Medicinal plant domestication of *kayu ules* (*Helicteres isora* Linn.) through stem cuttings: An additional prospective livelihood for the farmer at Bosen Village, East Nusa Tenggara, Indonesia

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**Abstract.** *Kayu ules* (*Helicteres isora*) or screw tree has bioactive compounds benefiting for anti-diabetes, antioxidant and antibacterial. In Indonesia, the fruits have been commercially harnessed for traditional medicine. The benefit of *kayu ules* has attracted some farmers to evolve this species in their garden, however, the domestication technique has not mastered well yet. Therefore, this study aimed to domesticate *kayu ules* under a home garden (HG) and analyze the feasibility of cultivating *kayu ules* through stem cuttings. *Kayu ules* development underwent two split HG's: tree shade (HG1) and open area (HG2). Other nursery performances at each home garden were made with no shade (N1), with shading net (N2) and a coco-leaf shade (N3). The result showed that within 60 days on HG1, the best survival was on N2 with 76% of survival and declined on N1 at 30%. Conversely, under HG2, N1 gave the best survival compared to N2, 81% and 46% each. Meanwhile, N3 was in between N1 and N2 on HG1 (56%) and HG2 (58%). The shading treatments, which allowed 20 to 40 % sunlight to pass through, effectively increased the survival of stem cuttings. According to an online market platform at the highest price, nursery N1 delivered the highest IRR at 106% and the second was on N3, followed by N2, which were 104% and 85%, respectively.

1. Introduction

Indonesia has been a place of mega biodiversity in flora, including valuable plants such as medicinal plants. A recent study by [1] has identified 5490 medicinal plants, of which 233 are a priority for conservation. The identified medicinal plants have various habits, including tree, liana, shrub, herb, tree-like palm, holoparasite, and climber. The use of medicinal plants for healing certain diseases has been used for a long time, and the first use of medicinal plants is instinctive as lack of information in using the plants [2]. However, as to date, the use of medicinal plants has been increasingly popular. In Indonesia, medicinal plants are usually harnessed in a traditional way known as a *jamu*, and this is similar to traditional healing used in India called *Ayurveda* [1].

Domestication could be an alternative to preserve the presence of the medicinal plant in the natural habitat, considering the important benefits of medicinal plants and the need for conservation. Domestication has been undertaken since ancient times, and it is an important technology of humans to meet community needs [3]. Domestication of plants to meet community needs usually begins with exploiting these plants in their natural habitat. These plants are usually preferred and have been...
recognized as beneficial to the local community, namely for medicine, food, building materials, etc. This then continues through the cultivation of plants with diverse ecosystems and agroecology to meet market needs. [4].

*Kayu ules* (*Helicteres isora*) is an important medicinal plant that can heal certain diseases. It is distributed in Western and Central India through some parts of South-East Asia [5]. The plant is a large shrub within the *Malvaceae* family that has been reported to be one important commercial *jamu* produced in Indonesia that is well known as herbal medicine for cold [6]. The health benefits that could be drawn from this species are from bark [7], root [8] and fruits [9], in which each has potential for certain diseases [10]. In Indonesia, based on report of [11], the distribution of *kayu ules* naturally occurred in Bosen Village, South Timor Tengah (Timor Tengah Selatan/TTTS), East Nusa Tenggara (Nusa Tenggara Timur/NTT). The plants grown in the natural habitat are associated with other tree species such as *Timonius sericeus*, *Cassia siamea*, *Acacia leucophloea* and *Leucaena leucocephala* [11]. Fruits of *kayu ules* are the main part of the plant that is used in medicinal plants. Local communities sell the fruits to the fruit collector in the area, but it is at a low price at the farmer level. According to the online shop platform, the fruits of *kayu ules* should be higher than at the farmer level.

*Kayu ules* cultivation has been carried out by [12], and it is reported that *kayu ules* are less viable for generative development than vegetative propagation. On the other hand, vegetative propagation of *kayu ules* has more potential and is easier to apply, although the seedling's survival is still under 80% [13]. However, these cultivations are still under research conditions, and little is known about how *kayu ules* can be domesticated under a home garden owned by a local farmer. Therefore, this study aimed to obtain information on *kayu ules* development under home garden with the cultivation method used in the previous trial [12, 13]. In addition, a financial analysis was also conducted to see the feasibility of *kayu ules* development under the home garden.

2. Materials and Methods

2.1. Location and materials

*Kayu ules* domestication trials were undertaken from July 2020 to March 2021 at Bosen Village, Mollo Tengah Sub-District, South Timor Tengah (Timor Tengah Selatan/TTTS) (Figure 1). Farmer’s home garden 1 (HG1) was located at 09° 43’ 02.0” S and 124° 17’ 15.2” E at ± 753 m above sea level (asl) with the shaded environment because of tree shade canopy (such as *Aleurites mollucana*, *Mangifera indica* and *Areca catechu*) covering the home garden thus low in light infiltration. Meanwhile, HG2 was located at 09° 43’ 13.0” S and 124° 19’ 22.2” E at ± 536 m asl with much less tree shade than HG1.

Materials and tools used in this study were cutting scissors, the stem of *kayu ules*, small logs, shading net, coco leaf, tie wire, topsoil, manure, plastic cover, polybag and *Atonik*™, the commercial growth hormone.
2.2. Nursery establishment
The *Kayu ules* stem cutting trial was grown under the home garden (HG) nursery. The nursery was established in two locations (Figure 1). For each, we conducted shading treatments; N1 (unshaded), N2 (75% shading net) and N3 (coconut leaf shading). *Kayu ules* stem was cut following the diameter class in the previous study [6]. Before planting *kayu ules* stem cuttings were immersed in Atonik™ growth regulators at 1% or 10,000 ppm for 30 minutes. For each shading treatment, *kayu ules* stem cutting was placed under a plastic shade dome to maintain the humidity.

2.3. Measurement of *kayu ules* stem cutting
The growth parameters, including the number of leaves and shoots, were collected for 30, 60 and 90 days after sowing. However, in the HG 2, this measurement just reaches the second observation (60 days after sowing) due to the symptom of heat stress in the N1 treatment. There are three shading treatments and ten replicates with 40 sub reps for N1 and 30 sub reps for N2 and N3. Hence, there are 400 stem cuttings for N1 treatments and 300 stem cuttings for N2 and N3 in 1000 pots for each location.

Microclimate parameters such as temperature, humidity, and light intensity were measured at 9 am, 12 am, and 4 pm. The measurement was carried out under the plastic dome under the shading treatment at three random points. The average result was then tabulated and added with standard deviation.

2.4. Feasibility analysis
After the site activity, a feasibility analysis was done to obtain the data of equipment necessity and expense estimation [1]. The predominant product derived from *kayu ules* would be the fruits, one of the main materials of *jamu* ingredients [2]. The price of the fruits was based on the online shop.
platform. The highest price ($hp$) of *kayu ules* fruit was IDR 135,000 kg$^{-1}$, while the lowest ($lp$) was IDR 43,500 kg$^{-1}$.

Several assumptions were determined regarding the *kayu ules* development. First, *Kayu ules* productivity scenario had three levels, namely 20, 50 and 100 g plant$^{-1}$, as the fruit productivity of a *kayu ules* plant could be fluctuating according to environmental conditions. Second, *Kayu ules* that had been planted at the farmer's home garden were 150 trees. Third, *Kayu ules* was regularly producing fruits three times a year, i.e., from July to September [3]. The discount rate used in this analysis referred to *Bank Rakyat Indonesia* or People's Bank of Indonesia (BRI) for small business credit (*Kredit Usaha Rakyat* (KUR) scheme at 6.5% per annum.

Evaluation criteria to determine the financial feasibility of *kayu ules* development were used, including net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR), as described in [1] and [4]

$$NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1 + i)^t}$$

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1 + i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1 + i)^t}}$$

Remarks:
$B_t$ = benefit at $t$
$C_t$ = Cost at $t$
*i* = discount rate

2.5. Data processing
Data from the growth parameters prompt the analysis of variance (ANOVA) using R studio version 3.6.2. The data were initially checked for normality using the Shapiro Wilk test, the Levene test for variance distribution, and the post-hoc test employed Tukey multiple comparisons. Finally, a feasibility analysis was carried out using spreadsheet software.

3. Results and Discussion
3.1. Kayu ules growth under home garden cultivation
The growth of *kayu ules* through stem cutting in the nursery showed a significant response toward the applied treatments. The results also correspond to the environmental parameters such as temperature, humidity and light intensity (Figure 2).

Shading treatment showed a significant difference at the beginning to the last observation in the Home Garden 1 (HG 1). Meanwhile, the HG 2 shading was significant to stem cutting survival rate. However, after two months, either net shading or coconut leaf shading showed an equal effect on stem cutting survival rate (Figure 2).
Figure 2. Kayu Ules' stem cutting growth under three shading treatments; no shading (N1), net shading (N2) and coconut leaf shading (N3). Stem cutting growth at 30 and 60 days after sowing at HG 1 on the left, Stem cutting growth at 30 and 60 days after sowing at HG 2 on the right. P-value * significant at 0.05, ** significant at 0.01, *** significant at 0.001 confidence interval.
Figure 2 indicated that the parameter of the number of leaves seems to be more accurate to capture the growth than the parameter of the number of shoots because the number of shoots is usually ruled by the number of stem nodes from donor plants. However, since the nodes exclude from the parameters, so the number of nodes was not uniform.

3.2. Microclimate manipulation affected by the shadings
Shading is likely to reduce the sunlight passed through the nurseries, resulting in higher humidity and lower temperature (Figure 3). These factors play an important role in the success of stem cutting, especially for evaporation and heat stress in the growth of the initial shoots.

In the nurseries (HG1 and HG2), N1 treatment showed a better percentage of live stem cuttings for 30 and 60 days after planting in HG1, while in the HG2 treatment, N3 promising the best live stem cuttings (Figure 2). There was a consistent range of shading ability between the best treatments, at above 60% shading, or 61 and 78% shading for HG1 and HG2, respectively (Table 1). The gradient temperature and humidity for both locations were varied between morning and noon and relatively identical in the afternoon for temperature and humidity. In general, the temperature gap between the treatments ranged from 0-5°C (Figure 3).

Table 1. Mean ambient temperature during the day, humidity and shaded light intensity.

| Weather variable | HG 1 | HG 2 |
|------------------|------|------|
|                  | N1   | N2   | N3   | N1   | N2   | N3   |
| T (°C)           |      |      |      |      |      |      |
| morning          |      |      |      |      |      |      |
| noon             |      |      |      |      |      |      |
| afternoon        |      |      |      |      |      |      |
| H (%)            |      |      |      |      |      |      |
| morning          |      |      |      |      |      |      |
| noon             |      |      |      |      |      |      |
| afternoon        |      |      |      |      |      |      |
| Average Passing light through shadlers (%) |      |      |      |      |      |      |

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| noon             |      |      |      |      |      |      |
| afternoon        |      |      |      |      |      |      |
| H (%)            |      |      |      |      |      |      |
| morning          |      |      |      |      |      |      |
| noon             |      |      |      |      |      |      |
| afternoon        |      |      |      |      |      |      |
| Average Passing light through shadlers (%) |      |      |      |      |      |      |

Remarks: T: Temperature °C, H: Humidity %, HG: Home Garden, Shading; unshaded (N1), net shading (N2) and coconut leaf shading (N3).

Shading, in general, reducing the light intensity varied between 60%-80% and 30%-70% light-shaded for HG1 and HG2, respectively, depending on the shading types (Table 1). In HG1, the nursery was located in a relatively canopy-shaded environment. Meanwhile, the HG 2 was a barely shaded canopy.
Figure 3. Humidity and temperature under shading treatments in the Home Garden 1 and Home Garden 2.

The specific site also affects the microclimate, such as temperature and humidity under the treatments. For example, in the morning (9 am), coconut leaf shading (N3) exhibited temperature max at 26 °C and humidity at above 60 % and 70 % for HG1 and HG2, while in the noon, the temperature between these locations was quite different. Furthermore, N3 was the lowest temperature in HG1. Conversely, N3 was the highest in HG2 (Figure 3). This can be caused by the existing canopy nearby and the slope that affects the direction of the light.

3.3. Shading treatment toward the percentage of alive stem cutting.
Shading treatments resulted in a different percentage of live cutting between the nurseries (Figure 3). The result indicated that unshaded nursery (N1) exhibited the best alive stem cutting percentage in HG1. In contrast, in HG2, N1 treatment showed the lowest alive stem cutting percentage. The disparity was caused by the different passed-through light and the location (Table 1), where the shading, which allowed 20 to 40 % sunlight to pass through, effectively increased the survival rate of stem cuttings. This effect of shading on stem cuttings survival rates was reviewed by [17], which elaborates that medium humidity, shading, and donor plants: length, nodes, and maturity affect the survival rate of stem cuttings.

At the initial growth (30 days after sowing), N1 treatment in the HG1 and HG2 resulted in an identical effect compared to N2 and N3 treatments (Figure 3). Nevertheless, 60 days after sowing, the HG2, N1 treatment showed a decline in the alive stem cuttings due to heat stress.
Figure 4. The percentage of live cutting at 60 and 90 days after sowing at the home garden (HG) 1 and HG 2. Unshaded (N1); net shading (N2); coconut leaf shading (N3).

3.4. Feasibility of kayu ules development

Financial feasibility analysis of the kayu ules development consisted of an initial investment of equipment that would describe the necessity of building a nursery to produce kayu ules seedling through stem cutting. The initial investment consisted of main parts in nursery activity conducted by the farmer, as presented in Table 2.

N2 had the highest cost at each nursery type in total at IDR 3,130,000 on nursery establishment compared to N1 (IDR 2,470,000) and N3 (IDR 2,520,000). The farmer’s key differences between these nursery establishments were the use of shading net in N2 that made the cost higher than other nursery types. Meanwhile, N1 did not use any shading on the nursery that made this type was a low-cost nursery. Nevertheless, the survival of the kayu ules seedling should be taken into account, which was declined as the effect of a harsh environment with full sunlight. At the N3 nursery type, the shading could be modified by using coco leaves that were available around the home garden; thus, the nursery expense on shading could be minimized.

| Table 2 | The main equipment needed in the nursery of kayu ules based on the nursery types. |
|---------|---------------------------------------------------------------------------------|
| Item    | Quantity | Unit  | Expense (IDR) of nursery type |
|         |          |       | N1                | N2                | N3                |
| Media   |          |       |                   |                   |                   |
| 1. Topsoil | 1      | Package | 400,000           | 400,000           | 400,000           |
| 2. Manure | 1      | Package | 500,000           | 500,000           | 500,000           |
| 3. Polybag | 4      | Kg     | 160,000           | 160,000           | 160,000           |
| Nursery |          |       |                   |                   |                   |
| 1. Wood poles | 6  | Pcs    | 480,000           | 480,000           | 480,000           |
| 2. Nails   | 2      | Kg     | 40,000            | 40,000            | 40,000            |
| 3. Tie wire | 2      | Roll   | 90,000            | 90,000            | 90,000            |
| 4. Bucket  | 2      | Pcs    | 60,000            | 60,000            | 60,000            |
| 5. Bamboo  | 1      | Package | 200,000           | 200,000           | 200,000           |
| 6. Shading net | 22 | meter  | -                | 660,000           | -                |
| Item                        | Quantity | Unit | Expense (IDR) of nursery type |
|-----------------------------|----------|------|--------------------------------|
|                             |          |      | N1   | N2   | N3   |
| 7. Coco leaves              | 1        | Package | -   | -   | 50,000 |
| 8. Plastic cover            | 1        | Roll   | 150,000 | 150,000 | 150,000 |
| Growth hormone              | 1        | Bottle | 40,000 | 40,000 | 40,000 |
| Tools                       |          |        |      |      |      |
| 1. Cutting scissors         | 2        | Pcs   | 100,000 | 100,000 | 100,000 |
| 2. Water sprayer            | 1        | Pcs   | 75,000 | 75,000 | 75,000 |
| 3. Watering bucket          |          |       |      |      |      |
| Maintenance                 | 1        | Package | 100,000 | 100,000 | 100,000 |
| Total                       |          |        | 2,470,000 | 3,130,000 | 2,520,000 |

The development of *kayu ules* at the home garden is expected to deliver benefits to the farmer. Fruit of *kayu ules* has been a predominant component in traditional commercial medicine for cold (*jamu*) [6]. In addition, the fruits of *kayu ules* are also used by local users on a daily basis, and they can be found through the online shop platform. According to table 2, it could be seen that the fruit of *kayu ules* could be an additional livelihood and benefiting the farmer at Bosen village through several conditions such as the moderate to high fruit productivity with the higher price of the fruit.

Concerning the nursery types established by the farmer, it could affect the financial feasibility of *kayu ules* based on the fruit productivity scenario. For example, a nursery type of N2 would not benefit at a lower price (*lp*) for farmers unless the fruit productivity could be maintained at 100 g plant\(^{-1}\). This trend also appeared on N1 and N2. However, the higher price (*hp*) could potentially increase the ratio of benefit and cost and the IRR even when the fruit productivity was at 20 g plant\(^{-1}\).

As presented in Table 3 that N2 had the highest cost on nursery establishment; thus, it had the lowest financial feasibility. For example, at the lowest fruit productivity at 20 g plant\(^{-1}\) with the *hp* of the scenario, it provided the lowest BCR; thus, the choice of equipment in establishing a nursery needed to be paid attention to without ignoring the survival of the *kayu ules* seedling.

In practice, farmers at Bosen village can further modify the equipment needed in establishing a nursery. Therefore, it could result in a low-cost nursery establishment. This is because the farmers can harness local equipment found in their environment and alter several items to minimize costs. Hence, this should also be increasing the financial feasibility of the *kayu ules* development.
### Table 3. Evaluation criteria on financial feasibility under different types of nursery establishment by farmer and fruit productivity scenario for ten years.

| Productivity scenario | Nursery types established by farmer | hp | lp |
|-----------------------|-------------------------------------|----|----|
|                       | N1                                  |    |    |
| 20 g/plant            | NPV                                 | -2,891,669 | -5,851,670 |
|                       | BCR                                 | 0.61 | -0.48 |
|                       | IRR                                 | 13% | -16% |
| 50 g/plant            | NPV                                 | 747,677 | -4,678,992 |
|                       | BCR                                 | 1.95 | -0.05 |
|                       | IRR                                 | 35% | -1% |
| 100 g/plant           | NPV                                 | 14,577,189 | -222,815 |
|                       | BCR                                 | 7.06 | 1.60 |
|                       | IRR                                 | 106% | 29% |

Remarks: hp: highest price at 135,000 IDR; lp: lowest price at IDR 43,500, the price accords to the online shop platform.

### 4. Conclusion
The shading treatments, which allowed 20 to 40 % sunlight to pass through, effectively increased the survival of stem cuttings. Therefore, Kayu ules development is feasible following two conditions: the fruit productivity and the price of the kayu ules fruit. In some conditions, farmers can modify the need for nursery equipment to minimize the cost during the nursery building.

### References
[1] Cahyaningsih R R, Magos B J and Maxted N 2021 Setting the priority medicinal plants for conservation in Indonesia Netherlands: Springer 68
[2] Petrovska B B 2012 Historical review of medicinal plants usage Pharmacogn. Rev. 6 1
[3] Purugganan M D and Fuller D Q 2009 The nature of selection during plant domestication Nature 457 843-48
[4] Vodouhè R, Dansi A, Avohou H T, Kpèki B and Azihou F 2011 Plant domestication and its contributions to in situ conservation of genetic resources in Benin Int. J. Biodivers. Conserv. 3 40-56
[5] Kumbhani N R, Kuvad R P and Thaker V S 2017 Development of linear model for leaf area measurement of two medicinally important plants: Helicteres isora L. and Vitex negundo L J. Appl. Biol. Biotechnol. 5 57-60
[6] Cunningham A B, Ingram W, Brinckmann J A and Nesbitt M 2018 Twists, turns and trade: A new look at the Indian Screw tree (Helicteres isora) J. Ethnopharmacol. 225 128-35
[7] Kumar G, Murugesan A G and Pandian M R 2006 Effect of Helicteres isora bark extract on blood glucose and hepatic enzymes in experimental diabetes Die Pharm. Int. J. Pharm. Sci. 61 353-55
[8] Sharma V and Chaudhary U 2016 Pharmacognostic and phytochemical screening of helicteres isora roots Asian J. Pharm. Clin. Res. 9 96-101
[9] Kumar T M, Christy A M V, Ramya RCS, Malaisamy M, Shivaraj C, Arjun P, Raaman N and Balasubramanian K 2012 Antioxidant and anticancer activity of Helicteres isora dried fruit solvent extracts J. Acad. Indus. Res. 1 148-152
[10] Dayal R, Singh A, Ojha R P and Mishra K P 2015 Possible therapeutic potential of Helicteres isora ( L . ) and its mechanism of action in diseases J. Med. Plant Stud. 3 95-100
[11] Umroni A, Pamungkas D, Tanopo O and Manurung G E S 2015 Aspek ekologi kayu ules
Helicteres Isora L.) sebagai tanaman obat Di Desa Bosen: penyanga Cagar Alam Mutis Kabupaten Timor Tengah Selatan Proc. Sem. of Seminar Nasional Biodiversitas Savana Nusa Tenggara Kupang: Kupang Forestry Research Institute 45-57

[12] Ferdousi A, Rahman M O and Hassan M A 2014 Seed germination behaviour of six medicinal plants from Bangladesh Bangladesh J. Plant Taxon. 21 71-76

[13] Pamungkas D, Siswadi and Manurung G E S 2019 Studi propagasi vegetatif tanaman obat kayu ules (Helicteres isora Linn.) melalui stek batang J. Penelit. Kehutan. Faloak 3 14

[14] Kusuma P T W W and Mayasti N K I 2014 Analisa kelayakan finansial pengembangan usaha produksi komoditas lokal: mie berbasis jagung Agritech J. Fak. Teknol. Pertan. UGM 34 194-202

[15] Siswadi, Umroni A, Pamungkas D and Manurung G E S 2018 Pengaruh pemupukan dan penjarangan terhadap produktivitas buah kayu ules (Helicteres isora) Di Desa Bosen, Timor Tengah Selatan, Nusa Tenggara Timur Proc. Conf. on Research Desimination: Optimalisasi Pengelolaan Hutan Berbasis Agroforestri untuk Mendukung Peningkatan Produktivitas Kayu dan HHBK, serta Pendapatan Petani Bogor: ICRAF-FOERDIA p 45-54

[16] Suharjito D, Sundawati L, Suyanto and Utami S R 2003 Aspek sosial ekonomi dan budaya agroforestri ed Widianto, Utami S R, Hairiah K Bogor: ICRAF 5

[17] Leakey R R 2004 Encyclopedia of Forest Science ed Burley J, Evan J and Yongquist J London: Academic Press p 1655-68

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Authors’ contributions
All authors contributed equally to this work as the main contributor.