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Test For Germination of Cocoa Seeds (*Theobroma cacao* L.) Using Different Storage Lengths

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ABSTRACT

Cocoa is one of the plantation commodities that has quite an important role in Indonesia's economic activities. Based on data from the International Cocoa Organization (ICCO) in 2021 and 2022, Indonesia is ranked 7th as the largest cocoa-producing country in the world. Apart from increasingly open export opportunities, the domestic cocoa bean market is still quite large. One of the problems in preparing high-quality seeds is seed storage time. Seeds that are stored will experience deterioration or decline in quality with signs of decreased quality, low viability and vigor, poor planting, and reduced yields. This research aims to determine the extent to which cocoa seeds are able to germinate well if stored for a certain time so that they can become a benchmark for seed users for sowing. The research approach was carried out qualitatively using mathematical methods. Data is analyzed and displayed in table form. Treatment 0 seeds were planted immediately. Treatment 1 seed was stored for 1 week, treatment 2 seeds were stored for 2 weeks, treatment 3 seeds were stored for 3 weeks, and treatment 4 seeds were stored for 4 weeks. The research results on the germination capacity of cocoa seeds with different storage periods showed that the best treatment was for seeds planted directly in the nursery, with water content 35.7%, germination time 12.3 days, germination capacity of 97.56%.

Keywords: *cocoa, germination, seed storage*

1. INTRODUCTION

The plantation industry is a resilient sector that can withstand economic shocks and play a crucial role in national economic recovery. In 2022, the plantation sub-sector is projected to contribute 3.76% to the total GDP and hold a significant share of 30.30% in the Agriculture, Forestry, and Fisheries sectors, making it the leading sector in this domain. Among the plantation commodities, cocoa holds a significant position in Indonesia's economic activities. It serves as an important export commodity, contributing to foreign exchange earnings. Remarkably, Indonesia ranks 7th globally as the largest cocoa producer. Furthermore, the domestic market for cocoa beans remains substantial, alongside the expanding export opportunities (Statistik Kakao Indonesia., 2022).

To support the increased development of cocoa in Indonesia, it is essential to implement effective cultivation techniques, starting with proper seed preparation. A critical issue in preparing high-quality seeds is the storage time of the seeds. Cocoa seeds are considered recalcitrant seeds, meaning they have a high water content. Prolonged storage of these seeds can lead to a decrease in germination rates, ultimately affecting the growth of seedlings in the field in terms of both quality and quantity. Taini et al. (2019) noted that stored seeds may deteriorate, resulting in reduced quality, low viability, decreased vigor, poor growth upon planting, and lower yields.

Seed deterioration poses a challenge to seed preservation. Both environmental and genetic factors impact the longevity of seeds. Temperature and humidity are key environmental factors that affect seed storability. High storage temperatures can accelerate metabolic processes within seeds, particularly respiration, leading to increased enzyme activity and faster breakdown of food reserves, ultimately compromising seed viability. In terms of humidity, seeds strive to maintain equilibrium between internal and external moisture levels. Cocoa seeds, with high water content, are typically stored without special treatment, resulting in water evaporation and condensation on the seeds. Seeds with strong vigor exhibit better longevity in storage. Different seeds necessitate distinct storage methods, with seed type being a significant factor. For instance, seeds from the recalcitrant group are prone to deterioration if stored for extended periods due to their high water content (Triani, 2021).

Recalcitrant seeds include seeds that spoil quickly and cannot withstand long storage at low temperatures and humidity. The purpose of seed storage is to obtain available seeds that have high viability at a certain time until the seeds are used for planting, as well as to provide seeds for the next planting season or preserve plant seeds.

The study conducted by (Aji et al., 2018) regarding the storage time for mahogany seeds significantly impacted the growth rate, number of leaves, and dry fruit weight, ultimately affecting the viability and growth of mahogany seeds. Notably, a storage time of 2 weeks resulted in the highest viability and growth. However, this study did not demonstrate any significant effects on water content, growth percentage, plant height, and stem diameter. On the other hand, in the research conducted by (Triani, 2021), it was found that long-term storage of lychee seeds for 6 days led to lower germination rates compared to seeds that were not stored or stored for 3 days. Additionally, lychee seeds stored for 6 days exhibited a 4-day delay in germination compared to seeds not stored or stored for 3 days.

Research conducted by Rohandi and Widyani in 2016 on Tengkawang seeds stored for 0-4 weeks revealed significant impacts on germination capacity and speed.

Given this, it is imperative to investigate the storage duration of cocoa seeds without any specific treatment. Understanding the germination potential of stored cocoa seeds can serve as a reference point for those utilizing them for planting purposes.

2. MATERIAL AND METHODS

The study was conducted in two different locations: Basic Labor to observe the seeds' water content and in the Experimental Garden's greenhouse at the Faculty of Agriculture, Kuantan Singingi Islamic University, to monitor germination time and power. The research took place between November and December 2023. The average air temperature during this period was 28.8 0C, with a relative humidity of 81%. The materials and equipment utilized included Porestero variety cocoa seeds from local plantations in Koto Kari village, Kuantan Tengah District, Dithane M45, Pasir Kali, an oven, digital scale, tray, polyethylene (PE) plastic, hand sprayer, and stationery. The research methodology involved a qualitative approach with mathematical analysis. Data was analyzed and presented in tabular format. Seeds for Treatment 0 were planted immediately, while seeds for Treatment 1, 2, 3, and 4 were stored for 1, 2, 3, and 4 weeks respectively. The research stages are illustrated in Figure 1:

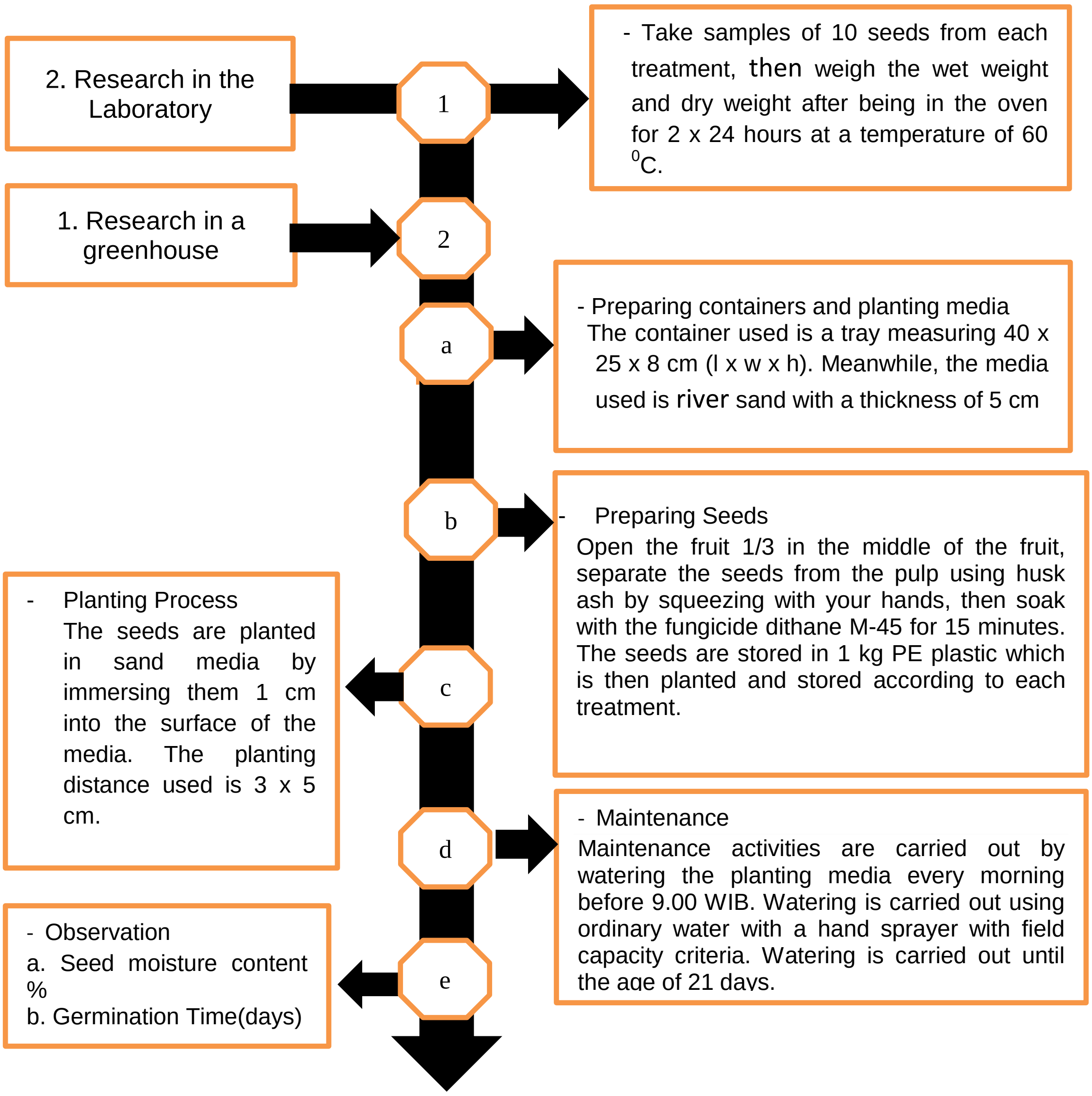

Figure 1. Research implementation flow diagram

The parameter observations carried out in this research are as follows:

a. Seed moisture content (%) is determined using the formula:

$$\text{Seed moisture content} = \frac{\text{M3} - \text{M2}}{\text{M2} - \text{M1}}\, x100$$

Note :
KA= Seed moisture content,
M1= weight of cup + empty lid,
M2= weight of cup + lid + seeds before heating,
M3= weight of cup + lid + seeds after heating.

Germination time (days) is calculated by the number of days the seed germinates with the criteria that the plumule has emerged on the surface of the planting medium. The formula for sprout speed is:

$$\text{Germination time} = \frac{\text{N1}}{\text{T1}}\ \text{x}\ \frac{\text{N2}}{\text{T2}}\ x\ \frac{N3}{T3}\ \frac{Nx}{Tx}\ \text{x}$$

Note :
N: Number of seeds germinated at time of Tx,
T: Time required to germinate, X: 1, 2, 3,.

Germination capacity (%) is seen from seeds that germinate up to 2
1 hss. The formula for germination is:

$$\text{Germination capacity} = \frac{\text{the number of seeds that germinate is normal}}{\text{Number of seeds germinated}}\, x100$$

3. RESULT AND DISCUSSION

3.1 Kadar Air Benih (%)

The results of research conducted on seed water content can be seen in Table 1.

Table 1. Seed Water Content at Different Storage Times (%).

Seed Treatment	Water Content (%)
Storage 0 Weeks	35.7
Storage 1 Week	36.3
Storage 2 Weeks	42.8
3 Weeks Storage	41.6
4 Weeks Storage	27.2

The seed moisture content refers to the quantity of water present in the seed. The presence of high or low water content in seeds significantly impacts their viability. According to the guidelines established by (Permentan, 2013), the recommended water content for recalcitrant seeds ranges from 30% to 40%. The process of weighing cocoa seeds to ascertain their water content is illustrated below in Figures 2 and 3.

Figure 2. Results of weighing the wet weight of cocoa seeds for each treatment of 0, 1, 2, 3, and 4 weeks of storage.

Figure 3. Results of weighing the dry weight of cocoa seeds for each treatment of 0, 1, 2, 3, and 4 weeks of storage.

Based on the findings from the observations conducted, the moisture content of seeds that underwent 0 and 1 week of storage complied with the standard, specifically 35.7% and 36%, respectively. However, the seeds subjected to 2 and 3 weeks of storage exceeded the standard, with 42.8% and 41.6% moisture content, respectively. Conversely, the seeds stored for 4 weeks had a significantly lower moisture content than the standard, measuring only 27.2%.

The reason behind the low water content in the seeds stored for 4 weeks can be attributed to the lack of airtightness in the PE plastic used. Consequently, the external environment substantially impacted the water content within the seeds as they attempted to achieve equilibrium with their storage surroundings. Sutopo (2012) states that seeds are hygroscopic and consistently strive to attain a state of equilibrium with their environment. Therefore, when the air humidity in the storage area is low, the seeds will endeavor to increase the surrounding air humidity by evaporating the water within them, decreasing their water content.

The reduction in seed water content observed during the 4-week treatment negatively impacted seed viability in this research. For instance, the germination time in Table 2 and germination capacity in Table 3 were affected, leading to abnormal growth processes in germinated seeds and eventual seed death. Tresniawati et al. (2014) state that a decrease in water content contributes to seed deterioration. Similarly, Sukesh and Chandrashekar (2013) emphasized that decreased water content during storage significantly influences seed viability.

Halimursyadah (2012) highlighted the importance of water in preserving the viability and vigor of recalcitrant seeds during storage, as it plays a crucial role in maintaining membrane and macromolecule stability. A decline in water content during storage can result in metabolic disorders, seed deterioration, and seed death.

3.2 Germination Time (days)

Based on the results of observations regarding the germination time of cocoa seeds can be seen in Table 2:

Table 2. Germination time for different seed storage (days).

Seed Treatment	Germination Time (Day)
Storage 0 Weeks	12.3
Storage 1 Week	4.4
Storage 2 Weeks	2.1
3 Weeks Storage	0
4 Weeks Storage	0

As per the observations, the cocoa seeds in the 0 week treatment exhibited the longest germination time, specifically 12.32 days after sowing (hss). Although this treatment requires a longer duration for growth, it does not imply that it is ineffective. Rather, it indicates that the seeds undergo various physiological germination processes within themselves. These processes include imbibition, enzyme activation, breakdown of food reserves, embryo formation, seed coat rupture, and eventual emergence of roots leading to sprout development.

Based on the research conducted by Wahyudi in 2019, the growth of the embryonic axis in seed sprouts results from two main events: the enlargement of existing cells and the generation of new cells through cell division at the growth point. As cells expand, various biochemical processes occur, facilitating the transportation of essential nutrients such as water, sugar, amino acids, and organic ions. These nutrients are then transformed into proteins, nucleic acids, polysaccharides, and other complex molecules, eventually developing into organelles, cell walls, cell membranes, tissues, and organs. Typically, this process is marked by the emergence of a radicle from the seed coat, which grows downwards to form the root system, while the plumule grows upwards to establish the shoot system. In line with the findings of Hasanah and Maharani in 2002, seed germination involves a series of metabolic activities that lead to the growth of the plumule and radicle. Post-harvest conditions, particularly seed storage, greatly influence the viability of seeds.

In the 1 and 2 week storage treatments, the seeds germinated at 4.4 days and 2.1 days, respectively. In contrast, the germination time for the 0 week treatment was 12.3 days, indicating that the seeds in the 1 and 2 weeks storage treatments germinated more quickly. The accelerated germination in the seeds stored for 1 and 2 weeks can be attributed to the preparation process of the cocoa seeds, which involves removing them from the fruit skin, separating them from the pulp, air-drying for 24 hours, and soaking them in the fungicide Dithane M45 for 15 minutes. This treatment allows the recalcitrant seeds to undergo metabolic processes necessary for germination, albeit slower than seeds planted directly. Observations in the storage room revealed that some seeds stored in PE plastic bags had already begun to release radicles. Consequently, when these seeds are transferred to the nursery, the metabolic processes will accelerate due to the optimal growth conditions, facilitating normal germination. Oktavia and Miftahorrachman (2012) noted that the transition from seeds to sprouts begins immediately after ripening and continues during storage.

Cocoa seeds are classified as recalcitrant seeds, meaning they cannot be stored for a long time due to their high water content. If these seeds are stored for an extended period, they will deteriorate and lose their viability. A study conducted by Sudrajat et al. (2017) found that after 3 to 4 weeks of storage, the germination of these seeds ceased. Even when planted in the nursery, the seeds stored in PE plastic showed signs of deterioration, such as a change in color to blackish brown and fungus growth. These observations indicate that the seeds had experienced decline or deterioration. This aligns with the findings of Kurniawan (2017), who stated that changes in the color of the seed coat, seed death, and the growth of fungus characterize seed deterioration.

3.2 Germination Power (%)

Based on the results of observations on the germination capacity of cocoa seeds it can be seen in Table 3 below:

Table 3. Germination Power at Different Seed Storage Times (%).

Seed Treatment	Germination Power (%)
Storage 0 Weeks	97.5
Storage 1 Week	43.9
Storage 2 Weeks	38.4
3 Weeks Storage	0
4 Weeks Storage	0

The 0 week or no storage treatment showed the highest germination capacity of cocoa seeds, reaching 97.5%, based on the observations. When the seeds are directly planted into the media, their food reserves remain intact, allowing for a successful germination process. The high percentage of germination indicates that the seeds have enough energy stored as food reserves for germination. This is possible because the cocoa seeds are planted directly into the nursery without any storage, ensuring their viability. Wulandari et al. (2015) mention that providing sufficient food reserves for the germination process allows for a longer growth period in the new environment before the plant can utilize its assimilation results. Figure 4 provides a visual representation of the germination capacity of cocoa seeds.

Figure 4. Germination capacity of cocoa seeds for each treatment of 0, 1, 2, 3, and 4 weeks of storage.

Cocoa seeds necessitate immediate planting in the nursery unless they receive special treatment. The treatment without storage in this study has resulted in a high germination capacity, considered a prerequisite for the physiological quality of recalcitrant seeds, as stated by Sudrajat et al. (2017). The physiological quality requirement for recalcitrant seeds is a germination capacity ranging from 60% to 100%.

The germination rates for the 1 and 2 week storage treatments were 43.9% and 38.4%, respectively, indicating a 56% and 63% decrease compared to immediately planted seeds. It is evident that as cocoa seeds are stored for longer periods, their viability decreases. The reduction in germination is attributed to a decrease in food reserves due to prolonged seed storage. Subantoro (2014) mentioned that reduced germination in seeds is a sign of diminished food reserves needed for germination. This reduction can result from extended seed storage or unsuitable storage conditions, leading to a loss of viability. Irawati et al. (2019) explain that respiration in recalcitrant seeds can deplete food reserves such as carbohydrates, fats, and proteins. Excessive respiration can generate alcohol, damage cell membranes, and reduce seed viability. Tatipata et al. (2004) also note that decreased germination is a physiological indicator of seed deterioration.

The lack of germination in the 3 and 4 week storage conditions was not solely due to food reserves but also to water content, as evidenced in Table 1 of the study. The water content in the 4 week treatment was only 27%, whereas the 0 week treatment had a water content of 35.7%. Regarding germination capacity, the 0 week treatment had a rate of 97.5%, while no sprouts emerged in the 4 week treatment. Anjarwati & Adelina (2020) stated that recalcitrant seeds are highly sensitive to drying, leading to decreased viability and germination with reduced water content. Similarly, Sari et al. (2019) mentioned that recalcitrant seeds with high water content do not undergo a dormant period. Although seed deterioration is inevitable, its progression can be slowed down through appropriate treatments (Sari *et al*., 2014).

Cellular changes occur in dry recalcitrant seeds, leading to damage to the cell membrane and cell walls, irregular and invisible cell nuclei, and a decrease in the mitotic index (Irawati et al., 2019). If recalcitrant seeds are exposed to critical water conditions, they will perish (Hasanah., 2002). Despite being stored in optimal conditions, the viability of recalcitrant seeds is limited to a few weeks or months (Anjarwati and Adelina, 2020).

4. CONCLUSION

According to the findings from the study on cocoa seed germination with varying storage durations, it was evident that the most effective approach involved planting seeds directly in the nursery. These seeds had a water content of 35.7%, a germination period of 12.3 days, and a germination rate of 97.56%.

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