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Germination Performance and Vigour of Pepper Seeds Stored in Different Environmental Conditions at Different Storage Periods

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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 first draft of the manuscript. Authors OA, UT, OJ managed the analyses of the study, literature searches and over all planning and supervision of the experiment. Authors OA and AT performed the statistical analysis. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

Pepper (*Capsicum annuum* L.) is an important fruit vegetable belonging to the family Solanaceae. The demand for this crop as a vegetable has increased especially in the urban centres, however, availability of quality seeds for sustainable production to meet the high demand has become a big challenge. The objective of this study was to investigate the influence of three storage environments on germination and vigour of pepper seeds. The experiment was arranged in 2 x 3 x 4 factorial using completely randomized design (CRD) in three replication. The factors were two accessions of pepper, three storage environments and four storage periods. The laboratory experiment was carried out at The National Centre for Genetic Resources and Biotechnology (NACGRAB) Ibadan,

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Nigeria starting from April 2015 to January 2016 which constituted four storage periods. The stored seed samples were drawn at three-month intervals and evaluated for germination and germination index. Analysis of variance (ANOVA) revealed that the effects of accession, storage environment and storage period were highly significant (P< .01) on germination of pepper seeds. Similarly, the effects of accession and storage environment were highly significant (P<.01) on germination index. The germination percentage for accession NGB 001010 was significantly higher (68.9%) than accession NGB 001066 which had germination percentage of 61.1%. In addition, germination index for NGB 001010 was significantly lower (5.3 days) compared with that of NGB 001066 which took about 5.9 days to germinate. Seeds stored under ambient conditions gave the lowest germination percentage (53.4%) and highest germination index (6.1 days). The germination percentages of seeds stored under short (70.3%) and medium (71.3%) term conditions were not significantly different. Similarly, germination index of seeds stored under short (5.6 days) and medium (5.5 days) term conditions were not significantly different. Moreover, germination declined as the storage time increased. The study suggests both short-term (15.1 to 21.3^{0}C) and medium term (-4.2 to 3.4^{0}C) conditions as effective storage environments for storing pepper seeds. In addition, the seeds must be stored inside moisture-prove packaging materials.

Keywords: Pepper; environment; period; storage; germination; germination index.

1. INTRODUCTION

Pepper (*Capsicum annuum* L) is a popular vegetable crop belonging to the family Solanaceae. Pepper fruits are rich in vitamin C and used for cooking and salad. The demand for this crop as vegetable has increased especially in the urban centres where people are not involved in pepper production, however, availability of quality seeds for sustainable production to meet the highest demand has become a big challenge.

Seed quality is determined by the genetics, physical, health, germination and vigour properties of a seed [1,2]. These properties are influenced by the agroecological conditions in the seed production field, seed handling and processing, storage conditions and storage period [3,4].

Germination capacity is a crucial aspect of seed quality, therefore, germination tests are used worldwide to determine the maximum germination potential of a seed batch under optimum conditions. The Association of Official Seed Analysts [5] defined seed germination as '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'.

Vigour is defined as those seed properties, which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions [6]. Vigour is, therefore, a measure of the performance of the seed under unfavorable conditions. The speed of emergence of seedlings is one of the oldest seed vigour concepts. Vigorous seeds have been shown to germinate rapidly. The speed of germination is measured through various techniques and given many different names such as emergence rate index, germination rate, germination index and speed of germination. Since seed germination and vigour are the main seed physiological quality attributes affected during seed deterioration, seed germination and vigour are therefore regarded as the two crucial components of seed quality.

The National Centre for Genetic Resources and Biotechnology (NACGRAB), located in Ibadan, Nigeria, is the national focal point for genetic resources conservation and utilization in Nigeria. NACGRAB holds many accessions of pepper in her gene banks and over the years, had been distributing pepper accessions from her working collections to meet the requirements of researchers in the National Agricultural Research System. Recently, the center has experienced a consistent interruption in power supply to the genebanks which often resulted in a fluctuation in temperature and relative humidity in the short and medium term storage environments. Considering these challenges, our assumption was that seeds stored in the medium term cold room should be able to give higher germination percentage and more vigorous considering at least ten hours power supply to the genebanks. This study might provide useful information for NACGRAB and other genebanks experiencing

such challenges on how to plan for proper storage conditions to maximize shelf-life of the pepper seeds and furnish additional information in making a decision on regeneration cycle of pepper under such conditions. The objective of this study, therefore, was to compare the effects of three storage environments namely, ambient (control), short term and medium term conditions on germination and vigour of pepper seeds.

2. MATERIALS AND METHODS

2.1 Plant Materials and Seed Production

The seeds of two accessions of pepper (NGB 001010 and NGB 001066) were sourced from the seed gene bank of the National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan. Seed production was carried out at the experimental field of the centre during the growing seasons of 2014.

2.2 Seed Processing and Storage

Fruits of the two accessions were harvested at physiological maturity stage and seeds were extracted directly after harvesting. The extraction was done by hand to minimize mechanical damage. The seeds of each variety were dried with seed dryer at 35°C to about 12% moisture content [7]. Two hundred grams of each accession were partitioned into three parts. Samples from each accession were kept separately in three storage environments: ambient (control), short and medium term storage conditions in February, 2015 using aluminium cans as packaging materials.

2.3 Temperature and Relative Humidity Measurement of the Storage Environments

Temperature and relative humidity of the three storage environments were taken daily using sensors. The power supply was ensured for at least of ten hours daily in the two cold room environments. The mean temperature and relative humidity values from the environments were presented in Table 1.

2.4 Laboratory Experiments and Experimental Design

The stored seed samples were drawn at quarterly intervals starting from April 2015 to January 2016 which constituted four storage periods. The laboratory experiment was conducted at the seed testing laboratory of NACGRAB. The seed samples were drawn from the storage environments and evaluated for germination and vigour tests. The experiment was arranged in 2 x 3 x 4 factorial using completely randomized design (CRD) in three replications. The three factors were two accessions of pepper, three storage environments and four storage periods.

2.5 Standard Germination and Vigour Tests

Initial germination test was conducted on the two accessions prior to storage. One hundred seeds of each variety were drawn at quarterly intervals 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 percentages were calculated by expressing the number of seedlings in a replicate that emerged 7 days after planting as a percentage of the number of seeds planted according to ISTA rules [8]. Germination Index (GI) was calculated by taking the germination counts at 5, 7 and 9 days after planting and the data were substituted into the following formulae:

$$GI = \frac{\text{No of germinated seed}}{\text{Days of first count}} + \ldots\ldots\ldots + \frac{\text{No of germinated seed}}{\text{Days of final count}}$$

2.6 Data Analysis

Data on germination percentage were subjected to analysis of variance (ANOVA) using Statistical Analysis Software, SAS Version 9.1 [9]. 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 Conditions of the Storage Environments

The mean temperature and relative humidity ranges in the ambient, short and medium term storage environments used during the study were presented in Table 1. Temperature values under ambient, short and medium term environments ranged from 28.5 to 33.1°C, 15.1 to 21.3°C and -4.2 to 3.4°C respectively while the relative humidity values ranged from 23.2 to 32.1, 26.9 to 53.7 and 42.7 to 72.3% respectively (Table 1).

3.2 Germination Performance of Pepper Seeds during the Study

The initial germination test conducted on the two accessions prior to storage showed that NGB 001010 had germination of 95% while germination percentage for NGB 001066 was 90%. The results of Analysis of variance (ANOVA) revealed that effects of accession (ACC), storage environment (ENV) and storage period (STP) were significant (P< .01) on germination of pepper seeds (Table 2). Similarly, effects of accession and storage environment were highly significant (P<.01) on germination index (Table 2). These results were in agreement with the report of Omal et al. [10] who observed significant effect of varieties, storage environments and periods on germination of wheat seeds and other characters studied.

3.3 Germination Performance of Pepper Seeds as Influenced by Accession, Storage Environment and Storage Periods

The germination percentage for accession NGB 001010 was significantly higher (68.9%) than accession NGB 001066 which had germination of 61.1%. This clearly indicates that storability of seed in storage environment is determined by genotype. Tame and Elam [11] observed significant difference for germination in three varieties of soybean. Olosunde et al. [12] also observed significant differences in germination of two varieties of cowpea. In addition, germination index for NGB 001010 was significantly lower (5.3 days) compared with that of NGB 001066 which took about 5.9 days to germinate. Since, vigorous seeds have been shown to germinate rapidly, it means that NGB 001010 is more vigorous than NGB 001066 which was obvious in the germination results. Effect of storage

Table 1. Mean temperature (°C) and relative humidity (%) ranges in the four storage environments used during the study

Storage environment	Temperature (°C)	Relative humidity (%)
Ambient	28.5 to 33.1	23.2 to 32.1
Short term	15.1 to 21.3	26.9 to 53.7
Medium	-4.2 to 3.4	42.7 to 72.3

Table 2. Mean squares from the analysis of variance for the germination test and emergence index on pepper seeds at NACGRAB, Ibadan

Source of variation	df	Germination (%)	Emergence index
Rep	2	763.39**	0.039ns
Accession (ACC)	1	1104.50**	2.175**
Storage environment (ENV)	2	2409.56**	2.49**
Storage period (STP)	3	1431.17**	0.46ns
ACC x ENV	2	420.67ns	0.20ns
STP x ENV	6	269.56ns	0.29ns
STP x ACC	3	32.94ns	0.05ns
ACC x ENV x STP	6	79.78ns	0.12ns
Error	46	132.26	0.20
Total	71	293.86	0.29
R^2 (%)		0.71	0.562
CV		17.70	7.721
Mean		64.97	5.761

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

Table 3. Effect of accession, storage environment and period in storage on seed germination of pepper seed at NACGRAB, Ibadan

Factors	Seed germination (%)	Emergence index (days)
A. Accession		
NGB 001010	68.9a	5.9a
NGB 001066	61.1b	5.6b
LSD	5.5	0.2
B. Storage environment		
Ambient	53.4b	6.1a
Short term	70.3a	5.6b
Medium term	71.3a	5.5b
LSD	6.7	0.2
C. Storage period		
Month 3	72.9a	5.7b
Month 6	70.1a	5.7b
Month 9	64.1b	5.7b
Month 12	52.8c	6.0a
LSD	7.7	0.3

Means with different letters within the column of the same factor are significantly different at P=0.05

environments was significant on germination and emergence index of pepper seeds. Seeds stored under ambient conditions gave the lowest germination percentage (53.4%) and highest emergence index (6.1 days). The germination percentages of seeds stored under short (70.3%) and medium (71.3%) term conditions were not significantly different (above Table 3). Similarly, germination index of seeds stored under short (5.6 days) and medium (5.5 days) term conditions were not significantly different. This corroborated with the report of Adriana et al. [13] who stated that seeds stored in ambient conditions lose their viability and vigour very fast due to changes in storage conditions of temperature and relative humidity. Chauhan and Nautiyal [14] also reported a much faster loss of seed viability at room temperature (10-35°C) and retaining of seed viability for more than two years (Storage at 0 to -5°C in refrigerator) in *Nardostachys jatamansi*. However, in this study, a non-significant difference observed between the germination percentages and germination index of pepper seeds stored in the short and medium term storage chambers could be attributed to the fluctuation in power supply, which could have masked the anticipated differences between the two cold rooms used in this study. Yakubu [15] gave a similar report that fluctuation of temperature and relative humidity in tropical countries accelerates rapid multiplication of molds and insects, which facilitate further spoilage of grain. There were differential germination responses of pepper seeds to storage time. Germination declined as the storage time increased. This finding is in agreement with the report of Verma and Tomer [16] where they stated that seed germination and seedling establishment decreased with increased in seed storage period in Brassica (*Brassica campestris*). Also, the result corroborated with the findings of Yilmaz and Aksoy [17] who reported a decrease in germination of *Rumex scutatus* with increase in storage time irrespective of different storage conditions.

4. CONCLUSION

In the study, accession of pepper, storage environment and period significantly influenced the germination and vigour of pepper seeds. The germination of pepper seeds declined as the storage time increased. The study further concludes that both short (15.1 to 21.3°C) and medium term (-4.2 to 3.4°C) conditions could retain viability of pepper seeds (>70%) at least for a year but the seeds must be stored inside moisture-proof packaging materials such as aluminium cans. However, the non-significant difference in germination and vigour performance of pepper seeds stored in both short and medium term conditions indicates that minimum of ten hours power supply could have masked the anticipated differences hence power generation to the cold rooms should be improved in order to obtain prolonged storability of pepper seeds.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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