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The development prospect of coppiced Dalbergia plantation in Indonesia

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Abstract

Dalbergia latifolia Roxb. is a premium wood traded in the international market as Rosewood, and currently included in the CITES Appendix II. In Indonesia, *D. latifolia* is suitable and popular to be intercropped within agroforestry system. However, the species is generally considered as too slow-growing to be preferred to timber plantation trees. Thus, promoting private, community and government plantations is necessary to support future timber stock and gene conservation. This study was aimed to examine the possibility of establishing coppiced *D. latifolia* plantation. This study involved observation and measurement in the field and nursery. Field observation and measurement were carried out both in a private and national forested land in West, Central and East Java of Indonesia, while propagation trials were conducted at a nursery in Bogor–West Java. Field observation indicated that certain population from West Java showed faster growth that in the 3-4-year- the trees reached 15-27 cm in DBH. Vegetative propagation trials showed that root cutting is more prospective that that of shoot cutting (sprouting ability >90%). Experiment on root growth from planting stocks originated from root cutting produced massive lateral roots (total root length 4 m - 8 m within six month). Small roots with 4 m – 5 m in length can be source for producing new individuals. Field observation also revealed that the stumps produced 3 - >20 sprouts that can further utilize as shoot cutting sources and among them (1-3 sprouts) would develop into new individual and take the role as new main stem replacing the previous harvested one. Thus, it is prospective to develop a coppiced plantation of *D. latifolia* which will be beneficial in term of ecology and economy. The slow-growing tree term previously accepted in general term may not be applied as at suitable habitat they may grow aggressively and categorize as fast growing with the diameter increment can achieve 4–7 cm/year.

Keywords: rosewood, plantation, propagation, regeneration potential, sprouts

Introduction, scope and main objectives

Dalbergia latifolia or commonly referred to as rosewood is included in the type of luxury/fancy wood. The fibre is decorative and the wood colour is exotic. Therefore, rosewood is among one of popular timber in the global trade. The woods are used for musical instrument, furniture, carvings, flooring, wallboards, sports equipment and handicrafts. Rosewood is important both ecologically and economically for the community (Safitri and Ashila 2019). Ecological function including their root characteristic that spreads massively thus enabling function for preventing erosion as well as to store water reserves. While the economic function is resulted

from their utilization as a raw material for various expensive and exclusive processed wood products. One meter cubic of rosewood in the domestic market (at a first chain from farmer) may reach IDR 40,000,000 (equal to $2.800/m3).

China is the main market and the biggest consumer of rosewood today. As a result, the volume for exporting rosewood to China is very high. Winfield et al. (2016) found that in 2014, Indonesia was ranked 18th as a supplier of logs and ranked 2nd as a supplier of rosewood sawn timber to China. The high demand for rosewood from China has led to an increase and illegal exploitation of timber in many producing countries, both in Southeast Asia and Africa (Lawson 2015, Treanor 2015). Efforts to reduce overexploitation and maintain the rosewood population was carried out by listed the species within the criteria as vulnerable (Vu) (Lakhey et al. 2020). Recently in the global trade, rosewood is listed in the CITES Appendix II, any trade of the product should be based on the Non detrimental finding to ensure their sustainability in the future (Stiles 2004).

Rosewood distribution stretched from India, Nepal, Bangladesh, Myanmar, and Indonesia (Plants of the World Online 2020). The distribution of rosewood in Indonesia is on the islands of Java, Lampung, Bali, and West Nusa Tenggara. Rosewood grows in state forest and also privately-owned land in form of mixed plantation or garden. It also reported as the species planted in reforestation program in community forests by the Forestry Service in 1978. There has not been any record of pure rosewood plantation forests as they propagate using roots and rather difficult to manage at operational scale (Halriah et al. 2003, Santoso et al. 2021). At Giriharjo village in Yogyakarta, there is community seed orchard that aimed to provide planting stocks to support rosewood processing industry sector (Safitri and Ashila. 2019). In addition to their potential for wood production within the scheme of agroforestry systems, rosewood flowers can also be used as feed for honey bees (Firdaus et al. 2013) and Perhutani, a state- owned company, produce and sell the product under the name of *madu sonokeling* (rosewood honey). However, the species is known for its slow growth so that economically less attractive for the community who depend on short cash flow.

Coppice determines various terms including periodically cut trees in a woodland; the multi-stemmed trees; production of new sprouts from by recently cut stools; and the practises of harvesting the trees itself. Coppice has been practising rely on a very basic and simple method to the fact that many trees have their ability to regrow from the stump after felling. Among those of coppicing ability of the tree species, rosewood has been showing the potential prospect to be established using the coppice technique both at community forest and commercial plantation. This study was conducted to examine the current propagation technique and prospective technique in establishing commercial rosewood plantation in Java, Indonesia.

Methodology

1- Propagation technique

a. Generative propagation by seed

From all observed and surveyed site of Rosewood population in Java and West Nusa Tenggara of Indonesia, we only found two fertile population from West Java region, those were Sumedang and Majalengka. However, fruiting season has already over in Majalengka population and only seed from Sumedang population could be sown in the nursery with also limited number. Most of the pods were in the early stage, thus only mature-brown coloured pods were picked and thus we got only 10 healthy seeds to sow. Seeds have no dormancy and so pre-treatment is not necessary especially for those of fresh collected seeds. Seeds were peeled from its pods and sown in well-raised seedbeds of porous roasted rice husk-soil medium.

b. Generative propagation by wildings collection

At the time of observation, seedlings only found at Majalengka population. Seedling with height of 15-20 cm were collected and packed to be brought to the nursery using technique developed by Rachmat et al. (2020) The acclimatization was needed to allow seedlings adjusted to the new environment. Acclimatization follows the basic principle of that Rachmat et al. (2020) with slight modification. Sprouting occurrence and survival were observed from first period of acclimatization until the fourth months. In general, seedlings were fully adaptive to their new environments after the fourth months. Sprouting ability and survival rate were observed from 1-6 months of acclimatization.

c. Vegetative propagation by shoot/stem cutting

Cutting materials were taken from different origin: 1) two localities from West Java population, covering Cikepuh and Sumedang; 2) Kebumen in Central Java; 3) Pacitan in East Java; and 4) Shoot materials collected from seedling and saplings available in the nursery. Shoot cutting materials were collected using method described by Rachmat et. al. (2020). Propagation by shoot cutting was conducted using method developed by Rachmat et al. (2018). Sprouting and survival were recorded once a month until 3 months after shoot planted. Shoot origin was analysed to determine the sprouting and rooting ability.

d. Vegetative propagation by root cutting

Root cutting materials were obtained under rosewood stand from different origin, covering Yogyakarta, West, Central and East Java with 30-45 cm in length. When arrived at the nursery, root materials were then seized to the average length of 15-20 cm. Sprouting ability correlated with root formation and recorded periodically once a month for three months. Observations were made once a month for sprouting ability during three months.

2- Regeneration capacity

a. Root growth rate

Observation was conducted to nine planting stock originated from previous one-year old rooted root cuttings. Root growth on these nine planting stocks were measured on primary and secondary root and presented as total root length (cm).

b. Small diameter roots as a source for planting stock production

The other experiment was conducted to see the regeneration capacity of the species by allowing very small diameter roots (diameter < 3 mm; length 4 -5 m) cultivated in a propagation box with top soil-roasted rice husk growing medium. The box was kept in nursery and the sprouting of new individuals were observed at 4, 6 and 8 months after cultivated.

c. Coppice shoot and the potential for establishing rosewood plantation

The study was conducted by observing the coppice potential of the species. Felled or burnt trees in the field were observed for their ability in producing sprouts. Diameter of felled tree and number of sprouts were recorded. Interview was conducted to farmers and Perhutani, a state-owned company, in order to get information on the age of *D. latifolia* tree growing in their area and or agroforestry land.

Results

1- Propagation technique

a. Generative propagation

Generative propagation studies were only carried out on seeds from Sumedang and natural seedlings/wildings from Majalengka. Germination of fresh seed takes 10 - 30 days with the germination rate was 70%. Meanwhile, wildings from Majalengka had a survival percentage of 100% and all acclimatized wildings have the ability to regenerate new shoots. The acclimatized wildings started to produce new shoots in the 2nd week.

Table 1: Germination capacity and natural seedlings/wildings potential originated from West Java population

Origin	numbers	Germinated seeds and number of new shoots at month					
		1	2	3	4	5	6
Sumedang*)	10	4	7 (70)	7 (70)	7 (70)	7 (70)	7 (70)
Majalengka**)	45	-	45 (100)	45 (100)	45 (100)	45 (100)	45 (100)

Note: *): generative propagation by seeds, **): generative propagation by wildings, number in bracket showed percentage

b. Vegetative propagation technique by shoot cutting

The germination ability of rosewood shoot cuttings on average is very low (<5%) except for the treatment of cuttings taken from juvenile plants grown in nursery (>70%) (Table 2).

Table 2: Propagation technique by shoot cutting of *D.latifolia* originated from several localities in Java

Localities	No. of shoots cutting	Number and percentage (%) of shoots at month-					Transporting period (days) *)
		1	2	3	4	5	
Kebumen	40	8 (20)	7 (17.5)	8 (20)	2 (5)	2 (5)	6
Pacitan	70	12 (17.1)	8 (11.4)	3 (4.3)	3 (4.3)	3 (4.3)	6
Sukabumi	200	45 (22.25)	49 (24.5)	19 (9.5)	7 (3.5)	5 (2.5)	4
Sumedang	5	5 (100)	2 (40)	2 (40)	0 (0)	0 (0)	4
Juvenile plants at nursery	67	55 (82.1)	62 (92.5)	55 (82.1)	51 (76.1)	48 (71.6)	0 (freshly cut and directly planted at nursery)
Total	**382**	**125**	**128**	**87**	**63**	**58**	

*) Transporting period from materials source to the nursery

c. Vegetative propagation technique by root cutting

The percentage of budding on root cutting from various origin as seen in table 3 is higher (ranging from 60% - 90%) than that of shoot cuttings. The sterile population in Central and East Java showed a high percentage of sprouting (>80%), while the fertile population in West Java had the lowest percentage of sprouting (60.2%).

Table 3: Root cutting potential from various origins

Origin	No. of root cuttings	Number and percentage of sprouted root cuttings at month-		
		1	2	3
DIY Yogya (Yogyakarta)	18	8 (44.4)	8 (44.4)	12 (66.7)
Central Java (Kebumen)	50	24 (48.0)	28 (56.0)	40 (80.0)
East Java (Pacitan)	195	78 (40.0)	158 (81.0)	176 (90.2)

West Java (Sukabumi, Majalengka, Sumedang)	221	77 (34.8)	124 (56.1)	133 (60.2)
Total	**484**	**187**	**318**	**361**

Table 4 shows that root cuttings planted at open growing bed had a higher percentage value of the number of shoots compared to cuttings in the propagation box.

Table 4: Root cutting potential by rooting container type

Treatment	No. of root cuttings	Number and percentage of sprouted root cuttings at month -		
		1	2	3
Open area growing bed	244	97 (39.8)	165 (67.6)	184 (75.4)
Propagation box at nursery	240	90 (37.5)	153 (63.4)	177 (73.8)
Total	**484**	**187**	**318**	**361**

The size of both the length and diameter of the root cuttings is an important factor in the success sprouted and rooted cutting. Cuttings with medium and large sizes had a high number and percentage of shoots from the 1st month of observation to the end of the 3rd month of observation (Table 5).

Table 5: Root cutting potential by size

Root materials size	Number of root cuttings	Number and percentage of sprouted root cuttings at month-		
		1	2	3
Small	192	37 (19.3)	73 (38.0)	99 (51.6)
Medium	168	81 (48.2)	137 (81.5)	150 (89.3)
Big	124	69 (55.6)	108 (87.1)	112 (90.3)
Total	**484**	**187**	**318**	**361**

2- Growth and regeneration capacity

a. Root growth rate

The spreading and regeneration capacity may be reflected by the growth pattern of D. latifolia root, considering that the species natural regeneration mostly occurred by root suckers. Figure 1 shows the root growth from nine planting stocks originated from root cutting.

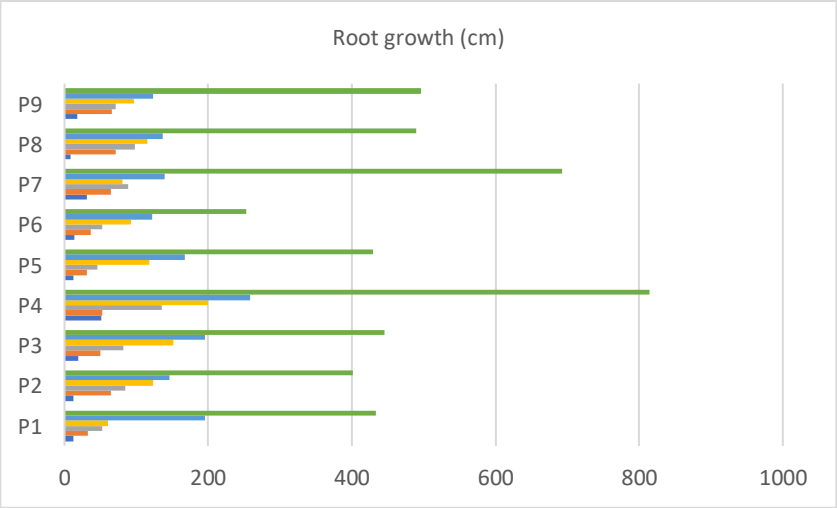

Fig. 1: The root growth of 1-year-old planting stocks originated from root cutting. P1-P9 indicating planting stock individuals. Root growth (cm) was measured each month for 6 months. Dark blue, red, grey, orange, light blue and green bar shows the root length at 1, 2, 3, 4, 5-and 6-months observation.

b. Small diameter roots as potential source for planting stocks production

Small roots <3mm with a length of 15-20 cm in previous preliminary studies (data not shown) were reported not having the ability as a source of propagation. However, in this study, small root (<3mm) with a length of 4-5 meters were cultivated in two propagation boxes. Even though the roots are small but sufficient length made them to be able to produce new individuals as shown in Table 6 and Figure 2.

Table 6: new individuals sprouting from small-diameter root cultivated in propagation box

Propagation box	Number of new individuals at month-		
	4	6	8
1	2	12	17
2	3	10	19

Fig. 2: Small roots cultivated as a source for producing new individuals (a, b) and developed into 6-months seedling (c) and 8-months seedlings (d).

c. Coppice shoot and the potential for establishing rosewood plantation

Several trees have the ability to resprout or produce coppice shoots as their adaptation mechanism for external factors (e.g. pathogens, fire, storm damage, etc) and in order to promote their survival in the nature. Our study result on this coppicing ability of the species as shown in Table 6 and Figure 3 below.

Table 7: The regeneration capacity by coppice shoots of *D. latifolia*

No.	Stump/stem diameter (cm)	Observed number of new individuals
1.	2 - < 10	7 - 20
2.	> 10 - < 15	7 - > 20
3.	> 15 – 20	5 - > 10
4	>20	3 - 8

Fig. 3: New individuals growing from adventious buds formed in cambium of D. latifolia tree with diameter of 2 cm - 10 cm (a), >10 cm - <15 cm (b), > 15 cm – 20 cm (c) and > 20 cm (d)

Discussion

1- Prospective propagation technique for rosewood

The generative propagation of rosewood either through seeds or by acclimatizing natural saplings are both potential to be developed because they have a fairly high growth percentage. However, fertile populations where the techniques can be applied are rarely found. Thus, for sterile population/stand commonly found in Central and East Java, vegetative propagation techniques will be more suitable to be applied.

The lag time of transportation from the source of the shoot cutting material to the nursery affects the physiological processes of the cutting material which causes the cutting material to lose its ability to grow shoots or take root. This can be caused by a decrease in water or mineral content during the trip (Melati et al. 2006). Propagation of rosewood shoot cuttings is therefore prospective only if the source of cutting material is close to the cutting site. Therefore, large-scale production using shoot cuttings can only be done with the construction of a hedge orchard as cutting sources.

Propagation by root cuttings for rosewood species is easier to apply on a field scale and produced higher shooting and rooting percentage than that of shoot cutting. Under the same conditions of lagging time during transporting cutting materials from field to the nursery, the shooting ability of root cutting remains high. When root cuttings were grouped into two treatments (planted in open growing bed/outdoor and in propagation box/indoor), those planted in open growing bed had slightly higher rooting percentage (75.4%) than those planted in propagation box (73.8%). Open growing bed get direct sunlight for the continuity of the carbohydrate synthesis process and hormone activity so as to stimulate the growth of shoots and leaves (Wawo 2010). However, growing beds that are located outside do not directly receive excessive sunlight because they got shade from trees growing around the beds and those make the microenvironment beneficial to support the sprouting and rooting ability.

The size of both the length and diameter of the root cuttings is an important factor in the success sprouted and rooted cutting. The importance of the length of the root cuttings is related to the food reserves in the root

cuttings which are needed as a source of energy for the development of rosewood roots and stems. Root cuttings with medium and large sizes had higher shooting percentage. Cuttings with large food/carbohydrate reserves will show earlier shoot formation due to the fact that the amount of food reserves were more than those of small cuttings. The carbohydrate content contained in the cutting material is the main factor for the development of shoot and root primordia (Hamidin 1983, Wahid 1990). Shoot growth is also highly dependent on the rate of formation of shoot primordia. Faster formation of shoot primordia will yield faster shoot growth because the growth of rosewood cuttings shoots clusters on the shoot primordia. With sufficient food reserves, cuttings will also be able to form more shoots (Hamidin, 1983).

2- Growth and regeneration capacity

The rate of root growth in one-year planting stock originating from root cutting is surprisingly very fast although they placed in a limited area inside a propagation box. Total root length in each individual was ranged between 4 m – 8 m within 6-month observation period with the fastest increase occurring in the 6th month observation. Massive growth rate at nursery scale indicating that the growth in open areas (in nature) will be more aggressive given the availability of more growing space and nutrients. With this phenomenon, no wonder that for some communities, the species was determined as to be invasive and suppress other surrounding trees.

Coppice has remained an important system of management in tropical areas. Even though coppices are usually practiced for fulfilling the demand of fuel, small-diameter wood and building purposes (Harmer, 2004), its potential is worth to consider in establishing rosewood plantation. Sprouts that grow from the stump of fallen/logged tree can develop into new individuals and replace the role as the timber stock for the future. Among those of more than 20 coppices growing from the stum, 1-3 coppices can be managed to replace the previously logged/fallen stem. The quality of stored coppices can be improved by thinning and only leaving those are judged to be the straightest and most vigorous, and it also can be designed as ‘singled coppice’ which means that we only leaving the best stem.

Interviews with Perhutani determined that rosewood generally grows mixed with the main tree species of teak or other trees such as of Swietenia macrophylla, Gmelina arborea, Pine, etc. However, when main trees have their planting time record, there is no record of planted year for rosewood. Regeneration occurs naturally and generally through root suckers or wildings that germinate from seeds (especially for West Java). Rosewood growing in this state-forest showed variative diameter range from those of seedlings to big trees of more than 100 cm in diameter. Interviews were also conducted with farmers who own agroforestry lands. There is a similar trend for the unclear planting time of the rosewood growing in their land due to the fact that they inherited the land from their parents or grandparents. However, one of the information obtained from interviews in Cikepuh (West Java) determined that there was a land owner who can usually sell rosewood from his garden periodically. At 3–4-year intervals, landowners can cut rosewood with a diameter of 20 cm – 25 cm, or in an average the annual increment recorded at 4 cm – 7 cm. Thus, indicating that in certain place, the species can have faster growth even though it may show different wood quality.

Conclusions/ wider implications of findings

Rosewood can be propagated both generatively and vegetatively depend on the availability of regeneration materials. Vegetative propagation by root cutting is easier to adopt at field scale with high percentage of rooted seedlings. The species was also characterized by aggressive root growth thus making the species has high ability to grow, propagate and occupy surrounding space easily and potentially invasive at certain places and condition. It also has high coppice shoot formation that often grow into big stem replacing the previous felled/cut/logged stem, enabling the establishment of rosewood plantation by applying coppice system.

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