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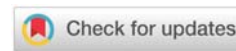
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## Research Article

# Effect of different storage methods on germination and seedling emergence of six pawpaw (*Carica Papaya L.*) varieties planted in Ogbomoso, Oyo state, Nigeria

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## Abstract

Pawpaw is known as a fruit that contains nutrients and vitamins ranging from green ripe to over-ripe and unripe fruits of various varieties. The poor and delayed germination, rapid loss of viability in seeds due to the presence of sarcotesta, and condition of storage of seeds could be addressed through the storage in various containers. This paper focused on the investigation of the best storage methods that aid germination, seedling emergence and seedling performance of six pawpaw varieties. The experiment was set up in the Crop and Soil Science Laboratory Department and Nursery Site of the Ladoke Akintola University of Technology, Ogbomoso (Oyo-State). It was a 6 x 5 factorial experiment that consisted of 6 varieties of pawpaw; Pink Solo, Green Solo, Ghana Solo, Sunrise Solo, Ajawa Local, and Berry likewise the 5 storage methods are desiccator, refrigerator, plastic container, aluminum foil paper, and earthen pot. Data were collected by counting the number of germinated seeds manually from 4 – 16 days after sowing inside Petri dishes, emergence rate was also counted after seeds have been sown inside polythene bags and nursed for 12 weeks and the number of seeds germinated and seedling emergence was transformed into percentages. Seedling emergence rates were also counted manually and analysed by using Analysis of Variance (ANOVA), means were compared using the least significant difference at a 5% probability level. Significant differences were observed among storage methods and pawpaw varieties in germination rate, seedling emergence, and performance. The highest plant height was observed in green solo at 12WAS in the nursery (25.63 cm), the highest stem girth was recorded in Ajawa local 3.86 cm while the highest number of leaves was recorded in sunrise 9.9. The total emergence percentage was recorded in Green Solo at 93.8%. The highest germination percentage was observed in Ghana Solo 59.4%. The highest germination, seedling emergence, plant height, and number of leaves were recorded in the desiccator as 44.96%, 84.4%, 23.32 cm, and 9.38. Ajawa Local and Green Solo are recommended to be kept inside a desiccator or plastic container.

## Introduction

Pawpaw botanically known as (*Carica papaya*) belongs to the family caricaceae, it is a herbaceous tree plant, with popular fruit, native to Central America and Mexico [1]. Plants are now found worldwide, fruits are attractive and acceptable because of their sweet flavours and bright colours. Fresh seeds are an

excellent way to grow a papaya tree, and these can easily be achieved by extraction from matured ripe fruits [2]. Fruits of pawpaw are big, oval in shape like berries, while seeds are embedded inside the cavity of the fruits [3].

Pawpaw fruit is rich in nutrients such as pro-vitamin A, carotenoid, vitamins C and B, lycopene, dietary minerals and

dietary fibers. It is also rich in folic acid which is reported to be important in converting homocysteine into amino acid [4]. Fresh fruits of pawpaw are used for drinks, jam candies, and dried crystallized fruits. Unripe green fruits can be sliced and dried and used as vegetables for cooking [5].

Pawpaw is propagated sexually by planting seeds which are normally cleaned to remove the sarcotesta and washed with clean water to enhance germinability [6]. Seeds have been grouped as recalcitrant [7,8]. Higher seed moisture content above 10% is reported to be injurious to seed life and this rapidly reduces seed viability during storage [9]. Vecchio and Shirwa, 1987 [10]; Furutani and Nagoa, 1986 [11] recommended seeds of pawpaw be stored at a moisture content of 10% in order to give a higher germination percentage, reduced dormancy, and also it reduces seed death rate as compared to seeds stored above 10% moisture content and above 23 °C.

The investigation had been concluded to determine the factors involved in the dormancy of papaya seeds [12]. Seeds of pawpaw germination were significantly affected by different storage methods. Desiccator gave a consistent increase in the number of germination of seeds from 8DAS – 16DAS. The highest value of the number of seedling emergences was also observed in seeds of pawpaw stored inside the desiccator, while the least was observed in seeds stored inside aluminum foil paper. Seeds that were desiccated in the shade germinated better than those dried in the sun [10]. The removal of sarcotesta, which is an enzyme inhibitor in pawpaw seeds and GA3 growth hormone gave a contrasting result in pawpaw seed germination [13].

The combined action of gibberellic acid and potassium nitrate has been reported to be advantageous for improving both germination and the emergence of papaya seeds [11]. Papaya seeds exposed to a combination of inhibition in gibberellic solution and inoculation with *Azosperillum* mixture suspension gave the highest germination capacity of 69.3% compared with seeds that were not treated and gave a germination percentage of 30.7% [14]. Due to heterogeneity in the characteristics of pawpaw, this paper aims to investigate the best storage methods for six pawpaw seed varieties that will enhance germination and improve seedling performance.

## Materials and methods

Seeds of six varieties of pawpaw namely Pink Solo, Green Solo, Ghana Solo, Sunrise Solo, Ajawa Local and Berry were collected from matured ripe fruits of pawpaw (*Carica papaya L.*). Pink Solo, Green Solo, and Ghana Solo were collected from the horticultural farm of Lower Niger River Basin Authority Ilorin, while Berry was gotten from the local market in Ilorin, Kwara State. Fruits of Sunrise Solo were collected from FUNMAN farm in Ajawa town and the Ajawa local was bought from Ajawa local farmer in Oyo State.

After extraction of seeds from the fruit cavity, the seeds were washed to remove the gelatinous substance and air dried

for 10 days before storage inside different methods for 4 weeks. The materials used were a desiccator, refrigerator, aluminum foil paper, plastic container, and earthen pot. Seed lots were kept inside different materials at room temperature, except the ones inside a refrigerator. Germination tests were carried out in the Crop and Soil Science Laboratory Department, Ladoke Akintola University of Technology, Ogbomosho. Twenty seeds were placed inside Petri dishes according to the treatment combination of 6 x 5 factorial experiment randomized in triplicate these gave a 30-treatment combination.

The nursery experiment was carried out in the nursery site of Ladoke Akintola University of Technology, Ogbomosho, to observe seedling emergence and physiological development of six pawpaw varieties planted.

A polythene bag of 45 cm depth, 38 cm diameter and 5mm thickness was filled with 10kg of topsoil collected from the Gmelina plantation. The polythene bags were perforated at the bottom to allow easy passage of excess water. Six seeds were planted inside each polythene bag at a depth of 2 cm deep. A total number of 90 polythene bags were used, each replicate contained 30 bags, each bag was arranged at a distance of 0.5 m apart within the rows and 1m apart between each replicate. Water was applied lightly immediately after sowing.

To determine the germination percentage of six (6) pawpaw varieties stated above, 5 mls of distilled water was applied to each of the Petri dishes, 20 minutes before sowing, while twenty (20) seeds of each of the pawpaw cultivars were counted inside. Application of water and observation of germination commenced from the 4<sup>th</sup> day – 16 days after sowing. Physical counting of sprouted seeds was carried out with the use of a handheld magnifying lens [15,16]. Manual recordings of the sprouted seeds were taken.

### Data collection on germination percentage

Germination percentage was obtained by recording the total number of seeds that sprouted within a maximum number of 16 days after sowing and dividing by the total number of seeds sown and multiplying x 100.

$$\% \text{ Germination} = \frac{\text{Total number of seeds germinated / treatment}}{\text{Total number of seeds sown}} \times \frac{100}{1}$$

Data collected were analysed by using analysis of variance (ANOVA) and significant means were separated by least significant differences at a 5% probability level.

### Data collection on emergence percentage

Data collected at the nursery include the emergence of seedlings, plant height of seedlings, stem girth and number of leaves produced by pawpaw seedlings.

The emergence percentage was calculated using the formula

$$\% \text{ Seedling Emergence} = \frac{\text{Total number of seedlings that emerged}}{\text{Total number of seeds planted}} \times \frac{100}{1}$$

## Results

### Germination percentage

Germination percentages of pawpaw varieties were significantly different from one another throughout the sampling occasions. A consistent increase in the number of seeds germinated was observed in Ghana Solo which gave the highest seed germination of (59.4%), this was closely followed by the Sunrise variety which had a germination percentage of (54.2%), these two varieties are not significantly different from one another but they were different from the Berry variety that had least germination percentage of (2.53%) (Table 1).

### Emergence percentage

The emergence percentage of the six varieties of pawpaw was recorded to be highest in Green solo (93.8%) (Table 2). This was on close par with Ajawa local (92.7%), these two varieties exhibited the highest seedling emergence percentage at the end of 10WAS. The least emergence percentage was obtained in Berry (28.3%). This same variety exhibited a low seedling emergence rate throughout the sampling occasions.

### Effect of variety of pawpaw on plant height

The green solo variety recorded the highest plant height of the pawpaw throughout the sampling occasions. At 4WAS (14.45 cm); 8WAS (21.32 cm) and 12WAS (25.63 cm) all these values were significantly different from the least plant height that was recorded in Ghana solo at 4WAS (7.26 cm); 8WAS (11.22 cm); and 12WAS (13.44 cm) respectively (Table 3).

Varieties of pawpaw planted in Ogbomoso had significant differences in the stem girth of pawpaw planted (Table 4). At 4WAS, the highest stem girth was observed in the Pink Solo (2.00 cm) followed by Green Solo (1.74 cm) and Ajawa local (1.72 cm), all these three (3) varieties did not have any significant differences. At 12WAS, seedlings of pawpaw nursed in the nursery house produced the highest stem girth in Ajawa local variety (3.86 cm), this was on close par with Green Solo (3.49 cm) and Pink Solo (3.48 cm). All these varieties were significantly different from the value recorded for Ghana solo as (1.48 cm).

### Effect of varieties on the number of leaves produced

There were no significant differences in the number of leaves produced by six varieties of pawpaw raised in the nursery

**Table 1:** Varietal Variation in Pawpaw Seed Germination.

Seed Germination						
Days after Sowing (DAS)						
Varieties	8DAS	10DAS	12DAS	14DAS	16DAS	Total Germination in %
Pink Solo	0.60 <sup>BC</sup>	0.93 <sup>C</sup>	1.66 <sup>C</sup>	1.93 <sup>C</sup>	2.06 <sup>C</sup>	11.7 <sup>C</sup>
Green Solo	0.80 <sup>BC</sup>	2.53 <sup>B</sup>	4.53 <sup>B</sup>	6.80 <sup>B</sup>	8.26 <sup>B</sup>	38.2 <sup>B</sup>
Ghana Solo	4.05 <sup>A</sup>	5.53 <sup>A</sup>	6.80 <sup>A</sup>	8.73 <sup>A</sup>	10.53 <sup>A</sup>	59.4 <sup>A</sup>
Berry	0.13 <sup>C</sup>	0.20 <sup>C</sup>	0.33 <sup>D</sup>	0.40 <sup>D</sup>	0.46 <sup>C</sup>	2.53 <sup>D</sup>
Sunrise Solo	1.40 <sup>B</sup>	3.46 <sup>B</sup>	6.66 <sup>A</sup>	9.40 <sup>A</sup>	11.60 <sup>A</sup>	54.2 <sup>A</sup>
Ajawa Local	0.77 <sup>BC</sup>	2.77 <sup>B</sup>	4.44 <sup>B</sup>	5.55 <sup>B</sup>	8.66 <sup>B</sup>	36.9 <sup>B</sup>

Means in the column with different superscripts are significantly different at  $p < 0.05$ .

**Table 2:** Varietal Variation in Pawpaw Seedling Emergence.

Seedling emergence (No/plot)					
Weeks after Sowing (WAS)					
Varieties	4	6	8	10	Total Emergence in %
Pink solo	2.8 <sup>B</sup>	5.7 <sup>B</sup>	8.6 <sup>B</sup>	11.7 <sup>BC</sup>	65.3 <sup>C</sup>
Green solo	4.0 <sup>A</sup>	8.3 <sup>A</sup>	12.6 <sup>A</sup>	16.9 <sup>A</sup>	93.8 <sup>A</sup>
Ghana solo	2.5 <sup>B</sup>	4.9 <sup>B</sup>	7.3 <sup>B</sup>	9.7 <sup>C</sup>	53.8 <sup>B</sup>
Berry	1.1 <sup>C</sup>	2.4 <sup>C</sup>	3.7 <sup>C</sup>	5.1 <sup>D</sup>	28.3 <sup>E</sup>
Sunrise solo	4.1 <sup>A</sup>	8.0 <sup>A</sup>	11.9 <sup>A</sup>	15.7 <sup>AB</sup>	87.2 <sup>B</sup>
Ajawa local	4.0 <sup>A</sup>	8.3 <sup>A</sup>	12.5 <sup>A</sup>	16.7 <sup>A</sup>	92.7 <sup>A</sup>

Means in the column with different superscripts are significantly different at  $p < 0.05$

**Table 3:** Varietal Variation on Plant Height of Pawpaw.

Effect of varieties of seedlings on plant height (cm)			
Plant Height (cm)			
Weeks after Sowing (WAS)			
Varieties	4WAS	8WAS	12WAS
Pink Solo	10.96 <sup>AB</sup>	15.11 <sup>BC</sup>	19.05 <sup>BC</sup>
Green Solo	14.45 <sup>A</sup>	21.32 <sup>A</sup>	25.63 <sup>A</sup>
Ghana Solo	7.26 <sup>B</sup>	11.22 <sup>C</sup>	13.44 <sup>D</sup>
Berry	7.38 <sup>B</sup>	10.93 <sup>C</sup>	14.30 <sup>CD</sup>
Sunrise Solo	11.38 <sup>A</sup>	16.33 <sup>B</sup>	20.22 <sup>B</sup>
Ajawa Local	11.74 <sup>A</sup>	17.23 <sup>AB</sup>	22.52 <sup>AB</sup>

Means with different superscripts are significantly different at  $p < 0.05$

**Table 4:** Effect of Variation of Pawpaw on Stem Girth.

Stem Girth (cm)			
Weeks after Sowing (WAS)			
Varieties	4WAS	8WAS	12WAS
Pink Solo	2.00 <sup>A</sup>	2.75 <sup>A</sup>	3.48 <sup>AB</sup>
Green Solo	1.74 <sup>A</sup>	2.52 <sup>AB</sup>	3.49 <sup>AB</sup>
Ghana Solo	0.58 <sup>C</sup>	1.09 <sup>D</sup>	1.48 <sup>D</sup>
Berry	1.16 <sup>B</sup>	2.01 <sup>BC</sup>	2.78 <sup>BC</sup>
Sunrise Solo	0.94 <sup>BC</sup>	1.65 <sup>CD</sup>	2.40 <sup>C</sup>
Ajawa Local	1.72 <sup>A</sup>	2.80 <sup>A</sup>	3.86 <sup>A</sup>

Means with different superscripts are significantly different at  $p < 0.05$

house. However, Sunrise Solo had a consistent increase in the number of leaves from 4WAS – 12WAS. The highest number of leaves recorded at 12WAS was (9.9) recorded in Sunrise Solo, while the least number (5.9 leaves) was recorded in Ghana Solo at 12WAS, these two values were significantly different at  $p < 0.05$ . (Table 5).

Pawpaw seed germination was significantly affected by the storage methods used (Table 6). The highest germination percentage (44.96%) was recorded for seeds stored inside the desiccator. These were followed by seeds stored inside a refrigerator and a plastic container that gave a germination percentage of (37.8%) and (34.76%) respectively. The least germination percentage was recorded inside aluminum foil paper (15.30%).



The storage methods significantly ( $p < 0.05$ ) influenced seedling emergence of pawpaw at all sampling occasions (4WAS – 10WAS) (Table 7). The highest total emergence percentage was recorded in the desiccator as (84.4%) and the plastic container was recorded with a seedlings emergence percentage of (83.3%). The least number of seedlings emergence of pawpaw was recorded for aluminum foil paper.

### Growth parameter

Different storage methods significantly influence the height of pawpaw seedlings as the plant aged (Table 8). Plants stored inside the desiccator had a consistent increase in height throughout the sampling occasions, these values were significantly ( $p < 0.05$ ) different from the least value observed in seeds stored inside aluminum foil paper. The highest plant height 23.32 cm at the end of 12WAS was recorded in the desiccator while the least plant height 13.17 cm was recorded in aluminum foil paper.

The stem girth of pawpaw seedlings was highest (3.28 cm) for seeds stored inside plastic containers while the least stem girth of (2.07 cm) was recorded in seedlings that emerged from seeds stored inside the earthen pot. These two values were significantly different at ( $p < 0.05$ ) (Table 9).

The number of leaves produced by different pawpaw varieties increased as the plant aged but the values were not significantly different ( $p < 0.05$ ) at 4WAS and 8WAS. At 12WAS, the highest number of leaves was recorded in seeds stored inside a desiccator (9.38) which was significantly different from the least number of seeds (7.80) produced from seeds stored inside an earthen pot (Table 10).

**Table 5:** Effect of Different Varieties of Pawpaw on the Number of Leaves Produced at Different Sampling Occasions.

Number of leaves			
Weeks after Sowing (WAS)			
Varieties	4	8	12
Pink Solo	2.53 <sup>A</sup>	6.00 <sup>AB</sup>	9.6 <sup>A</sup>
Green Solo	2.20 <sup>A</sup>	6.10 <sup>AB</sup>	9.3 <sup>A</sup>
Ghana Solo	1.30 <sup>B</sup>	3.70 <sup>C</sup>	5.9 <sup>B</sup>
Berry	2.10 <sup>A</sup>	5.60 <sup>AB</sup>	9.0 <sup>A</sup>
Sunrise Solo	2.60 <sup>A</sup>	6.30 <sup>A</sup>	9.9 <sup>A</sup>
Ajawa Local	2.10 <sup>A</sup>	5.10 <sup>B</sup>	8.6 <sup>A</sup>

Means with different superscripts are significantly different at  $p < 0.05$

**Table 6:** Effect of Storage Methods on Seed Germination of Pawpaw.

Seed Germination						
Days after Sowing (DAS)						
Storage Method	8	10	12	14	16	Total Emergence in %
Refrigerator	2.00 <sup>A</sup>	3.38 <sup>AB</sup>	4.72 <sup>AB</sup>	5.88 <sup>B</sup>	6.72 <sup>BC</sup>	37.8
Desiccator	1.94 <sup>A</sup>	3.61 <sup>A</sup>	5.44 <sup>A</sup>	7.44 <sup>A</sup>	8.55 <sup>A</sup>	44.96
Plastic Container	1.16 <sup>B</sup>	2.44 <sup>BC</sup>	4.16 <sup>B</sup>	5.77 <sup>B</sup>	7.33 <sup>AB</sup>	34.76
Earthen Pot	0.60 <sup>B</sup>	1.60 <sup>CD</sup>	2.86 <sup>C</sup>	4.20 <sup>C</sup>	5.53 <sup>CD</sup>	24.65
Aluminium	0.73 <sup>B</sup>	1.40 <sup>D</sup>	2.60 <sup>C</sup>	3.46 <sup>C</sup>	4.27 <sup>D</sup>	15.30

Means with different superscripts are significantly different at  $p < 0.05$

**Table 7:** Effect of different storage methods on seedling emergence of pawpaw.

Seedling Emergence (cm)					
Weeks after Sowing (WAS)					
Storage methods	4	6	8	10	Total Emergence in %
Refrigerator	3.2 <sup>AB</sup>	6.4 <sup>AB</sup>	9.6 <sup>AB</sup>	12.8 <sup>AB</sup>	71.1
Desiccator	3.5 <sup>A</sup>	7.5 <sup>A</sup>	11.4 <sup>A</sup>	15.2 <sup>A</sup>	84.4
Plastic container	3.6 <sup>A</sup>	7.3 <sup>A</sup>	11.0 <sup>A</sup>	15.0 <sup>A</sup>	83.3
Earthen pot	2.4 <sup>B</sup>	4.9 <sup>B</sup>	7.4 <sup>B</sup>	9.9 <sup>B</sup>	55.0
Aluminium	2.5 <sup>B</sup>	5.1 <sup>B</sup>	7.6 <sup>B</sup>	9.1 <sup>B</sup>	50.5

Means with different superscripts are significantly different at  $p < 0.05$

**Table 8:** Effect of storage methods on plant height of pawpaw

Plant Height (m)			
Weeks after Sowing (WAS)			
Storage Method	4	8	12
Refrigerator	11.59 <sup>A</sup>	16.20 <sup>AB</sup>	20.28 <sup>AB</sup>
Desiccator	12.71 <sup>A</sup>	18.92 <sup>A</sup>	23.32 <sup>A</sup>
Plastic Container	9.89 <sup>AB</sup>	15.31 <sup>AB</sup>	18.78 <sup>AB</sup>
Earthen Pot	9.71 <sup>AB</sup>	14.34 <sup>BC</sup>	18.12 <sup>B</sup>
Aluminium	7.74 <sup>B</sup>	10.40 <sup>C</sup>	13.17 <sup>C</sup>

Means with different superscripts are significantly different at  $p < 0.05$

**Table 9:** Effect of storage methods on stem girth of pawpaw.

Stem Girth (cm)			
Weeks after Sowing (WAS)			
Storage Method	4	8	12
Refrigerator	1.51 <sup>AB</sup>	2.25 <sup>A</sup>	3.01 <sup>A</sup>
Desiccator	1.46 <sup>AB</sup>	2.7 <sup>A</sup>	3.06 <sup>A</sup>
Plastic Container	1.63 <sup>A</sup>	2.4 <sup>A</sup>	3.28 <sup>A</sup>
Earthen Pot	0.79 <sup>C</sup>	1.4 <sup>BC</sup>	2.07 <sup>B</sup>
Aluminium	1.15 <sup>B</sup>	1.93 <sup>AB</sup>	2.66 <sup>AB</sup>

Means with different superscripts are significantly different at  $p < 0.05$

**Table 10:** Effect of storage methods on the number of leaves per plant of pawpaw.

Number of leaves/plant			
Weeks after Sowing (WAS)			
Storage Method	4	8	12
Refrigerator	2.11 <sup>A</sup>	5.44 <sup>A</sup>	8.94 <sup>AB</sup>
Desiccator	2.77 <sup>A</sup>	5.83 <sup>A</sup>	9.38 <sup>A</sup>
Plastic Container	2.22 <sup>A</sup>	5.66 <sup>A</sup>	9.00 <sup>AB</sup>
Earthen Pot	1.93 <sup>A</sup>	5.06 <sup>A</sup>	7.80 <sup>B</sup>
Aluminium	2.20 <sup>A</sup>	5.46 <sup>A</sup>	8.33 <sup>AB</sup>

Means with different superscripts are significantly different at  $p < 0.05$

## Conclusion

Different characteristic behaviours are naturally exhibited by pawpaw due to differences in genetic factors, growth requirement, variation in place of origin, and sex characteristics.

The highest germination percentage of pawpaw varieties

was observed in Ghana solo (59.4%) and Sunrise solo (54.2%) while the highest seedling emergence percentage was observed in Green solo 93.8% and Ajawa local 92.7%; these might be due to the thin layer of the seed coat and bigger size of seeds [16,17]. Increase in temperature and moisture retention within 10% as recommended by Nagao and Furutani, 1986 [11] and Zulhisyam, et al. 2013 [9].

The highest plant height recorded in both Green Solo and Ajawa local could be a result of the fast germination rate in these two cultivars and the big size of the seeds as compared to the Berry variety that had a low germination percentage, low emergence percentage, and also recorded least plant height, these might also be due to the climatic condition of the area because the Berry variety was obtained from another origin which may not be favourable for the crop.

Ghana Solo had the least stem girth and the least number of leaves produced. Is a variety that is known to be very small in size (both fruit and seed sizes). These factors may hinder the absorption of nutrients most importantly the number of leaves might affect the photosynthetic ratio of the plant that will distribute nutrients to the stem part of the plant.

The highest number of seed germination, seedling emergence, plant height, and likewise number of leaves were recorded for seeds stored inside desiccators and this was followed by plastic containers that gave a considerable size of stem girth. Aluminum foil paper produced seedlings with low stem girth, low germination percentage, low seedling emergence and least plant height. The desiccator might have been able to maintain the moisture content of pawpaw and also have the ability to prevent the seeds from building up microbial organisms and excessive drying out [18,19].

## Recommendations

In order to maintain seed viability of the pawpaw variety which is necessary for seed germination and seedling emergence, it is recommended that Green Solo and Ajawa local should be kept inside a desiccator or plastic container.

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