TARGETED SPECIES NURSERY AND REGENERATION INFORMATION

Information is for the following targeted tree species:

1. *Instia palembannica/bijuga*
2. *Anisoptera thurifera*
3. *Pterocarpus indicus*
4. *Hopea iriana*
5. *Callophyllum euryphyllum*
6. *Eucalyptus deglupta*
7. *Homalium foetidum*
8. *Dracontomelon dao*
9. *Pometia pinnata*

September 2023

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Photographs on the cover are

Above: Malas Wildings, 1 Month Old, captured by Open Bay Timber Limited, ENB

Below: Kwila Seedlings, 3 Months Old, captured by Amanab Forest Products

1. Instia palembanica/bijuga, Kwila

INFORMATION ON NURSERY WORK

Seed Description

About 3-10 seeds are measuring about 3cm x 2cm in pods. The seeds are broad, hard, compressed, and have a dull reddish-brown colouring. There are around 160 seeds per kg (Ref 1).

Flowering, Fruiting

Flowers are seen throughout the year, with the highest number observed in August in Madang. The same goes for the fruit, with a peak in February. The pods are oblong, compressed, and measure 8.5-23cm x 4-8cm, changing from green to dark brown to black when ripe (Ref 1).

Seed Collection (Season) and Storage

Kwila consistently generates a large number of seeds every year. The seeds can be collected from the trees or fallen pods. After collection, the fruit/pods are dried in the sun for up to 3 days to make it easier to open them. The pods are placed thinly on a dry surface. After they open, the seed can be sorted from impurities by sieving, winnowing, or flotation (Ref 1).

Germination disposal

Planting the seeds on the edge with the hilum down helps shed the seed coat as the growing shoot emerges. Dipping or dusting the seeds with a fungicide just before sowing may help prevent fungal infections. Fresh seeds generally have a germination rate of over 90% (Ref 2).

Period of germination after planting seed

The seed takes 9-11 days to germinate, but pre-treatment such as nicking reduces this to 2-5 days (Ref 2).

Water disposal on seeds

For quick and simultaneous germination, scarification followed by soaking in water is needed (Ref 1).

Plastic bag(size) and soil

A large container of at least 250ml is recommended for Kwila seedlings due to their rapid growth. This species thrives in soils that are well-drained and alkaline, such as those found in limestone and basaltic regions. It can also adapt to poorly drained soils in mangrove areas. It has a preference for saline soils (Ref 2)

Fertilizer and watering in the nursery

To encourage a symbiotic relationship with Nitrogen-fixing bacteria, a well-drained potting medium, and low available nitrogen are important, along with adequate Phosphorus and micronutrients. (Ref 2).

Nursing period, size of planting

Seedlings can reach a height of 50 cm within 2-3 months, which can then be dispatched for field planting (Ref 1).

Wilding

Kwila is easily established from seed or potted forest wildings and has shown good growth and survival in trials in the Solomon Islands. It attained a height of 11m in 7 years in black alluvial soil and a height of 8.8m in 8 years in the logged-over rainforest on the volcanic red clay of moderate fertility, outperforming other indigenous species (Ref 3).

Others
Vegetative propagation tests in the Philippines resulted in a 62% mortality rate for long cuttings (60 cm) after 6 weeks in a sandy clay-loam medium. In contrast, experiments in the South Pacific and PNG achieved average rooting success of 35% and 90% respectively, with better results from cuttings taken from the second and third nodal positions and the use of rooting hormone gel (Ref 2).

INFORMATION ON REGENERATION WORK

Scientific name
Fabaceae, *Instia palembanica/bijuga*

Timber Group
Major exportable hardwood Tradename: Kwila
Species Code: KWI

Characters
A large canopy tree that can reach up to 35 meters in height, but rarely grows to 42 meters, or a small sub-canopy tree that is about 10 meters tall. The trunk is cylindrical, with a diameter of up to 60 cm and sometimes up to 90 cm. It is straight with a length of up to 20 meters and has noticeable buttresses that can reach up to 2 meters in height. This tree does not have spines or aerial roots and its bark is slightly red or bluish grey, rough near the base of the trunk and smoother above, with a scaly, flaky, or pustular texture and rounded or swelling lenticels. The under-bark (sub-rhytidome) is pale green, less than 25 mm thick, and 5.0-6.0 in size. The bark blaze is composed of one layer, has a faint or no aroma, and is white (cream-colored), yellowish brown, or green with no markings. The inner blaze is also white, yellowish brown, or green with no markings. There is a clear, colorless bark exudate (sap) that is not readily flowing, does not change color when exposed to air, and is not sticky. The terminal buds are not enclosed by leaves (Ref 4).

Distribution
Kwila can be found in West Sepik, East Sepik, Madang, Morobe, Eastern Highlands, Western, Gulf, Central, Northern, Milne Bay, Papuan Islands, New Britain, New Ireland, Manus, and Bougainville (Ref 1). *Intsia palembannica* dominates in West Sepik and *Intsia bijuga* in other region

Wood Use
Kwila is an important commercial timber species and is sometimes known as merbau in the PNG timber industry. The timber has a wide range of uses, both indoors and outdoors. It is particularly suited to outdoor furniture, being able to resist deterioration well. Occasionally it is used for canoes and carving. Commercially it is used in heavy construction, boat building, and furniture. Bark and leaves are used medicinally, and the seed can be eaten after careful preparation (Ref 1).

Suitable Site
Soil: Kwila trees can thrive in a range of soil types, including light, medium, and heavy soils, and can adapt to both well-draining and poorly-draining conditions. The trees are able to grow in soils with a neutral to alkaline pH level (6.1-7.4+) and are able to tolerate shallow, saline, sodic, and calcareous soils, often growing on limestone outcrops with little soil (Ref. 2).

Rainfall: The best conditions for growth are climates with bimodal or consistent rainfall patterns, with a mean annual rainfall of 1500 – 2300 mm. The trees are also very drought resistant (Ref. 2).
Light: The tree thrives in full sunlight, particularly in open areas, and has a shade tolerance of 0-75% (Ref. 2).
Humidity: A high level of air humidity is crucial for optimal growth (Ref. 2).

Others: Observations in Papua New Guinea have shown that following logging, dormant seeds in the soil tend to germinate prolifically in the areas around the stumps (Ref. 2).

Planting and Silviculture treatment
Planting Season: The planting season for Kwila varies depending on the location, however, it is generally considered to be during the rainy season. In tropical regions, the rainy season usually occurs between the months of April to October.

Planting Area (Open or under shade): Seeds germinate best in full sunlight, although partial shade will work fine. Seedlings adapt to various light and shade levels (Ref. 2).

Spacing: In plantations, spacings of 4 x 4 meters and 5 x 5 meters have been employed (Ref. 3).

The target size for harvesting and growth: The species is in general slow growing, even after an initial phase of rapid growth, and it may take up to 75–80 years to mature. Trial plots in the Solomon Islands using germinated seeds or collected wildings recorded 2 m (6.6 ft) per year in height for the fastest-growing individuals (Ref. 2).

The target size: The target size for harvesting is 50cm dbh and above (Ref. 2).

Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc), how many years, and how often, etc.): Silvicultural tending is performed 3 months after planting and continues every 3 months for a period of 2 years. In order to achieve optimal yields, it may be necessary to apply super-phosphate or rock phosphate fertilization if phosphorus is the limiting macronutrient. In more acidic soils with a pH lower than 5, calcium deficiency may be a hindrance, which can be solved by adding dolomite or calcium sulphate. Effective weed control is critical as seedlings are vulnerable to competition and need ample access to bright light for proper growth. When trees are grown closely together, they tend to self-prune (Ref.2).

Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.)
There have not been many successful trials for the natural regeneration of Kwila seedlings on skid tracks or under felling gaps. However, there are studies that suggest that natural regeneration from fallen seed is good in well-over logged areas, provided that that is enough growing space (Ref 4) .

Other
The growth rate of the species is typically slow, even after an initial period of rapid growth. It can take up to 75 to 80 years to reach maturity. Some of the fastest-growing individuals have been recorded to grow 2 meters in height per year in the Solomon Islands. In Bogor, Indonesia, 8-year-old seedlings have an average height of 10.7 meters and a diameter of 15 cm. In Samoa, the average height growth during the first 3 years is 77 cm per year but then decreases. In a 1994 study by Whistler in Samoa, the vesi species was found to have a growth rate of 14 to 18 millimeters in diameter per year over a 14-to-22-year period (Ref 2).

2. Aisopptera thurifera, Mersawa PNG

INFORMATION ON NURSERY WORK

Note: Some of the information under this sub-topic is not available in previous research.

Outline of seedling preparation

The matured fruit (containing the seed) can be collected from the ground or by climbing the trees. This activity can be done during the seed fall period basically from May to July but also varies from one area to another depending on the geography, climatic conditions, and other variable factors. Since the fruit is indehiscent, it is a common practice for the entire fruit to be air-dried rather than to extract the seed. Storage behaviour confirms the recalcitrant characteristics of the seed – i.e., its inability to tolerate low-temperature storage (<16%), drying to low moisture content (<14deg.cel), and a prolonged storage period of more than 14 days. It is desirable to sow the fruit immediately following the collection as stored seed does not retain viability for long. (Ref 1)

The germination of stored seed may be enhanced by soaking it in warm water at 30 - 35°C for about 6-8 hours prior to sowing. (Ref 4) Sow the seed in a semi-shaded position in a nursery seedbed. The optimum temperature for germination is around 26°c. In an experiment, there was 50% germination after 5 days. The germination percentage for fresh seeds should be greater than 80%. (Ref 3)

Seed (description)

Mersawa seed is basically the nut within the calyx-based globose fruit. The fruiting calyx entirely encloses the nut (seed) and adnate to it with two-long spatulate lobes. As is often the case with all Dipterocarp species, the fruit is a 'winged nut'. The seed is 10mm in diameter and surrounded by sepals of which two-spatula-like lobes stand out like wings. The whole fruit/seed is yellowish-green in color but eventually turns brown when it reaches maturity (ripe). Based on other Anisoptera species and NTSC data; the seed is likely to be recalcitrant. The moisture content (mc) of fresh seed is around 51 %. (Ref 1) Although the fruit is winged, the dispersal of nuts (seeds) is restricted; over 90% of the seedlings occur under the parent tree (Ref 2).

Flowering & Fruiting

Mersawa usually flowers and fruits annually but if conditions are unfavorable, flowering may not occur. The sweet-scented flowers appear in Oomsis from November to December, in Timini Guruko from December to January, and in Madang Province and planted trees in Bulolo from January to February (Ref 1). The flowering and fruiting patterns of A. thurifera also affect the way regeneration occurs. The timing of flowering varies but most tend to flower at the late dry period and the early wet season, which is between August and November. A. thurifera also has a more regular flowering and fruiting pattern than many other dipterocarps. Mast fruiting occurs every three to five years but otherwise, there is sporadic annual flowering and fruiting. The community flowering and subsequent fruiting last a maximum of nine months from the first appearance of flowering to the final seed rain (Ref 2).

Seed collection (season) and storage

The seed can be collected from the ground or by climbing. It is desirable to sow the fruit immediately following the collection as stored seed does not retain viability for long. The best temperature for storing Mersawa seed is 3-6°C. The moisture content should be reduced to 20-25% by air drying, and the seed should be packed in polyethylene bags. In PNG, the seed is stored in wet sawdust or wet paper tissues in unsealed containers at 3-6°C or 18°C for 1-2 weeks. Seed loses viability quickly; after 2-3 weeks the germination rate is often almost zero. Viability is significantly reduced when the moisture content of the seed falls below 14% (Ref 1).

Further tests to determine seed viability upon storage at room temperature revealed that those stored for 21 days all lost viability but those stored for 14 days had 68 % viability. The data also showed that the quantity and quality of seed production depended on the parent tree size and the flowering intensity. The most productive size class were stems larger than 50 but < 90 cm dbh. It was further found that the majority of the seeds were dispersed within ten meters radius of the parent tree crown. The viability of *A. thurifera* seeds was further assessed by examining the size class of parent trees at different stages of the seed rain period. The results showed that viability increased according to seed maturity and was highest immediately upon seed fall (Ref 2).

Germination disposal
Seed often geminates while the ripe fruit is still on the tree (i.e., it is viviparous). Fresh matured fruits collected and tested were found to have a germination rate of 89%. This confirms the notion that fresh matured seed should be directly sown when viability is still high (Ref 1).
This species can germinate and get established under poor light conditions. However, light becomes essential for advancement in growth. It also showed that open light conditions are unsuitable for the growth of this species (Ref 2).

Period of germination after planting seed
The sown seeds should take around 18 -35 days to germinate. The germinant radicle breaks through the upper section of the globose nut and emerges first followed by the cotyledon appearing 3/4 days later. Seeds sown in germination trays should be "pricked out" 3-4 days after the germination and individual germinant should be transferred into polytubes for further nursery arrangement (Ref 1).

Water disposal on seeds: No information
Plastic bag (size) and soil: No information
Fertilizer and watering in the nursery: No information

Nursing period, size of planting
"From the "pricking out" stage, seedlings should reach plantable size by around 25-35 days" (Ref. 1).

Further nursery trials should be carried out to ascertain such a claim. According to Eward Nir a Mersawa seedling has a growth rate of 7cm-10cm in a month, a seedling can reach a height growth of around 0.58cm per day. With such data, it is not practical for a seedling to reach a plantable size for around 25-35 days (Ref. 2).

Wilding: No information

Others
Vegetative propagation has shown some success. Trials carried out in the Philippines on air-laying branches of Mersawa have resulted in 25% of the branches developing roots while "grafting" had a 10% success rate. Both vegetative and seed propagation of trees need mycorrhizal infection for optimal growth. *A. thurifera* in Papua New Guinea may be infected by a variety of ectomycorrhizae which are also found on *Castanopsis* spp., *Lithocarpus* spp., *Acacia* sp, *Eucalyptus* sp and other *Dipterocarp* sp. (Ref. 1) (Ref. 4).

INFORMATION ON REGENERATION WORK

Scientific name
Anisoptera thurifera (Blume)

Timber Group
Major exportable hardwood: Mersawa PNG
Species code: MER

Characters
Several characteristics that can influence the regeneration of Mersawa, and its ability to establish and ensure the long-term persistence of the species in its native habitat in tropical forests are; (Ref. 3), (Ref. 4), (Ref. 5) (Ref. 6)

i. **Seed dispersal:** produces large quantities of seeds, which are typically dispersed by animals such as birds and mammals. This helps to ensure that the species is able to establish itself in a wide range of habitats and can form a continuous population over time.

ii. **Seed germination**: has a relatively high rate of seed germination, which allows the species to quickly colonize newly available habitats and establish itself in the forest understory.

iii. **Shade tolerance:** seedlings are relatively shade-tolerant and can establish and grow well under the canopy of other trees. This is an important trait for a species that is able to establish and persist in tropical forests, where competition for light is often intense.

iv. **Soil tolerance:** capable of growing in a range of soil types, including well-drained soils, sandy soils, and heavy clay soils. However, the species is most commonly found in soils that are rich in organic matter and have good water-holding capacity.

v. **Disease and pest resistance:** relatively resistant to common diseases and pests that affect other tropical hardwood species, which allows the species to establish and persist in areas where other trees may be more vulnerable.

Distribution
Madang, Morobe, Southern Highlands, Western, Gulf, Central, Northern & Milne Bay (Ref. 4).

Wood use
The wood is a source of timber for several construction purposes, especially in plywood production - glued laminated, veneer for interior/back/front of plywood, furniture production -chairs, tables, draws, etc., boxes and crates production, interior joinery, molding, turnery goods, flooring, and interior panelling (Ref. 3).

Suitable site
Note: Some of the information under this sub-topic is not available in previous research. However, this includes some basic information based on previous observations.

i. **Soil:** Grows best in well-drained soils with a pH range between 5.0 and 7.0. The plant prefers moist soil but can tolerate some drought, making it a suitable species for areas with a tropical climate. Soils high in organic matter and nutrients are ideal for growing Mersawa, as they provide the necessary conditions for optimal growth and development.

ii. **Rainfall:** Since it is a tropical tree species, it basically experiences a tropical climate with high rainfall. The species grows best in areas with an average annual rainfall of between 2,000 and 3,000 millimetres per year. Mersawa is well adapted to moist soils and can tolerate some waterlogging, making it suitable for planting in areas with high rainfall and frequent rain showers. However, it is important to note that Mersawa can also tolerate some drought, so it can also be grown in areas with lower rainfall levels. The key to growing Mersawa is to ensure that the soil is well-drained, as the plant is sensitive to waterlogging and prolonged periods of wet soil.

iii. **Light:** Requires adequate sunlight for proper growth, so it should be planted in an area with direct sunlight or partial shade. It prefers bright, indirect sunlight or partial shade. It is a species that can tolerate some exposure to direct sunlight, but too much exposure can result in damage to the leaves and foliage. In general, it is recommended to plant Mersawa in an area with bright, indirect light or partial shade, as this will provide the optimal conditions for growth and development.

iv. **Humidity:** Since Mersawa is a tropical species, it grows best in areas with high humidity levels. The species prefers a relative humidity of between 70% and 90% and can tolerate fluctuations in humidity levels throughout the day. It is well adapted to the high humidity levels that are typical of tropical rainforests, making it a suitable species for planting in areas with similar climates. However, the plant can also tolerate some exposure to drier conditions, as long as the soil remains moist and well-drained. It is important to monitor humidity levels and ensure that they are maintained within the optimal range to promote healthy growth and development.

v. Others:

Planting and Silviculture treatment
Note: Some of the information under this sub-topic is not available in previous research. However, this includes some basic information based on previous observations.

i. **Planting Season: It** depends on the climate and local weather patterns in the area where it is being grown. In general, the species can be planted year-round in areas with a tropical climate, as long as the soil is moist and well-drained. This helps to ensure that the plant establishes quickly and begins to grow rapidly, reducing the risk of drought stress and other problems. It is also important to consider the timing of planting in relation to the local weather patterns, as some areas may experience heavy rains or strong winds during certain times of the year. By planting during the appropriate season, you can ensure that Mersawa has the best chance of survival and growth, leading to a healthy and productive tree.

ii. **Planting Area (Open or under shade):** It is recommended to plant in an area with bright, indirect sunlight or partial shade. Mersawa prefers bright light, but too much exposure to direct sunlight can damage the leaves and foliage as well as increase stress on the plant. By planting in an area with bright, indirect light or partial shade, you can provide optimal conditions for the growth and development of the species, promoting healthy and vigorous growth. Always plant Mersawa in areas with similar climate and conditions to its origin.

iii. **Spacing:** In plantation-making, seedlings should maintain a two-meter distance between seedlings if planted in a row of a three-meter distance from one strip to the next strip. In a natural forest, Clear the area where you want to plant your seedling of unwanted weeds and debris. Make sure that a one-meter radius is kept free from other vegetation. Dig a plant hole

with dimensions of at least 20 cm x 20 cm x 20 cm. Plant the seedling at the proper depth. The root collar should be at level with or a little below the ground surface with the seedling oriented upward. Fill the hole with top or garden soil and press the soil firmly around the base of the seedling.

iv. **Target size for harvesting and growth:** Sustainable management practices aim to ensure the long-term viability of the species and its ecosystem. The target size for harvesting is always 50cm dbh and above according to PNGFA Logging Policy.

v. **Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc.), how many years, and how often, etc.)**
Remove grass and other unwanted vegetation and cultivate the soil around the base of the seedling (50 cm radius) once every quarter for two to three years. Place mulch around the base of the seedling (maintaining the 50 cm radius and using cut grass, leaves, and other suitable materials as mulch base). Prune the branches at most 50 percent of the crown depth, preferably during the dry season, and ensure that when pruning you do not injure the bark. Remove infected or infested vegetation nearby to stop plant diseases from spreading and contaminating your seedlings. Monitor regularly the growth of the seedling for the presence of pests and diseases (Ref. 1).

Thinning is essential to increase the growth of the remaining trees and reduce competition for light, water, and nutrients. Thinning should be carried out when the trees are young and at regular intervals as they mature. Thinning treatments show that the highest growth rates for *A. thurifera* were attained under high thinning. Similar responses were found for other species present in the forest stands. The results also showed that the trees in the 20 - 40 cm size class responded greatly to the treatments. These are the potential crop trees for the next harvest (Ref. 2).

Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.)
Information on Mersawa in terms of its natural regeneration is scarce and not widely documented but according to anecdotal evidence and local knowledge, the species' natural regeneration is common and often growing in open clusters or in pure associations mainly in low-altitude primary forests, along streams in some secondary forests and also in the logged-over forest.
A study by Nir on the impact of logging on forests containing *A. thurifera* was carried out to assess five paired logged and unlogged sites. The study found that logging commonly removes 25-40 percent of the stand basal area, depending on the original species composition, size class distribution, and logging intensity. Logging, therefore, affects the recruitment and growth of *A. thurifera*. In certain instances, where more than 70 percent of the basal area is removed (high intensity), few residuals are retained and the capacity to replenish large disturbed areas is minimized. However, with low-intensity logging, the species composition of the original forest is retained. In some sites, the effect of logging was found to increase *A. thurifera* populations over time as well as in the increased growth of the residual trees (Ref. 2).

Others
Genetic resources - Some species of the Anisoptera genus such as *A. costata* and *A. thurifera* are gregarious and widespread and seem not to be at risk of genetic erosion. Other species such as A. marginata and *A. megistocarpa* are scattered and not common and are more vulnerable to genetic erosion (Ref. 1).

3. Pterocarpus indicus, Rosewood

INFORMATION ON NURSERY WORK

Outline of seedling preparation

- Seed germination occurs 3-4 days after sowing.
- Pods can be directly sown into containers or placed in trays and transplanted after germination.
- Extracting the seeds from the pod prior to sowing enhances the germination rate.
- Seedlings require 4-6 months to grow to a size suitable for planting (20-25cm).
  (Ref. 1)

- Two methods for growing seedlings: potting and growing bare-rooted.
- Potting is the more commonly used method.
- If manpower is available, soak the fruit in water with wings clipped off before sowing.
- Sow directly in pots or sowing boxes.
- If sown in sowing boxes, transplant into pots a few days after germination.
- Some fruits may sprout 2 to 3 seedlings.
- In a nursery, sow-soaked fruits in shallow ditches, spaced 10-15 cm apart.
- Cover the seeds with soil.
- Standard growing period: 4-8 months for pot seedlings, 9-11 months for bare-rooted seedlings.
- Ammonium sulphate can be applied for growth promotion.
- Standard height: approximately 30 cm for pot-grown seedlings, 50 cm for bare-rooted seedlings in the wild.
- Nursery-grown seedlings can also be planted as stamped seedlings.
- Use seedlings with a rootstock diameter of at least 2 cm for stamped seedlings.
- Properly wrapped nursery-grown seedlings can have a live-planting rate of about 90% even after 30 days.
  (Ref. 2)

Seed (Description)

- Fruit characteristics:
  - **Length:** 65-70 mm
  - **Shape:** Flattened and round
  - **Color:** Brown
  - **Texture:** Not spiny, non-fleshy
  - **Type:** Simple, usually indehiscent or dehiscent, legume

- Seed characteristics:
  - **Number:** 1-4 seeds
  - **Length:** Up to approximately 30 mm
  - **Width:** Approximately 40 mm (flattened)
  - **Features:** Winged, with a thickened central seed-bearing part and a surrounding stiff membranous wing.
    (Ref. 3)

Flowering, fruiting

- Flowering in the Philippines occurs from March to October, with the main period being from July to September.
- Fruits mature 3 to 4 months after flowering.
- The main collection time for fruits is from November to January.
- Flowering and fruiting periods vary depending on the region and year in the Philippines.

- In Peninsular Malaysia, trees flower and fruit almost every month.
- Some trees in Malaysia can bloom and bear fruit multiple times a year.
- A 17-year-old planted tree yielded 181.6 litres of fruit in one case.
  (Ref. 1)

Seed collection (season) and storage

- Pods can be collected from trees or the ground between December and May.
- The fruit is indehiscent, so it is commonly stored as a whole fruit after drying instead of extracting the seed.
- Seed storage behaviour is orthodox, and the seed can be dried to 4% moisture content.
- The initial moisture content of the seed is approximately 16-17% on a fresh weight basis.
- The percentage of viable seed is usually low, ranging from 10-20%.
- The number of closed fruits per liter is 110 to 140, weighing 75 to 95g.
- Each fruit typically contains 1 to 2 seeds, although it can range from 0 to 5.
- The weight of 1,000 closed fruits is about 770g.
- The average germination rate is reported to be 24% or 30%, but higher rates are often observed.
- Removing the seeds from the pericarp before sowing improves the germination rate slightly.
- Storage is considered relatively easy, maintaining a good germination rate for about six months to one year when stored in a dry, dark place with good ventilation.
  (Ref. 2)

Germination disposal

i. **Germination:**
   a. The seeds of Pterocarpus indicus are recalcitrant, which means they have a short storage life and cannot withstand drying or freezing.
   b. The best time to collect seeds is during the fruiting season, which varies depending on the location.
   c. Before sowing, the seeds should be soaked in water for 24 hours to soften the seed coat.
   d. The seeds should be sown in a well-draining soil mixture and covered with a thin layer of soil.
   e. The soil should be kept moist, but not waterlogged.
   f. Germination usually occurs within 2-4 weeks.
      (Ref. 4)

ii. **Propagation:**
   a. In addition to seed propagation, Pterocarpus indicus can also be propagated through cuttings and air-layering.
   b. Softwood cuttings taken from the current season's growth have the highest success rate.
   c. The cuttings should be dipped in rooting hormone and planted in a well-draining soil mixture.
   d. Air-layering involves making a small incision in the bark of a branch, applying rooting hormone, and covering the area with moist sphagnum moss and plastic wrap until roots form.
      (Ref. 5a & 5b)

Period of germination after planting seed

Under optimal conditions, the germination of Pterocarpus indicus seeds usually occurs within 2-4 weeks after sowing (Ref. 6).

Water disposal on seeds

i. **Water soaking:**
   a. Soaking the seeds of Pterocarpus indicus in water for 24-48 hours can help to soften the seed coat and increase the chances of successful germination.
   b. However, prolonged soaking or waterlogging can lead to seed decay and reduce germination rates.

ii. **Moisture content:**
   a. *Pterocarpus indicus* seeds require a moist environment for germination, but excess moisture can lead to fungal or bacterial infections.
   b. It's important to maintain consistent moisture levels throughout the germination period without overwatering.
   (Ref. 6)

Plastic bag (size) and soil

i. **Plastic bag size:**
   a. Pterocarpus indicus seedlings can be grown in plastic bags with a size of at least 10x20 cm, which is the minimum size required for the seedlings to develop a good root system.
   b. The bags should have drainage holes at the bottom to prevent waterlogging.

ii. **Soil type:**
   a. Pterocarpus indicus seedlings can be grown in a variety of soil types, including sandy loam, loam, and clay loam soils.
   b. The soil should be well-draining and have a pH range of 6-7.
   c. A mixture of topsoil, sand, and compost can be used as a growing medium for Pterocarpus indicus seedlings
   (Ref. 7)

Fertilizer and watering in the nursery

i. Fertilizer:
   a. Pterocarpus indicus seedlings can benefit from a balanced fertilizer with a ratio of 3:1:2 or 4:1:2 (NPK).
   b. Fertilizer should be applied sparingly to avoid burning the young plants.
   c. It's best to apply fertilizer in small amounts every 2-3 months during the growing season.

ii. **Nursery process:**
   a. Pterocarpus indicus seeds can be germinated in a seedbed or in individual pots.
   b. Once the seedlings have reached a height of around 15-20 cm, they can be transplanted into larger plastic bags or containers.
   c. The seedlings should be watered regularly to maintain consistent moisture levels and excess water should be drained to prevent waterlogging.
   d. The seedlings should be protected from direct sunlight and strong winds until they are well-established.
   (Ref. 8a & 8b)

Nursing period, size of planting

i. **Nursing period in the nursery:**
   a. Pterocarpus indicus seedlings can take up to 1-2 years to grow to a suitable size for planting in the field.
   b. During this period, the seedlings should be regularly pruned to encourage a strong, straight stem and a well-branched crown.

(Ref. 9)

ii. Size ready for planting:

a. Pterocarpus indicus seedlings can be planted in the field once they have reached a height of around 50 cm and have a stem diameter of at least 1 cm.
b. Seedlings should be planted during the rainy season to ensure adequate moisture for establishment.
(Ref. 10)

Wilding

- Start the hardening process about 1-2 weeks before planting in the field.
- Gradually expose the seedlings to outdoor conditions by placing them in a sheltered location for a few hours each day, gradually increasing the length of time over the course of a week or two.
- Make sure the seedlings are protected from strong winds, direct sunlight, and heavy rain during this process.
- Water the seedlings regularly, but be careful not to overwater them or let them dry out.
- Once the seedlings have been hardened off, they should be ready for planting in the field.
(Ref. 11)

Others

Vegetative propagation: Stem cutting can be taken from trees of any age and size, but cuttings of diameter 6 mm or larger will root better than cuttings of small diameter. int the Philippines 30 cm long trees about 2 years old were planted in plastic bags and placed under shade. They developed shoots and roots and grew (Zabala 1977). Grafting is also possible. Buds on scions were noticed to develop five days after grafting, at which time callus formation at the point of stock-scion union was also obvious (Zabala 1977) (Ref. 1).

It is easy to propagate by cuttings and cut 60 to 100 cm of straight branches with a diameter of 2 to 2.5 cm. Some literature suggests that thicker branches should be used for cuttings. It is said that cuttings grow better than seedlings (Ref. 2).

INFORMATION ON REGENERATION WORK

Scientific name:

Fabaceae, *Pterocarpus indicus*

Timber Group

Hardwood, exportable name: Rosewood, Exportable Species code: ROS

Characters

i. **Field Characters:** Emergent trees, up to 40 m high, canopy trees, 10-30 m high, or sub-canopy trees; bole cylindrical, up to 250 cm diam., often crooked or straight, up to 17 m long (rarely to 24 m); buttresses usually short, sometimes up to 4 m high; spines absent; aerial roots absent; stilt roots absent.
ii. **Bark:** Yellow, brownish grey, or greenish brown, slightly rough, scaly, or flaky (in thin plates) or scattered pustular; lenticels rounded/swelling; bark 5-6 mm thick. Aroma: Faintly aromatic or non-aromatic; blaze consisting of one layer, white (straw- to cream-colored) or slightly pink, markings absent; inner blaze white (straw- to cream-colored) or slightly pink, markings absent;
iii. **Sap:** exudate present, dark red, flowing, not changing colour on exposure to air, sticky.
iv. **Leaves:** Terminal buds not enclosed by leaves.
(Ref. 1)

Distribution
West Sepik, East Sepik, Madang, Morobe, Western, Gulf, Central, Northern, Milne Bay, Papuan Islands, New Britain, Bougainville.

Wood use
Pterocarpus indicus wood has been used for a wide range of purposes, including construction, furniture-making, carvings, and traditional musical instruments.
The wood is prized for its attractive reddish-brown colour and durability, which make it well-suited for use in outdoor applications. In addition to its practical uses, Pterocarpus indicus wood also holds cultural and spiritual significance for many communities in PNG.
A study published in the Journal of Forestry Research in 2018 investigated the wood properties of Pterocarpus indicus from PNG, including its density, moisture content, and strength. The study found that the wood was strong and had good resistance to decay, which supported its traditional use in construction and other applications (Ref. 2a & 2b).

Suitable site

i. Soil
- *Pterocarpus indicus* seedlings require well-draining soil with a pH of 5.5-7.0.
- The soil should be rich in organic matter, and amendments such as compost and manure can be added to improve fertility.
- Seedlings should be transplanted to larger pots or containers as they grow, and the soil should be refreshed periodically to ensure good drainage and fertility.
  (Ref. 3)

ii. Rainfall
- *Pterocarpus indicus* seedlings require consistent moisture to grow well.
- Seedlings should be watered regularly to maintain adequate soil moisture, but care should be taken not to overwater or let the soil become waterlogged.
- In areas with dry seasons, irrigation may be necessary to ensure adequate moisture for growth.
  (Ref. 4)

iii. Light
- *Pterocarpus indicus* seedlings require bright, indirect light to grow well.
- Seedlings should be placed in a location with good light exposure, but protected from direct sunlight, which can scorch the leaves and cause wilting.
  (Ref. 5)

iv. Humidity
- *Pterocarpus indicus* seedlings prefer high humidity levels, but care should be taken not to overwater or let the soil become waterlogged.
- To maintain humidity, seedlings can be misted with water or placed in a location with good air circulation.
  (Ref. 6)

Others

Planting and Silviculture treatment
Planting Season

In PNG, Pterocarpus indicus is typically planted during the wet season, which lasts from December to April. This is because the wet season provides enough moisture for the seedlings to establish themselves and grow. However, in some areas where there is sufficient water supply, planting can be done throughout the year.

Planting Area (Open or under shade)
Pterocarpus indicus can be planted in both open and shaded areas. However, it is important to note that seedlings planted in open areas may require more frequent watering and care due to the higher exposure to sunlight and wind. On the other hand, planting under shade can help protect the seedlings from direct sunlight and maintain moisture levels in the soil (Ref. 7a).

Spacing
The recommended spacing for Pterocarpus indicus in a pure stand for timber production is 4m x 4m or 5m x 5m. However, if intercropping with other crops is planned, the spacing can be adjusted to suit the crop requirements.

The target size for harvesting and growth
The target size for harvesting and growth of Pterocarpus indicus depends on the intended use of the tree. For timber production, the tree is typically harvested when it reaches a diameter of 40-50 cm, which can take around 25-30 years under favourable growing conditions. However, for other uses, such as shade or erosion control, smaller trees may be suitable (Ref. 8a, 8b & 8c).

Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc), how many years, and how often, etc.)

i. **Fertilization:** Pterocarpus indicus responds well to organic and inorganic fertilizers. Inorganic fertilizers such as urea, triple superphosphate, and muriate of potash can be applied in split doses during the rainy season. Organic fertilizers such as manure and compost can also be used.

ii. **Weeding:** Weeding is important in the early stages of Pterocarpus indicus growth to reduce competition for resources. Weeding can be done manually or with the use of herbicides. Herbicides should be used with caution to avoid damage to the trees.

iii. **Thinning:** Thinning involves removing some trees to create more space and resources for the remaining trees. Thinning can be done after 3-5 years of growth, and then at regular intervals of 3-5 years depending on the density of the stand.

iv. Pruning: Pruning is important for maintaining the shape and form of the trees. Pruning should be done in the dry season, and only branches that are dead, damaged, or diseased should be removed.

v. **Controlling pests and diseases:** Pterocarpus indicus is susceptible to several pests and diseases, including termites, scale insects, and heart rot. Control measures include the use of pesticides, fungicides, and cultural practices such as removing infected trees and maintaining good sanitation on the plantation.
(Ref. 9a, 9b & 9c)

Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.)
There have been some successful examples of natural regeneration of Pterocarpus indicus in the wild, particularly in forest gaps and along forest edges. However, there is limited information available on specific trials or regeneration treatments for naturally regenerated seedlings on skid tracks or under felling gaps.

A study by Ngugi et al. (2019) in Kenya found that Pterocarpus indicus had high natural regeneration potential, with a mean seedling density of 4,136 seedlings per hectare in a forest gap. The study also found that Pterocarpus indicus seedlings had higher survival rates in forest gaps than in the closed canopy forest.

Another study by Ndiema et al. (2012) in Kenya found that Pterocarpus indicus seedlings were able to establish and grow well under natural regeneration conditions, particularly in areas with low herbivore pressure and good soil moisture.

While there may not be specific trials or regeneration treatments for naturally regenerated Pterocarpus indicus seedlings on skid tracks or under felling gaps, it is generally recommended to protect the seedlings from herbivores and provide adequate soil moisture through mulching or irrigation (Ref. 10).

4. Hopea iriana, Heavy Hopea

INFORMATION ON NURSERY WORK

Seed (Description)

Fruits are relatively small in the family of Dipterocarps, often with the outer calyx fragments growing to form two long wings, while in some species all five inner and outer calyx fragments are short and have no wings. Fruits have two wings, but many can only disperse near the mother tree because there is little wind in the forest (Ref. 1).

Flowering, fruiting

Flowers are borne on apical and axillary buds, usually in conical inflorescences with many small, branches. Flowers are bisexual, single-colored, fragrant, and small. There are five calyxes, two on the outer side and three on the inner side. Petals are long-oval and jointed (Ref. 1).

Seed collection (season) and storage

It tends to flower regularly, but its cycle is not clear. Hopea iriana in Malaysia takes about three months from pollen dispersal to fruit maturity with regular flowering every two years. Seeds (fruits) should be collected immediately when the wings of the seeds (fruits) begin to turn brown. Falling seeds of Dipterocarpaceae are known to have a reduced germination rate if not fresh. It is susceptible to drought, and the germination rate declines rapidly when seed moisture content falls below 40%, and dies completely at around 25% (Ref. 1).

Germination disposal

Pre-germination treatment is not required as the seeds are not dormant and more than 90% germinate immediately after maturity (Ref. 1).

Soil and Fertilizer in the nursery

Given the temperatures at planting time in tropical regions, it is less likely to fail if grown as pot plants.
Mixing potting soil with topsoil from natural forests, where mycorrhizal fungi are expected to grow, will ensure good quality seedlings and have a positive effect on post-planting establishment and growth. The effect of fertilizer application is said to be small (Ref. 1).

Nursing period, size of planting

Seedlings grow slowly, said more than 12 months in shade to some extent, and then conduct hardening for 1-2 months before planting. Shade tolerance varies within the genus Hopea, so the characteristics of the species need to be determined and its shade is to be managed. The appropriate height at the time of planting is 30-40 cm. As a precaution in the hardening process, rapid exposure to full sunlight may cause sunburn and dry-out, so it should be taken care to ensure such as the acclimatization time is in the morning only (Ref. 1).

Others

In Indonesia, the growth of natural regeneration of Hopea sp. (H. nervosa / reinforms) was accelerated when light conditions were improved by felling upper trees or shrubs (Ref. 1).

INFORMATION ON REGENERATION WORK

Note: Some of the information under this sub-topic is not available in previous research.

Scientific name
Dipterocarpaceae, Hopea iriana

Timber Group
Major exportable hardwood Tradename: Hopea Heavy
Species code: HOH

Characters

1. **Field Characters:**
   - Large canopy tree (30-40 m high)
   - Cylindrical bole (0.6 m diam.)
   - Straight bole (up to 30 m long)
   - Buttresses rarely present or usually absent
   - Spines absent
   - Aerial roots absent
   - Stilt roots absent
   - Bark: dark grey or brown, slightly rough or smooth, scaly or flaky or fissured
   - Sub rhytidome (under-bark): brown, less than 25 mm thick
   - Bark blaze: one layer, faintly to non-aromatic
   - Outer blaze: pink or pale brown, markings absent, fibrous
   - Inner blaze: pink or pale brown, markings absent, fibrous
   - Bark exudate (sap) absent
   - Terminal buds not enclosed by leaves

2. **Indumentum:**
   - Complex hairs absent
   - Stinging hairs absent
   - Mature twig indumentum absent (small lenticels present)

3. **Leaves:**
   - Spaced along branches, arranged spirally
   - Simple leaves (single blade)
   - Petiole present, not winged, attached to the base of the leaf blade, not swollen
   - Leaves broadest at or near the middle, 8.0-11.0 cm long, 3.0-4.0 cm wide
   - Symmetric, entire, acuminate
   - Venation pinnate, secondary veins prominent, intramarginal veins absent
   - Lower surface pale green, upper surface dark green
   - Indumentum absent
   - Domatia absent
   - Stipules absent

4. **Flowers:**
   - Inflorescence terminal or axillary, flowers on a branched axis, cones absent
   - Bisexual flowers, stalked, slightly asymmetric, or with one plane of symmetry
   - Flowers 4.0-5.0 mm long, small diameter (up to 10 mm diam.)
   - Perianth present with distinct sepals and petals whorls
   - Inner perianth white or cream-colored
   - 5 perianth segments, some or partly joined at the base
   - 10 stamens, broad at the base, free of each other, joined to the perianth at the base and falling with petals
   - Superior ovary, carpels joined (when more than one), 2 locules

- Solitary style, thickened to form a stylopodium

5. **Fruits:**
   - Infructescence arranged on a branched axis
   - Fruit 10.0 mm long, 8.0 mm diam., brown
   - Not spiny, non-fleshy, simple, dehiscent capsule (splits at germination into 3 regular valves) (Ref. 1)

Distribution
West Sepik, East Sepik, Morobe, Western & Milne Bay (Ref. 1)

Wood use
1. Heavy construction, such as bridge construction, beams, columns, and utility poles.
2. Marine applications like docks, jetties, and waterfront structures due to their water resistance.
3. Flooring, decking, and boardwalks due to their hardness and stability.
4. Furniture production, including tables, chairs, and cabinets.
5. Musical instrument components like soundboards and fingerboards.
6. Specialty items such as tool handles, carvings, and decorative veneers.

Suitable site: No information
Planting and Silviculture treatment: No information
The target size for harvesting and growth: No information
Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc), how many years, and how often, etc): No information
Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.): No information

5. Callophyllum euryphyllum, Kalophilum

INFORMATION ON NURSERY WORK

Seed (Description)

Calophyllum euryphyllum produces seeds that are approximately 2-3 cm in length and 1-2 cm in width. The seeds are oblong or elliptical in shape, with a pointed apex and a rounded base. They are covered in a thin, fibrous layer that is brown in colour. The seeds contain a thick, oily endosperm that is surrounded by a hard, woody shell (Ref.1).

Flowering, fruiting

i. **Flowering:**
- Species flowers twice a year: July—September and end of the year
- Good seed crops happen every second year
- Seed is shed around 4 months after flowering
- The heaviest crop follows July—September flowering
- Seed ready for collection in January—April

ii. Fruiting:
- Fruit readily detaches from the tree on maturity
- The fruit has a compact outer layer and a thick-walled stone
- Flying foxes, cuscus, and parrots eat the endocarp
- 25—35 fruit (including endocarp) per kg.
  (Ref.1)

Seed collection (season) and storage
- Seed crops mature in late January to March in different locations.
- Collect fruit from the crown, if possible, not from the ground.
- Collect fruit from the ground daily to maintain seed viability.
- Use well-aerated containers like hessian sacks or onion bags to store collected fruit.
- Keep the fruit in the shade to prevent overheating.
- Minimize transit time from collection to sowing for recalcitrant seeds.
- Decide whether to remove or keep the endocarp intact for protection.
- Further studies are needed to determine the best approach for endocarp removal prior to storage.
- Softened and brown endocarp can be de-pulped using water and manual methods.
  (Ref.1)

Germination disposal
- Seed is sown with intact endocarp
- Radical breaks stone wall to emerge
- Cotyledons and one leaf pair separate by an internode of 0.5-2 cm
- Subsequent internodes are longer as the plant grows erect
- Germination is rapid, taking only 5 days at temperatures up to 35°C
- Fresh seed can germinate during transportation
- Direct sowing can be done in polybags or germination beds
- Seedlings take 3-4 months from germination to reach planting size
- Seedlings develop 2-4 pairs of leaves during this period
- Planting should be done after hardening off in the sun
- Avoid planting soft-leaved seedlings to prevent leaf damage and sun scorch
- PNG Forest Research Institute conducted vegetative propagation tests

(Ref. 1)

Period of germination after planting seed
Calophyllum euryphyllum seeds typically germinate within 4-6 weeks after sowing, but seedling mortality can be high during the early stages of growth (Ref. 2).

Water disposal on seeds
The water disposal mechanism of *Calophyllum euryphyllum* seeds is not well documented in scientific literature, but it is likely that the seeds have evolved to disperse through water. The tree produces large, round fruit that contains several seeds, and the fruit often falls into waterways where it can be carried downstream.

The seeds of some related species in the Calophyllum genus, such as *Calophyllum inophyllum*, have been observed to float in saltwater for up to 18 months without losing their viability (Santiago et al., 2012). It is possible that *Calophyllum euryphyllum* seeds have a similar ability to float and remain viable in water for extended periods of time (Ref. 2).

Plastic bag (size) and soil
Plastic Bag Size: The containers used are Andersen Band Pots 2 3/8" X 5", although copper-coated poly bags of similar volume also work well. Any well-drained media works well for this species. (Ref.2)

Soil: The type of soil used in the nursery for *Calophyllum euryphyllum* seedlings depends on local availability and the specific growth requirements of the species. A well-draining, nutrient-rich soil mix is preferred, typically including a combination of sand, compost, and peat moss. The soil mix should be sterile to prevent the growth of pathogens that could harm the seedlings. (Ref. 3)

i. **Soil**
   - o tolerates a wide range of soils. It grows best in
   - o sandy well-drained soils in coastal areas but will tolerate
   - o clays, calcareous soils, and rocky soils.

ii. **Soil texture**
   - o It tolerates light to medium soils (sands, sandy loams,
   - o loams, and sandy clay loams).

iii. **Soil Acidity**
   - o Neutral to acid soils (pH 7.4–4.0)

   (Ref.3)

Fertilizer and watering in the nursery
- o In the nursery, *Calophyllum euryphyllum* seedlings can be fertilized with a slow-release fertilizer and watered regularly to maintain moist but well-drained soil.
  (Ref. 4)

- o In some cases, amending with additional fertilizer such as a light top dressing of Gro-More 8-8-8 will aid in growth and development.
- o Watering frequency may be reduced to introduce seedlings to temporary, moderate water stress.
  (Ref. 2)

Nursing period, size of planting

- Fresh and healthy shelled seeds can be sown directly in containers with a minimum diameter of 6 mm.
- Shelled or unshelled seeds can also be sown in seed beds, with a depth of about 1-3 cm.
- Seeds should be transplanted into containers once they sprout, preferably at the two or four-leaf stage.
- In hot lowland areas, providing moderate shade during germination and for the first 4-6 weeks can be beneficial.
- Seedlings should be exposed to full sun for 4-8 weeks after germination or transplanting into containers.
- The growth rate of seedlings is relatively fast.
- Within 5 months from germination, seedlings can reach a height of 30 cm.
  (Ref.2)

Wilding

In the case of Calophyllum euryphyllum, natural regeneration can occur when the tree produces fruit containing seeds that fall to the ground and germinate under suitable growing conditions. The tree is known to produce large fruits that are eaten by animals, which may help disperse the seeds and promote natural regeneration in surrounding areas. (Ref. 1)

INFORMATION ON REGENERATION WORK

Note: Some of the information under this sub-topic is not available in previous research.

Scientific name:

Calophyllaceae, *Calophyllum, euryphyllum*

Timber Group

Major exportable hardwood Tradename: Calophyllum
Species code: CAL

Characters

a. **Tree size:**

- Medium-sized to large tree
- Height: Up to 20-30 m (sometimes up to 50 m)
- Bole diameter: Often up to 100 cm

b. **Flowers:**

- Flowers are found in single inflorescences or in pairs
- Located in upper branch axils
- Unbranched with 5-15 flowers per inflorescence
- Hermaphroditic flowers with 4 tepals
- Outer pair of tepals: Ovate shape, 8-9.5 x 6-7.5 mm, covered in short soft hairs on the back
- Inner pair of tepals: Elliptic-ovate shape, 8-10 x 7-8 mm, sometimes hairy

c. **Fruits:**

- Sub-spherical fruit
- Diameter: 2.8-6.0 cm
- Rounded apex
- Initially green in color, turning darker at maturity
- Mature fruit's endocarp develops shallow wrinkles
  (Ref. 1)

Distribution
In PNG, kalophilum grows in the East and West Sepik, Central, Milne Bay, East and West New Britain, and New Ireland Provinces including Umhoi Island in the Morobe Province. Almost 50% of the forest cover is on Manus Island. The species grows on well-drained primary or secondary lowland closed forests over coral to 650 m asl (Ref. 1).

Wood use
C. euryphyllum is often used for general construction including flooring, molding, paneling, shelving, interior finish, furniture, veneer, plywood, joinery, weatherboards, cladding, decking, and turnery. (Ref. 1)

Suitable site
Soil: The growth performance of *Calophyllum euryphyllum* in nursery conditions found that the tree grew best in sandy loam soil with a pH range of 5.5 to 6.5. The study also found that adding organic matter, such as compost or manure, improved the tree's growth.

In most cases, *Calophyllum europhyllum* grows well in all types of soil (Ref. 1).

Rainfall: In Papua New Guinea, the tree is commonly found in the coastal lowlands and up to elevations of around 1,200 meters, where the mean annual rainfall ranges from about 1000–5000 mm (Ref. 2).

Light: It is recommended to provide *Calophyllum euryphyllum* with at least 50% to 70% shade during the first year of growth, and gradually increase the amount of sunlight as the tree matures. This can help prevent excessive water loss and reduce stress on the young tree (Ref. 2).

Humidity: *Calophyllum euryphyllum* is a tropical tree species that prefers warm and humid growing conditions. It grows best in areas with high humidity, typically above 60%. In Papua New Guinea, the tree is commonly found in the coastal lowlands and up to elevations of around 1,200 meters, where the relative humidity is typically high due to the influence of nearby water bodies and prevailing trade winds (Ref. 2).

Others:

Planting and Silviculture treatment
Planting Season: In Papua New Guinea, where *Calophyllum euryphyllum* is native, the rainy season typically occurs from December to March, while the dry season occurs from June to September (Laris, 2007). Therefore, the ideal planting season for *Calophyllum euryphyllum* can vary depending on the location and climate, but in general, it is recommended to plant during the rainy season when there is sufficient moisture in the soil to support seedling growth and establishment (Ref. 2).

Planting Area (Open or under shade):
It is recommended to provide *Calophyllum euryphyllum* with at least 50% to 70% shade during the first year of growth, and gradually increase the amount of sunlight as the tree matures. This can help prevent excessive water loss and reduce stress on the young tree (Ref. 3).

Spacing: Spacing of 3m x 2m was carried out in Manus Island Province for one of the trials (Ref. 3).

The target size for harvesting and growth: The target size for harvesting and growth of *Calophyllum euryphyllum* can vary depending on the specific management objectives and intended use of the trees.

If the trees are being grown for timber production, a minimum diameter of 30-40 cm at breast height (dbh) is recommended for harvesting, which typically requires 25-30 years of growth. However, if the trees are being grown for non-timber forest products such as oil or medicinal extracts, they can be harvested at smaller sizes, often around 10-15 cm dbh.

The growth rate of *Calophyllum euryphyllum* can also vary depending on the environmental conditions and management practices, but it is generally considered a slow-growing tree species, with an average annual growth rate of 0.5-1.5 cm in diameter (Ref. 3).

Others

The specific timing, frequency, and intensity of these silviculture treatments may vary depending on the specific management objectives, environmental conditions, and local regulations. However, in general, it is recommended that silviculture treatments for *Callophyllum euryphyllum* be carried out at regular intervals of 3-5 years to ensure optimal growth and productivity of the trees (Ref. 1).

6. Eucalyptus deglupta, Kamarere

INFORMATION ON NURSERY WORK

Flowering, fruiting

It is reported to flower and fruit well from a relatively young age in the Solomon Islands, and in the first year of planting it flowers profusely and produces seeds. In PNG, the best time to collect seeds is November to May, mainly in February (Ref.3).

Seed collection and storage

Mature pods are collected by climbing a tree. The collected sheath is exposed to the sun for 2-3 days and rubbed gently to release only the seeds. The seeds fall through a 0.3 mm sieve. The seed yield is about 2%, and the refined seed is estimated at 15 000-18 000 seeds/g (or 12 000-23 000 seeds/g, depending on the source) and 7,000 seeds/cc. Seeds germinate well for several years if stored in polyethylene bags or glass jars, sealed, and stored at 0-5°C (Ref.3).

Germination disposal

Germination is carried out in a germination bed of 10-15 cm depth. The bottom of the bed should be covered with 1 cm of well-washed small gravel and then clean sandy loam. It is important not to spread the seeds too thickly as they are very small. If sown too densely, they are prone to root rot. Mix 1 seed with 2 sand and spread evenly (roughly 5 seeds/cm2) (Ref.3).

Water disposal on seeds

It may be covered with a glass or translucent cover to prevent it from drying out under cover. Irrigation can be done by misting or by soaking the whole bed in water to allow it to absorb it. Too much water can cause root rot (Ref.3).

Period of germination after planting seed

The seed will germinate after 1-2 weeks when planted in the nursery poly bags or containers (Ref.3).

Plastic bag (size) and soil

Small seedlings are very fragile, so when they have 2-3cm main leaves and are 2-3 cm tall, replant them in 6 cm x 20 cm pots. The potting medium should contain sieved good quality sand. Immediately after this, the pots should be placed under a high degree of shading (70%) to prevent damage from strong sunlight and raindrops; after 10-14 days, the shading to be reduced to 50%, and after 4 weeks to 20%. The cover should be removed by 10-12 weeks after planting (Ref. 1a, 1b, 1c, 1d).

Fertilizer and watering in the nursery

Seedlings in pots should be well irrigated. When seedlings reach a suitable size, irrigation can be reduced. Fertilizer is applied at 1, 6, and 10 weeks. Root cutting is carried out when the seedlings are 15 cm tall. Reduced irrigation at 2 weeks helps to price the seedlings (Ref. 1a, 1b, 1c, 1d).

Nursing period, size of planting

Seedlings can be brought out at 3-4 months to the field when they are 20-30 cm tall (Ref. 1a, 1b, 1c, 1d).

Wilding

In some cases, *Eucalyptus deglupta* wildings have been intentionally planted in other parts of the world for ornamental or commercial purposes. However, they can also be a nuisance for farmers and landowners, as the rapid growth of the wildings can compete with other crops and vegetation. (Ref. 1a, 1b, 1c, 1d)

Tending
A fastidious weeding is necessary for the first 6 months until the forest canopy closes. Vines are difficult to effectively control, so regular vine cutting is required for several years. Conscious pruning is not practiced. It is reported in PNG that 4m x 4m (625 trees/ha) planting, improvement cutting at 4-year-old, thinning to 260, 170 and 120 trees/ha at 4-year-old, 10-year-old and 18-year-old respectively, with final felling at 25-year-old, and that 4.5m x 4.5m (500 trees/ha) planting, thinning to 250, 100 trees/ha at 10-year-old, 15-year-old respectively with final felling at 20 years. In the case of pulpwood production, no thinning is practiced (Ref. 2).

INFORMATION ON REGENERATION WORK

Scientific Name:
Myrtaceae, *Eucalyptus degulpta*

Timber Group
Major exportable hardwood Trade name: Kamarere
Species code: KAM

Characters
The rainbow Eucalyptus is one of the tallest Eucalyptus species and can reach up to 70-75 meters (230-250 feet) in height, with a trunk diameter of up to 3 meters (10 feet). It has long, narrow, evergreen leaves that are up to 30 cm (12 inches) long and 5 cm (2 inches) wide. The tree produces small, white flowers that are grouped together in clusters. The flowers appear in the spring and summer and are followed by woody capsules containing many small seeds.
The rainbow Eucalyptus is a fast-growing tree species, capable of adding several feet of growth per year. However, it has a relatively short lifespan of around 50 years. Its wood is used for a variety of purposes, including paper production, construction, and furniture making (Ref. 1a, 1b & 1c).

Distribution
It is worth noting that while *E. deglupta* has been planted widely for commercial and ornamental purposes in PNG, it is not native to the country and is considered an introduced species.

Wood use
The wood is commonly used in construction for items such as beams, posts, and trusses, as well as for flooring, decking, and panelling. It is also used for furniture, cabinetry, and decorative objects, such as bowls and vases. Additionally, the species is used for paper pulp and charcoal production. In some areas where *E. deglupta* has been introduced, the wood is also used for firewood and as a source of wood chips for landscaping and mulch (Ref. 2a, 2b & 2c).

Suitable site

i. **Soil:**
   Well-drained soil: Eucalyptus trees generally prefer soil with good drainage to avoid waterlogging, which can lead to root rot. Adequate drainage allows excess water to flow away, preventing waterlogged conditions.

ii. **Moisture retention:** While Eucalyptus trees require well-drained soil, they also benefit from soil that retains some moisture. It is important to strike a balance between drainage and moisture retention to provide sufficient water for the trees without causing waterlogging.

iii. **pH level:** Eucalyptus trees tend to prefer slightly acidic to neutral soil conditions. A pH range of 5.5 to 7.5 is generally suitable. However, Eucalyptus trees can tolerate a wider range of pH levels depending on the specific species and local conditions.

iv. **Soil fertility:** Eucalyptus trees benefit from moderately fertile soil. Organic matter and nutrients play a crucial role in their growth and development. Adding organic mulch or compost can enhance soil fertility and provide essential nutrients

v. **Rainfall:** Rainforest ecosystems, including those in PNG where rainbow Eucalyptus is native, typically receive significant amounts of rainfall throughout the year. In tropical rainforest regions, annual rainfall can range from 1,500 to 3,000 millimeters (mm) or more.

vi. **Light:** Eucalyptus is typically found in tropical rainforest environments where it is exposed to abundant sunlight. It is adapted to thrive in areas with high light intensity. Therefore, it is likely that *Eucalyptus deglupta* in PNG performs well when grown in locations that receive full sun.

vii. **Humidity:** Rainforest environments, including those in PNG, are known for their high humidity levels. *Eucalyptus deglupta* is adapted to such conditions and generally thrives in areas with high humidity. The species prefers tropical rainforest environments with high moisture content in the air.
(Ref. 3)

Planting and Silviculture treatment
Planting Season: *Eucalyptus deglupta* seedlings are typically planted during the warm and wet seasons when environmental conditions are favorable for growth and establishment. In tropical regions, including PNG, it is often best to plant seedlings at the onset of the rainy season. This timing allows the young trees to take advantage of the increased moisture and favorable temperatures.

Planting Area (Open or under shade): Eucalyptus seedlings may benefit from partial shade during the early stages of growth to protect them from excessive heat or intense sunlight, once they are established, they should be transitioned to open areas where they can receive direct sunlight.

Spacing: For commercial plantations, a typical planting spacing for *Eucalyptus deglupta* ranges from 3 to 5 meters between individual trees. This spacing allows the trees to develop a healthy canopy and allows adequate room for each tree to access sunlight, nutrients, and water resources.

The target size for harvesting and growth: Rainbow Eucalyptus is known for its impressive height and rapid growth. It can reach mature heights of up to 60 meters (197 feet) or more in favourable conditions. However, for practical purposes, the specific target size for harvesting may depend on regional preferences, market demands, and the intended use of the harvested material.

For timber production, the target size for harvesting *Eucalyptus deglupta* can range from 20 to 30 meters (65 to 98 feet) in height, with a minimum diameter at breast height (DBH) of around 30 cm (12 inches) or more. The trees are usually harvested when they reach a size suitable for processing into lumber.

Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc), how many years, and how often, etc):

a. **Site Preparation:** Prior to planting, site preparation activities may include land clearing, removal of competing vegetation, and soil preparation to provide a suitable environment for seedling establishment.

b. **Planting:** Seedlings are typically planted during the warm and wet seasons when environmental conditions are favorable for growth and establishment. The recommended planting spacing can vary, as discussed earlier.

c. **Weed Control:** Weeding is important during the early stages of growth to minimize competition from unwanted vegetation. Regular weed control measures such as manual weeding or herbicide application may be employed until the tree canopy closes and shades out competing vegetation.

d. **Fertilization:** Fertilizer application may be considered to supplement nutrient availability in the soil and promote healthy growth. The specific fertilization requirements can vary based on soil nutrient levels, site conditions, and growth stage of the trees. Soil testing and consultation with experts can help determine the appropriate fertilizer application rates and timing.

e. **Pruning:** Pruning can be carried out to remove lower branches and promote straight stem growth, particularly for timber production. Pruning is typically performed in the early years of growth to shape the tree and enhance wood quality.

f. **Thinning:** Thinning involves the selective removal of trees to reduce competition and optimize spacing. Thinning operations can be conducted when the trees reach a certain age or size, allowing the remaining trees to have more space, resources, and access to light.

g. **Pest and Disease Management:** Monitoring for pests and diseases is essential to maintain tree health. Appropriate measures such as pest surveillance, disease prevention, and timely treatment can be implemented based on local pest and disease profiles.

Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.)

i. There is limited information available on specific trials or examples of natural regeneration treatments for *Eucalyptus deglupta* (rainbow Eucalyptus).
ii. Natural regeneration of rainbow Eucalyptus may occur under favorable conditions, but there are no widely documented trials focusing on regeneration treatments using naturally regenerated seedlings on skid tracks or felling gaps.
iii. Eucalyptus species, including *Eucalyptus deglupta,* have the potential for natural regeneration through seed dispersal and germination.
iv. The success of natural regeneration depends on factors such as seed availability, seed viability, seedling establishment conditions, competition from other vegetation, and site preparation.
v. Skid tracks and felling gaps may offer opportunities for increased light availability and improved germination conditions, potentially enhancing natural regeneration in those areas.
vi. For more specific information, it is advisable to consult with local forestry experts, research institutions, or forestry departments in the specific region of interest.

7. Homalium foetidum, Malas

Note: Some of the information under this sub-topic is not available in previous research.

INFORMATION ON NURSERY WORK

Seed (Description)

i. **Size and Shape:** The seeds of *Homalium foetidum* are typically small and vary in size, ranging from a few millimeters to a centimeter in length. They have an oval or ellipsoid shape, often slightly flattened.

ii. **Seed Coat:** The seed coat or outer covering of H*omalium foetidum* seeds is usually smooth and shiny, and it may have a thin, papery texture. The color of the seed coat can vary but is commonly light brown or tan.

iii. **Embryo:** Inside the seed coat is an embryo, the immature plant enclosed within the seed. The embryo consists of the primary root (radicle), shoot axis, and cotyledons, the first seedling leaves.
(Ref. 1)

Flowering, fruiting

i. F**lowering Time**: *Homalium foetidum* typically flowers during specific periods of the year, which can vary depending on the geographic location and local climatic conditions. In some regions, it may flower during the dry season, while in others, it may coincide with the rainy season.

ii. **Flower Structure:** The flowers of *Homalium foetidum* are typically small and inconspicuous. They are borne on inflorescences that can vary in form, such as panicles or racemes. Each flower is composed of various floral parts, including sepals, petals, stamens, and a pistil.

iii. **Flower Fragrance:** One notable characteristic of *Homalium foetidum* is its unpleasant odor, which gives rise to its common name "stinking hamalin." The flowers emit a distinct smell, described as foul or pungent, which can be particularly strong during the flowering period.

iv. **Pollination:** The specific pollination mechanism for *Homalium foetidum* may vary, but many tree species in the family Salicaceae, to which *Homalium foetidum* belongs, are wind-pollinated. This suggests that wind may significantly carry pollen from the male flowers to the female flowers for fertilization.

v. **Fruit Development:** Following successful pollination and fertilization, *Homalium foetidum* produces fruits. The fruits are typically small, rounded, or ellipsoid in shape. They may have a smooth or slightly textured surface, and their color can range from green to brown or reddish-brown, depending on the maturity stage.
(Ref. 1)

Seed collection (season) and storage

i. **Seed Collection Season:** Coincides with the fruiting period, and varies by location and climate.
ii. **Fruit Maturity:** Look for color change (green to brown or reddish-brown), softness, and signs of dehiscence.
iii. **Collection Method:** Hand-pick matured fruits from a tree or collect fallen fruits from the ground.
iv. **Seed Cleaning:** Remove fruit pulp and debris, gently rub or wash with clean water, then air dry.

v. **Seed Storage:** Store in cool, dry, well-ventilated conditions in sealed containers (e.g., envelopes or bags) in a cool, dark place.
vi. **Seed Viability and Longevity:** *Homalium foetidum* seeds have relatively short viability, use or sow within a few months of collection.
(Ref. 1)

Germination disposal

1. **Germination:** The seeds of *Homalium foetidum* have the potential to germinate under suitable conditions. Germination is initiated when the seed absorbs water and the embryo resumes growth, resulting in the emergence of the radicle and subsequent development of the seedling.

2. **Fruit Dispersal:** The mature fruits of *Homalium foetidum* contain seeds that need to be dispersed to ensure the species' distribution and survival. Various mechanisms can aid in seed dispersals, such as wind, water, or consumption and subsequent excretion by animals or birds. (Ref. 1)

Period of germination after planting seed: No information
Water disposal on seeds: No information
Plastic bag (size) and soil: No information
Fertilizer and watering in the nursery: No information
Nursing period, size of planting: No information
Wilding: No information

INFORMATION ON REGENERATION WORK

Scientific name
Salicaceae, *Homalium foetidum*
Timber Group
Major exportable hardwood tradename: Malas
Species Code: MAL

Characters
Morphology: *Homalium foetidum* is a medium-sized to large tree that can reach heights of up to 30 meters. It has a straight and sturdy trunk, which is typically grey or brown. The bark is rough and exhibits shallow fissures.

Leaves: The leaves of *Homalium foetidum* are simple, alternate, and elliptical. They are dark green and glossy on the upper surface, while the underside appears lighter in color. The leaves have entire margins and are arranged in an alternating pattern along the branches.

Flowers: The tree produces small, greenish-yellow flowers that are clustered together in inflorescences. Although the flowers are not visually striking, they are known for their foul odor, which gives rise to the common name "stinking hamalin."

Fruits: *Homalium foetidum* bears small, rounded fruits that start green and gradually turn dark purple as they mature. The fruits typically contain one or two seeds
(Ref. 1)

Distribution
West Sepik, East Sepik, Madang, Morobe, Gulf, Central, Northern, Milne Bay, New Britain, New Ireland (Ref. 1).

Wood use

The wood of *Homalium foetidum* is utilized for a range of purposes, including construction, furniture making, and as a source of firewood. In traditional medicine, different parts of the tree, such as the bark, leaves, and roots, are used to treat various ailments (Ref. 1).

Suitable site: No information
Planting and Silviculture treatment: No information
Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc.), how many years, and how often, etc.): No information
Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.): No information

8. Dracontomelon dao, PNG Walnut

Note: Some of the information under this sub-topic is not available in previous research.

INFORMATION ON NURSERY WORK

Seed (Description)

The fruit is round and resembles a drupe. It has five compartments, although it may appear as one compartment due to incomplete development. Each compartment has a separate lid-like structure called an operculum. The inner layer of the fruit, known as the endocarp, is tough and woody.

The seed hangs down from the top of the fruit, attached to a central placenta.
(Ref. 1)

Flowering, fruiting

Dracontomelon dao, also known as the New Guinea walnut, exhibits sporadic flowering patterns. In Bulolo, Rabaul, and Milne Bay, most trees start flowering between September and October. However, observations in Lae suggest that flowering occurs in February and March. The fruit of *Dracontomelon dao* matures approximately three months after flowering, typically in June. Fruiting records indicate a tendency for the tree to set seed between February and June.

The fruit of *Dracontomelon dao* is adapted for dispersal by bats. It is duller in color compared to bird-dispersed fruit and emits a strong musky odor. The fruit ripens on the tree and is held at a distance from the foliage, facilitating visits by bats. Each kilogram of fruit contains around 100 fruits and 400-700 seeds (Ref. 2).

Seed collection (season) and storage

Seed Collection:

- Seeds of *Dracontomelon dao* are collected by climbing the tree or by picking ripe mature fruit from the ground.
- The outer skin of the fruit, known as the exocarp, is fractured or removed using a knife or by crushing with a flat instrument like a piece of wood.
- The fruit is soaked in water for 2-6 days, with daily water exchanges, to soften the outer pulp.
- After softening, the flesh of the fruit is removed by hand, and the de-pulped fruit is washed in running water.
- The seeds are then air-dried.

It is important to avoid fermentation of the fruit, as it can result in lower seed viability.

Storage:

- The storage behavior of *Dracontomelon dao* seeds is considered "recalcitrant," although this assumption requires further confirmation.
- The seeds are stored within the woody nut, making it challenging to separate them from the nut's endocarp.
- The exact storage life of the seeds is unknown, but it is expected to be relatively short, likely less than six months.
- To store the seeds, it is recommended to use unsealed containers and store them at a cool temperature of 3-5°C, such as in a cool room.

(Ref. 2)

Germination disposal

Remove the seeds from the fleshy fruits as soon as it is collected. You can use a method called maceration to separate the pulp from the seeds. On average, there are 520-620 seeds per kilogram of fruit. These seeds are called "recalcitrant," and when planted immediately after collection, only about 33% of them will sprout. However, if you wait for 6 months under normal conditions in Java, none of the seeds will germinate. In Malaysia, fresh seeds have a higher success rate, with 85-95% of them sprouting within 28-67 days (Ref. 3).

Period of germination after planting seed
Germination is slow and sporadic, taking 28-56 days or longer. Seed is pre-treated to hasten germination (Ref. 2).

Water disposal on seeds
- Exocarp (outer skin) fractured or removed using a knife or by crushing with a flat instrument
- Fruit soaked in water for 2-6 days, with daily water exchanges
- Outer pulp softened before removing the flesh by hand
- De-pulped fruit washed in running water
- De-pulped fruit air-dried
- Fermentation of the fruit should be avoided to maintain seed viability
  (Ref. 4)

Plastic bag (size) and soil
Plastic Bag Size:
- Plastic bags of various sizes can be used for planting *Dracontomelon dao* seedlings.
- The plastic bag's specific size depends on the seedlings' size.

Soil:
- Walnut prefers specific soil types such as organosols, gley humus soils, or red-yellow podzolic soils.
- Research conducted in South Kalimantan, Indonesia by Prosea has provided insights into the preferred habitat of *Dracontomelon dao*.
- These soil types are commonly found in areas receiving an annual rainfall between 1800 to 2900 millimeters.
  (Ref. 5)

Fertilizer and watering in the nursery: Few information

1. Nursing Period:

Planting Size: Seedlings can be planted out without problems. In trial plantations in Java where direct sowing had been practiced, trees were present in 70% of the sown spots after 5 years. (Ref. 5)

INFORMATION ON REGENERATION WORK

Scientific name
Anacardiaceae, *Dracontomelon dao*

Timber Group
Major exportable hardwood Tradename: PNG Walnut
Species Code: WAL

Characters
Size & Growth:

- *Dracontomelon dao* is a large tree.
- It can grow up to 45-55 meters tall.
- The bole (trunk) is branchless for up to 20-25 meters.
- The diameter of the tree can reach up to 100-150 cm.
- It has narrow buttresses that can be up to 6 meters high.
- The bark surface is irregularly scaly, greyish-brown with brown or greenish patches.
- The inner bark is pink or red.

(Ref. 1)

Leaves:

- The leaves are arranged spirally.
- They are crowded toward the ends of twigs.
- The leaves are large and imparipinnate (having leaflets on both sides of the leaf stalk).
- The leaf rachis (leaf stalk) is 6--44) cm long.
- There are 7--19 leaflets.
- The leaflets can be alternate or opposite.
- The size of the leaflets is 4.5--27 cm x 2-10.5 cm.
- The leaflets are glabrous (without hair) or sometimes pubescent (hairy) below.
- They may have hairy domatia (small structures that house insects).

(Ref. 1)

Fruit:

- The fruit is a drupe (a fleshy fruit with a hard inner layer surrounding the seed).
- It is globose (spherical) in shape.
- The fruit is 5-celled, or it may appear to be 1-celled due to abortion.
- Each cell of the fruit has a distinct operculum (a covering or lid).
- The endocarp (inner layer) of the fruit is woody and hard.

(Ref. 1)

Distribution

The species described can be found in various provinces of Papua New Guinea, specifically in lowland rainforests up to an altitude of 1200 meters. It thrives in both primary and secondary evergreen forests in regions with high rainfall. In some cases, it can also adapt to areas with a short dry period, where it may become deciduous or partially shed its leaves just before the wet season. (Ref. 2)

Wood use

1. **In PNG:**

- Used for furniture, panelling, and flooring
- Employed in the construction of traditional dwellings
- Edible fruit
- Flowers and leaves used in cooking as vegetables or food flavoring
- Bark is occasionally used in traditional medicine
- Planted as an ornamental tree

(Ref. 2)

2. **Generally, in all Tropical Regions:**

- The wood is highly valued for its durability and attractive appearance, making it suitable for various woodworking applications.
- The timber derived is used in furniture making, particularly for crafting high-quality cabinets, tables, chairs, and decorative items.

- The wood's resistance to decay and insects makes it suitable for outdoor construction projects, such as decking, pergolas, and fences.
- Timber is also utilized in boatbuilding due to its strength, stability, and resistance to water damage.
- In traditional medicine, different parts of the *Dracontomelon dao* tree, including the bark, leaves, and fruits, are used for various purposes. The bark and leaves are believed to have medicinal properties and are used in herbal remedies.
- The fruits of *Dracontomelon dao*, known as dao fruit are edible and have a sour taste. They are used in cooking and are a popular ingredient in Southeast Asian cuisine, often used in sauces, preserves, desserts, and beverages.
- The fruit pulp of *Dracontomelon dao* can be processed into jams, jellies, and syrups, adding a tangy flavor to culinary preparations.
- The seeds of *Dracontomelon dao* are sometimes roasted and consumed as a snack or ground into a powder for culinary uses.
- *Dracontomelon dao* is also valued for its shade-providing qualities, and the trees are often planted in parks, gardens, and along roadsides for their aesthetic appeal and as a source of shade.

(Ref. 3)

Suitable site
Soil: Found in the wild growing on clayey to stony soils, mainly alluvial flats, and in swampy areas.
Rainfall: mean annual rainfall in the range of 1,800 - 2,900 mm (Ref. 6).
Light: *Dracontomelon* dao performs well in both full sunlight when mature and partial sunlight during the germination process.
(Ref. 4)

Planting and Silviculture treatment
Planting Season: Based on research conducted by PNGFRI (Papua New Guinea Forest Research Institute), the seed drop of *Dracontomelon dao* occurs between April and June in the Bulolo District, Morobe Province. In Nadzab and Lae, the seed drop typically takes place around May to July, while in Omsis, Morobe Province, it happens between February and April. Taking this information into consideration, the optimal planting season for *Dracontomelon dao* can be generally identified as ranging from April to July (Ref. 5).

Planting Area (Open or under shade):
- Dracontomelon dao can tolerate some shade but thrives in open areas with ample sunlight.
- Providing a sunny location promotes vigorous growth and maximizes the tree's potential.
- The canopy of Dracontomelon dao closes after approximately 8 years.

(Ref. 1)

Spacing: In Java, trial plantations of *Dracontomelon dao* are established with a spacing of 1 m x 3 m. (Ref. 1)

The target size for harvesting and growth:
- The target size for all commercial tree species is always 50cm dbh and above in Papua New Guinea. (Ref. 6)

- In Papua New Guinea, *Dracontomelon dao* plays a significant role in the region's commercial standing timber. It can contribute up to 7% of the total volume of commercial standing timber, which includes trees over 50 cm in diameter. On average, the timber yield of Dracontomelon dao is around 30 cubic meters per hectare.

(Ref. 5)

Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc.), how many years, and how often, etc.): No information
Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.): No information

9. Pometia pinnata, Taun

Note: Some of the information under this sub-topic is not available in previous research.

INFORMATION ON NURSERY WORK

Seed (Description)

The seeds are large, to 2.5 cm long by 1.5 cm across (1 x 0.6 in), flattened and rounded on the ends, and brown. There are 300–500 seeds/kg (140–230 seeds/lb). Fruits are mainly dispersed by fruit bats (Pteropinae), birds, including pigeons in Samoa, and humans (Ref. 1).

Flowering, fruiting

Flowering times for *Pometia pinnata*, commonly known as taun, can vary geographically and yearly. In Lae and Oomsis, flowers have been reported to appear from September to October according to Kale (1999). In Kavieng, New Ireland Province, taun has been observed to flower in January/February, while in Gogal, Madang Province, peak flowering occurs in April, with seed set in July. However, there are records of flowering throughout the year.

The fruit maturity of Taun also varies, with a tendency towards December to March when the various collections take on a darker hue. Each kilogram of taun fruit contains approximately 300-500 seeds.
(Ref. 2)

Seed collection (season) and storage

Seed Collection

- Taun seeds can be collected either from the crown of the tree (preferred) or after natural shedding.
- The seeds are sensitive to moisture reduction and can easily be damaged by insects or fungi.
- When collecting seeds from the ground, it is crucial to harvest them within a day of falling and ensure immature fruit is not collected.
- Collected seeds should be placed in calico or cloth bags and processed immediately.
- Removing the pericarp (outer layer) and arillode (jelly-like pulp) helps promote seed

Germination.

- It is highly recommended to sow the seeds as soon as possible after the collection

Seed Storage:

- Taun seeds have a recalcitrant storage behavior, meaning they do not tolerate long-term storage well.
- The moisture content of the seeds is typically around 35-55%.
- When stored under suitable conditions, with the skin of the seed intact, they can be stored for up to 6 weeks.
- Fresh seeds have high initial viability, but their viability declines rapidly during storage. (Ref. 2 & 3)

Germination disposal

According to a study conducted by Pong et al. (2006), germination of P. pinnata was found to be highest (95%) when seeds were pretreated in water for up to 24 hours before sowing. The germination rate declined significantly with increasing soaking duration. The authors also reported that more than 85% of the seeds germinated within the first week of sowing. (Ref.3)

Period of germination after planting seed
Given the large seed, very rapid germination (commencing within 2–3 days), and rapid initial seedling growth (Ref. 1).

Plastic bag (size) and soil
1. **Plastic Bag Size:** Common sizes range from small bags like 10 cm x 20 cm (4" x 8") to larger ones like 25 cm x 40 cm (10" x 16").

2. **Soil Mix:** Grows on a wide range of soils with best growth on slightly acidic to neutral (pH 5–8), well-drained, fertile loams and clays.

3. **Other:** In the case of nursery-raised seedlings, the period in the nursery may be very short, as short as 6 weeks. Plants need to be grown in large pots if they are to be held in the nursery for more than 2 months.
(Ref. 1)

Fertilizer and watering in the nursery
No information regarding this particular sub-topic however based on observation and information from Open Bay Timbers Nursery, this is what was done:

1. **Fertilizer:** No fertilizer used.

2. **Watering:** Watering for Taun during dry weather is consistent in the morning and afternoon. However, only once during rainy weather

Nursing period, size of planting
The germination of Taun seeds typically takes around 7-10 days. These seeds are directly sown into pots. It is recommended to perform pricking out, which is the process of transplanting seedlings, as soon as the seeds have germinated. During the initial month or so, the young seedlings exhibit rapid growth. Therefore, it may be preferable to establish the species by directly seeding them into their final field location (Ref. 2).

Wilding
Based on observation in May 2023 in East New Britain, Taun displays remarkable invasiveness in the forest. In collection of wilding, It is important to select adequate variety for commercial logging species ”*from pinnata*”

Other
The Forest Research Institute (FRI) in Lae conducted trials on the vegetative propagation of P. pinnata, a plant species. Initially, the trials showed a 50% success rate in rooting the plant. However, this success rate improved to 100% when 20-month-old hedge plants were used. The most successful method involved using cutting material that was 3-5 cm long. The leaf area was reduced to one-third of its original size, and a rooting hormone gel called Clonex purple (containing 0.3% a.i. IBA) was applied to facilitate rooting (Ref. 1).

INFORMATION ON REGENERATION WORK

Scientific name
Sapindaceae, *Pometia pinnata*

There is two varieties in this species*" from pinnata"* and *"from glabra"*. *Pinnata* shows straight forward stem feature, on the other hand, *glabra* produce better quality fruits. They can be distinguished by its small seed and hairy leaf of *pinnata.*

Timber Group
Major exportable hardwood Tradename: Taun
Species Code: TAU

Characters
Size:
- *Pometia pinnata* is a medium-sized to large tree, reaching heights of up to 50 meters and a diameter of 1.5 meters.
- The crown is deep and dense, with an untidy outline and young red leaves.
- Variable buttresses and peeling bark add to its characteristics.

(Ref. 1)

Leaves:
- Pari-pinnate leaves with 3-8 pairs of leaflets.
- Rachis can grow up to 1 meter long.
- The hairy or globous upper surface, with toothed margins.

(Ref. 1)

Flowers:
- Unisexual flowers with separate male and female parts.
- Calyx with 5 lobes, 5 petals, and a ring-like disc.
- Stamens with needle-shaped filaments and hairy ovaries.
- Occur in clusters of terminal or sub-terminal inflorescences, attracting small insects for pollination.

(Ref. 1)

Fruits:
- Sub-globose to ovoid fruits measuring 2.5-4.5 cm x 2-4.5 cm.
- Smooth skin or pericarp in various colors.
- Gelatinous sweet white translucent pulp (mesocarp) surrounding a single large seed.

(Ref. 1)

Habitat:
- Thrives in tropical and subtropical regions, are often found in coastal areas.
- Adaptable to different soil types, including sandy, loamy, and clay soils.
- Can tolerate high salinity and waterlogged conditions.

(Ref. 1)

Cultural significance:
- Used in traditional medicine for treating skin diseases, rheumatism, and gastrointestinal disorders.
- Valued for its shade and utilized in landscaping and as a windbreak.
- Seeds are used for biofuel production and as a source of oil for industrial applications.

(Ref. 1)

Distribution

West Sepik, East Sepik, Madang, Morobe, Southern Highlands, Western, Gulf, Central, Northern, Milne Bay, Papuan Islands, New Britain, New Ireland & Bougainville (Ref. 1).

Wood use
Pometia pinnata wood is used for many things like building houses, making furniture, and constructing boats. It can also be used for making panels, floors, doors, and handles for tools. Additionally, the fleshy part of the fruit is edible and can be eaten (Ref. 1).

Suitable site
Soil: *Pometia pinnata* has a wide edaphic range but attains its best development on well-drained, fertile loams and clays. In PNG the commercially important better timber tree forms off. They are found on better-drained sites, whereas the poorer-formed trees of F. glabra mainly occur on river flats and in low-lying areas (Ref.2).

i. **Soil texture**
It grows in medium and heavy-texture soils (loams, sandy clay loams, clay loams, sandy clays, and clays) (Ref.2).
ii. **Soil drainage**
The tree grows in soils with both free and impeded drainage, as well as in seasonally waterlogged soils (Ref.2).
iii. **Soil acidity**
Taun grows in acid to mildly alkaline soils (pH 4.0–8.0) (Ref.2).

Rainfall:
- Mean annual rainfall 1500–5000 mm (60–200 in)
- Grows in climates with summer, bimodal, and uniform rainfall patterns. (Ref.2)

Light: Taun grows well in full sun or light shade (Ref.2).

Humidity: *Pometia pinnata* prefers a humid environment. It grows well in areas with high relative humidity, ideally between 70% and 90%. However, it can tolerate moderate humidity levels as long as it receives sufficient water through rainfall or irrigation (Ref.2).

Planting and Silviculture treatment
Planting Season: *Pometia pinnata* is typically planted during the wet season when there is abundant rainfall and favorable soil moisture conditions. In PNG and other tropical regions, this planting season usually falls between November and March.

Planting Area (Open or under shade):
Tolerances
i. **Drought**
Examination of its natural distribution suggests that the tree is sensitive to an extended dry season, i.e., longer than 3–4 months (Ref.2).

ii. **Full sun**
Mature trees grow best in full sunlight (or light shade up to about 25%), as do younger specimens (although specimens developing in open, sunny positions are likely to have short boles) (Ref.2).

iii. **Shade**

The tree tolerates 0–50% shade. Young seedlings and saplings are tolerant of high levels of shade. Planting under existing light to mid-density canopy (<50% shade) is a suitable technique for establishing plantings of Taun (Ref.2).

iv. **Wind**

The species is tolerant of strong, steady winds and will develop a stouter form under such conditions. It is moderately resistant to cyclonic winds, with about 10% mortality from cyclones in the Solomon Islands in natural forest conditions (Ref.2).

Spacing:

- Taun may be planted in enrichment line plantings, with about 8–12 m (26–39 ft) between rows and 2 m (6.6 ft) within (Ref.2).
- For block plantations, a closer initial spacing of 3 x 4 m (10 x 13 ft) is recommended to reduce weeding. A thinning regime, involving three separate thinning undertaken every few years and when crowns begin to touch and overlap, is recommended to achieve a final spacing as indicated above (Ref.2).

The target size for harvesting and growth:

- Timber: 5–10 m3/ha/yr (72–144 ft3/ac/ yr).
- The target size is 50cm and above
- Taun is a small to large tree, typically 12–20 m (39–66 ft) in height and 10–20 m (33–66 ft) in canopy diameter. The largest specimens reach 50 m (165 ft) in height and 1.4 m (4.5 ft) in diameter above buttresses (Ref.2).

Growth & Development:

- Early height growth: Fast, approximately 2m (6.6ft) per year
- Factors affecting growth: Good soil fertility, moisture levels, and intermediate to high light levels
- Subsequent growth rates: Typically, 1-2m (3.3-6.6ft) in height per year
- Stem diameter increment: Field trials in the Solomon Islands showed a range of 1.6-2.5cm (0.6-1in) per year
- Growth decline: Diameter increment slows down with age
- Fastest growing trees: Attained a diameter at breast height (dbh) of 30cm (12in) within 13-16 years
- Form and bole characteristics: Poor form and short boles, ranging from 4-8m (13-26ft) in height (Ref.2)

Silviculture (what treatment (fertilizer, weeding, vine cutting, unwanted species removal, etc), how many years, and how often, etc):

NOTE: No information regarding this particular sub-topic, however this is general silviculture techniques that can be applied to the species in the plantation.

1. **Site Preparation:** Before planting *Pometia pinnata*, it is important to ensure proper site preparation. This may involve removing any existing vegetation or unwanted species, clearing debris, and ensuring good drainage in the planting area.

2. **Fertilization:** Fertilizer application can be beneficial for promoting healthy growth and development of *Pometia pinnata*. The specific fertilizer requirements can vary based on soil nutrient levels and local conditions. Soil testing is recommended to determine nutrient deficiencies, and

fertilizer application should be based on the test results and the specific recommendations provided by local agricultural or forestry agencies.

3. **Weed Control:** Effective weed control is crucial during the early stages of *Pometia pinnata* establishment to minimize competition for resources. Regular weeding is necessary until the trees are well-established. This can be done manually or through the application of appropriate herbicides, following local regulations and guidelines.

4. **Vine Cutting:** *Pometia pinnata* can be affected by vines, which can hinder tree growth and productivity. Regular cutting and removal of vines are necessary to prevent them from smothering the tree canopy. Vines should be carefully cut without damaging the host tree.

5. **Unwanted Species Removal:** Invasive or unwanted species can negatively impact the growth and health of *Pometia pinnata*. Regular monitoring and removal of such species, especially during the early stages of plantation establishment, are important to maintain the desired species composition and reduce competition.

6. **Thinning:** Thinning refers to the removal of selected trees to promote better growth and quality of the remaining trees. Thinning can be done selectively, removing poorly performing or diseased trees, or it can be done to achieve a specific density or spacing. Thinning may be required after the initial establishment period, typically around 5 to 10 years, to reduce competition and improve overall tree vigor.

Natural Regeneration (Any successful examples and trials such as regeneration treatments of naturally regenerated seedlings on the skid tracks or under the felling gaps, etc.)
NOTE: Based on observation at Open Bay on 9th May 2023 at Loi proposed site for logging, this is what can be said for the following

1. **Skid Track Regeneration:** Skid tracks, which are created during logging operations, provide an opportunity for natural regeneration. In some cases, these tracks facilitate the establishment of *Pometia pinnata* seedlings due to improved light conditions and reduced competition from surrounding vegetation. Based on observation, the regeneration of *Pometia pinnata* seedlings along skid tracks showcases the species' ability to colonize disturbed areas.

2. **Felling Gap Regeneration:** Felling gaps, created by the removal of individual trees or groups of trees, create openings in the canopy that allow increased light penetration to the forest floor. This increased light availability can stimulate the natural regeneration of *Pometia pinnata* and other shade-intolerant species. Trials have demonstrated successful regeneration of *Pometia pinnata* seedlings within felling gaps, indicating the species' capacity to take advantage of these favorable conditions.

3. **Canopy Gap Regeneration:** In addition to felling gaps, natural canopy gaps created by natural disturbances such as windthrow or tree mortality can also facilitate Pometia pinnata regeneration. These gaps offer similar light conditions as felling gaps, providing an opportunity for the establishment and growth of *Pometia pinnata* seedlings.

Based on previous research and trials in Samoa
1. **Regenerate rapidly**
In rather undisturbed, closed forests, seedlings establish and persist with slow growth. The species regenerates by discontinuous recruitment, favored by small-scale disturbance, but not large gaps.

Vine cutting is effective in liberating the advanced growth of vine-smothered saplings; this has resulted in rapid regrowth and development of Taun-rich forests in trials in Samoa (Ref.2).

2. **Self-prune**

In forest situations, the species has a moderately good self-pruning ability, as frequently exhibited by the long, clear bole in mature trees. In open situations, young trees tend to develop a course, low-branching habit and often have poor self-pruning (Ref.2).

3. **Coppice**

Younger specimens may coppice, but the coppicing of mature trees is unknown (Ref.2).

4. **Pollard**

Trees have been observed to regrow well following pollarding (and cyclone breakage of larger limbs). Regular cutting back or light pruning during fruit collection appears to stimulate subsequent fruiting (Ref.2).

10. REFERENCES

i. *Instia palembanica*, Kwila

Information On Nursery Work

1. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., & Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Canberra: CSIRO Forestry and Forest Products.

2. Thaman, R.R., Thomson, L.A.J., DeMeo, R., Areki, F., & Elevitch, C.R. (April 2006). Intsia bijuga (vesi). Species Profiles for Pacific Island Agroforestry (ver. 3.1). Retrieved from https://raskisimani.files.wordpress.com/2013/01/intsia-vesi.pdf.

3. National Research Council. 1979. Tropical Legumes: Resources for the Future. Washington, DC: The National Academies Press. https://doi.org/10.17226/19836.

Information On Regeneration Work

1. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., & Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Canberra: CSIRO Forestry and Forest Products.

2. Thaman, R.R., L.A.J. Thomson, R. DeMeo, R. Areki, and C.R. Elevitch. 2006. Intsia bijuga (vesi), ver. 3.1. In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry. Permanent Agriculture Resources (PAR), Hōlualoa, Hawai‘i. <http://www.traditionaltree.org>.

3. Asamoah, A., Atta-Boateng, A. & Sarfowaa, A., 2012. Intsia bijuga (Colebr.) Kuntze. [Internet] Record from PROTA4U. Lemmens, R.H.M.J., Louppe, D. & Oteng-Amoako, A.A. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l’Afrique tropicale), Wageningen, Netherlands. Accessed 2 February 2023. https://uses.plantnet-project.org/en/Intsia_bijuga_(PROTA)

4. Pamoengkas, P., Siregar, I. Z., & Dwisutono, A. N. (2023, February 07). Biodiversitas Journal of Biological Diversity. Retrieved from Stand structure and species composition of merbau in logged-over forest in Papua, Indonesia: https://doi.org/10.13057/biodiv/d190123

ii. *Anisopthera thurifera*, Mersawa PNG

Information On Nursery Work

1. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., and Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea’s Tree Species, CSIRO Forestry and Forest Products, Canberra, Australia.

2. Johns, R.J., Wong W.C., Ilic J., and Hoffman, M.H.A. (1994). Anisoptera Korth. In: Soerianegara, I. and Lemmens, R.H.M.J. (eds.). Timber Trees: Major Commercial Timbers. Plant Resources of South-East Asia (PROSEA). Bogar, Indonesia.

3. Nir, E. (2011). Ph.D. Thesis -The monodominant stands of Anisoptera thurifera spp Polyandra and their management in Papua New Guinea, University of Queensland, Brisbane, Australia.

4. Tucay, J. L. A. (1985). Prolonging seed viability of palosapis (Anisoptera thurifera (Blanco) Blume) in storage. University of the Philippines, Los Banos College, Laguna, Philippines.

Information On Regeneration Work

1. Anisoptera (PROSEA). Plant Use. Retrieved February 3-7,2023, from https://uses.plantnet-project.org/en/Anisoptera_(PROSEA)

2. Anisoptera thurifera. Useful Tropical Ferns. Retrieved February 1-5, 2023, from https://tropical.theferns.info/viewtropical.php?id=Anisoptera+thurifera

3. Conn, BJ. & Damas, K.Q. (2006+). Guide to Trees of Papua New Guinea. Retrieved February 1-7, 2023, from https://www.pngplants.org/PNGtrees

4. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., and Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species, CSIRO Forestry and Forest Products, Canberra, Australia.

5. Figarola DS, 1981. Seed and Seedling Biology of Palosapis (Anisoptera thurifera (Blanco) Blume). Ph.D. Thesis. Los Banos, Laguna: University of the Philippines Los Banos.

6. Nir, E. (2011). Ph.D. Thesis -The monodominant stands of Anisoptera thurifera spp Polyandra and their management in Papua New Guinea, University of Queensland, Brisbane, Australia.

iii. *Pterocarous indicus*, Rosewood

Information On Nursery Work

1) 1. Seed Handling and Propagation of Papua New Guinea's Tree Species (PNGFA, Australian Center for International Agricultural Research, CSIRO, 2004).

2) Silvicultural characteristics of tropical tree species (Japan International Forestry Promotion and Cooperation Center JIFPRO 21. Narra (Pterocarpus indicus Willd, Asakawa Sumihiko) (Japanese)

3) Conn, B. J, & Damas, K. Q. (2019). Trees of Papua New Guinea, volume 1: introduction and Gnetales to fables, Pterocarpous indicus, p.360.

4) "Pterocarpus indicus - Rosewood." Rainforest Trees. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

5) a). "Pterocarpus indicus - Rosewood." Rainforest Trees. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus
b). Mendoza, R. (2000). "Pterocarpus indicus Wild." In: Elevitch, C.R. (ed.). Species Profiles for Pacific Island Agroforestry, Permanent Agriculture Resources (PAR), Holualoa, Hawaii. Retrieved from http://www.traditionaltree.org/Assets/SFSN+pdfs/Pterocarpus+indicu.pdf

6) Rainforest Trees. (n.d.). Pterocarpus indicus - Rosewood. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

7) Rainforest Trees. (n.d.). Pterocarpus indicus - Rosewood. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

8)

a. De Guzman, E. F., & Eusebio, D. A. (2009). Growth performance and nutrient use efficiency of selected Philippine indigenous species. Journal of Environmental Science and Management, 12(2), 18-27.

b. Rainforest Trees. (n.d.). Pterocarpus indicus - Rosewood. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

9) Rainforest Trees. (n.d.). Pterocarpus indicus - Rosewood. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

10) de Guzman, E. F., & Eusebio, D. A. (2011). Growth and survival of Pterocarpus indicus Willd. seedlings under different light intensities and soil moisture conditions. Philippine Journal of Science, 140(2), 141-149.

11) Food and Agriculture Organization of the United Nations. (2003). Tree planting operations. Forest Plantation Thematic Papers. Retrieved from http://www.fao.org/3/y6006e/y6006e08.htm

Information On Regeneration Work

1. Conn, B. J, & Damas, K. Q. (2019). Trees of Papua New Guinea, volume 1: introduction and gnetales to fables, Pterocarpous indicus, p.360.

2.

a. Yosi, N. S., & Niu, M. (2018). Wood properties of Pterocarpus indicus from Papua New Guinea. Journal of Forestry Research, 29(4), 1129-1135.

b. O'Neill, G., & Marasinghe, G. (2012). Traditional uses of Pterocarpus indicus Willd. (Fabaceae) in Papua New Guinea. Journal of Tropical Forest Science, 24(3), 324-329.

4. Rainforest Trees. (n.d.). Pterocarpus indicus - Rosewood. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

5. de Guzman, E. F., & Eusebio, D. A. (2011). Growth and survival of Pterocarpus indicus Willd. seedlings under different light intensities and soil moisture conditions. Philippine Journal of Science, 140(2), 141-149.

6. Rainforest Trees. (n.d.). Pterocarpus indicus - Rosewood. Retrieved from https://www.rainforesttrees.org.au/trees/pterocarpus-indicus

7. Oster, J. D., & Shackel, K. A. (1985). The effect of humidity on growth and water relations of five tropical tree species. Journal of Applied Ecology, 22(2), 659-669.

8.

a. Papua New Guinea Forest Authority. (2015). Guidelines for the Establishment and Management of Tree Plantations in Papua New Guinea. Retrieved from https://www.fao.org/3/ca0667en/ca0667en.pdf

b. Slik, J.W.F. (2019). Pterocarpus indicus. The IUCN Red List of Threatened Species 2019: e.T32990A2810779. Retrieved from https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T32990A2810779.en

c. Orwa C, Mutua A, Kindt R, Jamnadass R, & Simons A. (2009). Agroforestry Database: a tree reference and selection guide version 4.0. World Agroforestry Centre. Retrieved from https://apps.worldagroforestry.org/treedb2/AFTPDFS/Pterocarpus_indicus.PDF

9.

a. Papua New Guinea Forest Authority. (2015). Guidelines for the Establishment and Management of Tree Plantations in Papua New Guinea. Retrieved from https://www.fao.org/3/ca0667en/ca0667en.pdf

b. Slik, J.W.F. (2019). Pterocarpus indicus. The IUCN Red List of Threatened Species 2019: e.T32990A2810779. Retrieved from https://dx.doi.org/10.2305/IUCN.UK.2019-2.RLTS.T32990A2810779.en

c. Orwa C, Mutua A, Kindt R, Jamnadass R, & Simons A. (2009). Agroforestry Database: a tree reference and selection guide version 4.0. World Agroforestry Centre. Retrieved from https://apps.worldagroforestry.org/treedb2/AFTPDFS/Pterocarpus_indicus.PDF

10

a. Papua New Guinea Forest Authority. (2015). Guidelines for the Establishment and Management of Tree Plantations in Papua New Guinea. Retrieved from https://www.fao.org/3/ca0667en/ca0667en.pdf

iv. *Hopea iriana*, Heavy Hopea

Information On Nursery Work

1. Conn, B., & Damas, K. (Eds.). (n.d.). PNGTreesKey – Hopea iriana Slooten. In Guide to Trees of Papua New Guinea. Copyright held by the authors, National Herbarium of New South Wales, and Papua New Guinea National Herbarium. Retrieved June 2, 2023, from https://www.pngplants.org/PNGtrees/TreeDescriptions/Hopea_iriana_Slooten.html (Original publication date: 1952)

Information On Regeneration Work

1. Plantation characteristics of tropical tree species Volume 1, 2 and 3, Tokunori Mori et all, 1997, JIFPRO

2. Forestry research institutions or organizations such as the Forest Research Institute Malaysia (FRIM), the Indonesian Institute of Sciences (LIPI), or the International Union of Forest Research Organizations (IUFRO).

3. Forestry and timber-related journals such as "The Journal of Tropical Forest Science," "Journal of Wood Science," or "International Wood Products Journal."

4. Books on tropical hardwoods or timber species, including those focusing on Southeast Asian flora or the Dipterocarpaceae family.

v. *Callophyllum euryphyllum*, Kalophilum

Information On Nursery Work

1. Papua New Guinea Forest Industries Association. (2023). Nursery techniques and seed handling of PNG's tree species: Calophyllum euryphyllum Laut (Publication No. NP00025). Retrieved June 29, 2023, from https://www.fiapng.com/Nursery_techniques.pdf (p. 25 - 26)

2. Elevitch, C. R., & Wilkinson, K. M. (n.d.). Clusiaceae (Calophyllum). In RNGR. Reforestation, Nurseries, & Genetic Resources. USDA Forest Service and Southern Regional Extension Forestry. Retrieved July 7, 2023, from https://rngr.net/npn/propagation/protocols/clusiaceae-calophyllum-2410

3.

(a) Zulkifli, Y., Ahmad, I., & Zakaria, Z. (2014). Guidelines for the propagation of Calophyllum species. Kuala Lumpur: Forest Research Institute Malaysia

(b) Friday, J. B., & Okano, D. (2006, April). Species Profiles for Pacific Island Agroforestry: Calophyllum inophyllum (kamani). Clusiaceae (syn. Guttiferae) (mangosteen family). Version 2.1. Retrieved from https://www.doc-developpement-durable.org/file/Fabrications-Objets-OutilsProduits/Huilesessentielles/FICHES_PLANTES&HUILES/calophyllum%20inophyllum/Calophyllum-kamani.pdf

4. Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., & Simons, A. (2009). Agroforestree database: a tree reference and selection guide. World Agroforestry Centre.

Information On Regeneration Work

1. Papua New Guinea Forest Industries Association. (2023). Nursery techniques and seed handling of PNG's tree species: Calophyllum euryphyllum Laut (Publication No. NP00025). Retrieved June 29, 2023, from https://www.fiapng.com/Nursery_techniques.pdf (p. 25 - 26).

2. Friday, J. B., & Okano, D. (2006, April). Species Profiles for Pacific Island Agroforestry: Calophyllum inophyllum (kamani). Clusiaceae (syn. Guttiferae) (mangosteen family). Version 2.1. Retrieved from https://www.doc-developpement-durable.org/file/Fabrications-Objets-Outils-Produits/Huiles-essentielles/FICHES_PLANTES&HUILES/calophyllum%20inophyllum/Calophyllum-kamani.pdf

3. Gunn, B. (2013, November). Facilitating the availability and use of improved germplasm for forestry and agroforestry in Papua New Guinea (Final report). Retrieved from https://www.aciar.gov.au/sites/default/files/2022-06/Final-Report-for-FST-2004-009.pdf

vi. *Eucalyptus deglupta*, Kamarere

Information On Nursery Work

1.

(a) World Agroforestry Centre. (n.d.). Eucalyptus deglupta. Retrieved from https://www.worldagroforestry.org/treedb/AFTPDFS/Eucalyptus_deglupta.PDF

(b) Morton, J. F. (1980). The Rainbow Eucalyptus. Economic Botany, 34(2), 154-156. doi:10.1007/bf02858601

(c) Pacific Island Ecosystems at Risk (PIER). (2005). Eucalyptus deglupta. Retrieved from https://www.hear.org/pier/species/Eucalyptus_deglupta.htm

(d) Zarnoch, S. J., & Hodges, A. W. (2011). Economic analysis of Eucalyptus deglupta (Rainbow Eucalyptus) plantations as an investment in the southern United States. Forest Policy and Economics, 13(5), 365-373. doi: 10.1016/j.forpol.2011.03.002

2. Plantation characteristics of tropical tree species Volume 1, 2 and 3, Tokunori Mori et all, 1997, JIFPRO

3. Gardenia. (n.d.). Creating Gardens: Eucalyptus deglupta (Rainbow Eucalyptus). Retrieved June 29, 2023, from https://www.gardenia.net/plant/eucalyptus-deglupta

Information On Regeneration Work

1.

(a) Little, E.L., Jr. and Roger G. Skolmen. 1989. Common Forest Trees of Hawaii (Native and Introduced). United States Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

(b) Myers, R. L. 1975. Eucalyptus deglupta Blume (Myrtaceae) in Florida. The Florida Entomologist, 58(2), 135-139.

(c) Pacific Island Ecosystems at Risk (PIER). Eucalyptus deglupta. Available online: https://www.hear.org/pier/species/eucalyptus_deglupta.htm (accessed on 16 May 2023).

2.

(a) Thaman, R. and Hassall, D. 2000. The introduction and cultivation of Eucalyptus deglupta Blume in the Pacific Region. The Journal of the International Association of Wood Anatomists, 21(2), 191-210.

(b) Hardiyanto, E. B., Rukmiyati, T., and Santosa, E. 2019. Physical and mechanical properties of Eucalyptus deglupta wood from community forests in Indonesia. Journal of Wood Science, 65(1), 55-62.

(c) Food and Agriculture Organization of the United Nations. 2014. Species profile: Eucalyptus deglupta. Available online: http://www.fao.org/forestry/34978/en/ (accessed on 16 May 2023)

3. Davidson, J. (1974). Reproduction of Eucalyptus deglupta by cuttings. New Zealand Journal of Forestry Science, 4(2), 191-203. https://www.scionresearch.com/__data/assets/pdf_file/0008/58751/NZJFS421974DAVIDSON191_203.pdf

vii. *Homalium foetidum*, Malas

Information On Nursery Work

1. Conn, B. J., & Damas, K. Q. (2019). Trees of Papua New Guinea, Volume 1: Introduction and Gnetales to Fables (Revised ed., pp. 317-318)

Information On Regeneration Work

1. Conn, B. J., & Damas, K. Q. (2019). Trees of Papua New Guinea, Volume 1: Introduction and Gnetales to Fables (Revised ed., pp. 317-318)

viii. Dracontomelon dao, PNG Walnut

Information On Nursery Work

1. Merr., C.F., & Rolfe, R.A. (1908). Dracontomelon dao. Philippine Journal of Science, 3, 108. Retrieved from https://www.pngplants.org/PNGtrees/TreeDescriptions/Dracontomelon_dao_Merr_&_Rolfe.html#:~:text=Fruits%3A%20Infrutescence%20arranged%20on%20branched,20%20mm%20diam.

2. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Dracontomelon, dao. Page 38.

3. Orwa, C., A. Mutua, R. Kindt, R. Jamnadass, and S. Anthony (2009). Agroforestry Database 4.0. Dracontomelon dao (Blanco) Merr. & Rolfe. Anacardiaceae. Page 4 of 5. Retrieved from https://apps.worldagroforestry.org/treedb/AFTPDFS/Dracontomelon_dao.PDF

4. "Papua New Guinea Forest Industries Association. (2023). Nursery techniques and seed handling of PNG Tree Species. Dracontomelon dao, p. 31. Retrieved from https://www.fiapng.com/Nursery_techniques.pdf(Accessed on 28th June 2023)."

5. Plant Resources of South-East Asia. (n.d.). Dracontomelon (PROSEA). Retrieved June 28, 2023, from https://uses.plantnet-project.org/en/Dracontomelon_(PROSEA)#:~:text=Dao%20occurs%20particularly%20in%20areas,flats%20and%20in%20swampy%20areas

Blume, Dracontomelon. (1850). Mus. Bot. Ludg.-Bat., 1, 231.

Information On Regeneration Work

1. Orwa, C., A. Mutua, R. Kindt, R. Jamnadass, & S. Anthony. 2009. Agroforestry Database 4.0. World Agroforestry Centre. Accessed on 20th June 2023. Available at: https://apps.worldagroforestry.org/treedb/AFTPDFS/Dracontomelon_dao.PDF

2. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Dracontomelon, dao. Page 38.

3. "Dracontomelon dao (Blanco) Merr." on PROSEA (Plant Resources of South-East Asia): A reference work that provides information about the useful plants of Southeast Asia. Available at: https://uses.plantnet-project.org/en/Dracontomelon_dao_(PROSEA)

4. Merr. & Rolfe. Dracontomelon dao (Blanco). Anacardiaceae. Agroforestry Database 4.0 (Orwa et al. 2009). Last update on 2022-07-20. Available at: https://tropical.theferns.info/viewtropical.php?id=Dracontomelon+dao. Accessed on 2023-06-27. Useful Tropical Plants Database 2014 by Ken Fern.

5. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Dracontomelon, dao. Page 75.

6. Plant Resources of South-East Asia. (n.d.). Dracontomelon (PROSEA). Retrieved June 28, 2023, from https://uses.plantnet-project.org/en/Dracontomelon_(PROSEA)#:~:text=Dao%20occurs%20particularly%20in%20areas,flats%20and%20in%20swampy%20areas

Blume, Dracontomelon. (1850). Mus. Bot. Ludg.-Bat., 1, 231.

ix. *Pometia pinnata*, Taun

Information On Nursery Work

1. Thomson, L. A. J., & Thaman, R. R. (2006, April). Species Profiles for Pacific Island Agroforestry: Pometia pinnata (tava) (ver. 2.1). Sapindaceae (soapberry family). Retrieved from https://raskisimani.files.wordpress.com/2013/01/pometia-pinnata-tava-soapberry-family.pdf

2. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Sapindaceae, Taun. Pages 52-53.

3. Pong, P., Lek, S., Chen, J., & Huang, Z. (2006). Germination of tropical tree species Pometia pinnata (Roxb.) J. R. & G. Forst. Seed Science and Technology, 34(1), 57-63.

Information On Regeneration Work

1. Gunn, B., Agiwa, A., Bosimbi, D., Brammall, B., Jarua, L., Uwamariya, A. (2004). Seed Handling and Propagation of Papua New Guinea's Tree Species. Sapindaceae, Taun. Pages 52.

2. Thomson, L. A. J., & Thaman, R. R. (2006, April). Species Profiles for Pacific Island Agroforestry: Pometia pinnata (tava) (ver. 2.1). Sapindaceae (soapberry family). Retrieved from https://raskisimani.files.wordpress.com/2013/01/pometia-pinnata-tava-soapberry-family.pdf