PKM1	78.0
VAR 2	PKM 2	74.3
VAR 2	PKM 3	70.5
LSD		14.2

VAR 1= SAMPEA 12, VAR 2= Ife Brown
PKM1= Aluminium bag, PKM2= Plastic Container, PKM3= Envelope

3.4 Interaction between Cowpea Varieties and Storage Periods

The observed significant interaction between variety and storage period indicated that the germination of cowpea seeds drawn at each period varied between varieties.This result is in agreement with that obtained by Titapata [20]. Although, SAMPEA 12 had the highest germination at 3 months in storage with germination value of 93.1%. Similarly, Ife Brown variety had its highest germination at 3 months in storage with germination value of 89.8%. However,the interactive effect was not significant between 3 and 12 months in storage but at 15 months in storage, the interactive effect was highly significant ($P<0.01$) with respective values of 41.1% and 54% for SAMPEA 12 and Ife Brown varieties. This finding indicates that varieties of cowpea responded differently to storage periods after 12 months in storage. Nevertheless, the results indicated that cowpea seeds can retain viability values of 70% and above up to 12 months under storage conditions with mean temperature ranged from 15.1 to 22.6^{o}C and relative humidity ranged from 26.9 to 50.7% with power supply of at least ten hours daily.

Table 4. Effect of variety and storage period interaction on seed germination of cowpea seeds at NACGRAB, Ibadan

Variety of cowpea	Storage periods	Germination (%)
VAR1	STP1	93.1
VAR 1	STP2	90.2
VAR 1	STP3	72.4
VAR 1	STP4	64.0
VAR 1	STP5	41.1
VAR 2	STP1	89.8
VAR 2	STP2	78.9
VAR 2	STP3	76.4
VAR 2	STP4	72.2
VAR 2	STP5	54.0
LSD		11.5

VAR 1= SAMPEA 12, VAR 2= Ife Brown
STP1= Month 3, STP2= Month 6, STP3= Month 9, STP4= Month 12, STP5= Month 15,

4. CONCLUSION

The study led to the conclusion that packaging materials significantly influenced the germination of cowpea seeds under short-term storage conditions. Among the three packaging materials, plastic container seems to be the best for storing cowpea seeds. Also, the study concluded that increasing storage periods from 3, 6, 9 12 and 15 months resulted in declining in germination percentage with respective values of 91.4, 84.6, 74.4, 68.1 and 47.6%. Moreover, cowpea varieties can retain viability values of 70% and above up to 12 months in storage under short-term storage conditions (15.1 to 22.6^{o}C, 26.9 to 50.7% RH with a power supply of at least ten hours daily in the short-term storage environment).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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