REVIEW AND CURRENT STATUS OF RAMIN PLANTATION ACTIVITIES

TECHNICAL REPORT NO. 03

ITTO PPD 87/03 REV. 2 (F)

IDENTIFICATION OF *GONYSTYLUS* SPP. (RAMIN) POTENCY, DISTRIBUTION, CONSERVATION AND PLANTATION BARRIER

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IDENTIFICATION OF GONYSTYLUS SPP (RAMIN) POTENCY, DISTRIBUTION, CONSERVATION AND PLANTATION BARRIER

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PREFACE

Recent data and information on ramin plantation efforts and activities are a very important to develop ramin plantation in large scale. To collect these data and information, direct investigations including interviews to experts were conducted in four provinces, i.e Riau, Jambi, West Kalimantan and Central Kalimantan. Additional data and information were also collected through literature search.

From this activity several findings are summarized below:

(1) Propagation technique of ramin has been developed by several research labs, but need further development.
(2) Field trials on ramin plantation have been conducted since several years. However, results are still insufficient.
(3) Forest concessionaires, research institute and universities have conducted the plantation trials both in Sumatra and Kalimantan.
(4) Effort to plant ramin has been consistently carried out by PT. Diamond Raya Timber, PT. Inhutani, and Regional Research Centers in Palembang (Sumatra) and Banjarbaru (Kalimantan).
(5) Types of planting trials conducted earlier were mixed planting with other species, enrichment planting and trial in non-peat sites.

It is expected the above findings are useful in preparing further steps toward rehabilitation and restoration ramin population and habitats.

The project thanks to Dr. Istomo, Senior scienties of Bogor Agriculture Institute (IPB), Dr. Machfudh, Dr. Harun Al Rasyid, Dr. Herman Daryono, and Dr. Chairil Anwar Siregar, senior researchers of the Center for Forest and Nature Conservation Research and Development who have given comments and suggestions to improve the content of the Technical Report and also to Mrs. Hiyama Chiharu (JICA) who has proof read this technical report. Contributions from other whose name are not mentioned are also greatly appreciated.

Ir. Tajudin Edy Komar, M.Sc
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ABSTRACT

Ramin is a trade name of timber from a group of species, which belong to *Gonystylus* genus. Although it has 30 species, there are only 7 species, which are known as large trees. One of those species is Ramin (*Gonystylus bancanus* (Miq) Kurz.). Ramin is well-known and very popular in terms of both its timber quality and (its) value.

Besides, a ramin tree is ecologically and morphologically easy to be recognized in forest. A freshwater swamp or peat-swamp forest habitat appears to be almost unique in the genus.

The ramin population decreased sharply and the species tend to be nearly extinct because of an over exploitation of ramin trees whichhas been occurred since last two decades.

Ramin plantation efforts to achieve sustainable management of peat-swamp forests should be done. Therefore, data collection on ramin plantation efforts and activities is very crucial as a point to start in establishing and developing of ramin plantations in large scale.

The objective of the ITTO Pre-Project PPD 87/03 Rev.2 (F) (Identification of ramin plantation activities and plantation barriers) is to provide sufficient data on ramin plantation activities and plantation barriers that was carried out from February to April 2005 by means of literature review and field survey. A direct investigations including interviews to experts were conducted in four provinces, where peat-swamp forests and ramin species occurred, i.e. Riau, Jambi, West Kalimantan and Central Kalimantan. From literature review, it is found that ramin flowering and seed production do not occur every year, and the seed is categorized as recalcitrant. To overcome this problem, therefore, ramin propagation is conducted by shoot tip cutting from wild seedlings and hedge-orchard. Propagation with tissue culture has been conducted, but it has not been successful yet.

Ramin is a very slow growth tree species that grows better on a deep peat soil and under moderate shading (during early growth). Planting activities of ramin species had been conducting by various stakeholders, either as enrichment planting or as rehabilitation effort of degraded peat soil. Ramin planting activities conducted by active HPH concessionaires to fulfill the requirement of TPTI guideline were difficult to evaluate in terms of its succes due to limited access to the areas.

Field survey to obtain data and information concerning ramin plantation activities has been carried out at eight sites in four provinces (Riau, Jambi, Central Kalimantan and West Kalimantan). The visited ramin plantation that established by HPH concessionaires, state forest enterprise, universities or research institutes and non-government organization were still within research scale. The age of the visited ramin plantations ranged between 1-7 years. The survival rate and growth increment also varied among them. The highest survival rate (100%) and the highest height increment (43.87 cm/year) occurred in Sei Bakau, West Kalimantan. While, the highest diameter increment (0.73 cm/year) found in PT. DRT, Riau.

To support and guarantee continuous ramin plantation activity, it is suggested to keep and save existing seed stands and to establish seed orchard, either seedling seed orchard or clonally seed orchard.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Ramin is one of the major exported timbers of South-East Asia. Indonesia is the most important exporter, followed by Sarawak and Peninsular Malaysia. In 1983 the total volume of standing timber of ramin in Indonesia was estimated at 220 million m^3; trees over 50 cm diameter comprised 89 million m^3. The average production of ramin in Indonesia in 1991-1992 was 900,000 m^3/year. Major production areas are central and southern Sumatra, Riau, West Kalimantan and, particularly, Central Kalimantan. In the early 1980s ramin was the most important species in Indonesia for sawnwood exports, accounting for 38% in volume and 46% in value of the total export. The average annual export was 598,000 m^3 with a value of US$ 119 million. In 1987 the export of sawn ramin was 299,000 m^3 (with a value of US$ 86 million) and in 1988 was 224,000 m^3 (with a value of US$ 74 million). On June 13, 1991 the export tax on ramin timber in Indonesia was increased from US$ 500/ m^3 to US$ 1200/m^3 (Soerianegara and Lemmens, 1995).

TRAFFIC South Asia (2004) reported that in the period of 1994-2000, the national production of Ramin in Indonesia declined sharply from 666,245 m^3 (in 1994) to 131,137 m^3 (in 2000). During this period, export of this species was recorded to 28 countries at the total of 1,666,626.55 m^3. At the same time, trade was also declined from 456,730 m^3 (1994) to 102,677 m^3 (2000).

Exploitation of peat-swamp forest conducted through selective cutting and planting system (Tebang Pilih Tanam Indonesia or TPTI) with the limit diameter at breast height of trees that could be cut was 40 cm. This limit diameter is smaller than that of dry land tropical rain forest where the limit diameter at breast height of trees that could be cut was 50 cm. However, other aspects of silviculture system, which were applied, were still similar with the dry land forest, whereas characteristics of this peat-swamp forest were obviously different with dry land forest. The most recent silviculture system declared in 1993 technically was only for dry land forest, so management of peat swamp forest was still based on silviculture system of TPTI mentioned in the decree of Directorate General of Forest Utilization number 564/Kpts/IV-BPHH/1989 and number 24/ Kpts/IV-Set/96 concerning the limit of tree cutting in swamp forest.

Due to high quality and (high) demand of the wood, an over exploitation of ramin trees had been occurred during the last two decades. Hence, ramin population decreased sharply and the species tend to be nearly extinct. In order to protect the population of ramin in natural forests, since the year of 2001, there has been a ban on ramin logging and trade (temporary stop of logging and trade of ramin or moratorium of ramin logging and trade) based on decree of Forestry Minister No. 127/Kpts-IV/2001, except for forest concession which had got eco-label certificate and hence can conduct logging by recommendation from Lembaga Ilmu Pengetahuan Indonesia (LIPI/Indonesian Institute of Science). Based on the CITES conference in Bangkok, Thailand 3 to 14 October 2004, the ramin wood has been uplisted into Appendix II of the CITES (Anonimous, 2004). This means that the ramin wood trade has to be controlled internationally and logging of ramin can only be conducted on plantation forest or man made forest.

Destruction of residual stand and regeneration of ramin was mainly caused by an uncontrolled logging, such as (1) diameter limitation was not followed precisely; (2) ramin trees were also used for construction of railway track, skidding road and tree felling. Hence, the ramin was almost extinct at tree and pole stages at the log over areas of the peat-swamp forests. Study by Alrasyid and Soerianegara (1978) as well as Soerianegara *et. al* (1996) showed that the extension of forest openness due to logging of each block (100 ha) was on the average of 21.9 ha or 21.9 %, i.e. 0.6% for railway

tracks, 0.6 % for ports or landing areas, 8.8 % for tree felling sites, and 12 % for skidding roads.

Although existing of ramin trees in natural peat-swamp forests is nearly extinct, there has not been enough initiatives to carry out ramin plantation activities yet. Research on silviculture of ramin was started by Soerianegara and Alrasyid in 1978. However, those kinds of research disappeared for about a decade. The research on ramin silviculure was initiated again around 1994. Actually, high exploitation of ramin trees must be balanced with ramin plantation efforts and activities in order to restore and sustain the ramin population and to achieve sustainable management of the peat-swamp forests. Therefore, data collection on ramin plantation efforts and activities is very crucial as a point to start establishing and developing of ramin plantations in large scales.

The objective of the ITTO Pre-Project PPD 87/03 Rev.2 (F), Identification of ramin plantation activities and plantation barriers, especially activity 1.2.1 is to provide sufficient data on ramin plantation activities.

This report presents data and information on the past and on-going plantation efforts and activities (current status of ramin plantations) including habitat and growth behaviour, starting from seed stand, sources of planting material, nursery, land preparation, planting activities and up to tree growth and maintenance of the ramin plantations.

II. METHODS

Activities of the "Identification of ramin plantation activities and plantation barriers" were carried out from February to April 2005. There were two methods used, i.e. literature review and field survey. Literature review was conducted in National Library, Library of LIPI, Research Institutions, Universities, Province and District Forestry Services, State and Private Companies as well as non-government organizations. The types and number of reviewed literatures were listed in Table 1.

Table 1. List of reviewed literatures

No.	Type of literature	Number of literature
1	Text book	11 books
2	Magazine	2 articles
3	Journal	7 articles
4	Proceeding	10 articles
5	Presented paper	1 title
6	Un-published research report	5 articles
7	PhD thesis	3 books
8	MSc thesis	1 book
9	Undergraduate thesis	3 books
10	Manual	2 books
11	Technical report	8 books
12	Yearly Operational Plan	8 books
13	News paper	1 articles
14	Pre-proposal	1 title

The review was focussed on ramin silviculture, starting from seed stand, sources of planting material, nursery, land preparation, planting activities and up to tree growth and maintenance of ramin plantation as well as ecology and growth behaviour of ramin species.

Field survey was conducted by means of interview and direct investigation. Method used to determine respondent institutions was purposive stratified sampling. There were three strata of respondent's institution, i.e. government (as regulator and/or executor), company and non-government organizations (as executors). The government institutions were province/district forestry services where peat-swamp forests and ramin species existed, and other organizations that were involved in ramin plantation activities. There were 14 institutions of respondents: 10 governments, 3 companies and 1 non-government institution in four provinces, namely Riau, Jambi, West and Central Kalimantan. The total respondents were 18 persons. The direct investigation was also carried out in those four provinces at eight sites of ramin plantations. Some amount of ramin sample plants were observed and measured with sampling intensity that ranged from 3 to 33 % and at one case the measurement was done to the all plants existed (census). Table 2 presents the eight visited sites of ramin plantation including the tree grower institutions and the sampling intensity of each site.

Table 2. Eight visited sites of ramin plantations, the tree grower institutions and sampling intensity of tree growth measurement

No.	Site	Province	Tree Grower Institution	Sampling intensity (%)
1	Rokan Hilir	Riau	PT Diamond Raya Timber	33
2	Muara Jambi	Jambi	PT Putraduta Indah Wood	3
3	Berbak National Park	Jambi	Institute of Berbak National Park	10
4	Sei Bakau	West Kalimantan	Tanjung Pura University	100
5	Mandor	West Kalimantan	PT Inhutani II	10
6	Kalampangan	Central Kalimantan	CIMTROP	5
7	Teluk Umpan	Central Kalimantan	BP2HT-IBB	20
8	Tumbang Nusa	Central Kalimantan	BP2HT-IBB	22

Data on survival rate and growth of ramin plants were tabulated for each site. Then, growth increment per year was calculated based on the age of ramin plants at each site.

III. LITERATURE REVIEW ON RAMIN SILVICULTURE

3.1. Botanical Information and Distribution

Ramin (*Gonytylus* spp.) is a genus of Tymelaeaceae family (sub-family Gonystyloidea) and the order of Myrtales (Myrtiflorae) (Keng, 1960). Ramin is a name of trade wood groups for some species of Gonystylus e.g. *Gonystylus affinis* Radlk., *G. bancanus* (Miq.) Kurz, *G. forbesii Gilg, G.macrophyllus* (Miq.) Airy Shaw, *G. maingayi* Hook.f, *G. velutinus* Airy Shaw (Soerianegara and Lemmens, 1995). There are many vercular names of ramin. In Indonesia, ramin is called as gaharu buaya (Sumatra, Kalimantan), medang keladi (Kalimantan). In Malaysia: it is knew as melawis (Peninsular), gaharu buaya (Sarawak) and in Philippines it is called as lanutan bagyo, anauan (general) (Soerianegara and Lemmens, 1995),

The genus of *Gonystylus* consists of 20 species (Anonymous, 1953), nevertheles at present Gonystylus consists of about 30 species but this number will probably increase further because new species are regularly discovered. The species are distributed almost throughout the Malesian area with the exception of Central and East Java and the Lesser Sunda Islands. Eastward the distribution area extends towards the Solomon Islands, Nicobar and Fiji. The vast majority of species is found in Borneo (27), especially in Sarawak. Peninsular Malaysia and Sumatra come second with 7 species each, and the Philippines have 2 species. All other areas are occupied by a single species. The most widespread one is *G. macrophyllus* (Soerianegara and Lemmens, 1995).

Plant species of *Gonystylus* are small to medium-sized trees, up to 42 m tall, occasionally shrubs; bole cylindrical, straight, branchless for up to 21 m and up to 60(-120) cm in diameter (Soerianegara and Lemmens, 1995). Species, which are categorized as large trees (having diameter 40 cm up) in the genus *Gonystylus* are *Gonystylus bancanus, G. velutinus, G. micranthus, G. maingayi, G. confusus, G. forbesii,* and *G. macrophyllus* (Anonymous, 1953). Meanwile the most popular species that has been traded for a long time in Indonesia, particularly in Sumatera and Kalimantan and occurs in peat swamp forests, is *G. bancanus.* Therefore, the next discussion is focused to ramin species (*Gonystylus bancanus* (Miq) Kurz.).

Gonystylus bancanus (Miq.) Kurz is a medium-sized to large trees. The trunks are up to 40 to 45 m tall. The boles are cylindrical and up to 120 cm in diameter but usually less. Sometimes, the boles are slightly fluted at the base. The tree has many knee-roots (pneumatophores). The bark surface often cracked and fissured, grayish to red-brown, inner bark fibrous, orange-brown to red-brown, sapwood pale cream or white; leaves elliptical, shortly oblong-oblanceolate or obovate, often conduplicate, broadly cuneate to rounded at base, suddenly narrowed into an acuminatecuspidate apex, quite glabrous (Soerianegara and Lemmens, 1995). Figure 1 shows performance and characteristics of a ramin tree.

G. bancanus is distributed in south-western Peninsular Malaysia, south-eastern Sumatra, Bangka and Borneo. *G. bancanus* is the most important source of ramin timbers. The wood is suitable for general light construction and numerous uses, where a clean and whitish timber is desired. The heartwood is used for incense (Soerianegara and Lemmens, 1995).

Figure 1. Appearance of stem and characteristics of a ramin tree (*G. bancanus*) (documented by: Istomo, 1994)

3.2. Ecology and Growth Behavior of Ramin

Ramin (*G. bancanus*) occurs gregariously in lowland freshwater swamp or peat-swamp forests outside the influence of tidal waters but often in broad belts along the coast. Mostly, ramin is subject to periodic inundation, but also in non-inundated areas up to 100 m, occasionally found in pure stands (e.g. Sarawak). Ramin is a well-marked species, both morphologically and ecologically. The small rigidly coriaceous leaves, often folded together along the midrib, with much less conspicuous nerves than most species and usually drying purplish-brown below, are very characteristic. The freshwater swamp habitat appears to be almost unique in the genus (Anonymous, 1953; Soerianegara and Lemmens, 1995).

Istomo (1994) reported ramin distribution on the peat-swamp forest. He indicated that ramin was found starting on peat with depth more than 1.2 m with average population 10 trees per ha. The ramin trees become dominant on peat with depth more than 5 m with average population 30 trees per ha. The diameter at breast height of those ramin trees was more than 15 cm. While, he found that ramin with diameter at breast height more than 20 cm was 53 trees per ha. Those ramin trees grow in groups. There was significant correlation between existing of ramin and depth of the peat. A research done in Central Kalimantan showed that the existence of ramin on peat was starting at the depth of 120 cm, deeper of the peat, more of ramin trees occurred. The ramin trees become dominant starting at peat depth of 350 to 600 cm. At peat depth of 120 to 300 cm ramin trees was only found 12% from total species grown in the peat-swamp forest. At peat depth more than 350 cm, the portion of ramin trees become larger, i.e 30% of the total species.

Illustration of vertical structure of a peat-swamp forest ecosystem, based on measurement at a sample plot with size of 0.2 ha at Lenggana, Sampit, Central Kalimantan on the peat dept around 6 m (Istomo, 1994), indicated that ramin canopy only occupied stratum A (dominant trees with total height more than 30 m)

of the forest layers. While, stratum B (co-dominant trees with total height 20 – 30 m), and stratum C (intermediate trees with total height less than 20 m), were occupied by the other peat-swamp forest species. This implicates that the number of small ramin trees was found less than the number of large ramin trees. Illustration of those species' composition at several stages of ramin growth can be explained more in detailed in Table 3.

Table 3 shows that the existing of ramin at tree stage is more than the existing of that at other stages. In the other words, ramin trees were dominant at tree stage in the community of peat-swamp forest. The existing of ramin at pole stage was the lowest one.

Table 3. Species composition at ramin community according to stages of ramin growth per ha at Lenggana, Sampit

Growth stages	Number of species	Dominant species	Rank of ramin	IVI of dominant species
Seedling	24	*Tetramersiata glabra*	5	29.88
Sapling	27	*Baccaurea bracteata*	5	31.99
Pole	28	*Palaquium rostratum*	14	43.07
Tree	40	*Gonystylus bancanus*	1	40.65

Source: Istomo (1994)

Less number of small trees (pole stage), when compared with number of mature trees (tree stage), may be caused by competition of growth space and sunlight. Limited sunlight transmission into the forest floor was caused by dense canopy of the primary forest. The indication of ramin dying at young tree stage due to limited light availability was proved that ramin, at that pole stage, requires much sunlight. Large number of ramin at seedling and sapling stages indicates that they did not need much sunlight during those stages. Appearance of ramin at seedling and sapling stages can be seen in Figure 2. At pole stage, they need more light, but the light transmission was limited. At tree stage (A stratum of the canopy), ramin received enough sunlight and hence the number of existing trees at this stage was much higher than the other stages. The growth behaviour of this species is called as semi-tolerant. This ramin behaviour implies that a silviculture treatment is needed at the pole stage of the growth to help canopy opening of the forest. This was conformed by Soediarto *et al* (1963), who reported that ramin trees needed sunlight, even though they need shading at seedling stage. Alrasyid and Soerianegara (1976) stated that ramin trees needed humid climate or A type of the climate (based on Schmidt and Ferguson classification, 1951) for their growth. This is concluded based on distribution regions of ramin, i.e. Riau, Jambi, South Sumatera, West and Central Kalimantan.

Figure 2. Appearance of ramin plants (*G. bancanus*) at seedling and sapling stages (documented by Istomo, 1994)

According to Istomo (1994), the number of ramin trees in thick peat layer is greater than that in thin peat layer, which is possibly because of higher level of soil fertility (in this case, the kinds of mineral under the peat layer) and root system of the ramin tree itself. Growth of ramin trees in Sampit associated with heath forest (with quarts sand soil). So that, the mineral soil under shallow peat nearby the heath forest that has sand textured soil. On contrary, mineral soil under thick peat that is far from heath forest has clay textured soil. As it has been known that clay textured soil is more fertile than sand textured soil.

Root system of ramin trees and seedling are rather unique (see Figure 3). Ramin trees are not buttressed but they have knee root which are scattered widely and deeply. Therefore trees which grow on thick peat are likely to be able to reach mineral soil under the peat. Measurement of ratio between root and stem length shows that ramin seedling has ratio 2 : 1 (Istomo, 1994).

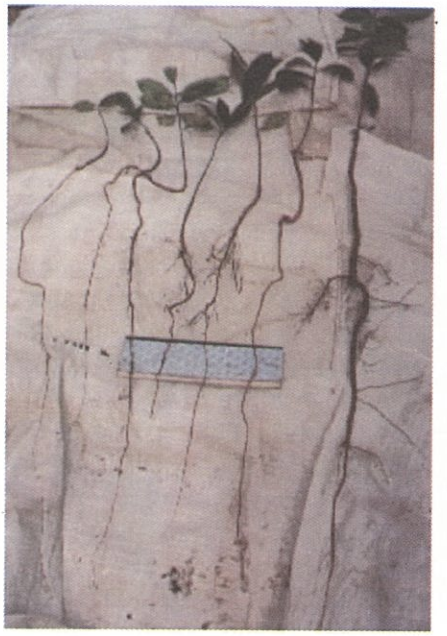

Figure 3. Form and rooting system of seedlings and trees of ramin (*G. bancanus*) (documented by Istomo, 1994)

The growth behaviour of ramin trees, show that they form a small group in one association, and even it was often found in the forest that their roots and stems are interconnected to each other (see Figure 4). Such growth behaviour is related to their growth site, which is inundated by water and low fertility of the soil. Seeds fallen down and seedlings will grow properly if they located among roots of other trees and not continuously inundated by water (Istomo, 1994).

Figure 4. Tree growth pattern in peat swamp forest, roots and stem are interconnected to each other on one association.

3.3. Seeds and Sources of Planting Material

It was reported that ramin trees do not produce fruit every year (Supriyanto and Witjaksono, 1994) and the fruiting season is different among various locations (Alrasyid and Soerianegara, 1978). The period of flowering and fruiting of *G. bancanus* trees are relatively short and irregular intervals. In West Kalimantan the flowering time was from August to October and in Central Kalimantan it was from April to May. Soediarto *et al* (1963) reported that ramin flowering in some regions occurred during February to March and in the other regions occurred in September to October. According to Anonymous (1953), the flowering time of ramin is from February to March (buds also noted in May and October). After 2 to 3 months of flowering season, fruiting season of ramin trees comes. In West Kalimantan ramin trees were fruiting during October to December and the fruit will be mature from December to January (Alrasyid and Soerianegara, 1978). According to Soediarto *et al.* (1963), ramin trees were fruiting from May to June.

The ramin fruit is a globose or rarely lanceolate, which contains 1 to 5 seeds. Fruit is large, up to 4 cm long, with a smooth softly coriaceous testa. Seedling with hypogeal germination with a tap-root emerges from one pole of the seed (Soerianegara and Lemmens, 1994). The mature fruits will release the seeds and it can be gathered on the forest floor. In average, there are 250 to 300 seeds per kg (Kartiko, 2001). Ramin seeds have the characteristic of recalcitrant (Supriyanto and Witjaksono, 1994) therefore they must be planted as soon as possible after collecting. The germination vigor will reduce sharply when the seeds are stored for more than two weeks without treatments. Water content of the seeds should be maintained during it's transportation from the forest by putting the seeds in a moist gunnysack under shading. Kartiko (1998) reported that the seeds could be stored mixed with moist sawdust in a covered plastic bag in a room with temperature 18 to 20°C for two weeks to maintain the germination vigour higher than 80%. Actually, the germination vigour of the seeds can be kept higher than 80% for three months period of storage, but a part of the seeds will germinate during those period. Hence, to avoid a bent stem, the storage bag should be substituted with an impermeable box. Form and size of fruits and seeds of ramin is presented on Figure 5.

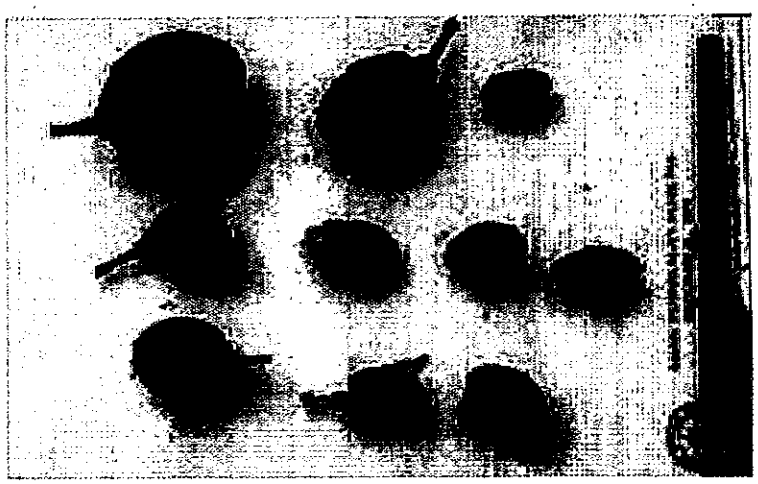

Figure 5. Form and size of fruits and seeds of ramin (*G. bancanus*) (documented by Istomo)

Ramin species is generally propagated generatively. As flowering and fruiting season of ramin trees do not occur every year and ramin mother trees are scarce in the natural forest nowadays, it is difficult to obtain a lot of ramin seeds (Daryono, 1994; Muin and Purwita, 2002). As alternatives of planting stock, shoot cutting and wild seedling were developed. Soerianegara and Lemmens (1994) reported that ramin could be planted by using wild-seedlings, nursery-seedlings and shoot cutting. Furthermore, in experiments with enrichment planting, the nursery-seedlings showed highest survival rate (67%) with height increment (12.4 cm/year) compared to shoot cuttings (44% and 5.5 cm/year, respectively) and wild-seedlings (40% and 12.6 cm/year, respectively)

The wild seedlings are collected in natural forest under ramin trees. They should be collected when they are young, with the height less than 20 cm (Direktorat Hutan Tanaman Industri, 1990; Supriyanto and Witjaksono, 1994). The seedlings are taken by process of turning around seedlings to get seedlings without physical defect (Alrasyid and Soerianegara, 1976). Sources of shoot cutting are wild seedlings with the height less than 1.5 m (Daryono, 1994) and according to Hendromono (1999), seedling height for cutting material is between 30 cm and 60 cm. It is better if source of the shoot cutting is from hedge orchard of ramin. Ramin could also be planted by using stump, but this is not recommended because the survival percentage in the field is low.

Although nursery-seedlings is the best choice to prepare ramin planting stock for ramin plantation activity, the seeds of ramin are not available over the time. Plantation efforts of ramin require qualified and healthy seedlings and it must be available in the right time with adequate number. Therefore, recent research on ramin planting stocks mostly emphasizes on how to produce seedlings in high quality and large quantity through shoot-cutting and tissue culture technologies.

3.4. Nursery

Nursery practice for ramin is divided into three phases, namely: propagation, tending, and culling and dispatch.

1. Propagation

Nursery for ramin should be located near planting area, source of water irrigation, with being easy to get manpower and in the flat topography. Nursery beds are made with size 5 m x 1 m, with the direction north to south. The distance between beds is 80 cm. The border of beds can be made from bulian wood or concrete brick. The nursery beds are rose to about 20 cm. The beds must be free from weeds.

Containers commonly used for ramin seedlings are black polyethylene bags (polybags) with the diameter of 5 cm and height of 40 cm. This size is appropriate for seedling growth and its root ramification (Supriyanto and Witjaksono, 1994). Each polybag has 12 holes at the bottom and sides of the bag (Briscoe, 1990). Medium used for generative propagation is pure peat (Muin, 2003) or peat + mineral soil + rice husk = 3 : 1 : 1 (v/v) (Fithri, 1997). Mixture medium of sawdust + mineral soil = 1 : 1 (v/v), or sawdust + mineral soil = 3 : 1 (v/v) were not significantly affect the growth of ramin seedling for 4.5 months (Soerianegara *et al.*, 1996). Medium for shoot cutting for rooting is pure sand (Daryono, 1996) or peat + rice husk = 7 : 3 (v/v) (Hendromono, 1999).

Generally, two ramin seeds are planted in each polybag with the embryo face downward and the depth of 1.5 cm. If both seeds germinate, one can be transplanted into another container (Briscoe, 1990). The polybags are placed under a tree stand in the nursery, or shaded by a permanent overhead wooded framework structure covered by paranet slats or other materials to allow sunlight intensity about 45 % (9990 lux) (Muin, 2003).

The similar manner is applied to plant wild seedlings and root shoot cuttings. Herman, Istomo and Wibowo (1996) conducted a research on the possibility of *G. bancanus* propagation by seedling shoot cutting and used Rootone-F as a growth regulator hormone on various rooting medium. The experiment was conducted in the nursery owned by HPH PT. SBA Wood Industries in South Sumatera. A completely randomized factorial design with two treatments and five replications was used in this experiment. Concentrations of 0, 50, 100, and 150 mg Rootone-F per cutting were applied. These cuttings were grown in polybags filled with peat, peat + sand (3 : 2 v/v), peat + dolomit (5 kg

dolomit/m³ peat) and peat + dolomit (5 kg dolomit/m³ peat) + sand (3 : 2 v/v). After 12 weeks observation, this study concluded that *G. bancanus* was possible to propagate by means of shoot cuttings because all cuttings produced buds and roots (100 % successful).

Deman (1998) reported that for increasing the height and number of roots, rootone F with the dose 150 mg per wild seedlings can be used, but for survival percentage it was better to use Rootone-F with the dose of 50 mg per wild seedling. The length of shoot cuttings is 5 to 8 cm with minimal two leaves (Hendromono, 1999) or 10 to 12 cm (Daryono, 1996). The bottom of the shoot cuttings is given Rootone-F powder before planted in polybag. The wild seedlings or cuttings are placed in concave cover made from transparent plastics under shaded condition. The temperature in concave cover should be between 25 and 29.5°C, with ambient relative humidity 96 % to 100 % and light intensity between 258 and 6026 lux (Hendromono, 1999). This condition can be reached by spraying concave cover with water when the weather is hot (temperature higher than 30 °C). Under this condition, shoot cuttings root about 90 % without hormone, and the ramification of root increases when the bottom of cuttings is given Rootone-F (Hendromono, 1999). Shoot cutting of ramin in sand medium which were given by Rootone-F hormone produced roots 8 %, by rhizattone produced roots 24 %, and by 3 % IBA hormone produced roots 91 % (Daryono, 1996). The wild seedlings or shoot cuttings are taken care in concave cover for 2 months, and then to be taken care of under shaded area for about 6 - 8 months. Figure 6 presents shoot cutting planting stocks of ramin.

Figure 6. Propagation of ramin (*G. bancanus*) by means of shoot cuttings (documentary of Herman, *et al*. 1996)

2. Tending

When seeds or cuttings start to root, they should be inoculated by endomycorrhyza from the genera of *Glomus* sp. The endomycorrhyza can be taken from peat propagule under ramin trees, pineapple garden or spores of *Glomus* sp. (Muin, 2003). Automatic watering is given every morning, and in hot conditions, it can be given twice a day. In permanent nursery with automatic irrigation, sprouting of water happens every certain period in certain minutes.

Several experiments showed that NPK fertilizer with dose of 1 to 3 g per seedling was not effective to increase growth of ramin seedlings (Xaverius, 1998). Even, Saragih (1998) reported that NPK fertilizer with the dose of 1 to 3 g per seedlings results the height and diameter increment of ramin seedlings were worse than without fertilizer. Effective fertilizer used for generative planting stocks was christmast natural phosphate $Ca_3(PO_4)2.CaF_2$ with the dose of 0.5 g/polybag. Each polybag contains 500 g of peat (Muin, 2003). Regular weeding is carried out manually.

After the planting stocks reach the height of 25 cm up to 30 cm, conditioning is conducted. The process of hardening off planting stocks commences about 2 to 4 weeks before outplanting. Conditioning is done by reduction of watering and shading. Ideal seedlings, which are suitable for planting should be sturdy with well-developed leaves, straight trunk, and compacts, fibrous root systems.

3. Culling and dispatch

Generative and vegetative planting stocks are generally ready to be planted out after 10 to 12 months in the nursery. Seedlings with poor stem form or other defects are culled during the transfer of seedlings from growing area. The containers of the seedlings are put into boxes and arranged in the truck. After seedlings have been loaded onto a truck, they are thoroughly watered. Cover is used to protect seedlings from wind and sunshine during transportation.

3.5. Plantation Activities

Research on ramin planting has been started since 1978. Most of them were done on the ramin habitat, i.e. peat-swamp forest areas. The research results in terms of the aspect of the ramin plantations are discussed in the following paragraphs. While, ramin planting trial activities conducted by several institutions and/or researchers including results and current status according to the time series are listed in Table 4.

1. Site characteristics

Soerianegara *et al* (1996) reported the result of ramin planting experiment conducted in HPH PT SBA Wood Industries, South Sumatera. In the experiment, ramin seedlings were planted on two levels of peat depth, namely 50 to 100 cm and 100 to 200 cm. Results of the experiment, which used nursery seedlings, indicated that the height and diameter increment of ramin planted on deeper peat (100 to 200 cm) were 17.10 cm and 1.81 cm per year, respectively. Those values were higher than the height and diameter increment of ramin planted on shallower peat (50 to 100 cm), i.e. 11.74 cm and 0.94 cm per year, respectively. Bastoni and Sianturi (2000) stated the impact of fire on peat-swamp, where depth of deep peat decreased for about 50 cm. Besides, a decrease of flood during the long dry season in 1997, formed a dry peat layer, which was inflammable. Ramin was assumed as a species that is relative less adaptive to those conditions.

An experiment result of ramin enrichment planting was reported by Butarbutar et al (2000). They planted ramin seedlings at two different places, first in area of HPH PIW, Jambi Province with peat depth more than 2 m and second at forest area of S. Indragiri Hilir, Riau Province with peat depth less than 2 m. The height and diameter increment of ramin, growing on peat depth more than 2 m, 18 months after planting were much higher (average height 2.68 m and average diameter 2.36 cm) than those height and diameter increment of ramin growing on peat depth less than 2 m, 9 years old (average height 2.97 m and average diameter 2.75 cm).

Level of shading also determines ramin growth. Bastoni (1998 and 1999) reported the growth of ramin planted on two type of sites, i.e. open area (0% shading from residual stand) with depth of peat 33 cm and log over area (LOA) with 50% shading from residual stand and depth of peat 425 cm. This

plantation experiment concluded that enrichment planting of ramin (in LOA with shading and deep peat) was more successful and easier (survival rate was > 65%) compared to plantation of ramin on open area without shading and shallow peat (survival rate was < 37%). Maintenance technique of ramin plantation only gave a significant effect to the diameter growth of ramin at 2 years old, whereas fertilization did not lead to a significant increased of height and diameter increment of ramin on those two type of sites.

Muin and Purwita (2002) reported a ramin plantation experiment result on a logged over area with three levels of light intensity, i.e. open area (light intensity > 65%); rather open area (light intensity between 35 to 65%) and under heavy shading (light intensity < 35%). There was a significant different of height and diameter growth of ramin on those three levels of light intensity, six months after planting. The most sufficient result was occurred on ramin planted on a rather open area (light intensity between 35 to 65 %), where height and diameter increment subsequently were 20.88 cm and 1.97 mm. While, height and diameter increment of ramin planted on open area were 17.96 cm and 2.33 mm; and under shading were 11.61 cm and 1.39 mm. Besides, natural regenerations of ramin growing on the open area have smaller and thinner leaf compared to the ramin plants growing under a medium shading.

Plantation experiment of ramin conducted and reported by Muin (2004), explains that height increment of ramin differs significantly among three conditions of the site, i.e. under shading, a half open area and open area. The highest height increment was occurred on the condition of a half open area (48.4 cm), whereas height increment under shading and on open area were 27.6 and 27.6, respectively. Other author (Daryono, 1996) reported that the height and diameter increment of ramin, which was planted on landing area were 20.01 cm and 0.27 cm per year respectively. While, ramin that was planted on skidding road, had increment of height and diameter of 14.66 cm and 0.24 cm per year.

2. Planting technique

Ramin planted with direction of East to West gave higher result on survival rate (51.17%) when it compared to south to north direction with survival rate of 41.91%. Treatments of strip form where strip wide of 0.5 m and seedlings planted in the center of the strip resulted highest height increment of ramin i.e. 12.28 cm per year (Supriyanto and Hamzah, 1983). Bastoni and Sianturi (2000) summarized that enrichment planting by using strip-planting technique was more economical or cheaper than group-planting technique since the strip planting technique could be saved labour cost. According to Bastoni (1999), strip planting consumed 17 man day per ha, whereas group-planting spent 32 man day per ha (4.5 our of working our per day). Besides, number of seedling for strip planting was 200 seedlings per ha and for group-planting was 259 seedlings with the similar planting space, 5m x 5m. Survival rate for strip planting technique was 82%, whereas for group-planting technique was only 29%, each 2 years after planting.

Subagio and Arinal (2000) used strip planting technique with spacing 3m or more on piles of soil with height of the piles similar with flooded height during peak of rainy season. At the other lower location, height of piled soil used was higher than flooded height. The plantation was done by random technique. However, there was no experiment result reported. According to Soerianegara and Lemmens (1994), ramin plantation should be done in strip or line at logged over forest or peat swamp forest with planting distance are 5mx5m for logged over forest and 3mx1m for secondary peat-swamp forest.

The main problem in planting technique for peat land is the presence of water inundation and unstable soil condition. Therefore, it is frequently occurred, that the soil medium, which is attached to the roots, is flushed by the water after planting. Besides, due to unstable peat soil, after planting, the seedlings are often drifted by the water and sometimes uplifted or even fall down that cause growth failure. There are several ways to overcome this problem, for instance, by not detaching the polybag completely but only cutting the lower base and puncturing the side of the polybag as it has been conducted by PT. DRT in Riau Province.

On the other hand, to solve the problem in soil stability, the planting technique should use a square elevated bed of soil where edges are restrained with wood as it has been practiced by Wetland-International in Berbak National Park, Jambi.

Planting technique which is seldom to be conducted is the planting of seedling between roots of other existing trees. The technique imitates nature, where ramin usually grow in clump between tree roots which still provide shade. In such clump of roots, usually the soil surface is higher than the surrounding area. It is free from continuous water inundation.

3. Planting stock

Alrasyid and Soerianegara (1978) conducted enrichment planting trials with various planting stocks, i.e. wildings (25 to 75 cm in height), nursery seedlings (average 25 cm in height) and stump from natural regeneration (20 cm stem height and 20 cm root length). The result after 11 months showed that survival rate of nursery seedlings was 75.35%, wildlings 74.93% and stumps 92.63%, but after 59 months in the field, survival rate of ramin plants from nursery seedlings decreased to be 49.69%, wildlings to be 40.46% and stumps to be 44.65%.

Ekamawanti *et al* (2001) reported that existing of spore of vesicular-arbuscular mycorrhizal fungi around ramin rhizosphere could be used as a source of mycorrhizal fungi inoculum that could be developed to accelerate the growth of ramin. Soerianegara and Lemmens (1994) suggested that ramin could be planted through wildling, nursery seedling and shoot cutting. Based on an enrichment planting trial, nursery seedlings show highest survival rate (67%) and average increment of the height (12.4 cm per year), compared to shoot cuttings and wildlings. Survival rate and height increment of shoot cuttings and wildlings were 44% and 5.5 cm; 40% and 12.6 cm per year, respectively.

4. Plantation maintenance

Bastoni (1999) and Bastoni and Sianturi (2000) suggested that horizontal liberation cutting should be done three times during first year of ramin plantation. Furthermore, the liberation should be carried out twice in a year during second and third year after planting. Xaverius (1998) reported that fertilizing of ramin with NPK compound fertilizer did not lead to a significant increased of ramin growth. Other author (Riyanto, 1999) explained that there was no significant effect of tablet compound fertilizer to diameter increment of ramin, planted in HPH PT PIW, Jambi. However, horizontal liberation cutting treatment shows a positive response to diameter increment of the ramin plants. The horizontal liberation cutting can be done by weeding and remove all undergrowth and non-commercial tree species in radius 1 m from the ramin trees.

According to Soerianegara and Lemmens (1994), thinning of ramin plantation can be started at five years old, then followed up every three years until the plantation reached 20 years old. Further, thinning should be applied every five years to the end of ramin life cycle or to the harvesting time.

Table 4 Ramin plantation activities based on the time series

No	Year	Institution /Researcher	Research Site	Treatment	Results	Current Status
1	1978	Alrasjid & Soerianegara	Teluk Belanga, West Kalimantan	Various planting stocks ▪ Wildlings (25-75 cm in height) ▪ Nursery seedlings (25 cm in height) ▪ Stump (20 cm in height)	After 59 months survival rate decreased to be: ▪ Wildlings 40.48% ▪ Nursery seedlings 49.69% ▪ Stumps 44.65%	Open area/bare land
2	1983	Supriyanto & Hamzah	Central Kalimantan	▪ Line directions ▪ Wide of strip line	▪ Survival rate: East – West 51.17%; North- South 41.91% ▪ Height increment on strip wide of 0.5 m and planted in centre of the strip 12.28 cm per year	Burned area
3	1994	Soerianegara & Lemmens	No data available	Planting techniques	▪ At LOA: planting distance 5m x 5m ▪ At secondary peat swamp forest: planting distance 3m x 1m	No information available
				Planting stocks	Survival rate & increment of the height: ▪ Nursery seedlings 67% & 12.4 cm per year ▪ Shoot cuttings 44% & 5.5 cm per year ▪ Wildings 40% & 12.6 cm per year	
				Plantation maintenance	Thinning can be starting at 5 years old, and then every three years until 20 years old	

Table 4 (*continued*)

No	Year	Institution /Researcher	Research Site	Treatment	Results	Current Status
4	1996	Daryono	Peat swamp forest area, HPH Arjuna Wiwaha, Teluk Umpan, Central Kalimantan	Different planting areas : Landing area and skidding road area	Height and diameter increment: ▪ on landing area 20.01 cm and 0.27 cm per year ▪ on skidding road 14.65 cm and 0.24 cm per year	The concession right of the area had been revoked but the plantation still there
5	1996	Soerianegara *et al*	Peat swamp fores area, SBA Wood Industries, South Sumatera	Two levels of peat depth: ▪ deeper peat (100 – 200cm) ▪ shallower (50 – 100cm)	Height and diameter increment: ▪ on deeper peat 17.10 cm & 1.81 cm per year ▪ on shallower peat 16.74 cm & 0.94 cm per year	The planting area was burned
6	1998 & 1999	Bastoni	Peat swamp forest, Air Sugihan, South Sumatera	Two site types : ▪ open area (0% shading) and 33 cm peat depth ▪ LOA (50% shading) and 425 cm peat depth	Survival rate: ▪ on LOA > 65% ▪ on open area <37%	The research area was burned
				Plantation maintenance (weeding and fertilization)	▪ Weeding only gave a significant effect to the diameter growth of ramin at 2 years old ▪ Fertilization not lead to a significant increased of height and diameter growth	

Table 4 (*continued*)

No	Year	Institution /Researcher	Research Site	Treatment	Results	Current Status
7	1999 & 2000	Bastoni ; Bastoni & Sianturi	Peat Swamp Forest, Air Sugihan, South Sumatera	Group planting and strip planting techniques	▪ Strip planting consumed 17 man day per ha and survival rate 82% ▪ Group planting spent 32 man day per ha and survival rate 29% ▪ Strip planting technique more economist or chipper than group planting	No information available
				Plantation maintenance	▪ Horizontal liberation cutting: three times during first year ▪ Twice a year during second and third year after planting	
8	1998	Xaverius	Central Kaliman-tan	Fertilization	NPK compound fertilizer did not lead to a significant increased of ramin growth	No information available
9	1999	Riyanto	Peat Swamp Forest, HPH PT. PIW, Jambi	Fertilization	No a significant effect of tablet compound fertilizer to diameter increment of ramin growth	No information available
11	2000	Butarbutar *et al*	Peat Swamp Forest, HPH PT. PIW, Jambi and S. Indragiri Hilir, Riau	Two different of peat depth: ▪ Peat depth more than 2 m (Jambi) ▪ Peat depth less than 2 m (Riau)	The height and diameter increment 18 months after planting on peat depth more than 2 m much higher than ramin planting on peat depth less than 2m	No information available

Table 4 (*continued*)

No	Year	Institution /Researcher	Research Site	Treatment	Results	Current Status
12	2001	Ekamawanti *et al*	Peat Swamp Forest, P. Maya Karimata, West Kalimantan	Rhizosphere of ramin natural regeneration	Genus of spora of vesicular arbuscular mycorrhizal fungi on ramin rhizosphere are *Glomus* and *Acaulospora*	No information available
13	2002	Muin & Purwita	Logged Over Area, HPH PT. Munsim, S. Pelunjung, West Kaliman-tan	Ramin plantation on three levels of light intensity: ▪ Open area (>65%) ▪ Rather open area (35 - 65%) ▪ Heavy shading (< 35%)	Height and diameter increment: ▪ On open area: 17.96 cm and 2.33 mm ▪ On rather open area : 20.88 cm and 1.97 mm ▪ On heavy shading : 11.61 cm and 1.39 mm	No information available after the area handed over to the local government
14	2003	Subagio & Arinal	Peat Swamp Forest, Jambi	Ramin plantation on piled soil	▪ Height of piles similar with flooded height during peak of rainy season ▪ Height of piles was higher than flooded height	No information available
15	2004	Muin	Sei Bakau, West Kaliman-tan	Ramin plantation on three condition of the site: ▪ Natural shading ▪ Half open area ▪ Open area	Height increment: ▪ Shading 27.6 cm ▪ Half open area 48.4 cm ▪ Open area 27.6 cm	The research area still exist

IV. CURRENT STATUS OF RAMIN PLANTATION ACTIVITY

4.1. Efforts Had Been Done

According to TPTI System (Tebang Pilih Tanam Indonesia or Selective Felling and Replanting System), activities of forest exploitation have to be followed by replanting activities. The replanting activities in peat-swam forest can be classified as follow:

1. Enrichment planting on logged over area
2. Rehabilitation of open areas, including ex landing area, ex skidding road and ex railway track

After logging, rehabilitation must be conducted in accordance with the extent of openness and damage of the forest areas. Open areas, which suffered much damage are ex railway tracks and log landing areas.

In PT Diamond Raya Timber (PT DRT), Riau, planting areas of the former log yards and railroads per year for area of 2000 ha of annual working plan (RKT) were 14,4 ha and 12,2 ha. The number of planting stocks needed was 23,940 (planting distances 3 m x 3 m) or around 26,500 planting stocks (added with 10 % for replanting of failures). On the ex skidding path and tree felling sites are not usually damaged so much. Therefore, in those areas, replanting or enrichment planting activities are not necessary. Here, besides the sufficient natural regenerations, crown gaps recover within 2 to 5 years after logging. Even, an observation at 8 months after logging in the year 2004, an open area was covered by undergrowth and pioneer species such as simpur, geronggang and jambu-jambuan.

Steps of rehabilitation activities that should be conducted, for each specific area are:

1. On open extensive area such as ex railway track and log landing, there should be planted with pioneer fast growing tree species such as durian burung (*Durio caricatus*), balam (*Palaquium sp*), and meranti batu (*Shorea uliginosa*). In such open areas, replanting with ramin is impossible since ramin seedlings need a medium shade during initial establishment.
2. On ex skidding road and ex tree felling site, rehabilitation should emphasize on maintenance of regeneration of commercial species and enrichment planting.
3. Uprooting wildling of ramin or other commercial species for replanting in other areas does not allowed, if there is no guarantee of success of such planting. This prohibition is necessary to avoid the decline of ramin stocks in nature because ramin does not bear fruit every year.
4. Propagation of shoot cutting from wildling or from hedge orchard could be justified if the wildlings or seedlings in the orchard could recovery after cutting. Experiment on shoot cutting propagation from ramin wildlings, gave satisfactory result, namely 100 % growth percentage (Istomo, 1997).
5. Concept of Reduced Impact Logging should be adopted to minimize the damage of residual stand.

Based on discussions with forest concession holders and forest services staff in several provinces, where ramin habitat located (Riau, Jambi, West Kalimantan and Central Kalimantan), some of the forest concession holders and state forest enterprises admitted that they have conducted replanting or plantation activities on ex skidding path, ex log yard and along both sides of ex railway tracks. Estimation of planted area on those specific locations in Riau, Jambi, West and Central Kalimantan Provinces up to year of 2004 is presented on Table 5.

Table 5. Estimation of planted areas on ex skidding paths, ex log yards, and ex railway tracks as well as logged over areas

Province	Site/Tree Grower Institution	Planting period	Number of seed lings	Enrich-ment Planting (trees or ha)	Rehabili-tation (trees or ha)	Problem
Riau	Rokan Kiri/PT DRT	1996 to 2004	61,200	153 ha	-	No recorded data available
Jambi	Muara Jambi/PT PIW	1997 to 2000	478,000	200 tress	2,633 trees (6.5 ha)	No recorded data available
	PT Rimba Karya Indah	1997 to 1999	17,000	-	-	No recorded data available
West Kalimantan	PT Inhutani II	1997 to 2001	na	24 ha	-	The right concession revoked, land conversion
	Forestry Services	1969 to 1975	na	-	570 ha	Land conversion
	PT Sumber Jaya Baru	1996/ 1997	10000	-	25 ha	No recorded data available
Central Kalimantan	PT Brata Jaya Utama	1995 to 1999	94,700	5,000 trees	577 ha	No recorded data available
	PT Bintang Arut	1999 to 2000	594,140	44.04 ha	491.98 ha	No recorded data available

Problem, which is often encountered in managing residual stand in the peat-swamp forests is limited access to reach the forest plantation areas, because the existing railway tracks is dismantled soon after logging. Therefore, generally there are no data or information concerning with those plantation after planting.

4.2. Activities of Ramin Plantation

Various institutions, either government or non-government organization including forest concession holders have been trying to plant ramin trees. Most of the activities were in small scales, such as research plots or demonstration plots, except in Jambi. There are eight sites of ramin plantation in the four provinces that were observed and measured. Characteristics of those plantations covering size or number of plants, age of plants, planting space, planting pattern and scale of the plantations are described in Table 6. Details of those on-going ramin plantations, starting from seed stand and planting stock, propagation and nursery technique, planting activities, survival rate and growth of ramin plants are described and discussed in the following paragraphs.

1. Seed Sources

Mother trees as a source of ramin seeds are scarce in most of peat-swamp forest areas. In concession area of HPH PT Diamond Raya Timber (PT DRT), the average number of existing mother trees are 16 trees per bloc or 16 trees per 100 ha forest area. The feature of the mother trees are, in general, with

Table 6. Characteristics of ramin plantation at eight visited sites in the four provinces

Province	Site	Tree Grower Insitution	Size or number of plants	Age of plants	Planting space	Planting Pattern	Plantation Scale	Constrains
Riau	Rokan Hilir	PT DRT	120 plants	20 months	5 x 5 m	Monoculture	Research	Land occupation, limited access to the area, seed source
Jambi	Muara Jambi	PT PIW	6 ha	3.5 years	5 x 5 m	Monoculture	Rehabilitation	Weed
	Berbak National Park	Berbak National Park	2.5 ha	6 months	5 x 5 m	Mixed	Rehabilitation	Flood, fire
West Kalimantan	Sei Bakau	Tanjung Pura University	1.5 ha	2 years	5 x 5 m	Monoculture	Research	Land status, seed source
	Mandor	PT Inhutani II	36 plants	7.3 years	5 x 5 m	Monoculture	Trial plot	Land conversion
Central Kalimantan	Kalampangan	CIMTROP	100 plants	1.3 years	2 x 2 m	Mixed	Field trial	Fire
	Teluk Umpan	BP2HT-IBB	150 plants	6.5 years	5 x 10 m	Monoculture	Planting trial	Illegal logging
	Tumbang Nusa	BP2HT-IBB	1 ha	1.3 years	5 x 3 m	Monoculture	Demonstration plot	Fire

Total height more than 30 m, height of clear bole more than 20 m, and the trunk are straight and the canopy are healthy and dense.

In concession area of HPH PT Putraduta Indah Wood (PT PIW), Jambi Province, ramin mother trees are still available surrounding nursery area, so ramin seeds were collected from those mother trees. The characteristics of those ramin mother trees is more than 15 years old, total height more than 10 m and diameter more than 20 cm.

In Central Kalimantan Province, initiative to build ramin seed stand was taken by PT Barito Baru and PT Rimbayu Barito. However, after the time of concession finished and replaced by other forest concession right holder, this seed stand was not taken care, especially after ramin moratorium regulation had been launched. Still, in Central Kalimanan Province, especially in area of Natural Laboratory of Peat-swamp forest managed under CIMTROP (Centre for International Cooperation in Management of Tropical Peatland), there were 6 ramin mother trees per ha. The area is about 50.000 ha, located in upper catchment of Sebangau river, around 20 km from Palangkaraya City. Figure 7 illustrates a ramin mother tree, which is growing near the CIMTROP camp, Sebangau Sub District.

In West Kalimantan, research on nursery and plantation techniques of ramin started in 2002 by the Research Institute of Tanjungpura University (Untan). At the beginning, they used nursery seedlings and wildlings as sources of ramin planting stocks, since at that time there were seed stands still available at Sei Labai (Sanggau District) and at Selat Kalbar.

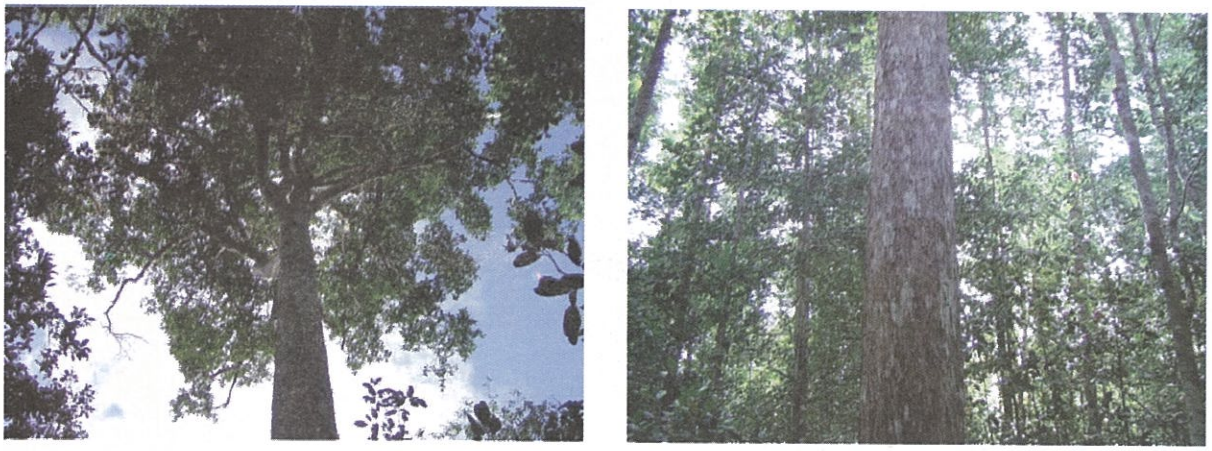

Figure 7. Feature of a ramin (*Gonystylus bancanus*) mother tree growing in area of Natural Laboratory of Peat-swamp forest, Sebangau Sub District, Central Kalimantan.

Fruiting season in PT DRT, Riau Province was in February 2004 and commonly occur once in five years. In Jambi, the fruiting takes place in June. While, in Central Kalimantan ramin trees are usually fruiting in February, once in 4 to 5 years. The seed stands at Sei Labai, West Kalimanan was fruited in Februari 2002 and that of at Selat Kalbar also in West Kalimatan was fruited in December 2002.

Methods used in collected ramin seeds vary among the companies and sites. Seed collection in Riau (PT DRT) was done by setting up a net under the tree canopy with radius of similar to the canopy wide. Whereas in Jambi (PT PIW), ramin seed collection was done manually, picking the seeds up from the ground surface surrounding the mother trees. Similar way was used also by CIMTROP in Central Kalimantan and by Untan in West Kalimantan. Based on field observation in West Kalimantan, the number of the fruits is up to 1000 fruits per branch.

2. Propagation and Planting Stock

PT DRT uses nursery seedlings and shoot cuttings. Wildlings had been forbidden to be pulled out since year 2003. However, the wildling can be used as planting material for shoot cutting. In Jambi (PT PIW), ramin planting materials were nursery seedlings and wildlings. Wildlings were used when the ramin seeds were not available. Shoot cutting method has not been developed yet. However, the company is already starting to prepare hedge-orchard as sources of shoots, as showed by Figure 8. CIMTROP in Central Kalimantan developed shoot cuttings by using natural seedlings (wildling) as sources of the shoots. The height of the wildling that can be used for shoot sources was 50 to 75 cm. They also prepared nursery seedlings when ramin seeds available. Untan in West Kalimantan used all kinds of planting stocks (nursery seedlings, shoot cuttings as well as wildlings). PT Inhutani II as a state forest enterprise in West Kalimantan has used shoot cuttings as planting stocks of ramin from 1997 to 2001.

Figure 8. Hedge orchard of ramin as a source of shoot cuttings in nursery area of PT PIW, Muara Jambi District, Jambi Province.

3. Nursery Technique

PT DRT in Riau, PT PIW in Jambi, and CIMTROP in Central Kalimantan Provinces are used traditional and modern nursery techniques in seedling preparation. While, Untan in West Kalimantan, is using a semi-modern technique only. Traditional method was used vegetation shading and manually watering, whereas modern technique used net shading and automatic watering. In both methods, the nursery period for nursery seedling and shoot cutting were almost 12 months. Limited water resource is the main problem in the nursery, particularly during dry season in concession area of PT DRT. Before planted in polybags, shoot cuttings were placed in concave cover by transparent plastic under shaded condition for about 2 months in order to produce roots. Untan has been developing a water rooting method of ramin shoot-cuttings as described by Figure 9.

To produce a big scale of ramin planting stocks, PT DRT have been conducting a joint research on the propagation of ramin through tissue culture with experts from Bogor Agricultural University (IPB) and Indonesian Institute of Sciences (LIPI). The objective of this research is to produce planting stocks of ramin that have better quality like faster growth, healthy and easy condition to take care of. Those efforts that have been conducted are related to inclusion of ramin in Appendix III of Cites, and even in Appendix II, beginning in the year 2004. However, after several trials, growth success has not been achieved yet. It is likely that ramin is difficult to propagate through tissue culture because of insufficient amount of cambium. Figure 10 shows a process of the tissue culture research of ramin in PT. DRT.

Figure 9. Experiment of water rooting method of ramin shoot cutting at Silviculture Laboratory, Faculty of Forestry, University of Tanjungpura (Untan), West Kalimantan

Figure10. A process of a tissue culture research of ramin (*G. bancanus*) (Documentary of PT. DRT, Riau, 2000)

4. Planting activities

a. Riau Province

Planting of ramin species in Riau by PT DRT was carried out as demo plot and as enrichment planting on the logged over area. Demo plot is arranged surrounding nursery area with number of the plants of 120. Planting time was August 2003, with planting space 5m x 5m. The planting materials were from shoot cuttings. Based on measurement carried out at 20 months after planting (see Table 7), the survival rate was 97.50% and the height and diameter increment were 34.24 cm/year and 0.73 cm/year, respectively. Performance of the ramin plant is presented in Figure 11. The site characteristics are as follow: depth of the peat is 3.5 to 5 m; height of flooded was 0 to 15 cm; vegetation was secondary forest with light intensity of 40 to 80%; rainfall was 2637 mm per year; altitude is 2 to 25 m asl; distance from the nearest village was 6 km and distance from the river 6 to 20 km.

Enrichment planting has been done since 1996 (9 years) with estimation area of 153 hectares or 61.200 seedlings of ramin. The enrichment planting was done in mixed with other peat-swamp forest species such as kapur (*Dryobalanops sp.*), jelutung (*Dyera lowii* Hook.f), pulai (*Alstonia angustiloba* Miq.), geronggang (*Cratoxylon arborescens* Bl.), bintangur (*Calophyllum soulattri* Burm.f) and balam (*Palaquium sp.*).

Figure 11. Performance of a ramin plant, 20 months old in the area of PT DRT, Riau

Table 7. Average survival rate, height and diameter growth of ramin plants, 20 months after planting at PT DRT, Riau Province

Strip	Average survival rate (%)	Average height (cm)	Average diameter (cm)
1	100	81.50	1.83
2	100	82.63	1.68
3	100	60.63	1.45
4	100	70.75	1.22
5	87.50	60.57	1.29
Average	**97.50**	71.21	1.49
Increment per year	-	**34.24**	**0.73**

b. Jambi Province

In Jambi Province, planting activity of ramin was carried out at two sites, i.e. along left and right sides of railway track of PT PIW and in Berbak National Park area. Those planting activities located on burned areas as rehabilitation initiatives. Plantation along left and right sides of the rail-track carried out by PT PIW used wild seedling with area of 6 ha. Planting time was October 2001 and planting space was 5 m x5 m. Measurement of the plantation was done in March 2005 when the plants are 3 years and 4 months old. The site characteristics are as follows: depth of the peat 2 to 6 m; height of the flooded was 20 cm; light intensity was 70% with undergrowth vegetation was fern and alang-alang grass; rainfall was 2000 to 2500 mm per year with temperature was 28.8 °C and relative humidity was 87%; altitude was 10 to 30 m asl; distance from the river was 5 to 10 km and distance from the nearest village was 10 km. Height and diameter growth as well as survival rate of those plants presented on Table 8 and performance of the plant can be seen on Figure 12.

Table 8. Average survival rate, height and diameter of ramin, 3.5 years old, planted along left and right side of railway track of PT PIW concession area, Jambi Province

Strip	Average survival rate (%)	Average height (cm)	Average diameter (cm)
1	33.3	49.34	0.98
2	29.17	38.71	0.91
Average	**31.25**	44.03	0.94
Increment per year	**-**	**2.58**	**0.13**

Figure 12. Performance of a ramin plant, 3.5 years old in area along left And right side of railway track of PT PIW

In Berbak National Park area, planting activity was done in September 2004 by Wetland International and in collaboration with PT PIW and Berbak National Park Institute. This activity involved the nearest human community, so the rehabilitation used participatory approach. The planting pattern was mixed with jelutung, pulai, perepat, rengas, balam, durian and jambu-jambu on area about 20 hectares. If it is calculated for the ramin only, the planting area was estimated 2.5 hectares.

In order to prevent the seedlings from flood that always occurred in the area, plantation was done on a pile of soil. The soil piles were prepared during dry season in order to make the muddy peat soil become compact by using wooded framework structure with size of 1m x 1m x 0.5m (see Figure 13). Hence, height of the pile was 50 cm with distance about 5 m from each other. By planting ramin seedling on the piles, it is expected that during pick rainy season the seedlings will not flooded until the end tip of the stem and the seedlings can be kept survive (see Figure 14).

Before this technology was applied, two times ramin plantation activities conducted in the same area were failed. This technology is very high cost. However, it must be applied in order to achieve the successful rehabilitation efforts. The site characteristics are as follows: depth of the peat 2 to 6 m; height of the flooded was 30 to 100 cm; light intensity was 70% with undergrowth vegetation was fern and alang-alang grass; rainfall was 2000 to 2500 mm per year with temperature was 28.8 °C and relative humidity was 87%; altitude was 10 to 30 m asl; distance to the river was 5 to 10 km and distance to the nearest village was 10 km. The growth of ramin including survival rate in the Berbak National Park is presented on Table 9.

Figure 13. Preparation of a soil pile for planting of a ramin seedling (documented by Wetland International Indonesia Project, 2004)

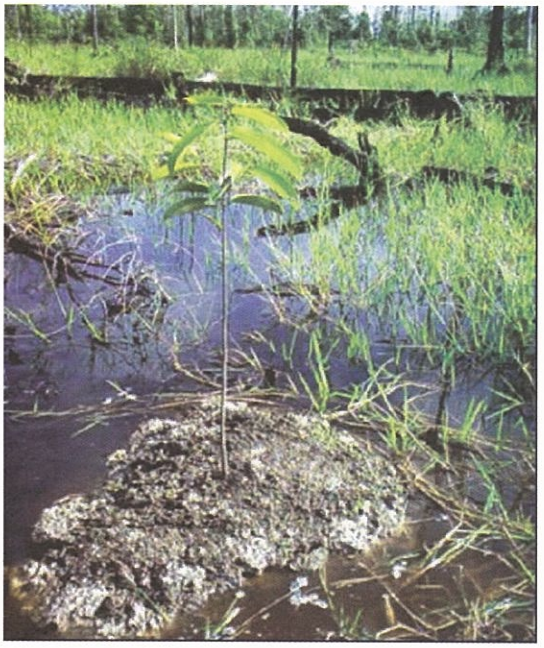

Figure 14. Ramin planted on a piled soil, in burned area of Berbak National Park (documented by Wetland International Indonesia Project, 2004)

Table 9. Average survival rate, height and diameter of ramin, 6 months old, planted in Berbak National Park, Jambi Province

Height of flloded	Average survival rate (%)	Average height (cm)	Average diameter (cm)
30-50 cm	-	49.68	0.97
50-60 cm	-	48.52	0.90
60-80 cm	-	52.44	1.06
> 80 cm	-	49.08	0.94
Average	60	49.93	0.97
Increment per year	-	**19.86**	**0.94**

c. Central Kalimantan Province

In Central Kalimantan Province, Ramin field trial and demonstration plot had been conducted by Centre for International Cooperation in Management of Tropical Peatland (CIMTROP) and Balai Penelitian dan Pengembangan Hutan Tanaman-Indonesia Bagian Timur (BP2HT- I BT). The r eason w hy CIMTROP conducted ramin field trial was that ramin species is endemic species in Central Kalimantan, it had been protected to be exploited because the species is scarce in natural forest, and economical value of ramin wood was high.

CIMTROP is doing ramin field trial in a small scale in Kalampangan, Sebangau Sub District, Palangkaraya Regency, near main road of Palangkaraya – Banjarmasin with distance about 30 km from Palangkaraya. The field trial area is dominated by resam fern and lalang grass. About 100 seedlings of ramin were planted with planting distance of 2mx2m in December 2003. They are consisted of two strips, each strip is 50 plants. Planting materials were ramin stem cuttings, with the mean high 20.34 cm and stem diameter 0.47 cm. The location was inundated by water about 0 to 40 cm. The site characteristics are as follows: depth of the peat 4 to 5 m; light intensity was 100% with undergrowth vegetation was fern and alang-alang grass; rainfall was 780 to 2660 mm per year; altitude was 0 to 10 m asl; distance from the river was 2 km and distance from the nearest village was 1 to1.5 km. The average growth and survival percentages of ramin plantation, measured in April 2005 can be seen in Table 10.

Table 10. The mean height, stem diameter, number of leaf increment per year and survival percentages of Ramin plants, 1.3 years old, in Kalampangan

Condition/strip	High (cm)	Diameter (cm)	Number of leaves	Survival rate (%)
Initial measurement/ strip 1	20.220	0.460	3.3	100.0
Initial measurement/ strip 2	20.460	0.480	2.7	100.0
Average	20.340	0.470	3.0	100.0
Increment/year, strip 1	-0.448	0.024	-0.8	88.0
Increment/year, strip 2	-1.520	0.048	-0.6	75.5
Increment/year	-0.984	0.036	-0.7	81.8

BP2HT-IBB planted ramin as field experiment or demonstration plot in two sites, i.e. in area ex concession of PT Arjuna Wiwaha, Teluk Umpan and in Demonstration Plot of Tumbang Nusa. Both sites located in Sebangau Sub District, Palangkaraya Regency, about 32 to 35 km from Palangkaraya. The site characteristics are as follows: depth of the peat more than 5 m; height of the flooded was 10 to 40 cm; light intensity was 40 to 80% with undergrowth vegetation was secondary forest; rainfall was 780 to 2660 mm per year; distance from the river was 2.5 km and distance from the nearest village was 1 km.

In the area ex concession of PT Ardjuna Wiwaha, ramin seedlings were planted in November 1998 by H. Daryono (BP2HT-IBB researcher) with the spaces of 5 m x 10 m. The plantations consist of five strips each with five plants, and other five strips with 25 plants each. Planting materials were wild seedlings with the high between 20 and 24 cm and stem diameter about 0.5 cm. The location was a logged over peat-swamp forest, consisted of various vegetations at the seedling up to pole stages. The area inundated by water for about 20 to 40 cm. Measurement of the ramin growth, which was conducted in April 2005 is presented on Table 11, while performance of the 6.5 years old of ramin trees can be seen in Figure 15.

Table 11. The mean height, stem diameter, number of leaf increment per year and survival rate of ramin plants at 6.5 years old in the area ex concession of PT Ardjuna Wiwaha, Teluk Umpan

Strip	Increment for 6.5 years			Number of twig	Survival rate (%)
	High (cm)	Diameter (cm)	Number of leaves		
1	149.00	0.910	60.5	8.5	40
2	157.00	0.910	20.0	4.0	60
3	228.00	1.640	42.0	7.0	40
4	71.00	0.580	13.7	1.6	40
Average	151.25	1.010	34.05	5.28	45
Increment/year	23.27	0.155	5.24	0.81	45

In demonstration plot of Tumbang Nusa, ramin seedlings were planted in December 2003 by Sudin P (a researcher of BP2HT-IBB) with planting space of 3 m x 5 m. Total number of strips are 16 and each strip consist of 20 plants. Planting materials were generative seedlings with the high between 18 and 20 cm, and stem diameter 0,35 and 0.4 cm. Vegetations around demo plot is secondary forest but not as dense as in Teluk Umpan. The demo plot was inundated by water about 10 to 20 cm. The growth of ramin plantation in Tumbang Nusa is presented on Table 12.

d. West Kalimantan

In West Kalimantan, plantation activity of ramin was observed at two sites. First, a ramin plantation at The Research Plot of Ramin Plasma Nutfah, Sei Bakau forest area, planted by Untan in year 2003. Second, a ramin plantation at Mandor area, planted by PT Inhutani II in year 1997/1998. At Ramin Plasma Nutfah plot, ramin seedlings was planted with space 5m x 5m at three level of light intensity, i.e. open area (full sunlight), moderate shading (light intensity 35%-55%) and heavy shading (light intensity less than 35%). Before ramin seedlings were planted, they were inoculated with mycorrhizal fungi inoculum and provided with natural phosphate fertilizer. The site characteristics are as follows: depth of the peat 0.6 to 4 m; height of the flooded was 5 to 50 cm; light intensity was 55% with undergrowth vegetation was secondary forest; rainfall was 1100 to 3300 mm per year with temperature was 25.9 to 32.7°C and relative humidity was 69 to 76 %; altitude was 10 m asl;

Figure 15. Performance of a ramin tree 6.5 years old in area ex concession of PT Ardjuna Wiwaha, Teluk Umpan, Central Kalimantan

Table 12. The mean height, stem diameter, number of leaf increment per year and survival rate of ramin plants, 1.3 years old, in Tumbang Nusa, Central Kalimantan

Strip	High (cm)	Diameter (cm)	Total of leaves	Survival rate(%)
1	4,55	0,09	1.00	60
2	5,46	0,12	0.71	70
Average	5.005	0,105	0.855	65
Increment/year	3.76	0.079	0.643	65

and distance from the nearest village was 0.5 km. Growth of those ramin plants, which was measured in April 2005, is presented in Tabel 9. While, performance of those ramin plants under various condition can be seen in Figure 16. As shown by Table 13, increment of height and diameter of ramin was higher under open area compare to the other conditions. Growth of ramin plants, which were planted by PT Inhutani II in 1997/1998, measured in April 2005 can be seen in Table 14.

Table 13. Survival rate, increment of height, diameter and number of leaves per year as well as average number of twig of young ramin trees, 2 years after planting at Plasma Nutfah Ramin area, Sei Bakau, West Kalimantan

Shading treatment (% of light intensity)	Increment per year			Average number of twig	Survival rate (%)
	Height (cm)	Diameter (cm)	Number of leave		
Full sunlight (100%)	56.76	0.561	7.75	2.8	100
Moderate shading (35–55)	42.87	0.498	8.55	2.9	100
Heavy shading (<35)	31.98	0.434	6.22	2.7	100
Average	43.87	0.498	7.51	2.8	100

Table 14. The mean height, stem diameter, number of leaf increment per year and number of twig of ramin plants at Mandor area, 7.3 years old.

No	Height (cm)	Diameter (cm)	Number of leaves	Number of Twig
1	159.0	2.27	18	5
2	176.5	2.35	31	7
3	147.0	1.92	10	4
4	183.0	2.27	34	6
5	161.0	1.93	26	4
6	147.5	1.57	15	3
7	182.0	2.65	32	7
8	125.5	2.04	17	5
Average	160.19	2.125	22.9	5.1
Increment/year	19.20	0.236	2.9	-

Figure 16. Performance of ramin plants, under various conditions, 2 years after planting. A. Full sunlight; B. Moderate shading and C. Heavy shading

V. ANALYSIS AND DISCUSSION

Information and data on past and on-going ramin plantation research and plantation activities, which were described in Chapter III and IV, provided an overview on current status of ramin plantation initiatives in Indonesia. In this chapter, an analysis and discussions on those reviews and recent plantation activities of ramin are presented.

Based on the introduction and the literature review on ramin silviculture, it could be summarized as follows:

1. Ramin is a high value commercial tree, either for sawn timber or wood processing material. During 1980 to 2000 exported of ramin wood reached 38% in volume and 46% in value of the total wood exported. However, the increasing demand to product of the wood caused over exploitation of the ramin trees beyond its natural regeneration capacity. Hence, since year 2000's, production of ramin wood is declining. Efforts have been done to take care of the ramin population in nature to be sustained through moratorium of logging and trading and also by incorporating ramin into CITES Appendix II since the year of 2004.
2. Ramin is one of the commercial woods coming from genus of Gonystylus of Thymelaeaceae family. It is a well-marked species, both morphologically and ecologically. The freshwater swamp habitat appears to be almost unique in the genus.
3. Ramin species prefers to grow on deep peat soils (deeper than 350 cm). However, it can grow on a shallow peat soil also, minimum at peat depth of 120 cm. Ramin species grow well on a temporary flooded peat-swamp with height of water surface is not higher than the end tip of ramin stem. In terms of response to the light intensity, ramin is semi-tolerant species. It needs a moderate shading during seedling stage, then it need more sunlight at sapling stage and finally, a full sunlight is needed during pole and tree stages. Implication of this characteristic to silviculture technique is that at the pole stage, a silviculture treatment is necessary to help canopy opening of the forest.
4. Ramin grows in a group among the roots of other trees; forming an association. Pattern like that goes together the nature of peat land; which inundated by water and poor of nutrient. Some research results indicated that ramin roots contain micorrhyzal fungi, which gave better expectation.
5. Discussion on availability of ramin mother trees or ramin seed stands; flowering and fruiting season as well as ramin seed feature, it is crucial to develop a vegetative planting stock of ramin. Ramin trees do not bear fruit every year, fruiting season different each other from one to another location. Besides, the fruits are quickly decay if do not immediately planted. Pattern of flowering and fruiting of the ramin trees apparently related to the low soil fertility in tropical zone, especially the availability of phosphorous.
6. Shoot cutting technology of ramin from wild seedling has been studying, it provides an opportunity to establish ramin plantations from this planting stock. However, the technology is still in a small scale or in a research scale. This technology also needs a hedge-orchard as a source of the shoots. Nowadays, most of the ramin growers used natural seedlings as sources of the shoots. Only a few of them are developing hedge-orchards. Efforts to develop propagation technology by means of a tissue culture in order to provide an adequate number of ramin planting stocks should be carried out continuously to support ramin plantation initiative in large scales.

In relation to ramin plantation activities in the field, it could be analyzed and discussed as follows:

1. To develop the shoot cutting technology in a large scale, it is needed to conduct short trainings on this matter at the peat-swamp forest regions (Riau, Jambi, South Sumatera, West and Central Kalimantan). Field level staffs at those areas must have enough knowledge and skill on the shoot cutting technology.
2. Site preparation (certainly on peat-swamp soil) and plantation maintenance should consider ramin natural habitat. The seedlings should be planted on a moderate shading in line or strip planting method. Horizontal liberation cutting suggested to be carried out at certain period to help canopy opening to allow sufficient sunlight transmission into the forest floor. To avoid drying of the peat, canals are should not be established. In contrary, soil piles have to be constructed and ramin seedlings should be planted on those piles to avoid over flooded during peak of rainy season.
3. Cultivation activity at the concession forest area, which still active pursuant to TPTI, most done by company in order to rehabilitate the ex railway and ex log yard by means of enrichment planting. While at ex skidding paths and logged over forests were not done because the young shoot of commercial plant species is still appropriate and quickly recovered. Since railways have been taken away after hewing, direct evaluation (ground check) of the enrichment planting is impossible to be done. Therefore, data and information on the growth of the planted trees cannot be obtained.
4. Based on data and information from various stakeholders in the four provinces of the field survey, ramin plantation in larger scales have been conducted in several areas. Those efforts were done by forest concession right holders and forestry services, either as enrichment planting on logged over area or as rehabilitation activities on open area, ex skidding paths, ex railway tracks and ex log yard (see Table 5). However, there was no evident that the ramin plantations still exist until now.

Based on data from the fields covering 8 sites of 4 provinces, which have been elaborated in Chapter IV, the growth and the survival rate (%) of ramin can be summarized as described in Tables 15. Growth increment and survival rate of ramin plants at those eight plantations areas could be discussed in the following paragraph according to the provinces and/or sites.

Tables 15. Summary of data on diameter and height increment as well as survival rate of ramin plants at eight visited sites

Province	Site/Tree Grower Institution	Average survival rate (%)	Average height increment (cm/year)	Average diameter increment (cm/year)
Riau	Rokan Hilir/PT. DRT	97.50	34.24	0.73
Jambi	Muara Jambi/PT. PIW	31.25	2.58	0.13
	Berbak National Park/Institute of Berbak NP	60.00	19.86	0.94
Central Kalimantan	Kalampangan/ CIMTROP	81.80	-0.98	0.04
	Teluk Umpan/BP2HT-IBT	45.00	23.27	0.16
	Tumbang Nusa/BP2HT-IBT	65.00	3.76	0.08
West Kalimantan	Sei Bakau/Untan	100	43.87	0.50
	Mandor/PT Inhutani II	-	19.20	0.24

5.1. Riau Province

In Riau province (PT DRT), survival rate of ramin planted by using shoot cutting, 20 months old in the field trial was 97.5%; the height and diameter increment were 34.2 cm and 0.73 cm per year, respectively (Table 7). This survival and height increment was higher than the other information (Soerianegara and Lemmens, 1994; Soerianegara *et al*, 1996). Soerianegara and Lemmens (1994) reported that the survival rate and height increment of ramin planted from shoot cutting were 44% and 5.5 cm per year, respectively. Whereas, Soerianegara *et al* (1996) reported the survival rate of ramin planted on peat soil with depth 50 to 200 cm and using nursery seedlings was 83 % and height increment was 14.42 cm per year. This sufficient result may be because of an appropriate level of light intensity received by the young plants. Here, ramin seedlings were planted on almost moderate shading. This result also indicated that survival and height growth of ramin from shoot cuttings was higher than that of from nursery seedlings.

5.2. Jambi Province

Survival rate and growth increment of ramin planted along left and right side of the railway track of PT PIW in Jambi Province were very low (survival:31.25%; height increment: 2.58 cm and diameter increment: 0.13 cm per year). This is assumed because of the site was full open area, with undergrowth vegetation dominated by resam fern. The area was burnt forest and the plantation was done as rehabilitation initiatives. At dry land area, fern as undergrowth species, can be acted as soil fertility indicator, where the soil fertility usually very low and very acid. In Berbak National Park area, the ramin growth was moderate (height and diameter increment per year were 19.9 cm and 0.13 cm, respectively) and survival rate was also sufficient (60%). Actually, the area was similar to area of PT PIW, burnt forest. However, the dominant undergrowth species was different. Here, undergrowth species was dominated by alang-alang grass. The main problem in this area is the flood occurred in long period and very high. At the same area, there were twice planted activities that were failed by the flood.

5.3. Central Kalimantan Province

In Kalampangan, ramin plants in open area showed negative high growth (-0.987 cm/year) (see Table 10), because the shoots of some ramin plants become dry. Therefore, the total height decreased after one year. Some of the plants shed several leaves prematurely without growing new leaf due to the dry condition. This explained that increment number of leaves was negative (decreased 0.7). Stem diameter growth was very slow (0.036 cm/year). This reality proved that ramin seedlings need a moderate shading for their growth in the field (Muin, 2002). Survival percentage of ramin after 1.3 years were high, i.e. 81.8 %, because the bottom of ramin stem was inundated by water. Therefore, they can live, even though their leaves were yellow in color. In moderate shaded area, the ramin leaves were green in color, it indicates that young ramin need a moderate shading for their normal growth.

In Teluk Umpan, Central Kalimantan, yearly height increment for 6.5 years old of ramin plants was 23.27 cm and yearly diameter increment was 0.155 cm. Survival percentages after 6.5 year were 45 % (see Table 11). Measurement in the same area when the ramin plant was 5 years old showed that the height growth increment was 20.01 cm $year^{-1}$ and stem diameter increment was 0.27 cm $year^{-1}$ (Daryono, 1996). Those two time series of data indicated that during period of fifth to sixth year of the ramin age, height growth was more dominant than diameter growth. This is caused by the need of the ramin plants to catch more sunlight at that stage of their life and this in line with Soediarto *et al* (1963) that ramin trees need sunlight although at seedling stage they need shading.

In Tumbang Nusa, Ramin plants which were planted in secondary forest with moderate light intensity showed normal growth, even though at the early year they grew slowly (see Table 12). Survival percentages were 65 %, maybe because the plants were still in seedling stage. Generally, a lot of death occurred in sapling and pole stages. However, research showed that ramin at the early growth in the field needed moderate shade, because ramin is semi-tolerant species. When the height of ramin seedlings were less than 50 cm, they need moderate shading (between 45 and 65 %), however

after the seedlings reach the height more than 50 cm, vertical liberation by cutting non commercial trees and shrubs around seedlings may increase the growth of seedlings in the field (Muin, 2002).

5.4. West Kalimantan

The research conducted by Untan, in West Kalimantan demonstrated that growth of ramin from nursery seedlings, which were inoculated with mycorrhizal fungi, at the second year was highest on full sunlight (see Table 13). This result was different compared with the ramin growth measured at the first year, where the highest one occurred at ramin growing under moderate shading. This fact shows a role of mycorrhizal fungi association in accelerating the ramin growth. The inoculated ramin seedlings grow faster in the field, where during the second year they show positive response to the full sunlight. This means at those still two years old, the ramin plants already go into the next stage of their life cycle. When the growth of ramin of the Untan research be compared to growth of ramin of PT Inhutani II (see Table 14), growth of ramin at Untan research much higher than those of PT Inhutani II plantation. This mainly related to thickness of the peat, at Untan depth of the peat was 60 to 400 cm, whereas at PT Inhutani II plantation was less than 100 cm.

From the all literature reviews and direct measurements of ramin growth in the fields, it can be concluded that ramin plants are included in species with very slow growth during their early growth. Therefore, it is necessary to find and to develop a technology to accelerate growth rate of the ramin plants. Application of mycorrhizal fungi inoculum is a promising technology, but their role in promoting the ramin growth and the cost needed must be tested and analyzed under various conditions of the peat-swamp soil in Indonesia.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

1. Ramin (*Gonystylus bancanus* (Miq.) Kurz; Thymelaeceae) is a tree species that grows better on a deep peat soil, under moderate shading (during early growth) and then under full sunlight.
2. Flowering and fruiting season of ramin species is not occurred every year and the seeds are recalcitrant.
3. Ramin species can be propagated through wildlings, nursery seedlings and shoot cuttings. The shoot cutting methods is suggested to be developed in a large scale to provide adequate number and high quality of ramin planting stocks over times. Technology of the shoot cutting has been comprehensively be understood at the research scale by universities and research institutes.
4. Ramin is a tree species with very slow growth during their early growth. The highest height increment was 43.87 cm per year found in Sei Bakau, West Kalimantan and the biggest diameter increment was 0.94 cm per year found in Berbak National Park, Jambi.
5. Planting activities of ramin species had been conducted by various stakeholders, either as enrichment planting or as rehabilitation effort of degraded peat soil. However, those activities were still in small scales such as planting trials and demonstration plots. There was no evident that ramin plantations in rather big scales, conducted by several forest concession right holders and forestry services are still exist until now.

6.2. Recommendations

1. To disseminate the shoot cutting technology of ramin propagation as well as planting technique in the field, it is necessary to carry out short trainings for the users especially for the field level of staffs.
2. Because ramin is a slow growing species, it is necessary to find and to develop a technology in order to accelerate ramin growth rate.
3. The existing seed stands should be kept and saved, and seed orchards should be developed, either seedling seed orchard or clonally seed orchard.

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