

Evaluation of Seed Viability at Various Storage Temperatures for Different Types of Seed

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Abstract

This trial aims to find out the best storage temperature for various seed types to improve viability during storage. More recently, a large quantity of economically important crop seeds is lost within a short period due to poor storage. In most circumstances, this can increase seed costs, reduce seed quantity and quality and may lead to seed shortages during peak seasons. As such, a project was carried out at NAREI Seed Laboratory to ascertain the best storage condition for different types of seed. This experiment was laid out in a Strip Plot Design with two factors: temperature with four levels (28.7°C, 7.8°C, 5.2°C and -14°C) and seed types with seven levels (corn, red beans, mung beans, ochro, boulanger, watermelon, and cucumber) and replicated four times. One kilogram of various seed types was then placed in different storage conditions. Germination test was conducted at intervals of 3, 6, 9 and 12 months after storage. The interaction of seed types and storage temperature was significant, whereby red bean and mung bean seeds recorded significantly greater germination percent at -14°C, while corn, cucumber, watermelon and ochro seeds prefer to be stored at 5.2°C due to significantly higher percent germination. On the other hand, cucumber and boulanger seeds recorded greater percent germination at 7.8°C. The interaction of storage temperature and storage time was highly significant where seeds stored at 5.2 and 7.8 degrees celsius recorded greater germination percent at 3, 6, 9 and 12 months after storage. Most seeds should be stored at 5.2 degrees celsius to maintain seed viability during storage. By utilizing this temperature, more seeds can be available to farmers in the desired quality and quantity. Regardless of storage temperature, all seed types experienced a considerable decline in percentage germination after 12 months. Therefore, these temperatures are only suitable for short-term seed storage.

Keywords

Storage Temperature, Germination Percent, Seed Viability, Storage Time

1. Introduction

Seed storage is critical for the long-term conservation of plant genetic resources. Maintaining seed viability over time is essential for preserving genetic integrity in stored samples. A lack of suitable storage, such as room temperature storage, frequently leads to reduced seed germination, seed degradation, and loss of viability, all of which are natural storage phenomena [1]-[4]. Several factors must be taken into conservation to improve seed longevity, such as temperature, moisture, nature of the seeds, seed moisture content and relative humidity [5]-[8]. The main factors affecting seed viability are storage temperatures and relative humidity in Guyana. Temperature increases will contaminate the storage facility by encouraging fungal growth and insect development in seeds [9] [10].

Proper storage conditions, on the other hand, may successfully sustain significant viability in seeds over an extensive period [8] [11]-[13]. According to [14], vegetable seeds should be kept at temperatures ranging from 2 to 4 degrees celsius with relative humidity at or below 40% to ensure viability for 1 - 2 years. Some household refrigerators typically keep temperatures just around 4°C, but the humidity level might be greater than recommended [14]. Bayer suggested that seeds can be stored in the refrigerator but must be kept in their original, unopened packages or in sealed containers to ensure low humidity levels.

Akamine found that vegetable and grain seeds stored at room temperature in air-tight containers with a relative humidity of 15%, 30% and 45% retained germination percentages ranging from 33% - 90% after six and a half years. A temperature of 7°C and 10°C is superior for the storage of lettuce and soya beans regardless of humidity levels than 15°C and 20°C [15]. Some authors reported that a storage temperature of 15°C had retained seed viability for nine months, while seeds stored at 30°C only maintain viability for three months [16]. Pradhan and Badola [17] found that seeds stored at 4°C for 24 months recorded substantially greater germination percentages than at -15°C and room temperature. Some authors argue that storage temperature is of high importance, while others suggest that temperature and humidity are equally important in retaining seed viability during storage.

The current storage temperature of 18°C - 20°C is inadequate for the medium-term storage of different species of grain, beans and vegetable seeds. This often leads to low germination, seed deterioration and loss of viability within a very short period. As such, this has led to the utilization of freezers (-14°C), cold storage (7.8°C), refrigerators (5.2°C) and Ambient temperature storage (28.7°C) and is a common practice in Guyana. However, many different types of seeds and varieties are stored in these conditions without any information available for the best temperature for

a particular seed type. Hence, a project was conducted to determine the best storage temperature for specific seed crops.

2. Research Objectives

- To determine the optimum storage temperature for various seeds.
- Germplasm conservation of seeds.
- To determine the germination percent at different intervals.
- To know which period is more suitable for seed storage.
- To determine the viability of seeds after one year of storage.

3. Methodology

This trial was done at NAREI Seed Laboratory, Mon Repos from 2021 to 2022. This experiment was set out in a Strip Plot Design with two factors, namely storage conditions and seed type. Storage temperature and humidity was the vertical factor with four levels (28.7°C, 7.8°C, 5.2°C, -14°C) and seed type was the horizontal factor with seven levels (corn, red beans, mung beans, ochro, boulanger, watermelon, and cucumber) and replicated four times. Seeds were collected, dried and weighed using a digital scale. The moisture content of each seed type was determined by a digital moisture meter and kept at 12 percent [18]. A thermometer was used to ascertain the temperature within the different storage conditions. One kilogram of various seed types was then placed in different storage conditions. Baseline data on initial germination was collected and recorded [17]. Germination test was conducted at three-month intervals from 3, 6, 9 and 12 months. A germination test was carried out using 400 seeds, which were randomly selected and placed on filter paper inside a petri dish [19]. Germination count was carried out between 7 and 14 days, depending on plant species and data recorded.

The following was calculated according to [20].

The germination percentage was calculated as follows:

Germination Percentage = (emerged plant/total number planted seeds) * 100.

4. Statistically Analysis

The Statistix 10 software was used to perform statistical analysis on data collected from various treatments. Analysis of variance (ANOVA) was used to compare the means of storage types, crop types and storage time. The means were separated using the least significant difference. Means were considered significantly different at $P < 0.05$.

5. Results

The germination percentages among seed types differ significantly from one another after 12 months of storage (Figure 1). Mung bean seed recorded substantially higher percent germination compared to all seed types. The second highest percent germination was obtained from red bean seeds, which differ considerably from other seeds except mung bean. There were no significant differences in germination per-

cent between cucumber and corn seeds; however, they differed notably from other seeds such as boulangier, watermelon and ochro. Boulangier seeds had considerably higher germination percentages than watermelon and ochro. Watermelon seeds recorded higher percent germination than ochro seeds. The lowest percent germination was obtained from ochro seeds.

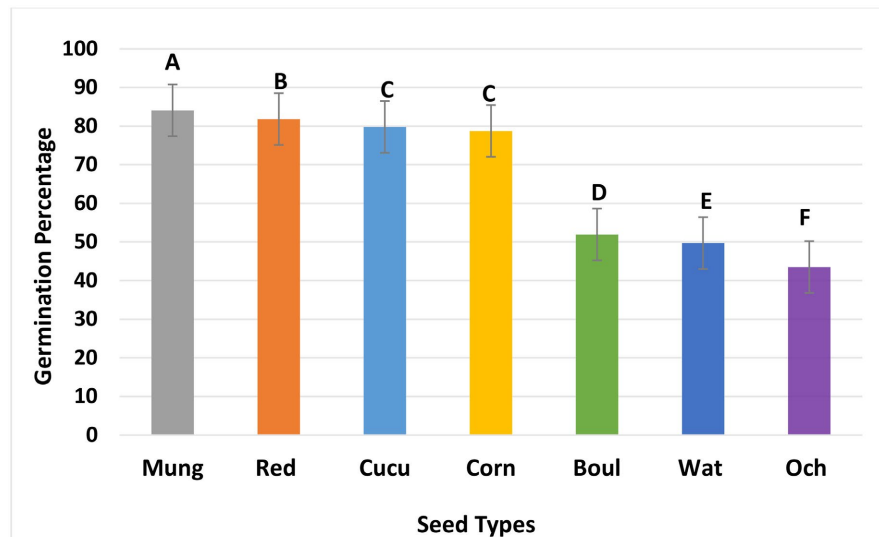


Figure 1. The effects of seed types on percentage germination after 12 months of storage (pooled data). Note: Means with the same letters are significantly different from one another according to the Tukey Test at $P < 0.05$. Mung: Mung beans; Red: Red beans; Cucu: Cucumber; Boul: Boulangier; Wat: Watermelon; Och: Ochro; SEM: 1.26; CV: 1.67; F-value: 5203.

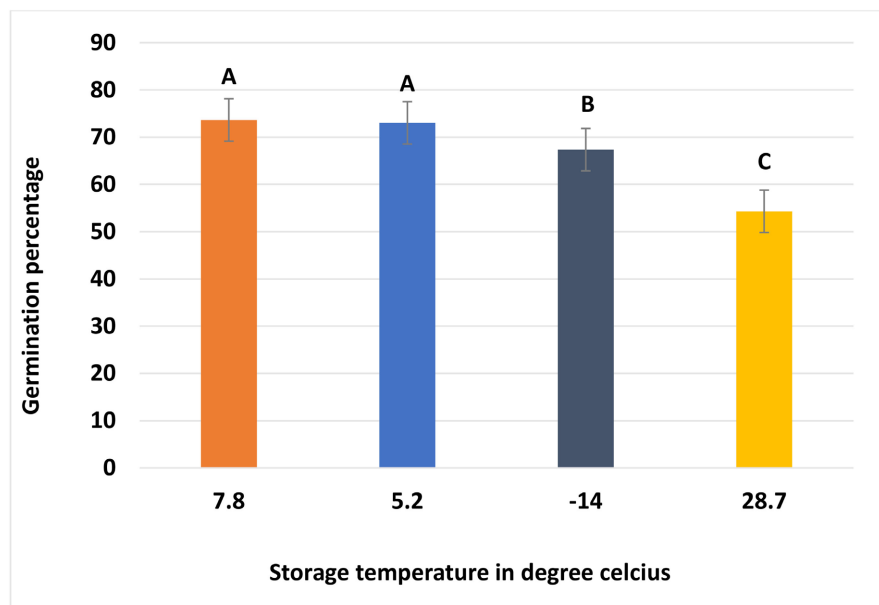


Figure 2. Effects of storage temperature on germination percentage after 12 months of storage (pooled data). Note: Means with the same letters are significantly different from one another according to the Tukey Test at $P < 0.05$. SEM: 0.32; CV: 0.85; F-value: 5203; P-value: 0.00.

Figure 2 shows substantial differences in germination percentage among storage temperatures. There were no significant differences in germination percent between storage temperatures of 5.2°C and 7.8°C; nevertheless, they differ considerably from other storage temperatures. Seeds stored at -14°C recorded significantly higher percent germination when compared to a temperature of 28.7°C. The lowest percent germination among storage temperatures was achieved by 28.7°C.

The germination percentage among storage times differs considerably from each other (**Figure 3**). The germination percent declined significantly after three months of storage when compared to the initial germination percent. There is no substantial difference in percent germination after three and six months of storage however, they had considerably higher germination percent when compared to nine and twelve months of storage. After nine months of storage, the germination percentage was substantially higher than twelve months of storage. The lowest percent germination among the different storage times occurred after twelve months of storage.

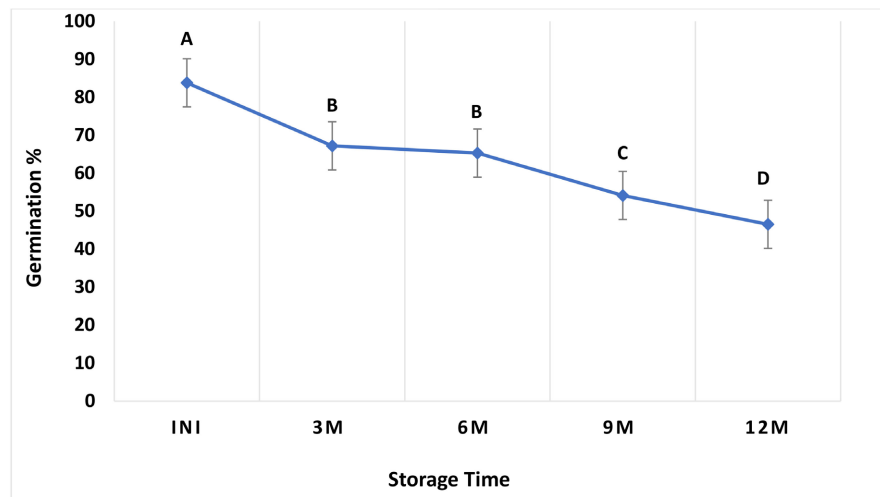


Figure 3. The influence of storage time on percentage germination after 12 months (pooled data). Note: Means with the same letters are significantly different from one another according to the Tukey Test at $P < 0.05$. INI: Initial germination; 3M: 3 months; 6M: 6 months; 9M: 9 months; 12M: 12 months; SEM: 2.12; CV: 2.34; F-value: 942; P-value: 0.00.

Storage temperature significantly influences the germination percentage of different seeds during storage. Treatment four (FS) substantially improves the viability of red beans and mung bean seeds when compared to the other treatments. Corn, watermelon and ochro seeds preferred to be stored in treatment two (RFS) due to considerably greater viability compared to other treatments. The viability of cucumber seed was notably higher inside treatments two and three. Boulanger seed germinated better when kept in treatment three. Treatment one obtained the lowest seed germination among all treatments and seed types (**Figure 4**).

The viability of the different types of seed was considerably influenced by storage duration. All seed types recorded a significant decline in viability after twelve

months of storage. Nevertheless, mung bean had the highest viability after nine months of storage compared to the other crops (**Figure 5**).

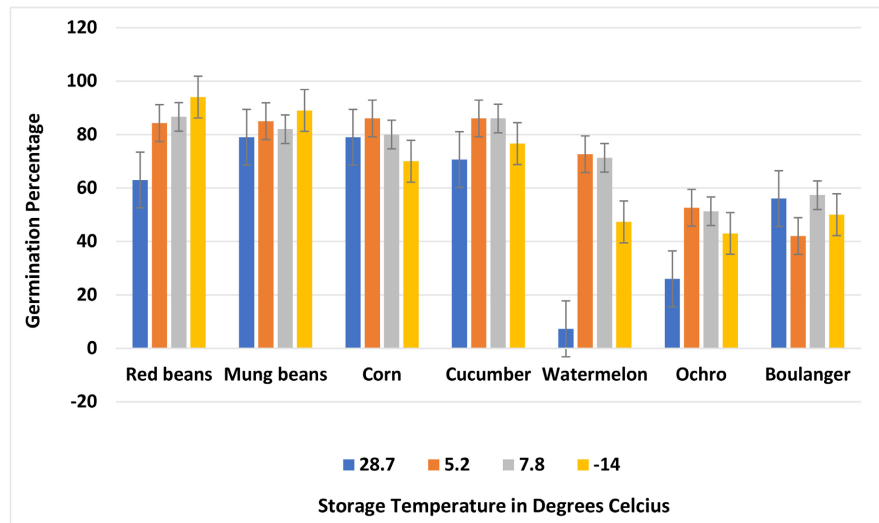


Figure 4. Effects of storage temperatures and seed crops on percentage germination of various crops (pooled data). CV: 1.32; P-value: 0.00; F-value: 544.5; SEM: 0.78.

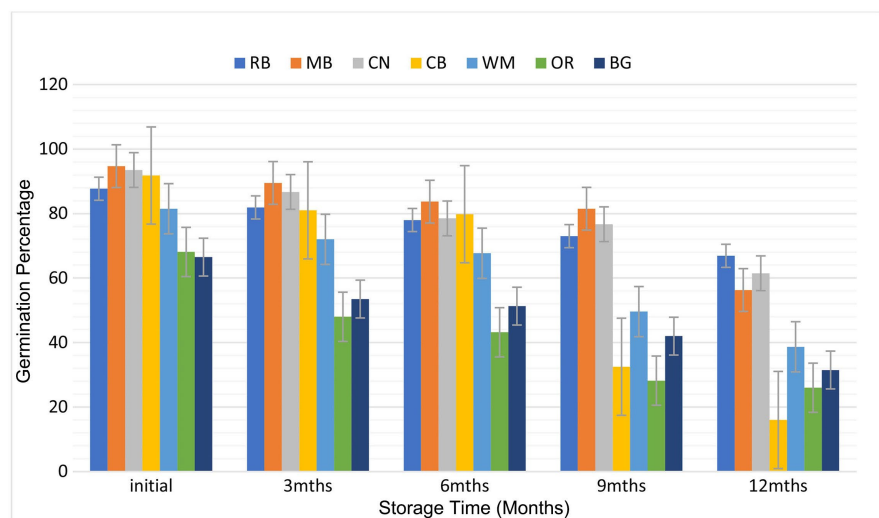


Figure 5. Effects of storage time on seed viability for various crops (pooled data). RB: Red beans; MB: Mung beans; CN: Corn; CB: Cucumber; WM: Watermelon; OR: Ochro; BG: Boulanger; CV: 2.64; P-value: 0.00; F-value: 105.4; SEM: 2.97.

Corn and red bean seeds remain viable after nine months of storage when compared to the other seeds. However, cucumber and watermelon seeds were more highly viable after six months of storage than watermelon, ochro and boulanger. After nine and twelve months of storage, the viability of some seeds, such as cucumber, watermelon, ochro and boulanger declined substantially.

The percent germination declines significantly for all storage periods and storage temperatures from the initial germination percent (**Figure 6**). Seeds stored at 5.2°C and 7.8°C recorded considerably higher germination percentages after three,

six, nine and twelve months of storage than the other treatments. A storage temperature of 5.2°C achieved significantly greater germination percent after 12 months of storage when compared to other treatments. Seeds stored at -14°C obtained considerably higher percent germination at 3, 6, 9 and 12 months when compared to room temperature storage. The lowest seed germination percent among all treatments was obtained from 28.7°C.

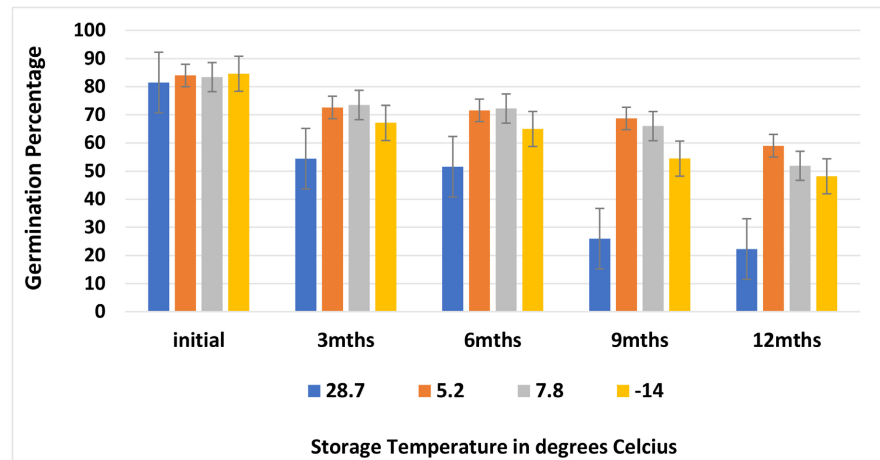


Figure 6. Effects of storage time and storage temperature on germination percentage. CV: 1.65; P-value: 0.00; F-value: 141.8; SEM: 1.10.

6. Discussion

The differences in percent germination among seed types may be a result of inherent genetic characteristics which allows some seeds to be stored for a longer period than others and also biotic and abiotic factors during production [21]. These factors considerably improved viability throughout the storage period. Storage temperature significantly influences the germination of seeds. Seeds stored at higher temperatures (28.7°C) recorded substantially lower germination percent than those stored at lower temperatures (-14°C, 5.2°C and 7.8°C). High storage temperatures hasten seed degradation, resulting in seed quality losses and, as a consequence, decreased seed germination percentage [16]. According to [22], high temperatures enhance metabolic processes such as premature enzymatic oxidation and protein denaturation, lowering the enzymatic activity of seeds before germination. With increasing storage time, there was a steady and substantial decline in percent seed germination for all storage conditions, which can be corroborated by [17]. According to [23], environmental and genetic variables such as storage temperature and seed moisture content have a considerable impact on storage time. Rajjou and Debeaujon [24] found that seeds degrade during storage, lose vitality, become more vulnerable to stress during germination, and eventually fail to germinate.

Interaction Effects on Seed Germination

There were significant interactions between storage temperatures and seed crops

on the germination percentage. Some seeds, such as red bean and mung bean, preferred to be stored at -14°C due to greater germination percentages. This storage temperature reduced the main metabolic processes such as premature enzymatic oxidation and protein denaturation, improving the enzymatic activity and thus enhancing seed germination [22]. Some authors found that seeds stored at sub-zero temperatures would suffer from freezing damage due to ice formation, which would render them unsuitable for most seeds [17]. Corn, cucumber, watermelon, and ochro seeds germinate better when stored at 5.2°C . Cucumber, watermelon, ochro, and boulanger seeds, on the other hand, retain great viability when kept at 7.8°C . This agrees with the findings of [16], who stated that seeds stored at low temperatures had substantially higher germination ability due to lower metabolic activity of the seeds.

There were positive interactions between storage time and seed crops for germination percentage. Some seeds such as red beans, mung beans and corn had relatively high viability throughout the storage period (3, 6, 9 and 12 months), which might be attributed to inherent genetic characteristics that allow some seeds to be stored for a longer period than others and also biotic and abiotic factors during production [21]. This can be further corroborated by [24], who stated that seeds deteriorate during storage, lose viability, and become more prone to stress during germination.

For germination percentage, there was positive interaction between storage temperature and storage time. Seeds stored at 5.2°C maintained the highest viability through the storage period (3, 6, 9 and 12 months). This might be attributed to a lower temperature, which maintained moisture content, humidity and oxygen, which decreased the respiratory activity and hence improved viability [15] [25].

7. Conclusion

This research highlights how storage temperature influences the germination capability of vegetable seeds. The findings indicated that different types of seed required different temperatures to promote viability during storage. Most seeds kept at 5.2°C remained viable throughout the storage period. Seed storage time was also essential since all seed types saw a reduction in viability after twelve months. After twelve months of storage, regardless of storage temperature, all seed types experienced a considerable decline in percentage germination. As a result, these temperatures are only suitable for short-term seed storage.

8. Recommendations

- Additional research should be conducted where temperature and humidity can be modified to suit specific species.
- The humidity should be modified at room temperature to accommodate short-term storage.
- The humidity in the current storage facility should be lowered to 30% - 40% to extend the storage life of seeds.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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