Klover Multidisciplinary Journal of Engineering
Volume 10 Issue 2, April-June 2022
ISSN: 2995-4118
Impact Factor: 6.40
http://kloverjournals.org/journals/index.php/Engineering

ENHANCING COCOA SEED VIABILITY: INSIGHTS FROM EXPERIMENTAL STUDY

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Abstract
Cocoa, a plantation commodity belonging to the Sterculiaceae family, has its origins in Central America and the northern part of South America. The Maya Indians and the Aztecs were the first to utilize cocoa as a source of food and drink. In Indonesia, the top five provinces in terms of cocoa productivity in 2020 were North Sumatra, Riau Islands, Lampung, Central Kalimantan, and West Sumatra. Various factors contribute to the success and increase in cocoa production, and the utilization of superior seeds and seedlings capable of optimal growth in the field is one such factor. Seed viability and germination significantly influence the ability of cocoa plants to thrive in the field. To maintain seed viability and vigor, seeds require suitable storage conditions. Cocoa seeds, categorized as recalcitrant seeds, exhibit rapid germination within 3-4 days after being removed from the fruit, unless subjected to specific treatment. Effective storage and packaging processes play a vital role in preserving seed quality, sustaining high viability and vigor, and extending the dormancy period of the seeds. The viability of cocoa seeds is greatly affected by the seed storage process, as deterioration during storage results in diminished seed vigor and subsequent low cocoa production. Recalcitrant seeds have a relatively short shelf life and are sensitive to both reduced water content below 30% and storage temperatures exceeding 15%. This study aims to investigate the effectiveness of different types of growing media and storage durations on the viability of cocoa plants. By examining the impact of various storage conditions on cocoa seed viability, this research seeks to provide insights into optimizing cocoa production and seed preservation techniques.

Keywords: cocoa, seed viability, recalcitrant seeds, storage conditions, seed preservation, cocoa production, growing media, dormancy period.

1. Introduction

Cocoa is one of the plantation commodities originating from Central America and the northern part of South America which belongs to the Sterculiaceae family of the order Malvales. The people who first used the cocoa plant as food and drink were the Maya Indians and the
Aztecs [1] [2]. In Indonesia, there are 5 provinces with the highest cocoa productivity in 2020, namely North Sumatra, Riau Islands, Lampung, Central Kalimantan, and West Sumatra. The success and increase in cocoa production are influenced by several factors. One of the factors that can increase the success of cocoa production is the use of superior seeds and seedlings that are able to grow optimally in the field. Cocoa plants can grow optimally in the field if seed viability and germination [3]. The purpose of the storage is to keep the seeds in good condition (high viability and vigor), protect the seeds from pests and fungus attacks, and provide a sufficient supply of seeds during the fruiting season that cannot meet the needs [4].

Cocoa seeds are recalcitrant seeds which when ripe and removed from the fruit will quickly germinate if there is no special treatment within 3-4 days [2]. Special treatment that can be done for cocoa seeds is during the storage and packaging process with the aim of maintaining seeds so that viability and vigor remain high and slowing down the dormancy period of seeds. The seed storage process is very influential on the viability of the seeds. If the cacao seeds have regressed during the storage process, it will result in low seed vigor so that cocoa production will also be low. Recalcitrant seeds have a relatively short shelf life and are sensitive to a decrease in water content below 30% and storage temperature of 15%. The purpose of this study was to determine the effectiveness of several types of growing media and storage time on cocoa plant viability [5] [6].

2. Literature Review

2.1. Cocoa Plant

Cocoa is a plantation crop belonging to the Steculiaceae family with the Latin name Theobroma cacao. This plant comes from South America and is widely cultivated in various tropical regions [7] [8]. Indonesia is one of the largest countries that cultivate cocoa plants after Ivory-Coast and Ghana with production reaching 1,315,800 tons/year [9] [10]. Cocoa seed is a type of recalcitrant seed that requires special treatment in storage and packaging so that seed quality is maintained. Seed moisture content and humidity of storage space are the main obstacles in storing recalcitrant cocoa seeds[11] [12] [5].

Fig 1. Cacao Fruit

Cocoa fruit is a buni fruit whose seed flesh is very soft. The skin of the fruit has ten grooves and is 1-2 cm thick. The shape, size and color of cocoa pods vary and are about 10-30 cm long. Generally, there are three colors of cocoa pods, namely light green to dark green when young and becomes yellow when ripe, red, and a mixture of red and green[13] [14] [15].

2.2. Types of Cocoa Storage Media

Seed storage is one of the activities that can support increasing the number and quality of seeds, so it needs to be considered in ensuring the procurement of plant material through planting programs [16]. Another purpose of seed storage is also to guard against pests and diseases, and maintain high vigor and viability. Seed storage technique is an important activity to be developed in order to produce seeds with high viability during the storage period until the period of planting the seeds in the field [17]. The range of critical water limits for cocoa seeds that are safe for storage is between 25-35% obtained by using a seed dryer at a temperature of 35-40°C, 16% obtained from using a fan at a temperature of 24,75° C, RH 63.37% and between 19 – 23% obtained by using a fan at room temperature [18] [19] [20].

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Types of Cocoa Storage Media include: a. Polyethylene (PE Plastic)

b. Burlap Sacks
c. Aluminum Foil
d. Glass Bottle

3. Methods

The materials used in this experiment were the seeds of the superior hybrid F1 variety cocoa plant and the tools used were aluminum oil paper, jute sacks, glass bottles, PE plastics, paranet, analytical scales, gunny needles, plastic filters, threads, knives, glue, paper. labels, stationery and cameras.

This treatment is carried out by giving treatment to cocoa seeds with several storage media and storage time. The seed storage treatment factor consisted of 3 levels of treatment, namely without storage media, the use of aluminum foil paper, burlap sacks and glass bottles. Meanwhile, for the treatment of seed storage time, which is stored in a span of 1 week, 2 weeks and 3 weeks. Observational parameters that were measured were seed germination, seed growth speed and seed growing simultaneously. The data obtained were analyzed using the F test at the 5% level, if the calculated F is greater than the F table then the analysis is continued with the DMNRT test at the 5% level.

Fig 2. Seed Treatment

The stages of carrying out the research are 1. Preparation of research tools and materials, 2. Preparation of cocoa seeds, namely by means of cocoa pods selected based on the criteria for ripening the fruit which are observed directly on the parent tree of the seedling from the Oil Palm Research Center, namely with physiologically mature criteria which can be seen from the color and cocoa pod size. The criteria for physiologically ripe fruit are that the fruit skin has completely changed color from green to yellow or from red to dark orange, the fruit stalk begins to dry, and when the fruit is shaken it will make a sound. Cocoa seeds are taken from 2/3 cocoa pods to get uniform beans, then the cocoa beans are cleaned from the pulp by kneading the beans with husk ash carefully so that the beans are not damaged. 3. Drying the seeds by means of After the seeds are cleaned of pulp and washed. Then the seeds are air dried. To have better seed viability and vigor, the seeds were air-dried at room temperature for 2 days. 4. Application of treatment by means of clean cocoa beans, then packaged according to treatment and stored for a period of 1 week, 2 weeks, 3 weeks in the Growth center Laboratory at room temperature ± 24°C. 5. Seeds are sown by means of seeds that have been stored for 1 week, 2 weeks, and 3 weeks.

Furthermore, they are sown on the prepared nursery media. The nursery media was designed using 70% paranet shade and using sand media with an area of 1×2 meters and a thickness of 5 cm. At the time of seeding the cocoa seeds are watered with water in the morning and evening or according to field conditions.

4. Results and Discussion

4.1. Germination of Cocoa Seeds (%)

Seed germination can be seen in Table 1.

Table 1. Germination of Cocoa Seeds (%) on the Treatment of Multiple Storage Media and Duration of Seed Storage

Treatment	Seed Germination
Media Type	
P0	0,25 B
P1	3267,50 A
P2	3333,50 A
P3	3333,50 A
P4	3333,50 A
Storage Duration	
D1	7960,45 A
D2	0,25 B
D3	0,25 B
Interaction	
P0D1	0,25 B
P1D1	9802,00 B
P2D1	10000,00 A
P3D1	10000,00 A
P4D1	10000,00 A
P0D2	0,25 B
P1D2	0,25 B
P2D2	0,25 B
P3D2	0,25 B
P4D2	0,25 B
P0D3	0,25 B
P1D3	0,25 B
P2D3	0,25 B
P3D3	0,25 B
P4D3	0,25 B

From Table 1, it can be seen that the PE plastic treatment (P1) had no significant effect on the aluminuim poil (P2), gunny sack (P3) and boto treatments; glass (P4), as well as one week of storage (D1), the

interaction of the two treatments, namely P1D1 had a significantly different effect with P2D1, P3D1, and P4D1 treatments. The treatment of PE palatic storage media (P1) was the treatment with the lowest germination percentage but not significantly different from the other treatments. This is presumably because PE (P1) plastic has properties that are impermeable to water vapor so that it is able to isolate the seeds from the influence of the humidity of the storage medium.

4.2. Growth Rate of Cocoa Seeds (%)

Table 2 shows that the P1 treatment had no significant effect on the P2 and P3 treatments at the age of 4-6 HST. The P4 treatment had a significantly different effect from the P1, P2, and P3 treatments at the age of 7 HST. The interaction of treatment P1, P2, P3, P4 with D1 had a significantly different effect on the interaction of treatment D2 and D3. From the results of the analysis, it can be seen that the P4 treatment at 7 HST was effective in maintaining seed vigor so that it had a very significant effect on the speed of seed growth.

Table 2. Growth Rate of Cocoa Seeds (%) on Treatment of Several Media Type and Seed Storage Time (Day 7)

Treatment	Growth Rate of Cocoa Seeds						
	1 HST	2 HST	3 HST	4 HST	5 HST	6HST	7 HST
Media Type							
P0	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 B	0,25 B
P1	0,25 tn	0,25 tn	0,25 tn	171 A	104,33 A	86,65 A	67,38 B
P2	0,25 tn	0,25 tn	0,25 tn	208,5 A	133,5 A	92,02 A	67,38 B
P3	0,25 tn	0,25 tn	0,25 tn	208,5 A	133,5 A	92,02 A	67,38 B
P4	0,25 tn	0,25 tn	0,25 tn	208,5 A	133,5 A	92,02 A	265,37 A
Storage Time							
D1	0,25 tn	0,25 tn	0,25 tn	447,55 A	302,55 A	217,28 A	158,62 A
D2	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 B	0,25 B
D3	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 B	0,25 B
Interaction							
P0D1	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P1D1	0,25 tn	0,25 tn	0,25 tn	512,5 A	312,5 A	259,46 A	187,94 A
P2D1	0,25 tn	0,25 tn	0,25 tn	0,25 A	400 A	275.46 A	201,64 A
P3D1	0,25 tn	0,25 tn	0,25 tn	0,25 A	400 A	276.46 A	201,64 A
P4D1	0,25 tn	0,25 tn	0,25 tn	0,25 A	400 A	277.46 A	201,64 A

P0D2	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P1D2	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P2D2	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P3D2	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P4D2	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P0D3	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P1D3	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P2D3	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P3D3	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C
P4D3	0,25 tn	0,25 tn	0,25 tn	0,25 B	0,25 B	0,25 C	0,25 C

4.3. Simultaneous Growth of Cocoa Seeds

Table 3 shows that treatment P2 had a very significant effect on treatment P0, but had a significantly different effect on treatment P1, P3, and P4 at 5 HST, and had a very significant effect on treatment P0, and had no significant effect on treatment P1, but had an effect on significantly different from treatment P3, and P4 at 6-7 HST. Treatment D1 experienced an increase in the percentage of simultaneous growth at 6 HST and decreased at 7 HST. This is presumably because the factors that can affect the simultaneous growth of seeds are still in sufficient and good condition stated that when the moisture content and structure of the seeds are still complete, and food reserves are still met, the seeds can grow simultaneously.

Table 3. Simultaneous Growth of Cocoa Seeds on Treatment of Multiple Storage Media and Seed Storage Duration

Treatment	Simultaneously Growing Seeds						
	1 HST	2 HST	3 HST	4 HST	5 HST	6HST	7 HST
Media Type							
P0	0,25 tm	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	924,24 B	3016,83 A	3171,00 A
P2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	3333,5 A	3333,50 A	3333,50 A
P3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	369,80 B	369,8 B	0,25 C
P4	0,25 tn	0,25 tn	0,25 tn	0,25 tn	185,02 B	185,02 B	0,25 C
Storage Time							
D1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	2887,19 A	4142,74 A	3902,65 A
Treatment	Simultaneously Growing Seeds						
	1 HST	2 HST	3 HST	4 HST	5 HST	6HST	7 HST
D2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C

D3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
Interaction							
P0D1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P1D1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	2772,23 B	9050,0 A	9512,50 A
P2D1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	10000 A	10000 A	10000, A
P3D1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	1108,89 C	1108,89 C	0,25 C
P4D1	0,25 tn	0,25 tn	0,25 tn	0,25 tn	554,57 A	554,57 A	0,25 C
P0D2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P1D2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P2D2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P3D2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P4D2	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P0D3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P1D3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P2D3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P3D3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C
P4D3	0,25 tn	0,25 tn	0,25 tn	0,25 tn	0,25 C	0,25 C	0,25 C

5. Conclusion

The use of various types of seed storage media (P0 (without treatment), P1 (PE plastic), P2 (aluminum paper), P3 (gunny sacks), and P4 (glass bottles) were treatments that gave insignificant results at 1-3 HST. and the yield was very significant at the age of 4-7 HST on the speed of seed growth, giving insignificant results at the age of 1-4 HST and very significant results at the age of 5-7 HST on the simultaneous growth of seeds, giving an insignificant result at the age of 3 HST and giving very significant results on seed germination. The storage time of 1 week (P1) had a very significant effect on all parameters, namely the speed of seed growth, the simultaneous growth of seeds, the germination of seeds, while the storage time of 2 weeks (D2) and storage time of 3 weeks (D3) had no significant effect on all observation parameters. It can be concluded that the interaction of the two treatment factors had a very significant effect on all parameters, namely the speed of seed growth, the simultaneous growth of seeds, and the germination of seeds.

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