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Exploration and characterization of Gayam (*Inocarpus fagifer*): Conservation foundation for sustainable tropical ecosystems

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ABSTRACT

The conservation of the *Inocarpus fagifer* plant, commonly known as Gayam, is a significant focus in protecting important tropical ecosystems. This research aims to assess the preservation and development of Gayam in the Conservation Garden Area of Postgraduate Science Education at Bengkulu University. The study employed a descriptive quantitative and qualitative approach, utilizing primary and secondary data collection methods. The analysis involved examining the growth rate of Gayam seedlings, environmental conditions, and factors influencing preservation. The findings revealed that Gayam has the potential for widespread distribution in Indonesia, with various local names. However, Gayam does not dominate at the seedling stage, making seed preservation crucial. The characteristics of Gayam, including its crown, stem, leaves, flowers, fruits, and seeds, define this plant. Preservation success is influenced by factors such as moisture content, temperature, storage medium, and light intensity. The observations of light intensity in the conservation area indicated favorable conditions for photosynthesis. To maintain Gayam seedlings, watering, fertilizing, and pest control are necessary. The use of both organic and inorganic fertilizers, as well as organic pesticides, supports the growth of the seedlings. A comprehensive understanding of these aspects is essential for enhancing the preservation and potential expansion of Gayam in the Bengkulu University Master of Science Education Conservation Area. This research contributes significantly to biodiversity conservation efforts and the sustainability of tropical ecosystems in Indonesia, particularly through the preservation of Gayam plants, which play important ecological, economic, and social roles.

Keywords**:** *Biodiversity; Tropical ecosystem; Palmyra; Preservation; environmental conditions.*

1. INTRODUCTION

Indonesia, known for its mega-biodiversity, boasts a remarkable array of ecosystems, species, and germplasm globally recognized as centers of diversity. However, this natural wealth is under threat due to the country's population growth and rapid development, which have led to changes in habitat function (Nugroho et al., 2023). As a result, Indonesia is now a priority area for global conservation efforts, as the pace of development has significantly impacted the decline in biodiversity. While shared biological resources, such as oceans and forests, offer opportunities for all, protecting biodiversity in the face of inevitable habitat destruction caused by human activities is crucial. Therefore, the urgency for biodiversity conservation action is growing, and it is the government's and society's joint responsibility to ensure the sustainability of Indonesia's biological resources (Tetelay & Siahaya, 2018).

Indonesia's abundant biodiversity is greatly influenced by tropical ecosystems, which play a crucial role in preserving the global ecological equilibrium. Nevertheless, the escalating population growth and rapid pace of development may present grave dangers to biodiversity, leading to the potential extinction of species and the destruction of habitats, consequences that cannot be overlooked (Nugroho et al., 2022). To confront these challenges, the style plant (Inocarpus fagifer) has emerged as a focal point in conservation strategies. These plants possess significant ecological value and contribute significantly to the economy and society, forming the cornerstone of sustainable conservation efforts for tropical ecosystems (Riyadi et al., 2023).

Tropical ecosystems, as one of the world's largest sources of biodiversity, provide terrestrial ecosystems that play an essential role in maintaining Earth's most diverse and productive biodiversity. Through the immense contribution of its flora and fauna, these ecosystems help maintain global ecological balance (da Silva et al., 2019). However, as an integral part of these tropical ecosystems, Indonesia faces significant environmental threats, particularly related to the risk of species extinction and habitat destruction that result in a decline in biodiversity (Villalobos et al., 2016). The development process, fueled by large population growth, has led to increased basic needs, which has triggered land conversion of forests, rice fields and community gardens, both by the government and the private sector. This impact is detrimental, causing a simultaneous decline in the population of various plant, animal and microbial species. Therefore, Indonesia is recognized as one of the priority areas in global biodiversity conservation efforts (Berger, 2023).

The Gayam plant (Inocarpus fagifer) has emerged as a crucial element in a significant conservation strategy in light of the diverse obstacles tropical ecosystems encounter. These plants play a vital role in upholding the equilibrium of tropical ecosystems and offer substantial benefits in addressing the environmental and economic challenges confronted by Indonesia. As the sustainability of tropical ecosystems becomes progressively demanding, the preservation of the Gayam plant establishes itself as a fundamental pillar of conservation (Tetelay & Siahaya, 2018).

The Gayam fruit, also known as Gatep, is a type of tree that belongs to the legume family (Fabaceae) and can grow up to 20 to 30 meters tall. It has a kidney-shaped pod-like appearance with a tough outer skin. Each Gayam fruit is flat and has a smooth surface. Gayam trees are considered perennial, and their fruits have a relatively hard texture without any ovaries, unlike most other fruits. The seeds of the Gayam fruit contain sap and are covered by a hard outer skin. When unripe, the Gayam fruit's skin is green and turns yellow or brownish when ripe. Gayam trees can

grow up to 30 meters tall with a trunk diameter of up to 65 cm. The trunks of Gayam trees often have irregular grooves, sometimes have buttress roots, and their branches hang down, offering various potential benefits (Smith et al., 2023)

Gayam exhibits a remarkable capacity to thrive in diverse weather conditions. This attribute proves particularly significant in light of the escalating effects of climate change. With its towering height of up to 20 meters and expansive canopy spanning 15-16 meters, the Gayam plant plays a crucial role in upholding the integrity and functionality of tropical ecosystems. Moreover, it is worth emphasizing that the Gayam plant not only delivers ecological advantages but also serves as a sustainable economic remedy, aiding communities in surmounting local economic challenges (Tetelay & Siahaya, 2018). In maintaining the balance of tropical ecosystems, the Gayam plant (Inocarpus fagifer) makes a significant ecological contribution. It has special benefits in maintaining soil stability and supporting various aspects of biodiversity. The sustainability of tropical ecosystems is increasingly being tested by increasingly pronounced climate change, and the Gayam plant can adapt to variations in climatic conditions, is becoming an important element in maintaining the structure and function of these ecosystems (Berger, 2023)

Preserving the Gayam plant is of utmost importance as it not only enhances the sustainability of tropical ecosystems but also offers tangible solutions to the intricate challenges faced by Indonesia's environment and economy. The conservation efforts play a pivotal role in safeguarding and harnessing the remarkable potential of the Gayam plant in promoting the well-being of the ecosystem and local communities. The presence of Gayam in diverse regions across Indonesia, including the islands of the Indonesian Archipelago, demonstrates its adaptability to varying environmental conditions. Despite being relatively overlooked in economic development, Gayam holds immense potential as an alternative food crop. The edible flesh of Gayam seeds can be consumed after boiling or roasting, thereby adding value as a local food source, particularly during periods of scarcity (Smith et al., 2023). Previous research shows that people know that Gayam seeds are delicious after being boiled and made into chips (Wawo et al., 2011). Even though the public knows about its benefits, until now, there has been no effort to cultivate the Gayam plant. Several factors that cause the lack of public interest in growing Gayam are the belief that this plant does not have significant economic value and limited information regarding how to propagate and cultivate it (Nugroho et al., 2023).

Research on the distribution and utilization of Gayam necessitates subsequent conservation endeavours. Despite the limited cultivation of Gayam, sustaining its presence in tropical ecosystems is imperative to ensure the continued provision of ecological, economic, and social advantages. This study aims to identify measures for preserving and enhancing Gayam within the conservation garden area of the University of Bengkulu's Postgraduate Science Education, thereby safeguarding the sustainability of tropical ecosystems facing mounting threats from environmental changes and population growth.

2. MATERIAL AND METHODS

The research location is the Postgraduate Science Education Postgraduate Conservation Garden Area at Bengkulu University (3°48'49.3"S-102°16'44.1" E), on October 8, 2023. The tools used for research activities in the field are the Lux Meter, Ph Meter, and temperature Humidity meter, and the materials needed include a camera, Stationery, and Gayam Plants. The data

collection method uses quantitative descriptive and qualitative descriptive methods. The quantitative descriptive method was carried out in several research stages: field research in 4 parts of the UNIB conservation garden area, library research, and data analysis, while the qualitative descriptive method was used to explain qualitative data.

The data collected is primary data and secondary data. Primary data is direct data from the field in conservation areas in the form of study data on the potential distribution and conservation of Gayam (Inocarpus fagifer). The secondary data used is in the form of climate data, accessibility and other supporting data. The Gayam planting procedure can be seen in Figure 1.

Figure 1. Research Procedure Diagram.

3. RESULT AND DISCUSSION

Gayam, also known as Tahitian chestnut, has the scientific name Inocarpus fagifer (Parkinson) Fosberg and belongs to the Fabaceae family. This plant has various local names, such as Gayam (Java), Gatet (West Java), Gatep (Bali), Bosua (North Sulawesi), Angkaeng (South Sulawesi), Ghaja (Flores), Polynesian chestnut (England), Kerepit, Kopit (Malaysia), Aila, and Lala (Papua New Guinea) (Thomson et al., 2022).

3.1 Seedling Stage

Research on the distribution and utilization of Gayam necessitates subsequent conservation endeavors. Despite the limited cultivation of Gayam, sustaining its presence in tropical ecosystems is imperative to ensure the continued provision of ecological, economic, and social advantages. The objective of this study is to identify measures for preserving and enhancing Gayam within the conservation garden area of the University of Bengkulu's Postgraduate Science Education, thereby safeguarding the sustainability of tropical ecosystems facing mounting threats from environmental changes and population growth (Amaal et al., 2023).

3.2 Seed Storage

Many plants, including the Gayam plant, cannot produce fruit all year round. Therefore, when the tree bears fruit, seed-saving measures become a necessity.

Seed storage ensures seed availability at all times, maintains high viability, and protects seeds from pest and fungal attacks. Factors influencing the success of storing seeds to maintain high viability involve seed moisture content, temperature, storage location, storage media, and seed packaging methods (Harayama et al., 2023).

3.3 Characteristics of Gayam

The Gayam tree is a plant that reaches a height of more than 20 meters with a wide canopy reaching a diameter of 15-16 meters. Its characteristic is a dense canopy, providing ample shade so that sunlight has difficulty penetrating the surrounding forest floor. The morphological characteristics of the Gayam plant are depicted in Table 1.

Table 1. Morphological Characteristics of Gayam Plants

Morphological Characteristics	Description
Stem	Woody, upright, rough skin, greyish brown
Leaf	Compound, spirally arranged, 20-30 cm long, 5-7 main leaves.
Flower	Single, hermaphroditic, small, white or yellowish.
Fruit	Pods are elongated, changing color from green to reddish brown when ripe.
Seed	Round and flat, surrounded by juicy flesh.
Root	Fibers, which develop well in loose soil, function to support plants and absorb nutrients.

The distinctive plank root system, buttress rooted, provides a strong foundation for this tree. The stem is greyish brown with a rough and twisted surface, difficult to cut, and has many horizontal branches scattered around.

Gayam leaves are oval, thick and shiny, spread out on branches or twigs in a spiral arrangement. There are variations in the size of mature leaves; some are wide with a length of more than 12-15 cm, and some are narrow with a length of around 10-12 cm. Gayam flowers are spike-shaped, emerge from the leaf axils or twig nodes, are white to creamy white, have five crowns, and have a distinctive aroma. The flowers are around 1-1.5 cm (Tetelay & Siahaya, 2018).

The Gayam fruit starts to appear when the tree is about 7-8 years old and clusters on the twigs. The young Gayam fruit is green in color and turns yellowish green when old. The fruit is round and plate-shaped, about 1-2 cm thick. Mature 10-15-year-olds will produce fruits yearly; each tree can have more than 1000 fruits (Wawo et al., 2011). The Gayam seed comprises a seed coat or shell, epidermis, and seed meat. Seed meat is the food source used, with an average size of between 5 and 8 cm and weighing around 40 to 60 grams (Smith et al., 2023).

3.4 Influential factors

At this stage, the factors that can influence the preservation of the Gayam plant can be seen in Table 2.

Table 2. Results of measuring environmental conditions.

Environmental Conditions	Measurement Result
Water humidity	RH 65.5%
Air temperature	26.8°C
Water temperature	27.1°C
Light intensity	145-900 µmol/m²/s

1. Water Content

Seeds with a high level of water content will experience a rapid decrease in viability. High water content will increase the activity of respiratory enzymes, causing a breakdown of food reserves in the seeds. As a result, the seeds experience energy exhaustion in their meristem tissue (Cefali et al., 2021). In addition, the energy produced in the form of heat, along with humid environmental conditions, can stimulate the development of microorganisms that have the potential to damage seeds. The initial moisture content of seeds safe for storage is 35-40%. To maintain this water content, seeds must be stored in a room with high humidity (RH 70-90%) (Hoang & Kim, 2018).

The water content in the Bengkulu University Master of Science Education conservation area reached RH 65.5%, as shown in Figure 2. This indicates that the Gayam seeds from Kediri could adapt well to the conservation area under these water content conditions. If these conditions do not change and tend to be stable, the Gayam seeds can show excellent development.

Figure 2. Water Content Measurement using Dissolve Oxygen Meter

2. Temperature and humidity

The viability of seeds is significantly affected by unfavorable environmental conditions in which they are stored. Temperature and humidity play a crucial role in seed storage. An adequately regulated seed storage room, maintaining optimal temperature and humidity, can preserve seed viability for an extended period (Gill et al., 2023). For fire-resistant seeds, indoor conditions with a temperature range of 4–20 °C and high humidity (RH 70–90%), depending on the species, are required. Gayam seeds, with a water content of 67.35% and a survival rate of 86.67%, showed better results when stored at 20°C for four weeks than those at 26°C (Tetelay & Siahaya, 2018). It was observed that seeds stored at 20°C experienced a lesser decline in viability compared to Gayam seeds stored at 26°C. Elevated temperatures stimulate enzymatic respiration, leading to energy loss and seed deterioration (Hoang & Kim, 2018). Higher humidity levels have been found to enhance plant growth by supporting photosynthesis processes and reducing evaporation rates (Hoang & Kim, 2018). Figure 3 provides data on air temperature and humidity measurements.

Figure 2. Measurement of air temperature and humidity

The data shows an air temperature of 28.8℃ and an air humidity of 69%. This air temperature can be considered optimal conditions for the growth of Gayam plants.

3. Storage Medium

Storage media also has an essential role in determining seed viability during storage. Media that has high humidity can effectively maintain the level of seed viability and vigor. Recalcitrant seed storage can use various types of media, such as charcoal husks and sawdust, which can keep the water content of the seeds high (Dadlani et al., 2023).

Based on this data, a good planting medium should use husk charcoal and sawdust. However, at this stage, when sending the seeds and seedlings, they are packed in plastic bags for days. According to the literature, they are able to reduce the water content significantly. In contrast, when planted in conservation areas, the planting medium is only husk, so development is relatively slow (Patel et al., 2022), as in Figure 4 and Figure 5.

Figure 4. Initial Gayam planting media

Figure 5. Gayam planting media in conservation areas

4. Light Intensity

Gayam seedlings need light intensity to conduct photosynthesis (Saka & Okoye, 2021). The literature on the growth of Gayam seedlings at various light intensities shows that Gayam seedlings require a range between 17,120 – 32,200 lux. In the conservation area, light intensity ranges from 15400 to 17800 Lux. This indicates that the potential for the development of Gayam in conservation areas is sufficient to facilitate photosynthesis, thereby encouraging good growth of Gayam seedlings (Smith et al., 2023). The following is a measurement of light intensity in the conservation area shown in Figure 6.

Figure 6. Light intensity measurement

Raising Gayam Seedlings in Conservation Areas

Several factors to consider when maintaining seedlings in the nursery include watering, fertilizing, pest control, and disease control. The first aspect to focus on is watering. Water is crucial for the survival of all living organisms, including plants. The key to effective watering is to control the moisture level of the planting medium and ensure the seedlings' growth remains fresh (da Silva et al., 2023). Gayam seedlings require adequate water, but excessive waterlogging can lead to root rot and the death of the seedlings. Generally, seedlings need a balanced amount of water, neither too little nor too much. Watering is necessary to maintain the moisture of the planting medium (Dadlani et al., 2023). It is advisable to water the seedlings in the morning or evening twice

a day (morning: 06.00-08.00 and afternoon: 16.00-17.00) or adjust the frequency based on the weather conditions during the rainy season. Providing proper water is crucial to support the optimal growth of Gayam seedlings. Tools such as sprayers and watering cans made from plastic bottles can ensure water penetrates the root area and maintains the moisture of the planting medium (Amaral et al., 2021).

The second maintenance in the form of fertilization is adding nutrients that plants need for their growth and development. In the seedling phase, fertilization stimulates vegetative growth to be transplanted into the field. Aspects that need to be considered in fertilization activities include selecting the type of fertilizer and determining the dose, fertilization time, and application method (Quemada et al., 2017).

In nurseries, a combination of organic and inorganic fertilizers is used. Organic fertilizers such as compost and manure are used with attention to maturity, are odorless, and have a soil-like appearance. Inorganic fertilizers such as urea, ZA, TSP, KCl, or NPK, which contain nitrogen, phosphorus, and potassium, are generally used after the seedlings are in individual pots. The dose of inorganic fertilizer is around 2-3 g per plant, planted around 3-4 cm from the seedling stem. Foliar fertilizers such as Gandasil D, Bayfolan, and Grow More can be applied to seedlings with more than six leaves because they are quickly absorbed and contain micronutrients (Harayama et al., 2023).

Gayam plants in conservation areas have been provided with organic fertilizer in the form of 500 grams of compost. The fertilization process occurs during planting, as the purchased Gayam plants are already five months old, and the seedlings have grown to a height of 50 cm. These seedlings are planted in large pots in the UNIB Conservation Area Garden. Applying organic fertilizer has proven beneficial, as it increases the number of leaves, plant height, and stem diameter of the seedlings (Guadalupe et al., 2023). In addition to organic fertilizer, inorganic fertilizer is also used. This involves a mixture of 3 handfuls of NPK, 10 kg of manure, and soil. The inorganic fertilizer is applied when the seedlings are active, allowing them to absorb nutrients quickly and effectively. This method of fertilization can be done either through the soil or by using it directly on the leaves. However, in this case, the fertilization is done through the soil media (Dadlani et al., 2023).

The next aspect of maintenance is focused on managing pests and diseases. Plant seeds can be affected by diseases caused by living organisms and non-living factors. Living organisms such as fungi, bacteria, and algae can attack the seeds, while there is currently no information on virus attacks in Gayam plants. On the other hand, non-living factors include nutrient deficiencies, excessive light intensity, and imbalances in water conditions (Vollmer et al., 2023). To address these issues, researchers utilized organic pesticides derived from papaya leaf extract and combined them with 15 grams of Rinso to control pests and diseases effectively (Husaini et al., 2022).

4. CONCLUSION

The findings derived from the conservation of Gayam in the Bengkulu University Master of Science Education Conservation Area reveal the significance of Gayam's potential spread in the UNIB Pendipa Conservation Area. A range of local names characterizes Gayam's presence in Indonesia, and this plant plays a unique role in biodiversity. While Gayam does not dominate at the seedling stage, it is crucial to comprehend the factors that influence its growth. The storage process for Gayam seeds is crucial to ensure their availability and viability. The distinct characteristics of Gayam, including its crown, stem, leaves, flowers, fruit, and seeds, contribute to its

uniqueness. Preservation is influenced by factors such as water content, temperature, storage media, and light intensity. Proper care for Gayam seedlings involves watering, fertilizing, and pest control. A comprehensive understanding of all these aspects enhances the potential for spreading Gayam in the UNIB Science Education Master's Degree Conservation Area.

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