Two-Layer Rubber Biological Nursery Bag with a Coconut Coir Fiber Oasis (RBC Bag) to Retain Water and Maintain Soil Moisture for Durian Seedling Cultivation

Project by

Tanyarat KhamKao

Ratiphat Buakaew

Advisors

Theerapap Kaewon

Sriyapai School, Chumphon Province

Thailand

I. Abstract: Two-Layer Rubber Biological Nursery Bag with a Coconut Coir Fiber Oasis (RBC Bag) to Retain Water and Maintain Soil Moisture for Durian Seedling Cultivation

Growing durian seedlings using plastic nursery bag requires regular watering of the seedlings. This is because plastic nursery bag cannot retain water and moisture causing a large amount of water loss and bring a significant problem about plastic waste in the community. The objectives of this research were 1) to study the effectiveness of RBC bag to conventional plastic nursery bag in terms of water retention and soil moisture retention during durian seedling cultivation, and 2) to study the use of RBC bag to reduce water usage in durian seedling cultivation.

The scope of this research was divided into 4 parts as follows; part 1: study on the optimum ratio and fabrication of a RBC bag to retain water and maintain soil moisture, part 2: efficacy study of RBC bag to retain water and maintain soil moisture for durian seedling cultivation, part 3: study of the cost of producing RBC bag, and part 4: Implementation on the farms area. The results showed that the rubber can be processed into RBC bag with the best water/tapioca starch ratio of 200 ml/50 g, and starch/latex ratio for forming a nursery bag was 100 ml/200 ml. RBC bag was the best water retention followed by single-layer rubber biological nursery bag, and conventional plastic nursery bag with 5.5, 90 and 93 ml of water flowing from the nursery bag, respectively. Meanwhile, RBC bag have the best soil moisture retention, followed by standard plastic nursery bas and single-layer rubber biological nursery bag, which have 71 percent (7 days), 66 percent (6 days), and 65 percent (5 days), respectively before watering. The production cost was approximately 6.62 baht (USD 0.19)/piece and it will degrade naturally. The use of an RBC bag in durian seedling cultivation on farms in Chumphon Province during the summer season in April could save 57.14 percent of groundwater and user satisfaction satisfied with the maximum to level around 5.0 - 4.7. This innovation can solve the problems in water/groundwater management, plastic waste, and agriculture that align with SDGs and Thailand's Bio-Circular-Green agriculture model.

Keywords: RBC bag, Biological Nursery Bag, Rubber, Coconut Coir Fiber, Retain Water, Maintain Soil moisture

II. Table of Contents

III. Abbreviations and Acronyms

Abbreviation

ml – Milliliter

ºC – Celsius degree

g – Gram

Definition

Biological connected with the natural processes of living things.

Maintain to continue to have; to keep in existence, or not allow becoming less.

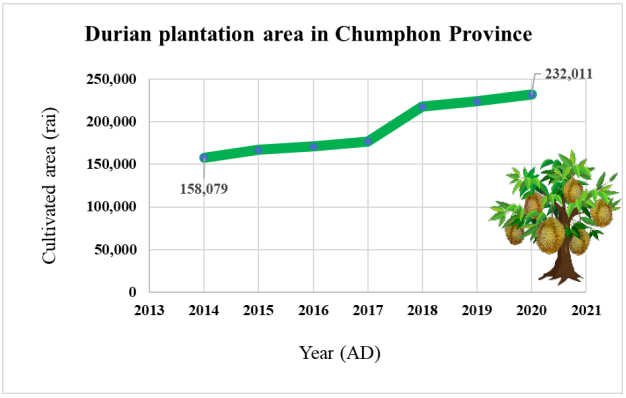
Moisture a liquid such as water in the form of very small drops, either in the air, in a substance, or on a surface

Cultivation the act of preparing land and growing crops on it, or the act of growing a particular crop

Chapter 1
Introduction

Statement of problems and significance

The King of Fruits, **Durian**, is a tropical fruit native to Southeast Asia. Thailand, Malaysia, Indonesia, and the Philippines produce the majority of durians. Due to the geography, climate, soil properties, and water resources appropriate for durian farming, Chumphon is one of the provinces where durian is the second largest economic crop in the country, behind Chanthaburi. In 2020, Chumphon has a durian plantation area of 232,011 rai due to the high price of durian. Therefore, this encourage farmers to plant more durian each year (Figure 1 (a)). In 2016, Thailand exported 402 million kilograms of durian, representing to 95% of global exports, followed by Malaysia, providing for 4% (Figure 1(b)). Durian has a retail value over USD 9 billion both locally and internationally, and farmers expect to earn more than USD 25 billion from durian exports by 2020 (Figure 1(c)). Moreover, durian has likely continued growing. Global demand is expected more than USD 25 billion by 2030.



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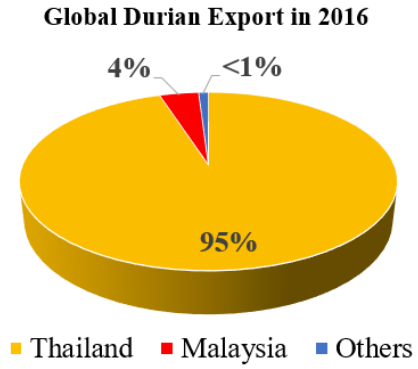

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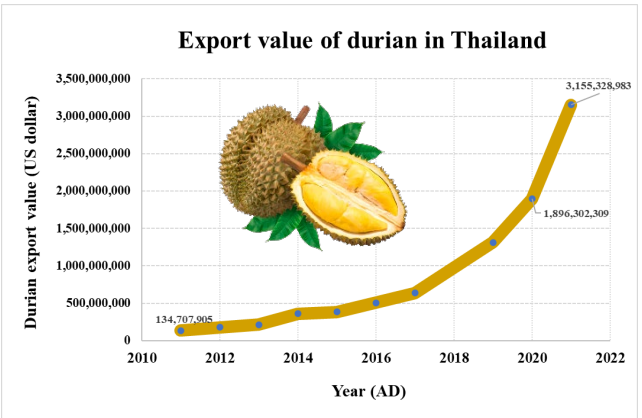


(c)

Figure 1: (a) Durian cultivation area data in Chumphon province from 2014 to 2020 (Office of Agricultural Economics, 2021) (b) Global durian export data in 2016
(Source: Durian Harvests Published, 2021), and (c) The export value of durian in Thailand. (Office of Agricultural Economics, 2021)

Durian seedling cultivation is an important step. At this stage, the durian needs a constant water to grow well. It requires 600-800 cubic meters of water per rai, optimum relative humidity between 75 and 85 percent. (Ministry of Commerce, 2020) and a huge number of nursery bags. Plastic bag are use in the commercial nursery bag. It takes about 600 years to decompose, which causing environmental problems as polluting waste on the ground, and some of it runs into water sources, seas, and ocean, polluting the water and harming aquatic wildlife. In the end, it will turn to microplastics as a contaminant in the environment (Figure 2), which will be dangerous to humans.

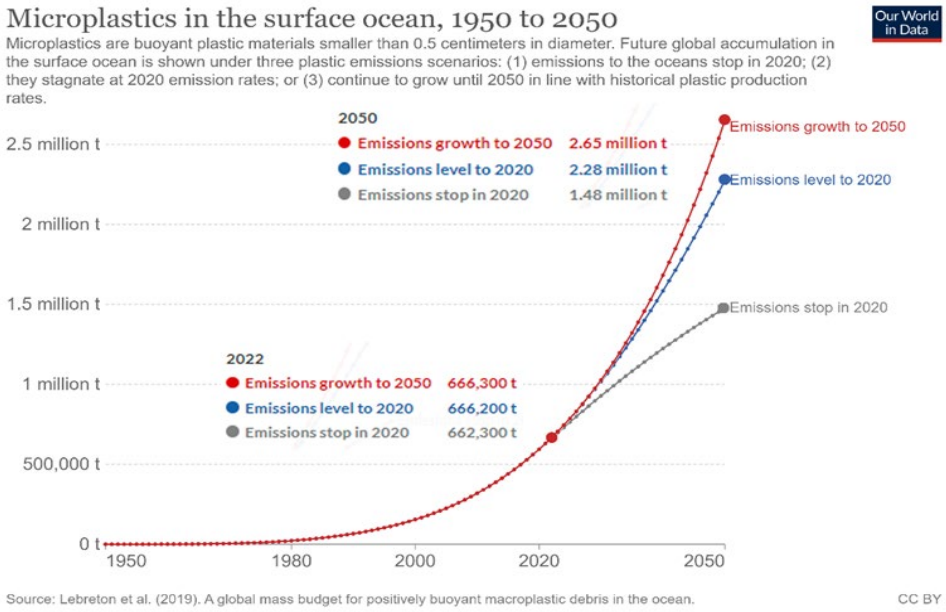


Figure 2: The number of microplastics in the surface ocean, 1950 - 2050.
Source: Our world in data (2022)

Therefore, we are interested in employing natural materials and low-cost such as rubber and coconut coir fiber to create two-layer rubber biological nursery bag with a coconut coir fiber (RBC bag). RBC bag is environmentally friendly, which will retain water, decrease plastic waste in the community, and minimize contaminated microplastics in the environment. In addition, it will increases the value of latex in economic and upcycling the coconut coir fiber in the community. The product is made in accordance with the Sustainable Development Goals (SDGs) 2, 6, 12, 13, 15 and the Bio-Circular-Green (BCG) Economy Model, which focuses on eliminating environmental problems and reducing the impact on the environment in a responsible way.

Research Questions:

1. How effective are RBC bag to retain water and maintain soil moisture for durian seedling cultivation?
2. How do RBC bag reduce water usage in durian seedling cultivation?

Hypotheses:

1. RBC bag are effective in water retention and soil moisture retention for durian seedling cultivation.
2. RBC bag reduce water usage in durian seedling cultivation.

Objectives:

1. To study the effectiveness of RBC bag to conventional plastic nursery bag in terms of water retention and soil moisture retention during durian seedling cultivation.
2. To study the use of RBC bag to reduce water usage in durian seedling cultivation.

Scope of study:

1. Study area

Sriyapai School, Tha Taphao Subdistrict, and Thung Kha Subdistrict, Mueang Chumphon District, Chumphon Province

2. Relevant factors desire to study for measurement.

2.1 Relevant factors

Soil moisture in nursery bag, Water holding capacity of coconut coir.

2.3 Statistic

Average and Percentage had been used for statistical analysis.

3. The period of research

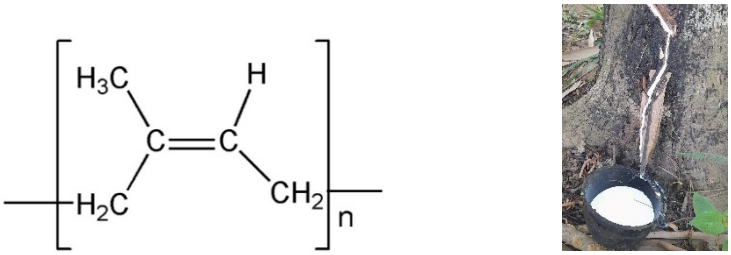
1 November 2021 – 23 May 2022.

Chapter 2
Literature Review

1. Rubber

The rubber tree (*Hevea brasiliensis*) can provide latex up to 30 years and have a lifespan of about 40 years. In Thailand, Para Rubber is classified as an important economic crop that generates millions of Baht per year for the country. The areas where Para Rubber is planted are the southern, eastern and some parts of the Northeast.

Rubber has highly flexible and excellent properties in terms of adhesion. It has very high tensile strength agents and tear resistance at both room temperature and high temperature. In addition, rubber has high abrasion resistance, and very high electrical insulation. Moreover, raw rubber is highly soluble in non-polar solvents. (Rubber Innovation Research and Development Institute, Prince of Songkla University, 2016)



(a) (b)

Figure 3: (a) Chemical structure of Para Rubber and (b) Raw rubber from tree.
Source: Pinyo Wongthong and Suda Kiatkamjornwong (2017)

2. Rubber Nursery Bag

Nowadays, seedling cultivation require a large number of plastic bags. Decomposition takes a long time, resulting in waste and having an impact on animals and the environment. The researchers experimented with the modified formulation of Para Rubber to be suitable for used as a seedling planting bag. The shape retention of the nursery bag by the formula invented and from the experiment can make the nursery bag decompose naturally without leaving toxic residues in the soil. As a result, rubber nursery bag will assist in the reduction of the problem. Farmers are encouraged to minimize production costs by reducing plastic trash created from the original planting bag, labor saving, includes the root treatment of seedlings arising from seedling transfers. (Chiang Mai News, 2019)

Important characteristics of rubber planting bag is good water holding capacity and durability in dry conditions depend on production methods. The bag can endure all types of seedlings, planting environment, and can nourish the seedlings. (Ministry of Natural Resources and Environment, 2019)

2.1 Method for Making Rubber Nursery Bag

The forming technique of nursery bag is dipping method that requires thin layer. It can increase the thickness by repeated dipping. (Patcharaporn Ongsaranakomkul, 2021)

2.2 The Benefits of Rubber Nursery Bag

The rubber nursery bag provides several advantages, including the ability to go simply into the soil without having to relocate the seedlings, the ability to decay without polluting the environment when planted in the soil, and the ability to help minimize the waste generated by conventional plastic nursery bag. Rubber nursery bag offer a high water absorption capacity, minimizing the need for regular watering, and reducing water consumption due to a swelling rate of 15% to 35% of the bag weight. Furthermore, it supports in the resolution of the rubber's cost issue, hence increasing the latex's value. (Chiang Mai News, 2019)

3. Durian Cultivation

Durian is known as the king of Thai fruit (King of Fruit) and is the main economic fruit of Thailand. Figure 4 illustrates the four stages of durian cultivation. It took about 5-6 years from the start of the process to the harvest.

Figure 4: Durian growth stage
Source: Jakkris (2018) and Meehay (2017)

4. Soil Moisture

Plants require a lot of moisture in the soil. Plants take water from the soil that retains it, which is measured by soil moisture. Because of water is a necessary element for usage in metabolism. (GuruKaset, 2020)

4.1 Soil Moisture Meter

Soil moisture refers to the amount of water that is distributed between the soil grains. Depending on the use, there are essential in helping to manage water in the soil to be more efficient that measure by soil moisture meter. (Neonics, 2020)

4.2 Soil Moisture of Durian Cultivation

A study of durian orchards during the off-season Durian is separated into four phases, with an average soil moisture content of 65 percent during four periods of soil moisture analysis. In summer season of Thailand, April, the water content of the soil drops by an average of 20 percent, necessitating irrigation to promote irrigation normal durian growth. (Wichan Pettong and Salila Vongkrachang, 2020)

5. Coconut Coir Fiber

The fiber found in coconut coir is known as coconut coir fiber. It will account for 60 percent of the coir in the fiber. Coconut coir contains 0.67 ppm of nitrogen, 3,477 ppm of phosphorus, and 8,530 ppm of potassium. (Preeya Phorn Namsai, 2003), a high water holding capacity, and the ability to keep moisture for a long period. Coconut coir fiber has a water absorption coefficient (Hydraulic Conductivity) 0.15 cm/s and particle sizes ranging from 0.5 to 2.0 mm. Most gaps are 0.0047 microns wide, with a Total Density of 0.06 g/mm, Total Porosity 95.53 percent, Total Air Space is 4.87 percent, Easily Available Water is 35.28 percent, and Water Buffering Capacity is 8.76 percent. (Sompop Phanthong, 2013)

Figure 5: Coconut coir fiber

Coconut coir fiber helps to store water and reduce water usage. Thanakan Aranpool and Panupon Hong Phakdi (2013) found that coconut coir fiber could effectively retain water when a random quantity of coconut coir fiber in the planting material was applied to marigolds at four different levels: 0, 25, 50, and 75 percent, respectively. Every levels can help to reduce water consumption (ETc), the rate of transpiration per unit of leaf area, Water utilization efficiency (WUE) and Water utilization coefficient (Kc). Because it has good water holding properties, is cheap, and is widely available in Thailand and the other countries. (Methawee Jeamjit, 2008).

6. Related Research

"Biodegradable Nursery Bag from Green Raw Materials," produced by Sa-ad Riyachan and Lalisa Bunmachimplee (2022), won an award from the Royal Forest Department's packaging contest project in an environmentally friendly substitute material for seedling bag. They created planting bag from Para Rubber, Tapioca Starch, and sugarcane leaves that had been changed. These materials are agricultural waste with relatively low price, water resistance, mold proof, good natural degradation, and does not damage the roots of plants after use.

Chapter 3
Materials and Methods

Materials

	Material	Unit
1.	Tapioca Starch	50 g
2.	Water	200 ml
3.	Mixing cup	6 cups
4.	Glass rod	6 rods
5.	Gas stove	1 stove
6.	Containers that can be exposed to heat	6 pieces
7.	Latex	200 ml
8.	500 ml and 1000 ml beakers	2 pieces
9.	Tissue paper	1 roll
10.	Coconut coir fiber	30 g
11.	Soil for cultivation	350 g
12.	Measuring cylinder	1 piece
13.	Moisture meter	1 piece

Data Analysis

Analyze the results by using Mean and Percentage

Methods

The methods have been designed into four experiments as following:

Experiment 1: Study on the optimum ratio and fabrication of a RBC bag to retain water and maintain soil moisture.

Experiment 2: Efficacy study of RBC bag to retain water and maintain soil moisture for durian seedling cultivation.

Experiment 3: Study of the cost of producing RBC bag.

Experiment 4: Implementation on the farms area.

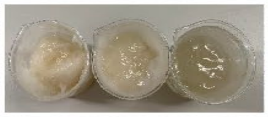
Scan QR Code to see the complete methods

Experiment 1: Study on the Optimum Ratio and Fabrication of a RBC Bag to Retain Water and Maintain Soil Moisture.

Tapioca Starch
25, 50, 75 g

Water
200 ml

Stir to combine and set over medium heat.
Stir until viscous until it turns into a paste.



Compare the characteristics of each ratio of the paste.

Choose the optimum ratio

Paste 100 ml

Latex 100, 200, 300 ml

Mix and stir with a glass rod until it turns into a paste and choose the optimum ratio

Forming nursery bags

8 hours in the sun

Nursery bags removed from the mold

Drill a hole and insert the coconut coir fiber.

RBC Bag

Experiment 2: Efficacy Study of RBC Bag to Retain Water and Maintain Soil Moisture for Durian Seedling Cultivation.

Plastic nursery bag, single layer biological nursery bag, and RBC bag

Add 350 g of soil.

Ready-to-test nursery bags

Water the nursery bag with a volume of 300 ml.

Set for 5 minutes

Measure the amount of water that flows out.

Measure soil moisture

Experiment 3: Study of the Cost of Producing RBC Bags.

$$\text{Production Cost/Unit} = \frac{\text{Raw Material Cost} + \text{Production Cost} + \text{Labor Cost}}{\text{Number of Units Produced}}$$

Experiment 4: Implementation on the Farms Area.

Implement the product in the field and record the efficacy.

Chapter 4

Results

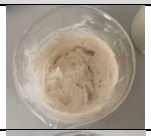
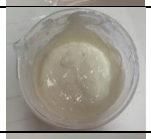
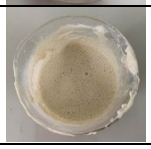
<u>Experiment 1</u>: Study on the Optimum Ratio and Fabrication of a RBC Bag to Retain Water and Maintain Soil Moisture

Table 1: Study of the optimum ratio between water and Tapioca Starch in the fabrication of Biological nursery bag from rubber.

Water (ml)	Tapioca Starch (g)	Appearance	Illustration
200	25	too liquid	
	50	good viscosity	
	75	too viscous	

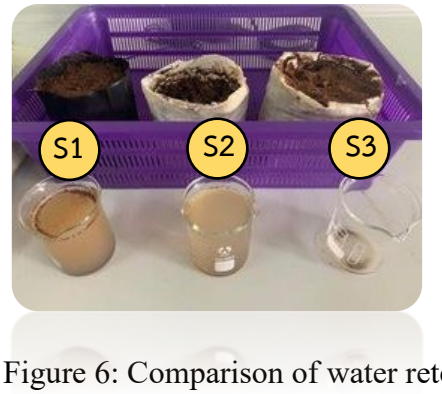
From Table 1, it was found that the mixing ratio between 200 ml of water per 50 g of tapioca starch yielded a paste, which is a viscous appearance suitable for the invention of biological bag. While, the ratio 200 ml of water per 25 g of tapioca starch, which is too liquid, and 200 ml of water per 75 g of tapioca starch, which is too viscous.

Table 2: Study of the optimal ratio between paste and latex in the fabrication of biological nursery bag.

The ratio between paste and latex	Appearance	Illustration
1:1	too viscous	
1:2	good viscosity	
1:3	too liquid	

From Table 2, it was found that the mixing ratio 1:2 (100 ml paste per 200 ml of latex) had a good adhesion between the paste and the latex. It is easier to form the shape than a 1:1 mixture ratio, which has poor adhesion, and a 1:3 mixture ratio, which is too liquid.

<u>Experiment 2</u>: Efficacy Study of RBC Bag to Retain Water and Maintain Soil Moisture for Durian Seedling Cultivation



Sample 1: S1 is a conventional plastic nursery bag.
Sample 2: S2 is a single-layer rubber biological bag.
Sample 3: S3 is RBC Bag

Figure 6: Comparison of water retention efficiency of three types of nursery bag.

When 350 g of soil and 300 ml of water were added to three types of nursery bag, it was found that RBC bag (S3) had the least amount of water flowing from them, followed by single-layer rubber biological bag (S2) and conventional plastic nursery bag (S1). As illustrated in Figure 7, the amount of water measured from the measuring cylinder is 5.5, 90, and 93 ml, respectively.

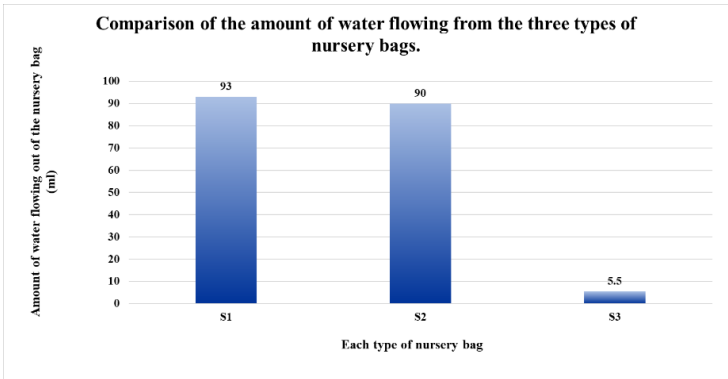


Figure 7: Comparison of the amount of water flowing from three types of nursery bag.

In the three nursery bag, RBC bag were able to maintain soil moisture the longest, followed by conventional plastic nursery bag and single-layer rubber biological bag, which could keep soil moisture at 71 percent (7 days), 66 percent (6 days), and 65 percent (5 days), respectively. When the effectiveness of soil moisture retention was lowered below 65 percent, it needs the re-watering, because it unsuitable for the growth of durian seedlings. There is a need for more watering, as shown in Figure 8.

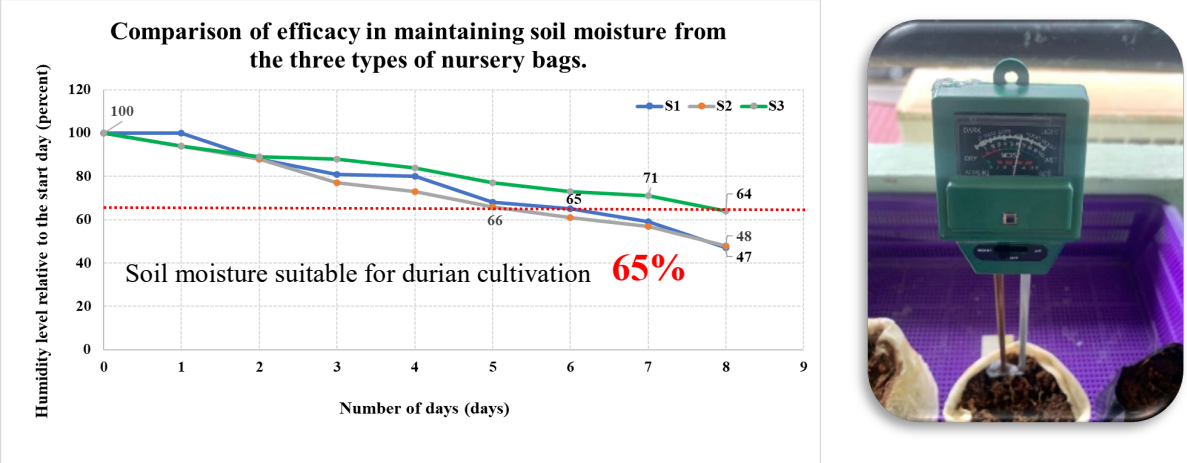
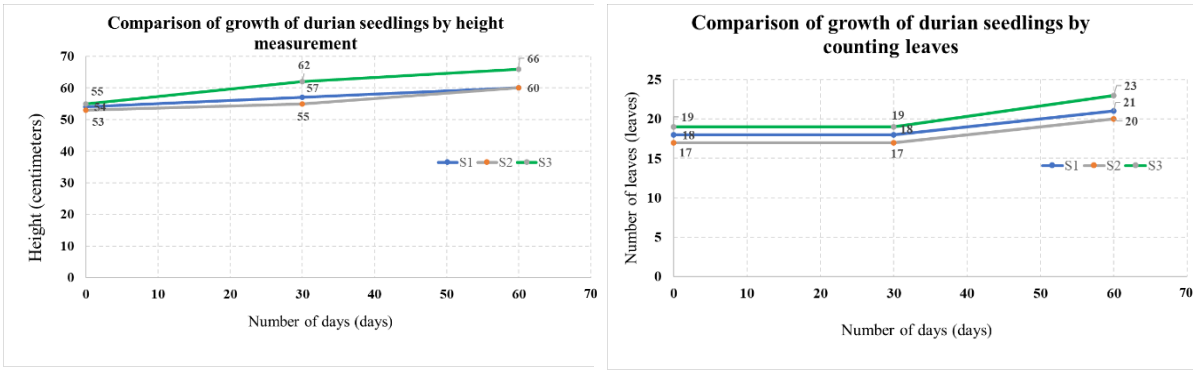


Figure 8: Comparison of the efficacy in maintaining soil moisture from three types of nursery bag.

Durian height grew two months after the plants were planted in the ground. The RBC bag, durian trees grew to a height of 66 cm. While employing a single-layer rubber biological bag, the height of durian trees increased to 60 cm. And a durian tree grown in conventional plastic nursery bag grows to a height of 60 cm (Figure 9 (a)). In the same result, the durian trees that utilized the RBC bag had the most leaves, followed by single-layer rubber biological bag and conventional plastic nursery bag with a total of 23, 20, and 21 leaves, respectively (Figure 9 (b)).



(a) (b)

(c)

Figure 9: Comparison of durian seedling growth over a two-month period (a) height of durian trees, (b) Number of leaves on durian trees, and (c) Measurement the durian height.

Experiment 3: Study of the Cost of Producing RBC Bag

$$\text{Production cost/unit} = \frac{\text{Raw Material Cost + Production Cost + Labor Cost}}{\text{Number of Units Produced}}$$

Source: Department of Industrial Promotion (2021)

$$\text{Production cost of RBC bag per piece} = \frac{\text{Total cost of production}}{\text{Number of units produced}}$$

$$= \frac{\text{Latex Cost + Tapioca Starch Cost + Coconut Coir Fiber Cost + Labor cost}}{120}$$

$$= \frac{187 + 7 + 0 + 600}{120}$$

$$= \frac{794}{120}$$

$$= 6.62 \text{ baht (USD 0.19)/ piece}$$

Remark: Raw Material Cost and Production Cost are 3,427 ml of latex, 427 g of tapioca starch, and 50 g of coconut coir fiber.

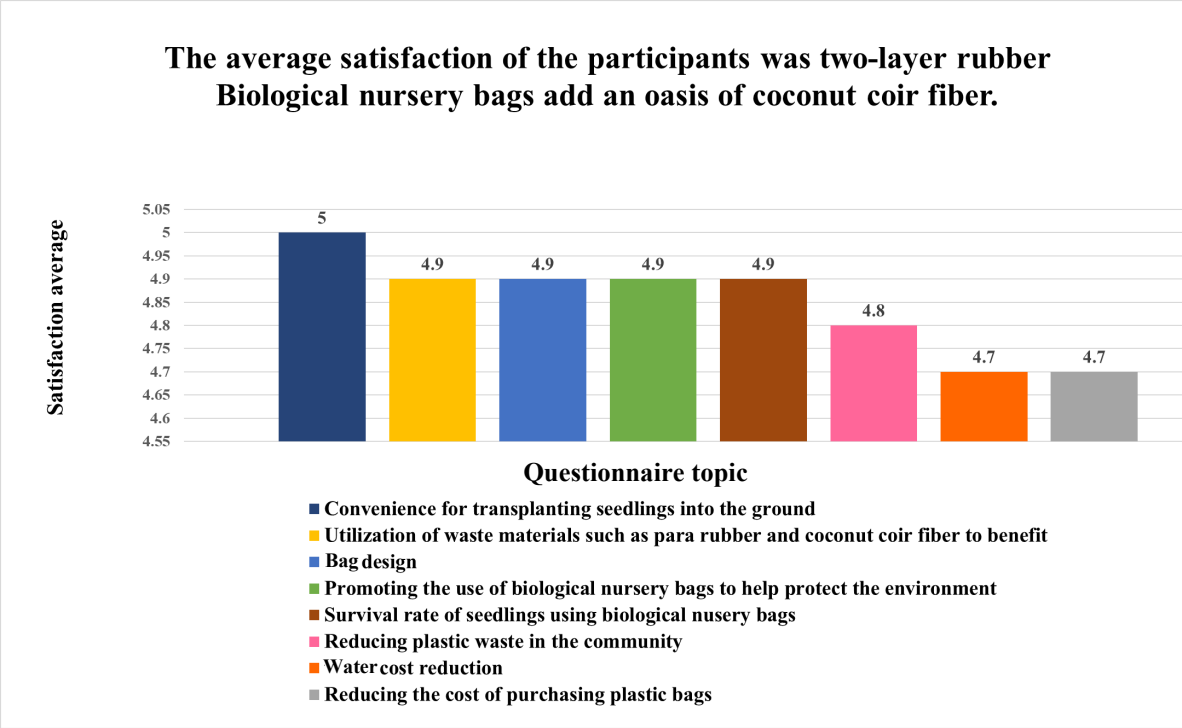
RBC bag reinforced with coconut coir fiber oasis and made of double-layered Para Rubber. The cost of creating 120 bags was estimated to be about 6.62 baht (USD 0.19) each piece, however if the bag were made in larger quantities, the cost per piece may be lower. Although, RBC bag will be more expensive than conventional plastic nursery bag, but it is biodegradable because it is composed of natural materials. There will be no plastic bag waste management or recycling costs.

Experiment 4: Implementation on the Farms Area

In Chumphon Province, RBC bags were utilized to nurture durian seedlings in farm areas. For 60 days, 15 people in the sample group planted 25 durian plants, spaced 8x8 meters in one rai, with groundwater for watering, which is a local water source. The result shown that Thailand's summer in April is extremely hot weather with an average maximum temperature of 36°C (Freemeteo, 2022), the soil moisture declined dramatically below 65 percent in a day. Therefore, conventional plastic nursery bags need to be watered every day and used groundwater 875 liters/rai/week (0.55 liters/m^2/week). While the RBC bag can be watered every two days and required groundwater 375 liters/rai/week (0.23 liters/m^2/week) because the soil moisture is still over 65 percent. As a result, using RBC bags can help reduce groundwater

use in agriculture by 500 liters/rai/week (0.31 liters/m^2/week), or 57.14 percent. Consequently, the use of RBC bags is part of contributing to the conservation of groundwater use.

For the other aspect, the leaders' satisfaction in the real trial revealed that the majority of users agree that transplanting durian seedlings into the ground is most convenient at level five. Utilization of waste materials; latex and coconut coir fiber, the design of RBC bag, the survival rate of seedlings using RBC bag was at a level of 4.9. Plastic trash reduction in the community was rated at 4.8, and the cost of water usage and purchasing plastic bags was rated at 4.7. In conclusion, every consumers reported to be satisfied with the implementation of the RBC bag in durian seedling cultivation in their field.



(a)

(b)

Figure 10: (a) Average user satisfaction

Chapter 5
Conclusion and Discussion

Conclusions

1. The study on the optimum ratio and fabrication of RBC bag to retain water and maintain soil moisture, found that the best ratio between water and tapioca starch was 200 ml/50 g. The ratio of starch and latex which appropriate for forming a nursery bag was 100 ml/200 ml. Due to rubber's high flexibility allows it to be used in a variety of applications. It offers outstanding adhesive capabilities as well as a high tensile strength without the use of reinforcing agents. It has a very high tear resistance at both room temperature and high temperature. (Rubber Innovation Research and Development Institute Prince of Songkla University, 2016)
2. Efficacy study of RBC bag to retain water and maintain soil moisture for durian seedling cultivation, showed that RBC bag was the best water retention followed by single-layer rubber biological nursery bag and conventional plastic nursery bag with 5.5, 90 and 93 ml of water flowing from the nursery bag, respectively. Meanwhile, RBC bag has the best soil moisture retention, followed by standard plastic nursery bag and single-layer rubber biological nursery bag, which have 71 percent (7 days), 66 percent (6 days), and 65 percent (5 days), respectively, and are watered after 8 days. Because RBC bag include coconut coir fiber, which helps retain water, it should be developed as a suitable seedling material. According to Methawee (2008), coconut coir fiber can hold a lot of water, cheap, and retain the most moisture. (Thanakan Aranpool and Panupon Hong Phakdi, 2013)
3. The study on the cost of producing RBC bag, found that in the production of 120 bags, the production cost was about 6.62 baht (USD 0.19)/piece. Nevertheless, the cost per piece could be reduced if the bag were produced in higher quantities. Although, RBC bag will be more expensive than conventional nursery bag, but it is biodegradable because it is made from natural material. There will be no charges associated with waste management or recycling of plastic bag. The community will produce less plastic garbage, which will result in many types of contamination, including the future problem of microplastics. In addition, when degraded, coconut coir fiber can provide nutrients to seedlings, according to Preeyaporn (2003), who discovered that coconut coir contains 0.67 percent of nitrogen, 3,477 ppm of phosphorus, and 8,530 ppm of potassium. Moreover, Latex and coconut coir

fiber are added to increase the product's value and help durian seedlings preserve water by holding moisture.

4. Implementation on farms in Chumphon Province reported that during Thailand's summer season in April, the weather was extremely hot, causing the soil moisture to deplete faster than in the experiment. As a result, more frequent watering is required, and the use of an RBC bag in durian seedling culture can save 57.14 percent of groundwater. User satisfaction showed their satisfaction with the implementation of the RBC bag in durian seedling cultivation in their field with the highest or high level around 5.0 - 4.7.

Recommendation

RBC bag is the biological nursery bag, which provides effective for water storage and humidity. It can be used on other plants and will degrade naturally as friendly product. Furthermore, the biological nursery bag help to preserve the roots of seedlings that have been transferred. The roots of the seedlings may be broken because of the slicing of the bag to bring the seedlings into the ground, which may affect the growth of the seedlings. Additionally, the RBC bag project will minimize plastic waste in the community as well as microplastics in the environment. It will also improve the community's economic by increasing the value of latex and upcycling coconut coir fiber, which is currently a waste product.

IV. Acknowledgement

The innovation of biological rubber nursery bag made from two layers of coconut core fiber added to oasis to store water for cultivating durian seedlings are part of a study on water saving solutions. This research will help the organization's creativity and awareness of water resource conservation, and finally apply the experience to the community.

This research was completed with the help of Teacher Theerapap Kaewon, a teacher research advisor, and Mr. Udomporn Suamak, a research scientist adviser, who provides advice on how to conduct the research in accordance with the research principles. Thank you to the Director and all of the Sriyapai School's deputy directors for their assistance in promoting the equipment and locations for research on Two-Layer Rubber Biological Nursery Bag with a Coconut Coir Fiber Oasis to Retain Water and Maintain Soil Moisture for Durian Seedling Cultivation. It is hoped that this RBC bag is expected to benefit the educational community in the future.

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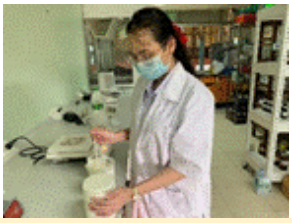
VI. Annexation

The process of preparing the latex and paste

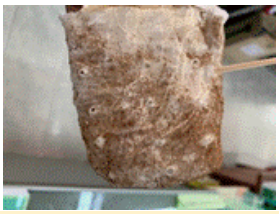
The latex and the finished paste

The process of mixing the latex and paste according to the ratio and stirring to combine



The process of forming a biological nursery bag from rubber

The process of removing the nursery bag from the rubber from the mold



The process of drilling holes in the rubber nursery bag

The process of inserting coconut coir fiber oasis between the two sizes of rubber nursery bags and filling the soil in the rubber nursery bags

The water retention test procedure with the nursery bag placed on the sieve

Implementation on the farms area