MINISTRY OF FORESTRY OF INDONESIA
IN COOPERATION WITH
INTERNATIONAL TROPICAL TIMBER ORGANIZATION

ITTO PD425/06 Rev. 1 (I)

Production and Utilization Technology
for Sustainable Development of Eaglewood (Gaharu)
in Indonesia

Proceeding of Gaharu Workshop

BIOINDUCTION TECHNOLOGY
FOR SUSTAINABLE DEVELOPMENT AND CONSERVATION OF GAHARU




Edited by:
Maman Turjaman

R & D CENTRE FOR FOREST CONSERVATION AND REHABILITATION
FORESTRY RESEARCH AND DEVELOPMENT AGENCY (FORDA)
MINISTRY OF FORESTRY
INDONESIA
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PREFACE

The second gaharu workshop in 2011 signifies as a dissemination technique which proved effective to provide information for the stakeholders coming from various parties. The topic of second gaharu workshop was “ Bioinduction Technology for Sustainable Development and Conservation of Gaharu”. This workshop could represent the collection of information about the development of gaharu technology from various parties, such as universities, research institutions, community self-sufficiency institutions, private companies, policy holders, and gaharu practitioners in the field. In other sides, this workshop also offered the current information about gaharu development already achieved by the ITTO PD425/06 Rev.1(I) project. The most current information and invention can be scrutinized technically and discussed in-depth by the workshop participants. The participants were also given a chance to tell their practical experiences in performing gaharu development in each of their own regions.

The conducting of workshop afforded the outputs that brought benefits to the decision makers sticking to the policies on gaharu production in Indonesia. In different views, other stakeholders such as forest-farmer group, privates, gaharu enterprisers, community self-sufficiency community have forwarded some valuable inputs to immediately arrange and compile the master plan about the management of gaharu production in national scale. The gaharu workshop also offered benefits by the establishment of gaharu-communication forum under the name called Indonesia’s Gaharu Forum (IGF) as the informal holding-place between the stakeholders who are interested in gaharu development.

In gaharu workshop, there were a lot of inputs put forward by the participants abiding by their own experience in gaharu development. These inputs become the items which can be very valuable to develop inoculation technology and all the related aspects in the future. Nevertheless, there were some participants whose opinions differed from or did not get along with the workshop theme, as they might have different understanding-views or since the reference they learnt so far was different from the gaharu development currently conducted by the FORDA (Forestry Research Development Agency).

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THE DEVELOPING OF DATABASE REGARDING THE POTENCY OF GAHARU-YIELDING TREES IN INDONESIA

by :

Sulistyo A. Siran[1]

ABSTRACT

Gaharu is a name of commodity of non timber forest products (NTFPs) which at present become the subject of discussion by many parties. Gaharu is actually a product in the form of solid lump with color ranging from blackish brown to black, and has fragrant smell occurring in the wood and roots of the host plants (for instance *Aquilaria* spp.) which have undergone physical and chemical change due to infection by a kind of fungi. Objective of this paper is to describe the database regarding the potency of gaharu-yielding trees in several regencies of Indonesia, and factors that affect potency increase of gaharu population.

Keywords : gaharu, database, population.

I. INTRODUCTION

Since the gaharu was already endeavored about five decades ago, there have been a lot of benefits as positively felt by the community and government. As of this occasion, the gaharu as harvested still relies on natural sources. The gaharu demand/consumption which tends to increase brings about the increase in uncontrolled exploitation of gaharu from the nature. Due the worrying decline in gaharu potency, then the particular gaharu-yielding species, i.e. *Aquilaria* dan *Gyrinops*, have been included in Appendix II of the CITES (Sitepu, 2010). Although the gaharu trade is already regulated in the convention, but unfortunately the gaharu exploitation from the nature still continues, and also its intensity tends to increase (Siran and Turjaman, 2010).

The development of gaharu-processing technology and the expanding of market have encouraged the gaharu harvest more intensively. Because of such high demand, the potency of gaharu the nature decreases continuously. In order that the gaharu trade remains sustainable, then the appropriate cultivation of gaharu-yielding trees becomes the option. In several regencies, the community have planted the gaharu-yielding trees,

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either in their own attempt or with the government aid. The identification on potency/ data regarding the gaharu-yielding trees in several regencies of Indonesia therefore becomes urgently important to conduct.With the properly available data base, then the plan of gaharu development in the future will be better by paying thorough attention to: (i) Inoculant production; (ii) Production forecast; (iii) Processing technology; (iv) Marketing projection; (v) Technology transfer and Training patterns.

Some problems have found to collect data base as follows : (i) difficulty in the species identification; (ii) the potency identification is still unable to be done accurately, since it only use the estimate of average tree diameter that grow on the stretching place; (iii) the tree owners are usually unwilling when the data/information about their trees are questioned, unless their trees will be inoculated; (iv) estimation about the number of trees are often related to the seeds already planted; (v) the involvement of government institution is still limited and minimal.

Objective of this paper is to describe the database regarding the potency of gaharu-yielding trees in several regencies of Indonesia, and factors that affect potency increase of gaharu population.

II. DATABASE REGARDING THE POTENCY OF GAHARU-YIELDING TREES IN SEVERAL REGENCIES OF INDONESIA

A. Database Format

1. The database format should be prepared and arranged as ideally as possible to collect and acquire all information about the planting of gaharu-yielding trees situated as far distance as the village.
2. The information that wants to be collected is formatted in the table as in the following example:

The Input Form Regarding the Potency of Gaharu-yielding Trees

Province : ....

Regency : ....

Sub District/Village : ....

No.	Tree species	Age./ Year of planting	Number of Trees	Area vastness	Land (Site) Status	Geographical Coordinate Location	Owner Name	Re-marks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)

Data source:

- Ordered No; Tree Species (*Aquilaria*, *Gyrinops*); Ages or Year of Planting; Planting Area (Vastness); Land Status; Geographical Coordinate Location; and Remarks

- The data format should be prepared/arranged in systematic way by: (1) planting location; (2) regency recapitulation; and (3) province recapitulation. In this way, each addition/insertion of number of trees in a certain province can be traced until the regency, sub district, or village levels.

Data The Data-Collection Methods

- The data collection is done by visiting the information sources, either from individuals, farmer group, Regency's Forestry Service, Forestry Research Institute, Institute for Natural-Resource Conservation, either other regional government office.
- Kinds of information as wanted is formatted in columns covering species of tree plant; age of year when planted; number of trees; area vastness; land/site status; location (sub district/village), geography coordinate location. Each of the data sheets should be provided with explanation for each column to assist the column filling.
- At data sheets are also included with the data/information about: province, regency/city, owner name of the gaharu-yielding trees, and data sources
- The inclusion/mentioning of owner name and data source is intended in order that the data can be verified in the field, when there are found some doubtful cases.

B. The collected data

1. The planting data of gaharu-yielding trees in 45 regencies

No	Regency name	Species	Age/ Year when planted	Number of trees (stems)	Remarks (source)
1	Bogor	*A. malaccensis, A. microcarpa, A. crassna*	3-15 years 2008/1989	3750	Erdy S.
2	Sukabumi	*A. crassna*	11 years /2000	*80*	Erdy S.
3	Pandeglang	*A.microcarpa, A.malaccensis*	2 years /2009	43.000	Erdy S.
4	Sragen	*A.filaria*	2 s/d 6 years	22.000	Head of forestry service
5	Purworejo	*Gyrinops*	7 years /2003	165	Farmers
6	Sleman	*A.microcarpa*	7 years / 2004	4.000	Head of forestry service
7	Malang	*Gyrinops*	4 years / 2007	30.000	Farmers and Enterprisers
8	Banyuwangi	*Gyrinops*	4 years / 2007	7.000	Farmers and Enterprisers
9	Tapak Tuan Ds	*A. microcarpa*	10 years/2001	17.000	Data processed from a lot of sources

No	Regency name	Species	Age/ Year when planted	Number of trees (stems)	Remarks (source)
10	Bahorok Ds	*A.microcarpa*	Various age/2003	125,000	Farmer and Farmer Group
11	Sijunjung	*A.microcarpa*	7 years / 2004	750	Farmer
12	Padang Pariaman	*A.microcarpa*	2001-2003	1,500	Head of forestry service
13	Kota Padang	*A.microcarpa* *A.malaccensis*	2004	2,250	Farmer
14	Muara BungoDs	*A.microcarpha*	1-5 years / 2006-2010	50,000	Farmer
15	Sorolangun Ds	*A.microcarpha*	1-5 years / 2006-2010	75,000	Farmer
16	Lingga	*A. malaccensis*	2001-2004	11,000	Farmer/Community Petani/masy
17	Riau	*A.Malaccensis*	10 years/ 2001	5,000	Farmer/Owner
18	Bangka Selatan	*A.malaccensis, A. microcarpa*	2008/2009	283,414	38.414 (naturally)
19	Bangka Tengah	*A.malaccensis, A. microcarpa*	2008/2009	286,890	Head of forestry service Kadishut (Province level).
20	Bangka Barat	*A.malaccensis, A. microcarpa*	2008/2009	29,500	Head of forestry service Kadishut (Province level).
21	Bangka	*A.malaccensis, A. microcarpa*	-		Head of forestry service Kadishut (Province level).
22	Belitung	*A.malaccensis, A. microcarpa*	2008	26,000	Head of forestry service Kadishut (Province level).
23	Belitung Timur	*A.malaccensis, A. microcarpa*	2008/2009	9,850	Head of forestry service Kadishut (Province level).
24	Lampung Barat	*A.malaccensis, A. microcarpa*	2004	50,000	Forestry Counselor
25	Lampung Timur	*A.malaccensis, A. microcarpa*	2005	30,000	Similar as above
26	Lampung Selatan	*A.malaccensis, A. microcarpa*	2008/2009	5,000	Similar as above
27	Sawaran	*A.malaccensis, A. microcarpa*	2009	15,000	Similar as above
28	Tanggamus	*A.malaccensis, A. microcarpa*	2009	15,000	-idem
29	Lampung Tengah	*A.malaccensis, A. microcarpa*	2007/2008	25,000	Similar as above
30	Lampung Utara	*A.malaccensis, A. microcarpa*	2006	30,000	Similar as above
31	Pringsewu	*A.malaccensis, A. microcarpa*	2009	5,000	Similar as above

No	Regency name	Species	Age/ Year when planted	Number of trees (stems)	Remarks (source)
32	Kutai Barat	*A.malaccensis, A. microcarpa*	2007	100,000 (100 ha)	Head of forestry service/
33	Pasir	*A.malaccensis, A. microcarpa*	2007	15,000	Head of forestry service/ Water Run off Institution
34	Kutai Kartanegara	*A.malaccensis, A. microcarpa*	2006	75,000	Head of forestry service/ Water Run off Institution
35	Samarinda	*A.malaccensis, A. microcarpa*	2006	60,000	FORDA/ Water Run off Institution
36	Malinau	*A.malaccensis, A. microcarpa*	2007	400,000	Forestry Service/ Water Run off Institution
37	Berau	*A.malaccensis, A. microcarpa*	2007	100,000	Forestry Service/ Water Run off Institution
38	Sanggau	*A.malaccensis, A. microcarpa, A.beccariana*	2005	143,000	Forestry Counselor
39	Pontianak	*A.malaccensis, A. beccariana*	2006	29,800	Farmer
40	Kandangan	*A.malaccensis, A. microcarpa*	2009	20,000	Community/ Farmer
41	Barabai	*A.malaccensis, A. microcarpa*	2009	10,000	Community/ Farmer
42	Balangan	*A.malaccensis, A. microcarpa*	2005	25,000	Community/ Farmer
43	Pulau Laut	*A.malaccensis, A. microcarpa*	2003	10,000	Community/ Farmer
44	Tomohon	*Gyrinops*	2005	2,000	Owner
45	Gorontalo	*Gyrinops*	2006	5,000	Owner
	Total			**2,218,949**	

2. Data Recapitulation regarding Gaharu-Yielding Trees in 29 Provinces

No.	Province	Species of Stem Tree	Area vastness (ha)	Remarks
1	West Java	3,830	2.5	
2	Banten	43,000	43.0	
3	Central Java	22,165	22.0	
4	Special Region of Yogyakarta	4,000	4.0	
5	East Timur	37,000	35.5	
6	Special Region of Aceh	17,000	17.0	

No.	Province	Species of Stem Tree	Area vastness (ha)	Remarks
7	North Sumatera	125,000	125.00	
8	West Sumatera	4,500	4.0	
9	Mainland Riau	5000	5.0	
10	Riau Archipelago	11,000	10.0	
11	Jambi	150,000	150.0	
12	Bengkulu	20,000	19.00	
13	Bangka Belitung	602,854	600.0	
14	Lampung	175,000	175	
15	South Sumatera	20,000	10.0	
16	East Kalimantan	750,000	750.0	
17	West Kalimantan	172,800	15.0	
18	Central Kalimantan	12,600	10.0	
19	South Kalimantan	40,000	40.0	
20	North Sulawesi	2,000	2.0	
21	Gorontalo	5,000	5.0	
22	Central Sulawesi	-	-	
23	South East Sulawesi	-	-	
24	South Sulawesi	-	-	
25	Bali	4,000	3.0	
26	West Nusa Tenggara	25,000	20.0	
27	East Nusa Tenggara	3,000	3.0	
28	Maluku	1,500	1.5	
29	Papua	-	-	
	TOTAL	2,218,949		

C. Estimation on the Potency (An Approach)

1. Total number of gaharu-yielding trees that resulted from cultivation in February 2010 approximately reached 2,218,949 stems, with their ages varying from 2 to 20 years.
2. Referring to the assessment as already done at several sites in Sumatera and Kalimantan, the annual growth increment for gaharu-yielding reached 2-3 cm per year
3. Results of the cutting done on several gaharu-yielding trees (planting results) of the *Aquilaria crassna* dan *Aquilaria microcarpa* species with their ages approximately 15 years old, situated in Sukabumi, Bogor, and Banten, then it was acquired that their volume averaged about 25 kg (net) per tree. Meanwhile, for both tree species with their ages 10 years old in the same locations, their average volume reached 15 kg (net) per tree. And correspondingly, also for both tree species but with their ages 5 years old in the same locations as well, their volume averaged about 10 kg (net) per tree.

4. If the lower-level scenario is chosen, whereby the average growth increment of gaharu-tree diameter reaches 2 cm/year, then based on the above data, the the potency as acquired will be, as follows:
   - 25% x 2.218.949 stems (age: 4-5 years) x 10 kg = 5,547,372 kg (1)
   - 30% x 2.218.949 stems (age: 10 years) x 15 kg = 9.985270 kg (2)
   - 30% x 2.218.949 batang (age: 15 years) x 25 kg = 16.642.118kg (3)
   - 15% x 2.218.949 batang (age: > 20 years) x 40 kg = 13.313.694 kg (4)
   - Total of potency = 45,488,454 kgs [=(1)+(2)+(3)+(4)] or 45,488 tons

III. FACTORS THAT AFFECT POTENCY INCREASE

A. Supporting-Factors

1. The engineering technology of gaharu production which is already found
2. The increase in mastering (a know-how) of gaharu-yielding tree cultivation by farmers.
3. The development in technology of gaharu-products processing
4. The chance of market which tends to develop for gaharu products and their derivatives

B. Hindrance-Factors

1. The Indonesia's government decree (PP No. 8, in 1999) regarding the Uses of Flora and Wild Fauna has hinted that each hatching/catching of plant seeds is protected and should ask for permission from the government (Directorate General of Forest Protection and Nature Conservation, administratively under the Indonesia's Ministry of Forestry)
2. The availability of the seed-yielding host trees, which are still limited
3. The hatching/catching of seeds that has not yet developed.

IV. FURTHER ATTEMPTS

1. Continuing of further data collection to the regions, which have once become the main supplier of gaharu from the nature. Such collection can be done by a direct visit or submitting the questionnaires to the information source
2. Conducting the dissemination to the community regarding the engineering technology of gaharu products that comprises prospects and chances of gaharu products from engineering results. The knowledge about the prospect of inoculation technology will encourage the spirits of planting to farmers.
3. Changes in government policies (PP No. 8, in 1999) related to the planting (cultivating) of gaharu-yielding trees
4. Incorporating of the gaharu-yielding trees into the government program, among others: establishment of community-managed plantation forest, rehabilitation of critical land, community empowerment, etc.

5. Counseling to the community regarding the procedures of gaharu endeavors that results from cultivation

V. CONCLUDING REMARKS

1. The mastering and controlling of gaharu-yielding trees that result from cultivation through the database development should be taken as the priority programs.
2. The necessitating of data-collecting methods, which are fast, in order to work out the valid and accurate data. The accurate data can serve as an item to draw-up strategies of gaharu management in order to be sustainable.
3. The sustainable gaharu management will certainly render it free or excluded of the regulation as imposed by the CITES.

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CHEMICAL COMPOSITION OF GAHARU PRODUCTS THAT RESULT FROM INDUCEMENT

By

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ABSTRACT

Gaharu signifies as one of the non-timber forest products (NTFPs) commodities in Indonesia that exerts significant roles on acquiring the state earnings and a direct income from the community who reside in the vicinity of forests. The gaharu-yielding trees, which stand high and are hunted the most by the gaharu-seekers, belong to the genus *Aquilaria* sp. and *Gyrinops* sp. This is because such gaharu affords high quality as well as high commercial (selling) values. The hunting of gaharu with uncontrolled harvest capacity has brought about the situation that the potency of those two species tends to decrease, and as a result gaharu is listed in the list of the CITES' Appendix II. One of the solutions to deal with those inconvenient cases are to synthesize/produce gaharu products through inducement. In relevant, the chemical composition in gaharu products that result from the inducement, in their six-month age, contained 9 kinds of chemical compounds, while in their 20-year age present 150 kinds of compounds, where the latter can be categorized into 24 phenolic derivatives. The phenolic derivatives contained in the induced-gaharu products afford many benefits/uses, such as anti-fungal, anti-microbe, insecticide, coughing remedy, perfumes, cosmetics, etc.

Keywords: Gaharu products, inducement result, chemical composition, phenol.

I. INTRODUCTION

Gaharu is virtually a trade name of wood products (incense) yielded by several species of gaharu-yielding trees. In international trade, this item is known as gaharu, aloeswood, or oudh. This gaharu intrinsically signifies as resin deposit accumulated in the wood tissues, as a reaction or inducement due to tree injury or patogenic infection.

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Variation in gaharu qualities during its synthesis can occur that takes so long a time, where gaharu with high qualities is acquired at the end of this synthesis process (Sumadiwangsa dan Harbagung 2000).

Gaharu in incense shape will give off fragrant smells, if it is burnt (Anonim, 1998). Nevertheless, the trade shape of gaharu varies, beginning from lumps, chips, flour, and gaharu oil (Surata dan Widnyana 2001). Di Indonesia, gaharu commodity in oil form is usually acquired from the distillation or extraction of chips, from the low-quality class. The main economic values of gaharu bears strong relation with its corresponding stems that contain an accumulated sweet-smell dammar. In the drugs/remedy field, gaharu is utilized as traditional sedative, to neutralize unbearable pain, and as digesting medicine particularly in East Asia (Yagura *et al*., 2005). Gaharu is also used as anti *inflammatory* (Trupti *et al*., 2007), to overcome/remedy toothache, kidney troubles, rheumatic, asthma, diarrhea, tumor, diuretic, anti-poison, anti-insect, anti-microbial, stimulus, nerve-system cure, digesting system, liver, hepatitis, cancer, smallpox, malaria, vitality enhancement, pregnancy period, and giving birth (Hayne, 1987; Barden *et al*., 2000; Suhartono and Mardiatuti 2002; Adelina 2004). Recently, it was found that other portions of gaharu-yielding trees can be used as drugs/medicine, such as the extract of *Aquilaria sinensi*s (Lour.) Gilg, which exhibits laxative effects to deal with constipation diseases (Hara *et al.,* 2008). In perfumery industries in Europe, gaharu become one of the expensive items. Smoke or gaharu oil is used by the community at Middle East to make fragrant the body or room. The gaharu fragrance is also used in the manufacture of soap, shampoo, and aromatherapy.

Indonesia is potentially rich in gaharu-yielding tree sources, but unfortunately the trees sought the most by gaharu-hunters are of the genus *Aquilaria* sp. and *Gyrinops* sp., because the gaharu as such affords high quality and high commercial values. The high intensity of gaharu hunting with its uncontrolled harvest capacity has brought about the gaharu potency from those two species tends to decrease, and consequently gaharu is listed in list of the CITES's Appendix II (Blanchette, 2006; Sumarna, 2005a; Sumarna, 2005b; CITES, 2004; Suhartono and Mardiastuti, 2002).

II. CHEMICAL COMPOSITION

Sapwood gaharu exemplifies as merely unexuded resin, but rather it is deposited in the wood tissues of trees. This resin deposit renders the wood with loose fibers and white color becoming solidly compact, white in color, and fragrant in smell. This resin belongs to sesquiterpene group, which is easily volatile (Ishihara *et al*., 1991). Most of the compounds in gaharu are identified as sesquiterpenoid group. One of the fragrant-smelling compounds in gaharu was first identified by Bhattacharyya dan Jain as *agarol,* categorized as mono-hydroxy compunds (Prema and Bhattacharyya, 1962).

Research conducted by Nakanishi succeeded in characterizing *jinkohol* (2β-*hydroxy*-(+)-*prezizane*) in gaharu originated from Indonesia, through benzene extraction. This team also found two new sesquiterpene compounds in *Aquilaria malaccensis* Lamk. from Indonesia, comprising jincoheremol dan jincohol II, called as type B to differentiate it from the type A of *A. agallocha* Roxb., and isolated *alpha-agarofuran* and (-)-10-*epi-gamma-eudesmol*, *oxo-agarospirol* as the main constituent at gaharu type B (Burfield 2005a). In Burfield (2005a), it was stated that Yoneda managed to identify the main sesquiterpene that existed in gaharu type A (in *A. agallocha*) and type B (in *A. malaccensis*). Gaharu type A contained β-*agarofuran* 0,6%, *nor-ketoagarofuran* 0,6%, *agarospirol* 4,7%, *jinkoh-eremol* 4,0%, *kusunol* 2,9%, *dihydrokaranone* 2,4%, and *oxo-agarospirol* 5,8%. Meanwhile, in gaharu type B were identified compounds comprising β-*agarofuran*(-)-10-*epi*-β-*eudesmol* 6,2%, *agarospirol* 7,2%, *jinkohol* 5,2%, *jinko-eremol* 3,7%, *kusunol* 3,4%, *jinkohol* II 5,6% dan *oxo-agarospirol* 3,1%.

III. RESULT OF INDENTIFICATION ON CHEMICAL COMPOSITION

Results regarding the analysis of GCMS (gas chromatography – mass spectrometry) on 6-month old induced-gaharu brought out 9 chemical constituents, of which only 4 constituents were identifiable that comprised 4-hydroxy-4-3thyl-2-pentanone (5.3%), Oxirane, 2,3-epoxy butane (0.6%), 2-butoxy ethanol (70.5%) dan 1,2 benzene dicarboxylix acid (9%) (Wiyono, 2008).

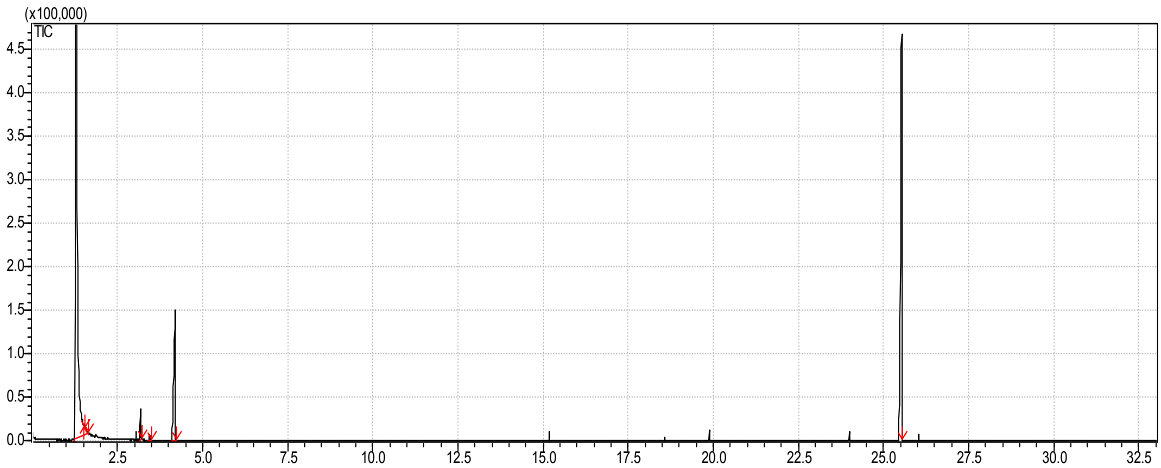

Figure 1. Chromatogram revealing constituents in 6-month old induced gaharu

Further, results of GCMS analysis on the induced gaharu products originated from Dramaga and Carita each comprising 2 sample trees revealed that there were 16 phenol compounds that belong to high group, and 8 phenols as low group (Table 1). Scrutinizing that Table 1, it seems that there has occurred a sequence (series) of secondary metabolite process, such as the evolving/release of iseugenol and veratrol compounds that function as perfumes and medicine, whereby those two compounds are not encountered in regular wood. The veratrol itself is evolved from phenol compounds that undergo hydrolysis into catechol, which further through a sequence of complex mechanisms, i.e. Kreb cycle, is transformed to veratrol. Likewise, eugenol compounds are evolved from guaiacol (main constituent of lignin) through ferulic acid intermediate.

Results of identification on gaharu resin indicated the presence of caryophene compounds that typify the main constituents for eugenol which usually exists in clove leaves. In gaharu resin were also identified cembren compounds (diterpenoid) that comprised a feromon compound effective for termites, a palustrol compound as antitusive, and copaene compounds that can function as essential oil and are rather toxic to be taken orally if the LD is 5000 mg/kg.

Chemical composition of gaharu that resulted from inducement (induced gaharu) varied remarkably with different sample trees, and even the sample tree code-named as no. 10 contained particular compounds not already present in other sample trees (Table 3).

Regarding the chemical composition, 6-month old induced gaharu just yielded 9 chemical constituents (Figure 1), while the induced gaharu products with 21-year age brought out more than 100 chemical constituents (Figure 2), and the corresponding gaharu resin yielded about 15 chemical constituents. This is explainable since the 6-month gaharu product was still in the early stage of gaharu development, which further brought out chemical compounds, thereby in the end leaving the gaharu resin with fewer chemical constituents.

Table 1. Phenol compounds present in the induced gaharu products

No.	Compound name	High total of phenolic		Low total of phenolic	
		H0C18	H0D7	H0C14	H0D10
1	benzene, 1,2-dimethoxy- (CAS) veratrol	0.38			0.19
2	1,2-benzenediol, 3-methyl- (CAS) 3-methylpyrocathecol	0.99		0.47	0.94
3	1,2-benzenediol (CAS) pyrocathecol		2.2	3.53	4.07
4	1,4-benzenediol, 2-methoxy- (CAS) hydroquinone, 2-methoxy	0.14			0.36
5	1,4-benzenediol/hydroquinone	8.91	10.93	6.41	
6	phenol, 4-methoxy- (CAS) Hqmme	6.97	0.87		
7	caffeine	0.19			
8	phenol, 2-ethoxy- (CAS) guethol	4.66			
9	phenol, 4-ethyl-2-methoxy (CAS) p-ethylguaiacol	1.1	0.86	0.88	3.11
10	phenol, 2-methoxy-4-propyl- (CAS) 5-propyl-guaiacol	0.39	0.18		
11	phenol, 2-methoxy- (CAS) guaiacol		4.43	2.64	1.56
12	phenol, 2-methoxy-4-(1-propenyl)- (E) (CAS)(E)-isoeugenol	0.95	0.85	1.12	1.38
13	phenol, 2-methoxy-4-(2-propenyl)- (CAS) eugenol			0.19	
14	Phenol, 4-(3-hydroxy-1-propenyl)-2-methoxy-(CAS) coniferil alkohol	4.23	3.92	3.56	1.44
15	phenol, 3,4,5-trimethoxy (CAS) antiarol	0.88	1.69		2.01
16	quinic acid	5.96	1.91	0.69	

No.	Compound name	High total of phenolic		Low total of phenolic	
		H0C18	H0D7	H0C14	H0D10
17	4H-1-benzopyran-4-one, 2-methyl- (CAS) 2-methylchromone				1.23
18	4H-1-benzopyran-4-one, 6-hydroxy-2-methyl- (CAS) 6-hydroxy-2-methylchromone				0.1
19	benzaldehyde, 4-hydroxy-3-methoxy- (CAS) vanilin				0.7
20	benzeneacetic acid, 4-hydroxy-3-methoxy-(CAS) homovanillic acid				0.56
21	Capcaisin				0.09
22	Jasmolin II (CAS) cyclopropane carboxylic acid, 3-(3-methoxy-				0.22
23	octanoic acid (CAS) caprylic acid				0.16
24	1,3-benzenediol, 4-ethyl- (CAS) 4-ethylresorcinol				1.4
Total concentration		40.45	39.89	19.78	22.57

Remarks: Relative concentration in percentage (%); trees with high total of phenolic compounds are presumed as the resistant trees; trees with low lotal of phenolic compounds are presumed as the vulnerable trees; H0C18 = sample tree with code-number 18, growing in Carita; H0C14 = sample tree with code-number 14, growing in Carita; H0D7 = sample tree with code-numbered 7, growing in Dramaga; H0D10 = sample tree with code-numbered 10, growing in Dramaga
Source: Novriyanti (2008)

Table 2. Uses of compounds present in gaharu

Compounds	Remarks
Caffeine	exists in simple phenol form, i.e. caffeic acid; it exerts the role as antibacterial, anti-fungi, and anti-virus (Cowan, 1999)
Hidroquinone	referring to the diphenol, easily oxidized to ketone called as quinone. Quinone is potentially efficacious as anti-microbial, since it can involve in complex reaction with the nucleophilic amino acid in protein; it frequently brings about inactivation and loss of protein function. As an example is the anthraquionone isolated from *Cassia italica* (Cowan, 1999).
Eugenol	characterized as bacteriostatic against fungi and bacteri (Cowan 1999). eugenol is used in the manufacture of perfumes, essential oils, and drugs. This compound is used to synthesize iso-eugenol, required in the manufacture of tannin, which is needed in the synthesis of vanillin. Vanillin serves as essential stuff in drugs, perfume industry, and fragrance inducer. Eugenol and iso-eugenol are derived from the lignin precursors, which present ferulic acid or coniferyl alcohol (Rhodes, 2008).
Coniferyl alcohol	signifies as imunity (defence) compound with type of phito alexin; it belongs to phenyl-propionic group; as an example is the compound present in *Linum usitiltissimum* (Sengbusch, 2008).
Guaiacol	serves as intermediate in the synthesis of eugenol dan vanillin; it is also used as antispeptic and parasiticide (Li and Rosazza, 2000).
Catechol and pyrogallol	virtually an hydroxylated phenol which is toxic to microorganisms; position and number of hydroxyl (OH) group at the phenol group are presumably related to their relative toxicity against microorganisms, whereby such toxicity tends to increase with the greater intensity of hydroxylation (Cowan, 1999).

Compounds	Remarks
Veratrol	Merely dimethyl ether of pyrocatechol. This compound and its derivatives are used as antiseptic, expectorant, sedative, deodorant, and paraticide (Wikipedia, 2008a). The resveratrol as derived from *p*-hidroxycinnamic acid and 3 units of malonate exihibits anti-microbial charateristic (Torssel, 1983).

Compound name	Remarks
Caprilic acid	intrinsically phenolic compund, which is used a lot commercially in the synthesis of ester for perfume industry; it exhibits anti-bacteria, and can cure bacteria infection (Nair *et al*., 2005).
Capsaicin	basically terpenoid at *Capsicum annuum*, which exhibits anti-microbial characteristics (Cowan, 1999).
Jasmolin II	virtually one of the compounds in the stuff called *Pyrethrins*, which affords toxicity and can be used as insecticide (Spurlock,2006).
3-hydroxychroman; 2-methy;chromone; 6-hydroxy-2-methylchromone	chromone compounds are essentially the compounds isolated from gaharu, besides sesquiterpenoid group (Yagura *et al*., 2005; Yagura *et al*., 2003).
Vanilin dan asam vanilic acid	*Vanillin* signifies as the essential stuff in drug synthesis, perfume industry, and fragrance inducer.

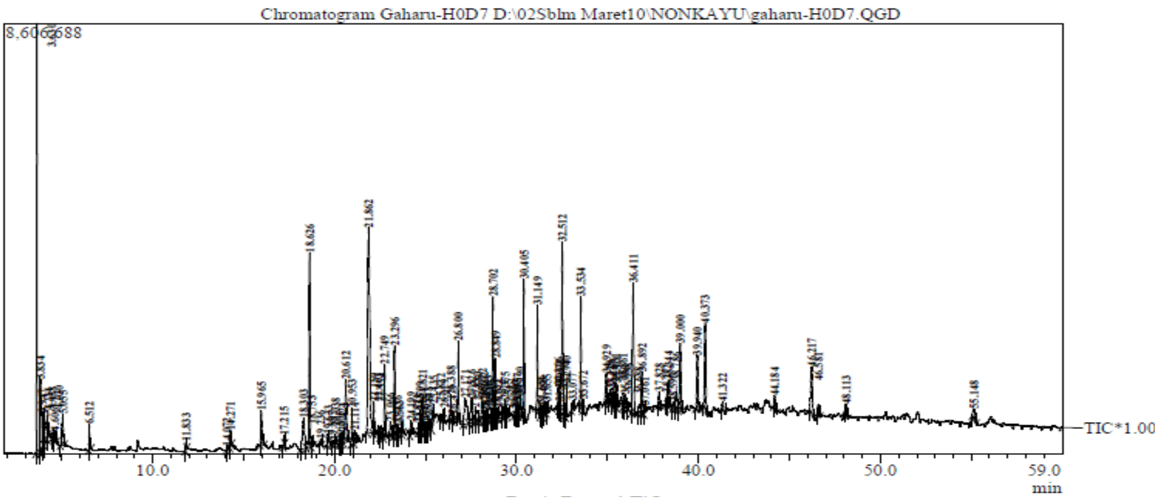

Figure 2. Chromatogram of the induced gaharu, originated from Dramaga (sample tree with code-number 7)

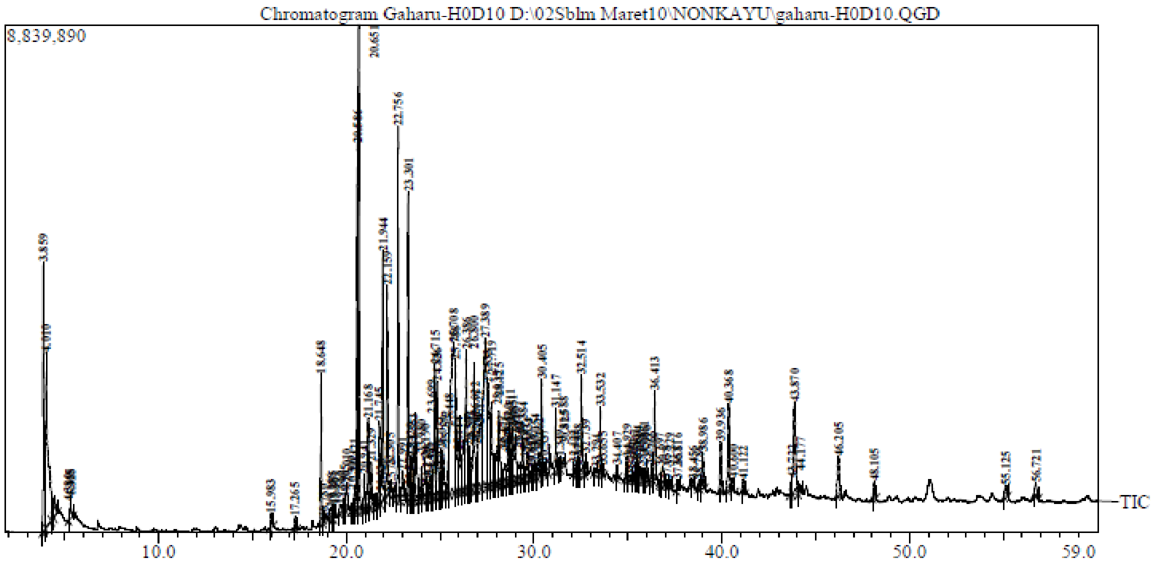

Figure 3. Chromatogram of the induced gaharu, originated from Dramaga (sample tree with code-number 10)

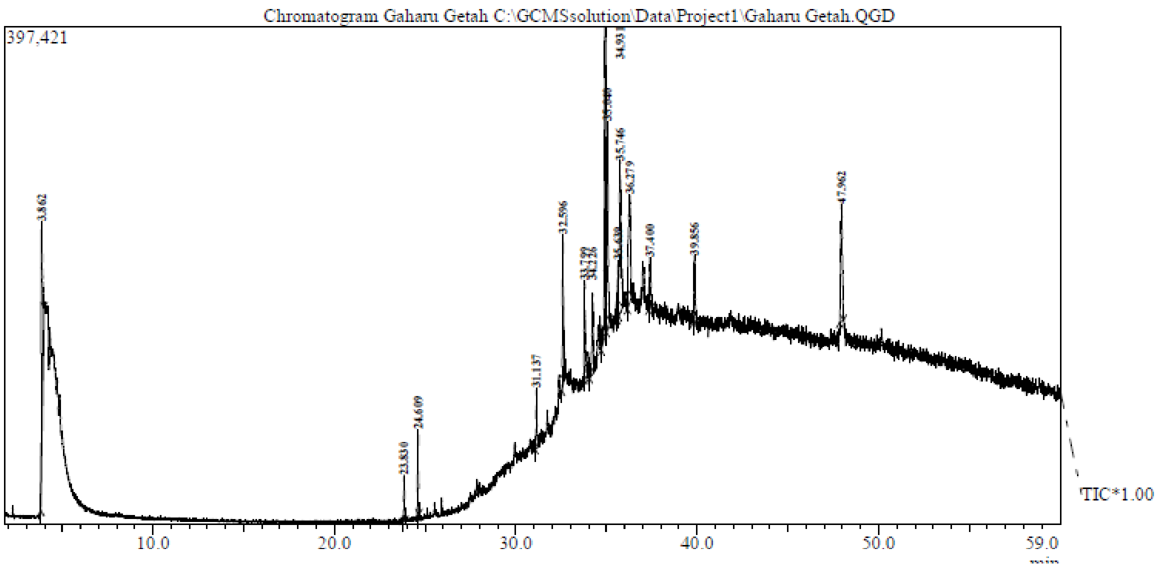

Figure 4. Chromatogram of gaharu resin

IV. CONCLUDING REMARKS

Gaharu that results from inducement (i.e. induced gaharu) signifies as one of the solutions to deal with the scarcity of the conventional gaharu products which so far are acquired from the nature. Chemical composition in the induced gaharu contained 24 phenol compounds, each of which afforded its own benefits/uses. Those benefits/uses are among others as coughing remedy, perfumes, anti-bacteria, anti-fungi, insecticides, etc.

The induced gaharu exhibited significant variation in chemical compositions among different gaharu-yielding trees. As the future challenges for the induced gaharu, it is how to synthesize such induced gaharu that its chemical compositions are relatively similar to those of the conventional gaharu, thereby enabling it to produce induced-gaharu products with their uniform qualities.

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STANDARDIZATION DAN EFFECTIVENESS OF BIOINDUCTION ON GAHARU DEVELOPMENT AND ITS QUALITIES

by:
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ABSTRAK

Gaharu signifies as one of the non timber forest products (NTFPs) commodities which affords high economy value in enhancing the state earnings. Gaharu presents a resin product that evolves fragrant smell occurring to the secondary metabolism reaction between the gaharu-yielding and particular fungi. In nature, the gaharu-yielding trees can be induced by fungi through the nature injury, but only with limited extent. Until this occasion, there are no fewer than 26 tree species that yield gaharu, two of which, namely *Aquilaria* spp. dan *Gyrinops* spp. still belong to the category regarded as scarce. The Forest Microbiology Laboratory, under the R&D Centre for Forest Conservation and Rehabilitation so far has collected particular fungi able to develop gaharu, called *Fusarium* spp. from Aceh until Papua, which in reached 54 fungi species. Meanwhile, 8 out of those 54 fungi species have been trial tested, comprising FORDA CC-00499 (from West Kalimantan), FORDA CC-00500 (Jambi), FORDA CC-00509 (FORDA CC-00509), FORDA CC-00501 (West Sumatera), FORDA CC-00512 (Papua), FORDA CC-00495 (South Kalimantan), FORDA CC-00497 (Central Kalimantan), and FORDA CC-00511. Further 3 out of those 8 species afforded their virulence consecutively FORDA CC-00509, Papua, and Kalimantan Tengah (as the highest virulence), followed in decreasing order by those from Jambi, West Nusa Tenggarta and Kalimantan Barat (as the medium virulence), and ultimately those from West Sumatera dan South Kalimantan Selatan (as the lowest). For the bio-inducement on gaharu development, it needs standardization and effectiveness toward such bio-inducement in order to develop gaharu with favorable qualities.

Keywords: *Fusarium* spp., bio-inducement, standardization.

I. INTRODUCTION

The gaharu products originated from the nature, their sources tend to become alarmingly limited. Meanwhile, gaharu products in shape can form like cut sizes, chips,

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lumps, or flour. The commercial value of gaharu is determined by the fragrance smell, and wood aroma that evolves when being burnt. The community recognizes (identifies) the class and qualities of gaharu through the names of consecutively sapwood, kemedangan, and flour. Besides, in raw material (unprocessed) form as wood chips, at present through the distillation can be obtained gaharu-essential oil with high value. The uses of gaharu in Indonesia by the community particularly the inland Sumatera and Kalimantan has procceded for quitea long time. Traditionally, gaharu is used as among others incense for ritual and religious ceremony, body fragrance, room scent, cosmetics, and simple drugs. Recently, the market demand of gaharu by the Middle East and several European, American countries, and East Asian countries (Korea, Japan, and China) tends to increase, whereby such gaharu is used as rawm material for herbal drugs (Siran and Turjaman, 2010).

As of this occasion, the gaharu distributed in the market either domestic or abroad is still originated from mostly the nature with its varying qualities. The increase in gaharu traded since the last tree decades has brought about the scarcity in the production of gaharu sapwood from the nature. For these reasons, the particular species of gaharu-yielding trees, that comprise *Aquilaria* dan *Gyrinops* have been included in the Appendix II of the CITES, as the protected species. Besides being due to the high intensity of gaharu hunting, the decrease in gaharu production is also brought about by the declining supportive ability of natural production-forest that goes concomitantly with the uncontrolled illegal logging and converstion of forest area for other purposes (e.g. plantation establishment, community resettlement, etc).

In an attempt to accelerate gaharu production, the R&D Centre for Forest Conservation and Rehabilitation has invented the technology for gaharu inducement with the help of gaharu-developing fungi. Santoso *et al*. (2006) reported that results of purification on those gaharu-developing fungi were indicatively dominated by the particular fungi species of *Fusarium* spp . For this technology, the gaharu development as such afforded to reach 90-100%. The research on gaharu by the group of Forest Microbiology researchers started in 1984, who conducted the bio-inducement using soild isolates, whereby the gaharu-developing fungi was grown on wood sawdust, and then those isolates were inoculated into the stem of gaharu-yielding trees. Prior to the inoculation, the boring (drilling) was performed on the stem surface, using the drill bit with 10-15 mm in diameter, while the direction of holes inclined at 45^o angle to the stem surface. Afterwards, the solid isolates were induced into the stem through a pipe that was pushed inward using a wood stick, thereby causing such isolates entering the induction holes that were further closed with a paraffin. With such treatment, it turned out that the success of gaharu development reached 40-60%. Usually, the rotting (decay) occurred to the resulting gaharu, when the raindrops entered into the induction holes.

In 2000, the R&D Centre for Forest Conservation and Rehabilitation researchers improved the induction technology, and used the liquid-inoculant media. Meanwhile, the diameter of drill (boring) bit was reduced to 3 mm. The induction treatment in direction was almost perpendicular to the stem surface, and as such the resulting holes reached as a third (1/3) in depth inward as the steam diameter. The drilling (boring) work should be such that it avoid reaching or hitting physically the pith. The liquid inoculant as induced into the holes in amount reached about 1 cc, and afterwards the holes left unclosed (unplugged).

The group of Forest Microbiology researchers has collected 54 fungi isolates from Aceh until Papua. Out of those 54 fungi species, as many as 8 species was already induced, comprising FORDA CC-00499, FORDA CC-00500, FORDA CC-00509, FORDA CC-00501, FORDA CC-00512, FORDA CC-00495, FORDA CC-00497, and FORDA CC-00511. Further, from those 54 species of gaharu-developing fungi, only 36 fungi species was already identified (Sitepu *et al*., 2010).

Objective of these researchs were to acquire the data and information about the distance and amount of liquid inoculant as induced into the stem of the gaharu-yielding trees, therefore the reliable standard can be determined for the induction and regarding the appropriate amount of liquid inoculant as induced into the trees that develop gaharu, and to acquire the data/information about the direction and the depth of induction holes, which afterwards remain unclosed.

II. MATERIALS AND METHODS

A. Object Description

The process of inoculant preparation was done at the Forest-Microbiology, R&D Centre for Forest Conservation and Rehabilitation (Bogor) The location as selected for the inducement process took place at consecutively Sukabumi, Carita (Banten), Bodok (West Kalimantan), and West Nusa Tenggara, that each served as the demonstration plot. In this research, there was also a demplot situated at Sukabumi, where thein inducement was done on the gaharu-yielding trees, growing (plots).

B. Materials

The materials consisted of consecutively:

1. Gaharu–yielding trees, comprising *Aquilaria malaccensis* (plot Sukabumi), *Aquilaria microcarpa* (West Kalimanta), *Gyrinops* sp. (West Nusa Tenggara).
2. Fungi species, comprising (FORDA CC-00509/FORDA CC-00509), FORDA CC-00500/ Jambi), (FORDA CC-00501/West Sumatera), (FORDA CC-00499/Wst Kalimantan), (FORDA CC-00497/Central Kalimantan), (FORDA CC-00495/South Kalimantan), (FORDA CC-00511/West Nusa Tenggara), and FORDA CC-00512/Papua).
3. Gaharu-yielding trees which were already induced, which in number reached 15 trees

Meanwhile, the equipment as used consisted of portable electric generator set, electric drill (borer), drill bits with 3-mm diameter, inducement device, measuring (gauge) tool, writing sets, camera, and labels.

C. Methods

The method as implemented presented the induction using liquid-inoculant as done in the following:

1. The induction using four species of gaharu-developing fungi, comprising (FORDA CC-00509/FORDA CC-00509), (FORDA CC-00500/Jambi), (FORDA CC-00511/West Nusa Tenggara), (FORDA CC-00501/West Sumatera), dan (FORDA CC-00499/West Kalimntan). Such induction was done in Sukabumi, on *Aquilaria malaccensis* tree species.
2. Other induction using 4 species of gaharu-developing fungi, comprising (FORDA CC-00497/Central Kalimantan), (FORDA CC-00495/South Kalimantan), (FORDA CC-00511/West Nusa Tenggara), and (FORDA CC-00512/Papua). Such induction took place was performed on two species of gaharu-yielding trees (*Aquilaria microcarpa* dan *Gyrinops* sp.) originated from West Kalimantan and West Nusa Tenggara.
3. For induction no. 1, the stem of on *Aquilaria malaccensis* tree was drilled (bored) using a drill bit with 3-mm diameter, through its surface, until reaching the depth inward one third (1/3) of the stem diameter. The distance between the resulting holes and the next holes was 10 cm. After drilling, into the holes was injected 2 cc of liquid inoculant. The drilling in direction was perpendicular in direction to stem surface.
4. For induction no. 1, the drilling manner was similar to no. 1, but distance between the inoculatio holes varied in 4 levels, namely 5 cm, 10 cm, 15 cm, and 25 cm. This was indended, because the varying distances would determine the induction standard regarded as effective in gaharu development.
5. All the resulting inoculation should not be closed (remain unplugged).
6. The gaharu-yielding trees as induced with four fungi species still not yet recognized (identified) regarding their role on those trees comprised the fungi from consecutively Papua, South Kalimantan, Central Kalimantan Tengah, and West Nusa Tenggara. Each of those 4 fungi specues was inoculated to *Aquilaria microcarpa* trees. For the fungi originated from West Nusa Tenggra location, the distances between injection/inoculationi holes varied at 5 cm, 10 cm, 15 cm, and 20 cm, each with 3 replications, or 4 *Fusarium* sp. fungi species x 4 injection treatements x 3 replicates; and therefore as many as 48 trees were needed. Likewise, for the fungi originated from West Kalimantan location, the distances between injection/inoculation holes varied at 10 cm, 15 cm, 20 cm, and 25 cm, each with 3 replications, or 4 *Fusarium* sp. fungi species x 4 injection treatements x 3 replicates; and therefore as many as 48 trees were needed as well.

7. For further induction test in West Kalimantan and West Nusa Tenggara, these activities revelaed a part of a series regarding the trial test on gaharu induction at various species of gaharu-yielding trees in various locations with their varying micro-climate conditions. The induction activities took place in locations of West Kalimantan and West Nusa Tenggara. The four fungi isolates which were already recognized/ identified afforded their favorable qualities 3 years after their induction, comprising FORDA CC-00509, FORDA CC-00500, FORDA CC-00499, dan FORDA CC-00501. Such induction was done on each of their particular trees, in each of their locations, thereby reaching the total of 80 trees, with the details involving 4 isolates x 10 trees x 2 species of gaharu-yielding trees (i.e. *Aquilaria microcarpa* dan *Gyrinops* sp.) with the induction distance as far as 10 cm.

D. Parameters

The parameters as performed were as follows:

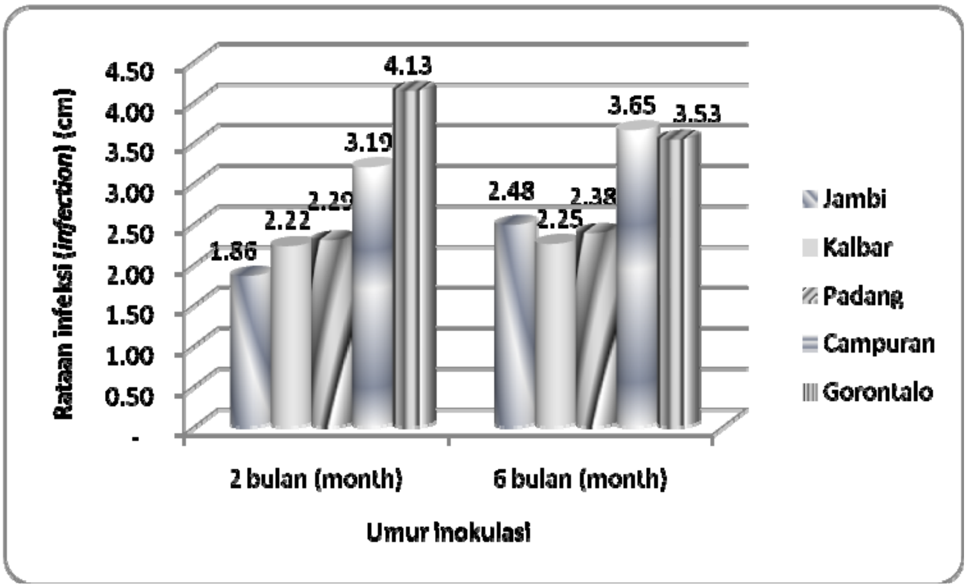
1. Observing the infection symptom, and effect of the gaharu-developing fungi
2. Measuring the induction symptom in length and in width, when the induction results reached 3-month age.
3. Observing the effect of environment which revealed the role in the infection caused (induced) by the gaharu-developing fungi.
4. For the trees which were induced by the fungi species of consecutively FORDA CC-00509/FORDA CC-00509, FORDA CC-00500/Jambi, FORDA CC-00505/West Sumatera, and FORDA CC-00499/West Kalimantan, the sample-taking was done when the induction results reached the age of 1 year, 2 years, and 3 years, respectively.

III. RESULTS AND DISCUSSION

Results of induction using the particular fungi (i.e. FORDA CC-00509, FORDA CC-00500, FORDA CC-00501, dan FORDA CC-00499) on *Aquilaria malaccensis* trees, under the condition facing the infection by those fungi, the trees would repond to defend and restore themselves. The tree resistance would determine who was the winner between the trees themselves and the disease caused (induced) by those microorganisms (fungi). In the gaharu development, certainly the disease was expected to win, thereby developing the gaharu as desired. The chemical compounds owned by in this regard the *Aquilaria malaccensis* trees signified as an attempt of tree resistance against the disease-inducing microorganisms (fungi). The gaharu itself was already indentified as containing among others sesquiterpenoid, a defending compund of phytoalexin type. The vulnerability of trees in facing the fungi infection was related to development of gaharu, whereby the gaharu qualities either qualitatively or quantitatively could be each reflected by the extent of infection and the content of other compounds.

In Figure 1 can be seen that the length of infection that occurred to the stem of *Aquilaria malaccensis* trees, when the inoculation results reached 2-month and 6-month age. At two-month age, the isolat FORDA CC-00509 isolate exhibited the highest infection value (4.13 cm in length), followed in decreasing order by the mixed isolates, Padang, West Kalimantan, until the lowest as shown by the infection induced by the isolates from Jambi. From the analysis of variances, it revealed that the isolate origin significantly affected the infection length as occurred to *Aquilaria malaccensis* (Tabel 4). Further test using the Duncan's mulitiple range test convinced that 2 months after inoculation the FORDA CC-00509 isolates brought about the largest infection on the stem of this gaharu-yielding tree species, followed in decreasing order by the mixed isolates (Table 1).

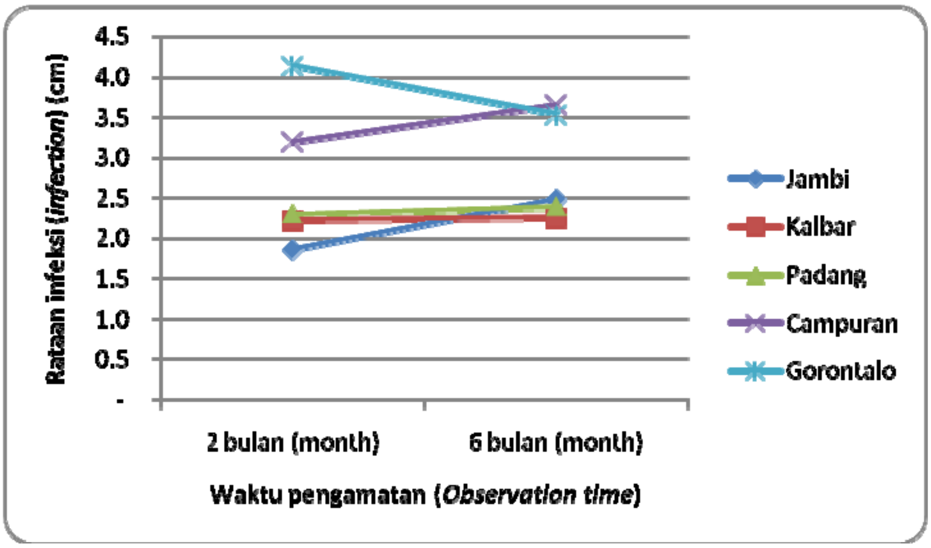
Different from the condition at 2-month inoculation age, at 6-month inoculation age the fungi (isolates) exhibited their typical infection symptom. At this 6-month age, statistically the isolate did not inflict significant effect on the infection that occurred at *Aquilaria malaccensis* stem. This was shown by the analysis of variance (Table 2). Nevertheless, similar to the condition at 2-month inoculatiuon age, from Figure 1 could be seen that the highest infection was caused (induced) by the FORDA CC-00509 isolates and its mixture.



Remarks: Umur inokulasi = Inoculation age; Asal isolat = Isolate origin; panjang infeksi = infection rate; campuran = mixed isolates; Kalbar = West Kalimantan

Figure 1. Length of infection that occurred to the stem of *Aquilaria microcarpa* trees

Figure 2 shows that the changes in infection length that occurred beginning 2-month inoculation age until 6-month age. Although the FORDA CC-00509 isolates still inflicted the largest infection, the infection at 6-month inoculation age did not undergo significant changes. Meanwhile, the infection by another four isolates (with their different origins) revealed the varying increase. Nevertheles, statistically at 6-month inoculation age the different isolate origins did not bring about significant effect on the infection rate (the significant level reaching 0.186 at a = 5%).



Remarks: Umur inokulasi = Inoculation age; Asal isolat = Isolate origin; panjang infeksi = infection rate; campuran = mixed isolates; Kalbar -= West Kalimantan

Figure 2. Infection rate at the stem of *Aquilaria mcrocarpa* trees

Table 1. Analysis of variance regarding the effect of treatment (region origin of the *Fusarium* sp. isolates) on the length of infection at the stem of *Aquilaria microcarpa* trees (β=0,05)

Pengamatan (*Observation time*)	Sumber keragaman (*Source*)	Db (df)	Jumlah kuadrat (*Sum of square*)	Kuadrat Tengah (*Mean of square*)	Fhit (*F-calc*)	Sig.
2 bulan (2 *months*)	Asal isolat (*Isolate origin*)	4	10,172	2,543	16,760	0,000 **
	Galat (*error*)	10	1,517	0,152		
	Total	14	11,689			
6 bulan (6 *months*)	Asal isolat (*Isolate origin*)	4	3,809	0,952	2,894	0,079 **
	Galat (*error*)	10	3,290	0,329		
	Total	14	7,099			
Laju infeksi (*Infection rate*)	Asal isolat (*Isolate origin*)	4	0,153	0,038	1,907	0,186 ns
	Galat (*error*)	10	0,201	0,020		
	Total	14	0,354			

Remarks: ** = significant at 1% level, ns = not significant

Table 2. Further test using the Duncan's multiple range tests on the infection length on the stem of *Aquilaria microcarpa* trees, at 2-month inoculation age

Asal isolat (Isolate origin)	Rataan (Mean value of the infection length)
Jambi	1,857a
Kalimantan	2,223a
Padang	2,297a
Campuran	3,193b
FORDA CC-00509	4,133c

Note: *values followed by the same letters are insignificantly different*); β=0,05

The development of infection as occurred 6 months after inoculation revealed that region origin did not bring about significant effect any longer on the infection length (Table 1), although the largest infection was still caused (induced) by the mixed isolates, and the FORDA CC-00509 isolate caused the largest infection, the consistency in the infection development still deserves firther research by viewing the development of infection rate by the isolat FORDA CC-00509 isolates until reaching the particular period.

Scrutinizing the infection development on the stem of *Aquilaria malaccensis* trees, it can be inferred that the FORDA CC-00509 isolates brought about the largest infection (in length), which implied that this isolate afforded the development of gaharu the most favorable qualities. Although the mixed isolates exhibited the longest infection length 6 months after inoculation, there was a possibility that this was merely caused (induced) by the FORDA CC-00509 isolates themselves. Meanwhile, the longer duration as allowed for those 4 species of gaharu-developing fungi as described as above, then the better the qualities of the resulting gaharu.

For the induction using other fungi species, that comprised FORDA CC-00497, FORDA CC-00495, FORDA CC-00511, and FORDA CC-00512, as induced on the stems of *Gyrinops* sp. that existed in West Nusa Tenggara, 3 months after inoculation could be presented in Table 3.

Table 3. Inoculation some isolates of *Fusarium* spp. to *Gyrinops* sp. after 3 months di West Nusa Tenggara

No	Number of replication	Tree	Inoculant	Distance	Infection development (in average), cm	
		Code No.	origin	between injection holes (cm)	Vertical direction	Horizontal direction
1	3	1	FORDA CC-00512	5	X	x
2	3	1	FORDA CC-00512	10	0,50	2,00
3	3	1	FORDA CC-00512	15	1,00	6,00
4	3	1	FORDA CC-00512	20	1,33	8,57

No	Number of replication	Tree	Inoculant	Distance	Infection development (in average), cm	
		Code No.	origin	between injection holes (cm)	Vertical direction	Horizontal direction
5	3	2	FORDA CC-00495	5	0,63	3,67
6	3	2	FORDA CC-00495	10	0,70	2,57
7	3	2	FORDA CC-00495	15	0,67	1,47
8	3	2	FORDA CC-00495	20	0,60	2,43
9	3	3	FORDA CC-00497	5	0,50	2,50
10	3	3	FORDA CC-00497	10	0,53	3,83
11	3	3	FORDA CC-00497	15	0,77	2,17
12	3	3	FORDA CC-00497	20	0,47	2,17
13	3	4	FORDA CC-00511	5	0,40	3,40
14	3	4	FORDA CC-00511	10	0,23	2,43
15	3	4	FORDA CC-00511	15	0,40	3,33
16	3	4	FORDA CC-00511	20	0,37	2,77

Remarks: distance (between injection holes) 5 cm, 10 cm, 15 cm, and 20 cm

From Table 3, it can be indicated that the injection using the FORDA CC-00512 isolates at 5 cm distance (between the injection holes), all the injected trees become dead, while at the distance of 10 cm and 15 the tree death portion reached 66.67%. Likewise, the tree induction using the FORDA CC-00511 isolates at 5 cm distance, the tree death portion reached 66.67 as well (Table 4), and this was brough by among others the distance effect, the ferocity (severity) of *Fusarium* fungi, and the resistance of the trees themselves.

Table 4. The portion (percentage) of tree death at 3-month age (duration) after inoculation by the fungi isolates.

Inoculant origin	Number of dead trees	Number of replications	Distance of injection	Portion the dead trees
FORDA CC-00512	3	3	5	100
FORDA CC-00512	2	3	10	66.67
FORDA CC-00512	2	3	15	66.67
FORDA CC-00512	0	3	20	0
FORDA CC-00495	0	3	5	0
FORDA CC-00495	0	3	10	0
FORDA CC-00495	0	3	15	0
FORDA CC-00495	0	3	20	0
FORDA CC-00497	0	3	5	0
FORDA CC-00497	0	3	10	0
FORDA CC-00497	0	3	15	0
FORDA CC-00497	0	3	20	0

Inoculant origin	Number of dead trees	Number of replications	Distance of injection	Portion the dead trees
FORDA CC-00511	2	3	5	66.67
FORDA CC-00511	0	3	10	0
FORDA CC-00511	0	3	15	0
FORDA CC-00511	0	3	20	0

Remarks: injection distance (between injection holes)

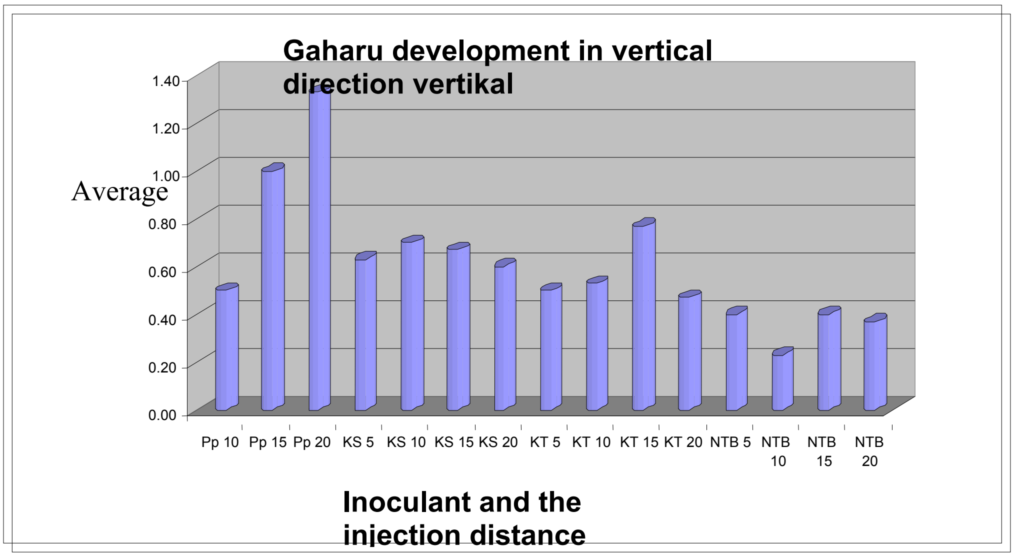
The induction using those fungi isolates, that comprised FORDA CC-00497, FORDA CC-00495, FORDA CC-00511, FORDA CC-00512, as done on the stem of pada *Aquilaria microcarpa* trees growing in Bodok (West Kalimantan), when the inoculation results reached 3-month age is presented in Table 5.

Table 5. Induction results using *Fusarium* spp. isolate conducted on the stem of *Aquilaria* spp. (in West Kalimantan) at 3-month inoculation age

No	Number of replication	Tree code No.	Inoculant origin	Injection distance	Infection development (in average), cm	
					Vertical direction	Horizontal direction
1	3	1	FORDA CC-00512	10	0.80	3.80
2	3	1	FORDA CC-00512	15	0.77	4.47
3	3	1	FORDA CC-00512	20	0.80	4.60
4	3	1	FORDA CC-00512	25	0.83	4.73
5	3	2	FORDA CC-00495	10	0.67	1.70
6	3	2	FORDA CC-00495	15	0.70	1.50
7	3	2	FORDA CC-00495	20	0.70	1.73
8	3	2	FORDA CC-00495	25	0.70	1.70
9	3	3	FORDA CC-00497	10	1.00	3.47
10	3	3	FORDA CC-00497	15	1.00	4.30
11	3	3	FORDA CC-00497	20	1.00	3.73
12	3	3	FORDA CC-00497	25	1.00	3.57
13	3	4	FORDA CC-00511	10	0.80	2.63
14	3	4	FORDA CC-00511	15	0.87	2.80
15	3	4	FORDA CC-00511	20	0.77	2.53
16	3	4	FORDA CC-00511	25	0.87	2.73

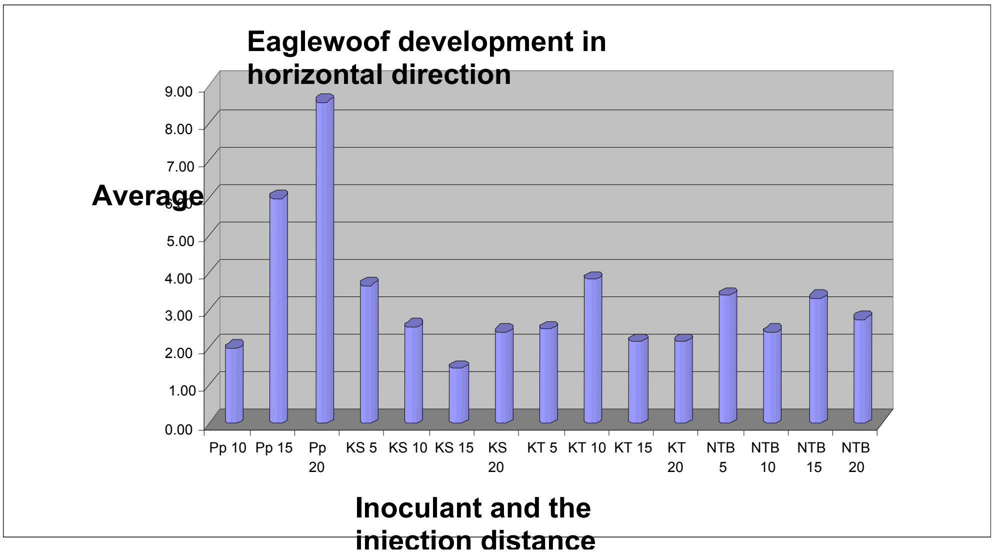
Remarks: injection distance (between injection holes)

Viewing Table 5, it turns out that with the injection using the isolates of consecutively FORDA CC-00512, FORDA CC-00495, FORDA CC-00497, and FORDA CC-00511 at 10-cm, 15-m, dan 25-m injection distance, all the injected trees survived, or no tree death occurred. This could be so, due to the suitability (compatibility) between the induction (injection) distance, the *Fusarium* isolates, and the resistance of the injected trees themselves. To examine the average reaction regarding the gaharu development in vertical and horizontal direction, it is presented in Figures 3, 4, 5, and 6.



Remarks:
Pp : Isolates originated from Papua (FORDA CC-00512)
Ks : Isolates originated from South Kalimantan (FORDA CC-00495)
Kt : Isolates originated from Central Kalimantan (FORDA CC-00497)
NTB : Isolates originated from West Nusa Tenggara (FORDA CC-00511)

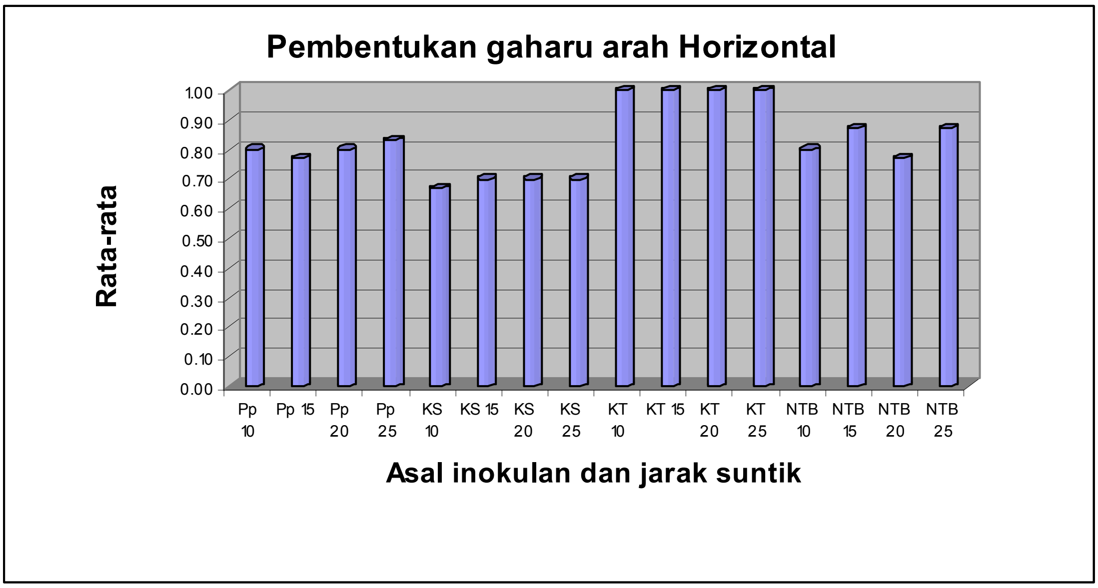
Figure 3. The reaction of gaharu development in vertical direction, as observed 3 months after the inoculation treatment (the experiment took place in West Nusa Tennggara



Remarks:
Pp : Isolates originated from Papua (FORDA CC-00512)
Ks : Isolates originated from South Kalimantan (FORDA CC-00495)
Kt : Isolates originated from Central Kalimantan (FORDA CC-00497)
NTB : Isolates originated from West Nusa Tenggara (FORDA CC-00511)

Figure 4. The reaction of gaharu development in horizontal direction, as observed 3 months after the inoculation treatment (the experiment took place in West Nusa Tennggara

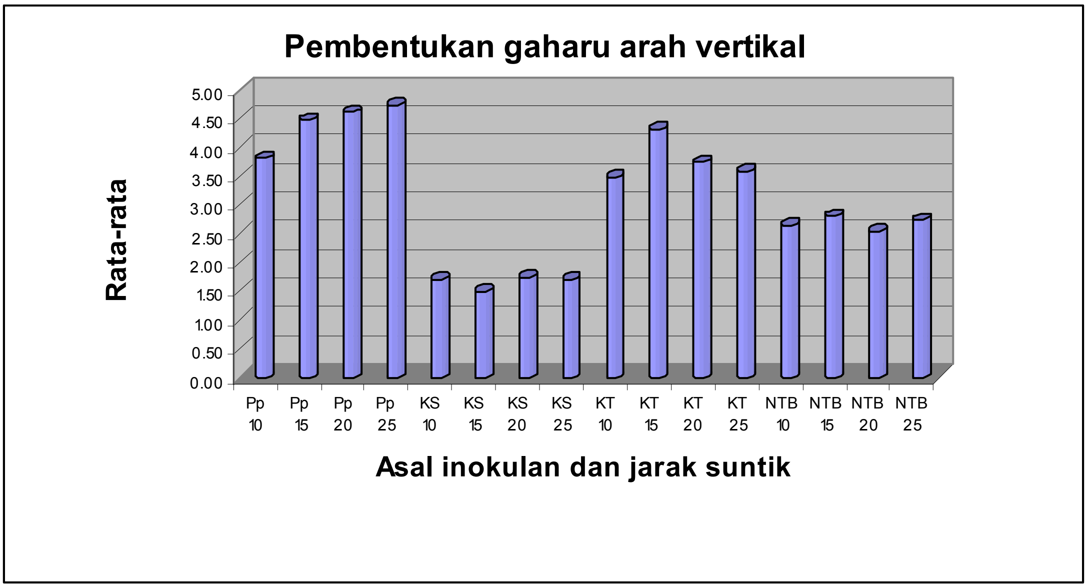
Figures 3 and 4 reveal that all the isolates afforded significant effect/role on the gaharu development on the stem of *Aquilaria* spp. trees. Meanwhile, with 20-cm injection distance, the isolates originated from Papua inflicted the most favorable responses/role (average gaharu development in vertical and horizontal directions reaching consecutively 1.33 cm and 2.87 cm) compared to other isolates from South Kalimantan, Central Kalimantan, and West Nusa Tenggara.



Remarks:
Pp : Isolates originated from Papua (FORDA CC-00512)
Ks : Isolates originated from South Kalimantan (FORDA CC-00495)
Kt : Isolates originated from Central Kalimantan (FORDA CC-00497)
NTB : Isolates originated from West Nusa Tenggara (FORDA CC-00511)

Figure 5. The reaction of gaharu development in horizontal direction, as observed 3 months after the inoculation treatment (the experiment took place in West Kalimantan)

Rata-rata = Average; Pembentukan gaharu arah vertikal = Eglewood development in vertical direction; asal inoculum dan jarak suntik = inoculant origin and the injection distance (between the inoculation holes)



Remarks:
Pp : Isolates originated from Papua (FORDA CC-00512)
Ks : Isolates originated from South Kalimantan (FORDA CC-00495)
Kt : Isolates originated from Central Kalimantan (FORDA CC-00497)
NTB : Isolates originated from West Nusa Tenggara (FORDA CC-00511)

Figure 6. The reaction of gaharu development in vertical direction, as observed 3 months after the inoculation treatment (the experiment took place in West Kalimantan)

Rata-rata = Average; Pembentukan gaharu arah vertikal = Eglewood development in vertical direction; asal inoculum dan jarak suntik = inoculant origin and the injection distance (between the inoculation holes)

Examining Figures 5 and 6, it reveals that all the isolates as inoculated to the tree stem using the injection (inoculation) distance that rached consecutively 10 cm, 15 cm, 20 cm, and 25 cm inflicted the favorable responses on gaharu development. Meanwhile, the inoculation isolates originated from Papua inflicted the remarkable responses in that the gaharu development reached 4.73 cm (in vertical direction) and 0.83 cm (in horizontal direction).

In activities regarding the standardization and effectiveness of isolates which were already recognized such as FORDA CC-00509, FORDA CC-00500, FORDA CC-00501, and FORDA CC-00499, the induction was done using those 4 isolates, on the stem of *Aquilaria microcarpa* dan *Gyrinops* sp. trees.

Further tests on activities of gaharu induction were done in two locations, comprising West Kalimantan and West Nusa Tenggara by observing the measurement of gaharu development as induced in vertical and horizontal directions (presented in the Appendix). To look into the measurement results on the gaharu-development symptom in vertical and horizontal directions, it is presented in Tables 6 and 7.

Table 6. Analysis results on gaharu-development sympton in vertical and horizontal directions (the research taking place in West Kalimantan location)

No	Repetion	Tree code	isolates code	average vertical (cm)	Duncan test	average Horizontal (cm)	Duncan test
1	10	1	FORDA CC-00509	3,11	A	0,97	A
2	10	2	FORDA CC-00501	2,29	C	0,58	C
3	10	3	FORDA CC-00500	2,81	B	0,81	B
4	10	4	FORDA CC-00499	2,75	B	0,77	B

Table 7. Analysis results on gaharu-development sympton in vertical and horizontal directions (the research taking place in West Nusa Tenggara)

No	Ulangan	Kode pohon	Asal inokulan	Rata-rata Vertikal (cm)	Uji Duncan	Rata-rata Horizontal (cm)	Uji Duncan
1	4	1	FORDA CC-00509	5,00	A	0,85	A
2	10	2	FORDA CC-00501	3,73	B	0,67	AB
3	8	3	FORDA CC-00500	2,60	C	0,55	BC
4	10	4	FORDA CC-00499	1,67	C	0,41	C

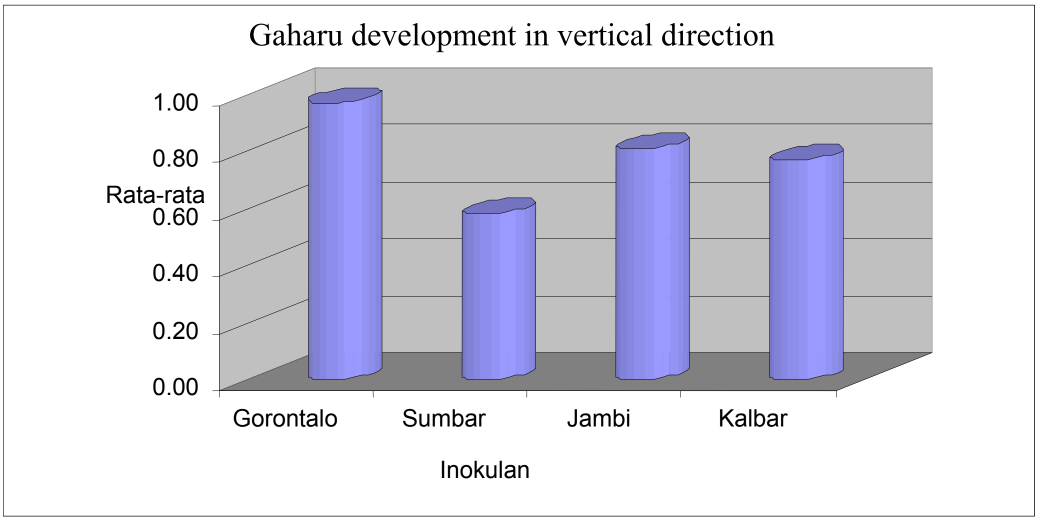
Remarks for Tables 6 and 7: Ulangan = Number of replications; Asal inokulan = Inoculant origin; Rata-rata vertikal = Average of the symptom in vertical direction; Rata-rata horizontal = Average of the symptom in horizontal direction; Uji Dunan = Duncan's multiple range test; The figures followed horizontally by the same letters (A, B, C) are not significantly different

Data in Tables 6 and 7 reveals that the isolates in West Kalimatan that exhibited high virulence were FORDA CC-00509 (with gaharu development reaching 3.11 cm in vertical direction and 0.97 cm in horizontal direction, respectively). Likewise, in West Nusa Tenggara, the FORDA CC-00509 isolates were also still very virulent, but unfortunately caused the death to the gaharu trees. This occurred due to the aspects of relation between stitability (compatibility), *Fusarium* spp. severity/ferocity, and the resisteance of the trees themselves. The percentage of tree death is presented in Table 8.

Table 8. The percentage level of tree death, as observed 3-year after the inoculation treatment (the research took place in West Nusa Tenggara)

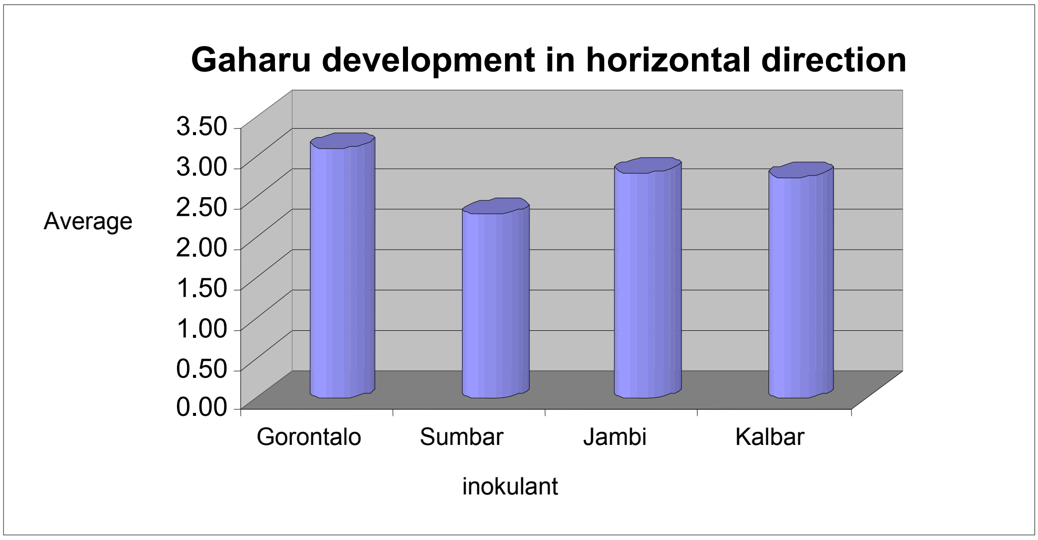
No	Tree code no	Inoculant origin	Number of dead trees	Number of replications (trees)	Percentage of tree death (%)
1	1	FORDA CC-00509	6	10	60
2	2	FORDA CC-00501	0	10	0
3	3	FORDA CC-00500	2	10	20
4	4	FORDA CC-00499	0	10	0

To examine the induction reaction that induced gaharu development, it is presented in Figures 7, 8, 9, and 10.



Remarks: Isolate origin
Gorontalo : (FORDA CC-00509)
West Sumatera : (FORDA CC-00501)
Jambi : (FORDA CC-00500)
West Kalimantan : (FORDA CC-00499)

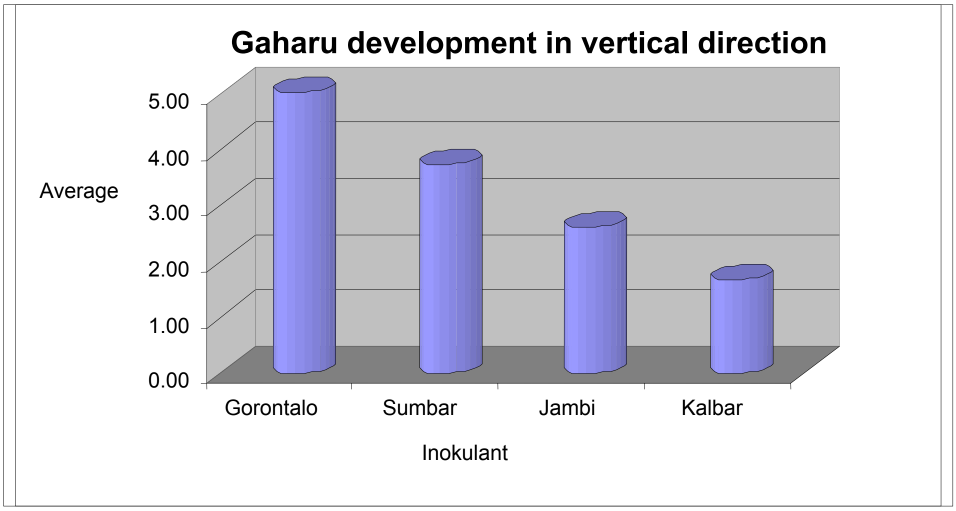
Figure 7. The induction that occurred at gaharu trees development in vertical direction (the experiment took place in West Kalimantan)



Remarks: Isolate origin
Gorontalo : (FORDA CC-00509)
West Sumatera : (FORDA CC-00501)
Jambi : (FORDA CC-00500)
West Kalimantan : (FORDA CC-00499)

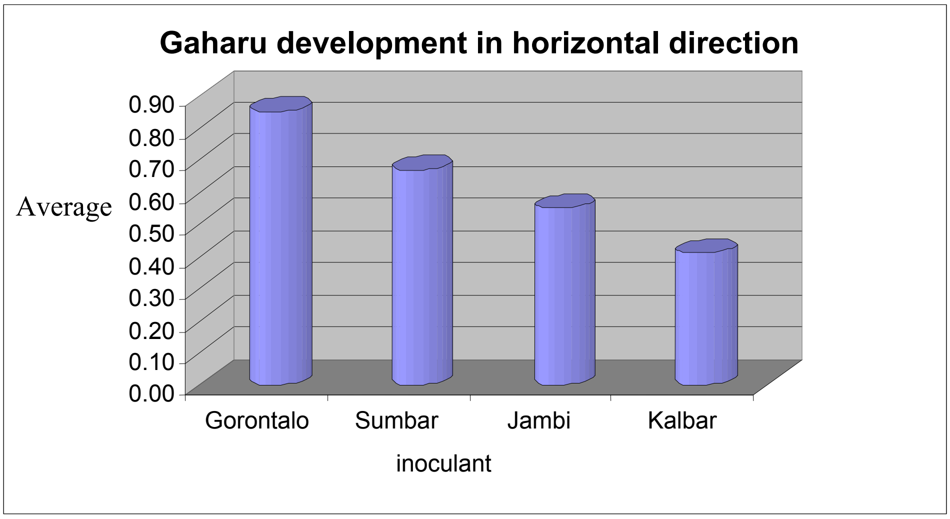
Figure 8. The induction that occurred at gaharu trees development in horizontal direction (the experiment took place in West Kalimantan)

Examining Figures 7 and 8, it reveals that the FORDA CC-00509 isolates inflicted the virulence, which were higher than those of FORDA CC-00500 dan FORDA CC-00499 isolates, followed in decreasing order the FORDA CC-00501.



Remarks: Isolate origin
Gorontalo : (FORDA CC-00509)
West Sumatera : (FORDA CC-00501)
Jambi : (FORDA CC-00500)
West Kalimantan : (FORDA CC-00499)

Figure 9. The induction that occurred at gaharu trees development in vertical direction (the experiment took place in West Nusa Tenggara)



Remarks: Isolate origin
Gorontalo : (FORDA CC-00509)
West Sumatera : (FORDA CC-00501)
Jambi : (FORDA CC-00500)
West Kalimantan : (FORDA CC-00499)

Figure 10. The induction that occurred at gaharu trees development in horizontal direction (the experiment took place in West Nusa Tenggara)

Examining Figures 9 and 10, it reveals that the FORDA CC-00509 isolates inflicted the highest virulence, followed in decreasing order by the FORDA CC-00501 dan FORDA CC-00500 isolates, until the FORDA CC-00499 isolates as the lowest virulence.

From those data, it can be inferred that the induction distance of those isolates as induced to the stem of gaharu-yielding trees could be figured out. The induction distance for each of those isolates as induced to the stem of gaharu-yielding *Aquilaria* spp. trees reached about 10-15 cm, and this should recognize the environment conditions such as humidity, temperature, and light intensity. The isolates such as CC-00509, FORDA CC-00512, and FORDA CC-00497 afforded high virulence, thereby being very effective to all species of gaharu-yielding trees that grow in almost any locations or regions.

Meanwhile for *Gyrinops* sp., it turns out that the induction distance between should be 20 cm. When examining the results of induction tests on *Gyrinops* sp., it states hat the induction distance ranged about 5 cm - 15 cm. Most of the *Gyrinops* sp. trees as induced by the FORDA CC-00509 dan FORDA CC-00512 isolates suffered from their death. As such, at 5-cm injuction distance the tree death reached 100%, while at consecutively 10-cm and 15-cm induction distances, the portion of the dead trees were equal (66.67%, respectively). Meanwhile, for the FORDA CC-00511isolates at 5-cm induction distance, the tree death reached 66.67% as well. This implied the particular gaharu-yielding trees (in this regard *Gyrinops* sp. species) exhibited different resistance against the different induction isolates.

IV. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

Isolates of FORDA CC-00509 dan FORDA CC-00512 inflicted the highest virulence on the gaharu-yielding trees, followed in decreasing order by the FORDA CC-00497, FORDA CC-00500, FORDA CC-00511, FORDA CC-00499 dan FORDA CC-00501. The standard of distances between inoculation-hole distance for the gaharu-yielding *Aquilaria* spp tree species was 10 cm, and for Gyrinops sp. species, it was 20 cm. The FORDA CC-00509 dan FORDA CC-00512 isolates turned out very effective in gaharu development. Each of the species of gaharu-yielding trees exhibited different resistance, such as *Aquilaria malaccensis*, *Aquilaria microcarpa*, and *Gyrinop*s sp. species which were more sensitive (vulnerable) to the FORDA CC-00509 dan FORDA CC-00512 isolates. The induction using FORDA CC-00500 on *Aquilaria malaccensis* with the induction duration for 3 years afforded the gaharu development with favorable qualities.

B. Recomendations

The Forest Microbiology Laboratory (under the R & D Centre for Forest Conservation and Rehabilitation) currently own 54 isolates, and so far 8 isolate species have been trial tested, and therefore the remaining isolates (46 species) still deserve further trial tests.

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Annex 1. Table Results of measurement on gaharu development at *Aquilaria* spp. in vertical and horizontal direction (the experiment took place in West Nusa Tenggara), as observed 3 months after inoculation treatment

No.	Number of replications	Tree code no.	Inoculant origin	Injection (inoculation) distance	Gaharu development	
					Vertical direction	Horizontal direction
1	1	1.5.1	FORDA CC-00512	5	X	X
2	2	1.5.2	FORDA CC-00512	5	X	X
3	3	1.5.3	FORDA CC-00512	5	X	X
4	1	1.10.1	FORDA CC-00512	10	2	0,5
5	2	1.10.2	FORDA CC-00512	10	X	X
6	3	1.10.3	FORDA CC-00512	10	X	X
7	1	1.15.1	FORDA CC-00512	15	X	X
8	2	1.15.2	FORDA CC-00512	15	X	X
9	3	1.15.3	FORDA CC-00512	15	6	1
10	1	1.20.1	FORDA CC-00512	20	10	1
11	2	1.20.2	FORDA CC-00512	20	10	1
12	3	1.20.3	FORDA CC-00512	20	5,7	2
13	1	2.5.1	FORDA CC-00495	5	2	0,5
14	2	2.5.2	FORDA CC-00495	5	3	0,6
15	3	2.5.3	FORDA CC-00495	5	6	0,8
16	1	2.10.1	FORDA CC-00495	10	3,5	0,7
17	2	2.10.2	FORDA CC-00495	10	2,2	0,6
18	3	2.10.3	FORDA CC-00495	10	2	0,8
19	1	1.15.1	FORDA CC-00495	15	1,6	0,7
20	2	1.15.2	FORDA CC-00495	15	1,3	0,7
21	3	2.15.3	FORDA CC-00495	15	1,5	0,6
22	1	2.20.1	FORDA CC-00495	20	2,8	0,6
23	2	2.20.2	FORDA CC-00495	20	2,8	0,8
24	3	2.20.3	FORDA CC-00495	20	1,7	0,4
25	1	3.5.1	FORDA CC-00497	5	2,3	0,6
26	2	3.5.2	FORDA CC-00497	5	2,5	0,4
27	3	3.5.3	FORDA CC-00497	5	2,7	0,5
28	1	3.10.1	FORDA CC-00497	10	7	1
29	2	3.10.2	FORDA CC-00497	10	2	0,3
30	3	3.10.3	FORDA CC-00497	10	2,5	0,3
31	1	3.15.1	FORDA CC-00497	15	3,1	1
32	2	3.15.2	FORDA CC-00497	15	2,2	1
33	3	3.15.3	FORDA CC-00497	15	1,2	0,3
34	1	3.20.1	FORDA CC-00497	20	2,5	0,4
35	2	3.20.2	FORDA CC-00497	20	1,8	0,4
36	3	3.20.3	FORDA CC-00497	20	2,2	0,6
37	1	4.5.1	FORDA CC-00511	5	X	X
38	2	4.5.2	FORDA CC-00511	5	3,4	0,4
39	3	4.5.3	FORDA CC-00511	5	X	X

No.	Number of replications	Tree code no.	Inoculant origin	Injection (inoculation) distance	Gaharu development	
					Vertical direction	Horizontal direction
40	1	4.10.1	FORDA CC-00511	10	2,5	0,4
41	2	4.10.2	FORDA CC-00511	10	2,5	0,2
42	3	4.10.3	FORDA CC-00511	10	2,3	0,1
43	1	4.15.1	FORDA CC-00511	15	3,5	0,4
44	2	4.15.2	FORDA CC-00511	15	1,5	0,5
45	3	4.15.3	FORDA CC-00511	15	5	0,3
46	1	4.20.1	FORDA CC-00511	20	3	0,5
47	2	4.20.2	FORDA CC-00511	20	2,5	0,2
48	3	4.20.3	FORDA CC-00511	20	2,8	0,4

Annex 2. Results of measurement on gaharu development at *Aquillaria* spp. in vertical and horizontal direction (the experiment took place in West Kalimantan), as observed 3 months after inoculation treatment

No.	Number of replications	Tree code no.	Inoculant origin	Injection (inoculation) distance	Gaharu development	
					Vertical direction	Horizontal
1	1	1.10.1	FORDA CC-00512	10	3.3	0.9
2	2	1.10.2	FORDA CC-00512	10	4.2	0.7
3	3	1.10.3	FORDA CC-00512	10	3.9	0.8
4	1	1.15.1	FORDA CC-00512	15	4.5	0.8
5	2	1.15.2	FORDA CC-00512	15	4.4	0.7
6	3	1.15.3	FORDA CC-00512	15	4.5	0.8
7	1	1.20.1	FORDA CC-00512	20	4.6	0.9
8	2	1.20.2	FORDA CC-00512	20	4.7	0.8
9	3	1.20.3	FORDA CC-00512	20	4.5	0.7
10	1	1.25.1	FORDA CC-00512	25	4.8	0.9
11	2	1.25.2	FORDA CC-00512	25	4.7	0.8
12	3	1.25.3	FORDA CC-00512	25	4.7	0.8
13	1	2.10.1.	FORDA CC-00495	10	1.6	0.7
14	2	2.10.2	FORDA CC-00495	10	1.8	0.6
15	3	2.10.3	FORDA CC-00495	10	1.7	0.7
16	1	2.15.1	FORDA CC-00495	15	1.6	0.6
17	2	2.15.2	FORDA CC-00495	15	1.4	0.8
18	3	2.15.3	FORDA CC-00495	15	1.5	0.7
19	1	2.20.1	FORDA CC-00495	20	1.9	0.8
20	2	2.20.2	FORDA CC-00495	20	1.6	0.7
21	3	2.20.3	FORDA CC-00495	20	1.7	0.6
22	1	2.25.1	FORDA CC-00495	25	1.7	0.6
23	2	2.25.2	FORDA CC-00495	25	1.8	0.7
24	3	2.25.3	FORDA CC-00495	25	1.6	0.8
25	1	3.10.1	FORDA CC-00497	10	3.5	1
26	2	3.10.2	FORDA CC-00497	10	3.3	1
27	3	3.10.3	FORDA CC-00497	10	3.6	1
28	1	3.15.1	FORDA CC-00497	15	4.5	1
29	2	3.15.2	FORDA CC-00497	15	4.1	1
30	3	3.15.3	FORDA CC-00497	15	4.3	1
31	1	3.20.1	FORDA CC-00497	20	3.7	1
32	2	3.20.2	FORDA CC-00497	20	3.6	1
33	3	3.20.3	FORDA CC-00497	20	3.9	1
34	1	3.25.1	FORDA CC-00497	25	3.4	1
35	2	3.25.2	FORDA CC-00497	25	3.7	1
36	3	3.25.3	FORDA CC-00497	25	3.6	1
37	1	4.10.1	FORDA CC-00511	10	2.6	0.8

No.	Number of replications	Tree code no.	Inoculant origin	Injection (inoculation) distance	Gaharu development	
					Vertical direction	Horizontal
38	2	4.10.2	FORDA CC-00511	10	2.5	0.7
39	3	4.10.3	FORDA CC-00511	10	2.8	0.9
40	1	4.15.1	FORDA CC-00511	15	2.8	0.9
41	2	4.15.2	FORDA CC-00511	15	2.9	0.9
42	3	4.15.3	FORDA CC-00511	15	2.7	0.8
43	1	4.20.1	FORDA CC-00511	20	2.7	0.8
44	2	4.20.2	FORDA CC-00511	20	2.5	0.7
45	3	4.20.3	FORDA CC-00511	20	2.4	0.8
46	1	4.25.1	FORDA CC-00511	25	2.9	0.8
47	2	4.25.2	FORDA CC-00511	25	2.6	0.9
48	3	4.25.3	FORDA CC-00511	25	2.7	0.9

FEASIBILITY OF GAHARU INOCULATION BUSINESS AT DIFFERENT STEM DIAMETER AND PERIOD OF INOCULATION

by :

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ABSTRACT

Indonesia is the biggest gaharu producer country in the world. Its demand and price which tend to increase has resulted over exploitation of gaharu. Consequently, its population in nature has decreased significantly. To overcome the situation, since 1995, gaharu has been included in CITES Appendix II, however illegal exploitation remained occur until it reached excessive level. In order to conquer it, several efforts on gaharu cultivation and artificial gaharu production have been undertaken at several provinces of Indonesia. Several supporting factors for cultivation and artificial production of gaharu are availability of potential land for extensive gaharu cultivation, appropriate agro climate condition, cultivation technique which is relatively easy and has been well adopted by farmers, availability of necessary pathogen for gaharu inoculation and its demand that tends keep increasing with relatively high price. The research aims to analyze feasibility of gaharu inoculation business at several stem diameters (Ø ≥15 – ≤25 cm; Ø > 25 – ≤ 35 cm and Ø > 35 cm - 40 cm.) and period of inoculation (1 – 5 years). Data collection was done through field observation and literature study. The result showed that inoculation on gaharu producer tree stands at 12.5 % interest rate produced positive NPV value, IRR much higher than market interest and B/C ratio >2 for those three diameter class. Furthermore, if gaharu harvesting is delayed until five years after inoculation, NPV, IRR and B/C ratio would be much higher. It can be concluded that inoculation on gaharu producer tree stands (at appropriate age for inoculation) is feasible to be developed.

Keywords: Feasibility, financial, inoculation, production, price, diameter, gaharu.

I. INTRODUCTION

Gaharu is produced from certain infected tree species in tropical area and generally originated from genus *Aquilaria, Gyrinops* and *Gonystylus* which are classified in Thymelaeaceae. Genus of *Aquilaria* consists of 15 species, covering tropical Asia

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including India, Pakistan, Myanmar, Lao PDR, Thailand, Cambodia, South China, Malaysia, Philippine and Indonesia. Amongst them, six are found in Indonesia i.e. *A. malaccensis, A. microcarpa, A. hirta, A. beccariana, A. cumingiana* and *A. filaria* dispersed in almost all of Indonesia Island *Gonystylus* genus has 20 species, scattered in Southeast Asia until Solomon and Nicobar archipelago. While *Gyrinops,* genus has seven species. Six of them are founded in East part of Indonesia and one species is founded in Srilanka (Anonym, 2002; Aswandi, 2006).

Many people fail to notice between gaharu and gaharu producer tree stands. According to SNI 01-5009.1-1999 gaharu is defined as kind of wood with different form and distinctive color and contain aromatic resin originated from trees or part of trees that naturally grow or has died as a result of infection process either through naturally or artificial process. Among all, gaharu mostly could be found on *Aquilaria* sp. Economic value of gaharu is located on gubal contain emerging after gaharu has been infected or died (Persoon, 2007).

Indonesia is the biggest gaharu producer in the world coming from 16 species of gaharu producer trees. In 1985, export of gaharu from Indonesia was 1.487 ton. High gaharu price has induced excessive exploitation, not only from died gaharu tree but also through cutting live gaharu tree. As a result, gaharu species became scarce or even vanished. Therefore in 1995, CITES included *A. malaccensis,* one of best gaharu producer tree species into Appendix II and since then, gaharu export has been limited through quota i.e. only 250 ton/year (Anonym, 2005; Blanchette, 2006).

In 2000, Indonesia Gaharu Exporter Association (Asgarin) conducted a survey to identify population of natural gaharu tree stands at several forest areas. The result showed that its population in Sumatera, Kalimantan, Nusa Tenggara, Sulawesi, Maluku and Papua is 26%, 27%, 5%, 4%, 6%, 37% respectively (Adijaya, 2009). Subsequently, other study on gaharu population/ha revealed that in Sumatera, Kalimatan and Papua average gaharu population is only 1.87 trees/ha; 3.37 trees/ha and 4.33 trees/ha respectively (Anonym, 2008).

In order to anticipate its demand which tends to increase and also to evade gaharu in nature become extinct, several efforts to cultivate trees producing gaharu have started to develop in many areas of Indonesia such as North Sumatera, Riau, Jambi, West Java, NTB, South Kalimantan and West Kalimantan. Gaharu cultivation keeps on developing especially after several research results showed that cultivated gaharu could provide feasible benefit for its growers (Marliani, 2008; Tarmiji, 2009; The Angel, 2009; Suharti, 2009).

Some supporting factors for gaharu cultivation are availability of potential land for extensive gaharu cultivation, appropriate agro-climate condition, cultivation technique which is relatively easy and has been well adopted by farmers, availability of necessary pathogen for gaharu inoculation and gaharu demand that tends keep increasing with relatively high price. Key success for gaharu agribusiness mainly lies on success of pathogen inoculation technique, sustainability of inoculated pathogen with inoculated trees and resistance level of inoculated trees. If those three requirements could meet, one year after inoculation process gaharu could already be initially harvested. This paper tries to describe feasibility of gaharu inoculation at several stem diameters and harvesting period after trees have been inoculated.

II. MATERIALS AND METHODS

A. Type and Source of Data

Data presented in this paper were collected from field survey (primary data) and literature study (secondary data). Data collected including age, diameter, price of trees, prepared for inoculation, cost of labor, price of inoculation material and chemical compound, price and depreciation value for tools and equipments used for inoculation process and price of gaharu at different quality. Source of secondary data and information are Ministry of Forestry, CITES, Statistical Centre Bureau (BPS), and Indonesia Gaharu Exporter Association (Asgarin).

B. Data Analysis

All collected data and information was processed and analyzed by using financial analysis based on several feasibility criteria i.e. Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit Cost Ratio (B/C ratio) which is formulated as follow (Grey, *et.al*.1987):

a. $$\mathrm{NPV} = \sum_{t=0}^{n} \frac{\mathrm{Bt} - \mathrm{Ct}}{(1+\mathrm{i})^{\mathrm{t}}} \quad \text{.......(1)}$$

where:
NPV = Net Present Value,
Bt = benefit or revenue at year t,
Ct = cost at year t,
i = interest rate of Bank,
n = period of project.
One project is considered to be financially feasible if NPV is > 0.

b. $$\mathrm{IRR} = \mathrm{i1} + \frac{\mathrm{NPV1}}{\mathrm{NPV1} - \mathrm{NPV2}}(\mathrm{i2} - \mathrm{i1}) \quad \text{.......(2)}$$

where:
IRR = Internal Rate of Raturn,
i1 = interest rate to produce NPV1 positive close to zero,
NPV1 = value of NPV close to zero positive,
i2 = interest rate to produce NPV2 negative close to zero,
NPV2 = value of NPV close to zero positive.

One project is considered to be financially feasible if IRR value is higher that interest rate from Bank.

c. $$B/C = \frac{\sum_{t=0}^{n} \frac{Bt}{(1+i)^t}}{\sum_{t=0}^{n} \frac{Ct}{(1+i)^t}} \quad \text{..........(3)}$$

where:
B/C = Benefit Cost Ratio,
Bt = benefit or revenue at year t,
Ct = cost at year t,
i = interest rate,
n = period of project.
One Project is considered to be financially feasible if B/C ratio > 1.

C. Assumptions and Restrictions

Several assumptions and restrictions used in this research are:

1. Trees producing gaharu used in this research are bought from farmers. It consists of three different stem diameter (≥15 - ≤ 25 cm, > 25 - ≤ 35 cm dan > 35 cm - 40 cm) with total number trees used is 300 (100 trees for each diameter).
2. Price of each tree is Rp 250,000, 300,000 and Rp 350,000 for diameter ≥15 - ≤ 25 cm; > 25 - ≤ 35 cm and > 35 cm - 40 cm respectively.
3. Number of trees assumed alive and successfully inoculated are 90% from total initial population (90 trees). Gaharu harvesting is done periodically (once a year) started from one year until five year after inoculation (20% per year). Hence every year there are 18 trees (20%) are harvested.
4. Productivity of gaharu is assumed as follow (Table. 1):
   - For stem diamater ≥15 - ≤ 25 cm, gaharu production with high quality varies from 0.6-1.20 kg/tree whereas low quality production varies from 3-7 kg/tree.
   - For stem diamater > 25 - ≤ 35 cm gaharu production with high quality varies from 0.75-1.35 kg/tree while low quality production varies from 4-8 kg/tree.
   - For stem diamater > 35 cm - 40 cm gaharu production with high quality varies from 0.9-1.45 kg/tree and low quality production varies from 5-9 kg/tree.

Table 1. Productivity of gaharu at different stem diameter and age of tree

Age of harvesting gaharu after inoculation	Diameter ≥15-≤25Cm		Diameter >25-≤35Cm		Diameter >35-40Cm	
	Production (kg/tree)		Production (kg/tree)		Production(kg/tree)	
- Gaharu 1 year	0.60	3	0.75	4	0.90	5
- Gaharu 2 year	0.75	4	0.90	5	1.0	6
- Gaharu 3 year	0.90	5	1.05	6	1.15	7

Age of harvesting gaharu after inoculation	Diameter ≥15-≤25Cm		Diameter >25-≤35Cm		Diameter >35-40Cm	
	Production (kg/tree)		Production (kg/tree)		Production(kg/tree)	
- Gaharu 4 year	1.05	6	1.20	7	1.30	8
- Gaharu 5 year	1.20	7	1.35	8	1.45	9

5. Cost for harvesting is Rp 100,000,-/kg gaharu production (similar for both high and low quality production).
6. For 100 gaharu trees inoculation, it takes 10 days done by labours with different skill and wage level as follow:
   - Wage for specialist technical labour doing inoculation is Rp 150,000,-/manday
   - Wage for technical assistant for inoculation is Rp 100,000,-/manday
   - Wage for labour carrying equipment and inoculation material is Rp 150,000,-/manday
7. Price of gaharu at different harvesting period for high and low quality product are as follow (Table 2).

Table 2. Price of gaharu at different harvesting period

Period of harvesting after inoculation i	Price of gaharu				Note
	High/Super Guality		Low quality		
	$	Rp	$	Rp	
- Gaharu 1 year	100	900,000	25	225,000	$ 1 = Rp 9,000,-
- Gaharu 2 year	250	2,250,000	25	225,000	
- Gaharu 3 year	800	7,200,000	25	225,000	
- Gaharu 4 year	1500	12,000,000	25	225,000	
- Gaharu 5 year	2000	18,000,000	25	225,000	

8. Interest rate used in this financial analysis is 12.5%/year.

III. RESULT AND DISCUSSION

A. Ecological Aspect and gaharu distribution in Indonesia

Gaharu has an important role in Indonesia as it contributes to country foreign exchange. High economic value of gaharu has induced gaharu to become one prominent commodity (Pratiwi *et al*., 2010).

According to its natural habitat, gaharu grows well at low until hilly land (< 750 meter above sea level). *Aquilaria* spp. Grows optimally at yellow red podzolic soil, clay sandy soil with moderate to good drainage system, A – B climate, 80% humidity level, average temperature between 22-28^0 C and average annual rainfall between 2000-4000 mm. Gaharu trees will not grow well on inundated soil, swamp area, soil solum thickness less than 50 cm, quartz sand and soil with acidity level < 4 (Rizlani and Aswandi, 2009).

Until now, gaharu is produced by tropical tree species infected by fungi such as: *Aquilaria* spp., *Gonystylus* spp., *Wikstroemea* spp., *Enkleia* spp., *Aetoxylon* spp., *Gyrinops* spp. (Chakrabarty *et al.,* 1994, Sidiyasa *et al*., 1986) and *Excocaria agaloccha* (Chakrabarty *et al.,* 1994, Sidiyasa *et al*., 1986, Sidiyasa and Suharti, 1987, and Sumarna, 1998 in Sudarmalik *et al.,* 2006). Those species are spread out at several Indonesia islands. More complete description about it is shown in Table.3.

Gaharu producing trees could grow well at different ecosystem and forest type. Pratiwi *et al.,* (2010) showed that *performance* of gaharu producing trees especially *A. crassna* and *A.microcarpa* in Dramaga and Kampung Tugu (Sukabumi) are better than that of Carita. If looking at environmental condition, those three locations have almost similar characteristics i.e.: Type of rainfall A, average temperature between 20-30 ^{0}C, level of humidity between 77-85% and its topography varies from flat until undulating. It seems that performance differences among gaharu producing tree species in those three locations are influenced by its soil fertility. Soil in Carita might already further decomposed compared with the other two locations (Dramaga and Kampung Tugu, Sukabumi), hence soil fertility in Carita is lower than that of in the other two.

Table 3. Gaharu producing tree species in Indonesia

No.	Botanic name	Family	Distribution
1.	Aquilaria malaccensis	Thymeleaceae	Sumatera, Kalimantan
2.	A.hirta	Thymeleaceae	Sumatera, Kalimantan
3.	A.filaria	Thymeleaceae	Nusa Tenggara, Maluku, Irian Jaya
4.	A.microcarpa	Thymeleaceae	Sumatera, Kalimantan
5.	A.agalloccha	Thymeleaceae	Sumatera, Kalimantan, Java
6.	A.beccariana	Thymeleaceae	Sumatera, Kalimantan
7.	A.seccunda	Thymeleaceae	Maluku, Irian Jaya
8.	A.moszkowskii	Thymeleaceae	Sumatera
9.	A.tomentosa	Thymeleaceae	Irian Jaya
10	Aetoxylon sympethalum	Thymeleaceae	Kalimantan, Irian Jaya, Maluku
11.	Enkleia malaccensis	Thymeleaceae	Irian Jaya, Maluku
12.	Wikstroemea poliantha	Thymeleaceae	Nusa Tenggara, Irian Jaya
13.	Wikstroemea tenuriamis	Thymeleaceae	Sumatera, Kalimantan, Bangka
14.	Wikstroemea androsaemofilia	Thymeleaceae	Kalimantan, Nusa Tenggara Timur, Irian Jaya, Sulawesi
15.	Gonystylus bancanus	Thymeleaceae	Sumatera,Kalimantan,Bangka
16.	G.macrophyllus	Thymeleaceae	Kalimantan, Sumatera
17.	G.cumingiana	Thymeleaceae	Nusa Tenggara, Irian Jaya
18.	Gyrinops rosbergii	Thymeleaceae	Nusa Tenggara
19.	G.versteegii	Thymeleaceae	Nusa Tenggara
20.	G.moluccana	Thymeleaceae	Maluku, Halmahera
21.	G.decipiens	Thymeleaceae	Sulawesi Tengah
22.	G. ledermanii	Thymeleaceae	Irian Jaya

No.	Botanic name	Family	Distribution
23.	G. salicifolia	Thymeleaceae	Irian Jaya
24.	G. audate	Thymeleaceae	Irian Jaya
25.	G. podocarpus	Thymeleaceae	Irian Jaya
26.	Dalbergia farviflora	Leguminosae	Sumatera, Kalimantan
27.	Excocaria agaloccha	Euphorbiaceae	Java, Kalimantan, Sumatera

Source: Sidiyasa and Suharti (1987), Sumarna (1998) in Sudarmalik (2006)

Other study done by Sumarna (2008) in Jambi (Tabir Angin sub district, Merangin Regency) revealed that habitat ecology based on distribution of mother trees of *A. malaccensis* and *A.microcarpa,* they could grow well at 100 m above sea level, with average temperature 27^{0}C, relative humidity 78% and light intensity 75 %. It could also grow well at 200 m above sea level with average temperature 24^{0}C, relative humidity 85% and light intensity around 67%. Whereas at 200m above sea level , it grow well with average temperature 20^{0}C relative humidity about 81% and light intensity around 56%.

From those two studies, it can be assumed that *Aquilaria* spp. could grow well on areas with average temperature between 20-33^{0}C, relative humidity varies from 77-85% and light intensity between 56-75%. However, environmental factor which is optimum for gaharu production still need further study.

B. Artificial Gaharu Development through Inoculation Process

Inoculation process is an important aspect in gaharu agribussiness. Since gaharu resin will not easily formed naturally, human intervention is needed to make trees wounded and then provide it with gaharu resin accelerator material such as fungi and other substances to quicken gaharu formation process (inoculation process).

After gaharu producing trees are five year old and its stem diameter already at least 15 cm, artificial process to induce gaharu formation could already be initiated. The process is done by inoculating process using gaharu composing disease suitable with inoculated tree species. Artificial gaharu could be initially harvested one or two years after inoculation. Harvesting could be done before the trees died, however, ideally gaharu is best harvested on dead trees because three types of production i.e. gubal, kemedangan and ash/powder could be obtained all together (Sumarna, 2007).

Types of fungi commonly used for inoculation process are *Fusarium* sp., *Phialopora parasitica*, *Torula* sp., *Aspergillus* sp., *Penicillium* sp., *Cladosporium* sp., *Epicoccum granulatum*, *Clymndrocladium* sp., *Sphaeropsis* sp., *Botryodiplodia theobromae*, *Trichoderma* sp., *Phomopsis* sp., *Chunninghamella echinulata* (Anonym, 2009).

Basically, inoculated fungi would make trees got injured. This open wound will stimulate trees to produce resin from woody tissue. Method of Inoculation varies depend on size of hole and how to make holes. Holes with 5 mm size diameter could be done at 5 – 10 cm depth with more dense holes (with short distance i.e. 5 cm). Hence in one tree, thousands of holes could be made. If size of holes are bigger, distance of holes shoud be wider, therefore trees could stand from violent wind. Physiology process mechanism of gaharu production begins when disease mocrobe enters woody tissue. In order to survive, this microorganism utilize liquid cell from woody tissue as source of energy. Gradually, lost of liquid cell would decrease metabolism process of tree woody tissue in flowing nutrient throughout the trees and even until its leaves.

Tissue cell, where it's contain, has been consumed by microbes then will develop collection of dead cell at artery tissue. As a result, function of leaves in nutrient processing to become energy decelerate and then even stop. Eventually tree leaves turn out to be yellowish and trees subsequently died. Physically, tree branches and twigs are getting dry; stem skin is broken and therefore easy to remove. The condition is biologically describing trees producing gaharu. In simple words, gaharu is developed as a result of tree response due to pathogen infection, injury or stress.

With the purpose of getting gaharu with gubal or kemedangan quality, five year old *Aquilaria* spp. was inoculated by using *Fusarium*. Inoculation process was considered to be successful if brownish scratch appears followed by wilted leaves before finally the tree fell down. Level of success at inoculation process varies. Pessimistic estimation of artificial gaharu production at seven year tree old (two years after inoculation) is 1 kg of gubal, 10 kg of kemedangan and 15 kg of ash/powder. Super quality of gaharu, comes from long dead and fell down tree that already mix up with surrounding soil. In nature, best quality gaharu i.e. gubal is getting difficult to acquire as a result of continuous gaharu over exploitation. It is estimated that best quality of gaharu only could be found far in the forest which needs several weeks to get it.

At international market, price of gubal gaharu (super double) indicated by blackish color could reach Rp 25 million/kg. In spite of its price, which is so expensive, demand for gubal and kemedangan gaharu at international market keeps increasing. Some of imported countries are Arab Saudi, Taiwan, Singapore, Korea, Hongkong, and Japan (Anonym, 2008).

Although inoculation of fusarium is a crucial process to stimulate gaharu production on gaharu producing trees, if it is not done carefully this could cause death of inoculated tree hence instigate lots of loss and failure. Those situation might be caused by inoculated *Fusarium* which is too savage. Violent fusarium may cause the tree viciously attacked that instigate death of the tree. Other problem in inoculation might also caused by failure of the inoculated fungi to respond since different tree species would give different reaction. Failure of inoculation could be caused also by unsustainability of pathogen inoculated on the trees. Appropriateness of inoculated microbe with inoculating trees is a crucial factor that should be met. Therefore, one important factor that determines the success of inoculation process is to find out pathogen microbe that best suit with tree species as each tree species fits with certain pathogen microbe only (Duryatmo, 2009).

C. Market Prospect and Gaharu Business

As already mentioned before, demand on gaharu, tends to increase far beyond its supply. Rise in demand is induced by increasing in utility variations as a result of progress in science and industrial technology. Gaharu is not only used as aromatic material in perfume industry, but it is also used for medicinal raw material, cosmetics, incense, and preservative for accessories. Advancement in medical technology has proved that gaharu is clinically could be used as anti asthmatic, anti microbe, stimulant for neuron work and digestion. In ancient China, gaharu was used as therapeutic treatment for stomachache, pain killer, cancer, tumor, diarrhea, kidney problem and lungs problem. In Europe and India, gaharu is mainly used for cancer medicinal treatment. Furthermore, in other countries like Singapore, China, Korea, Japan, and United States, gaharu is developed as anti depressant and also used as medical treatment for stomachache, kidney problem, asthma, cirrosis of liver. Besides used for therapeutic treatment, for several religion, aromatic burnt gaharu is required for religious ceremonial activities (Anonym, 2010).

As an illustration, description about gaharu trade in Indonesia published by CITES in 2003 can be seen at Table. 4.

Table 4. Production and export of gaharu (*Aquilaria* spp.) in Indonesia during 1995-2003

Year	Quota of Production at Formal Harvesting *)	Actual Quota of Production *)	Actual Export based on CITES Indonesia *)	Net Export Report CITES **)	Total Export of Gaharu (all species) *)
1995	n/a	n/a	n/a≠))	323,577	n/a≠
1996	300,000	160,000	299,523 (including *A. filaria* and other species)	293,593	299,593
1997	300,000	120,000	287,002 (including *A. filarial* 180,000 kg)	305,483	287,002
1998	150,000	150,000	148,238	147,212	n/a ≠)
1999	300,000	180,000	81,079	76,401	313,649
2000	225,000	225,000	81,377	81,377	245,150
2001	75,000	70,000	74,826	74,826	219,772
2002	75,000	68,000	70,546	n/a	175,245
2003	50,000	50,000	n/a	n/a	n/a

*) CITES Management Authority of Indonesia
*) CITES Annual Report Data Compiled by UNEP-WCMC
≠) the reason for the unavailability of data for 1995 1nd 1998 is not known

Table. 4 showed that during 1995 – 2002, there was a significant decrease of gaharu export from Indonesia (almost 40%). Decrease in gaharu supply from Indonesia influenced gaharu price both at local (intermediate market) and in international market.

In 1980, gaharu price at intermediate market was between Rp 30,000-50,000/kg for low quality gaharu, and Rp 80,000/kg for super quality gaharu. During that period, increase of gaharu price was relatively slowly and in 1993 its price was only Rp100,000,-/kg. Extreme increase of gaharu price occurred when economic crisis took place in Indonesia in 1997. At that time, price of gaharu increased tremendously and reached Rp 3-5 million/kg. Price of gaharu kept increasing and in 2000, the price was already Rp10 million/kg and even in 2009, it achieved Rp 15 million/kg (Adijaya, 2009; Wiguna, 2006).

From the explanation above, it can be concluded that gaharu business very potential and prospective to be developed especially in Indonesia that has biological potency such as availability of lots of gaharu producing tree species, plenty of potential forest area which is appropriate for gaharu cultivation and availability of supporting inoculation technique for gaharu cultivation.

Several attempts for gaharu cultivation has already been initiated since 1994/1995 by gaharu exporter company, PT. Budidaya Perkasa in Riau province by cultivating more than 10 ha of *A.malaccensis*. Subsequently, Regional Forestry Service in Riau also developed gaharu cultivation at Syarif Hasim Grand Forest Park. After that in 2001 – 2002, some farmer groups were also interested to grow gaharu producing trees. As an example, farmer group in Pulau Aro Village, Tabir Ulu Sub District, Merangin Regency, Jambi cultivated two gaharu species i.e. *A. malaccensis* and *A. microcarpa*. Subsequently, in the village, at the end of 2002, there were 116 farmers under Penghijauan Indah Jaya farmer group developed 100 thousands of gaharu seedling (Anonym, 2008). In 2004/2005, Batanghari Watershed Management Institute (BP DAS Batanghari) collaborated with Forestry research and Development Agency (FORDA) established demonstration plot of gaharu cultivation in between private owned rubber cultivation (Sumarna, 2007).

D. Investment Cost for Inoculation and Management

To make a financial analysis of gaharu inoculation business, some investment and management cost are needed. Gaharu inoculation business is capital intensive, hence the amount needed to finance the activity is a lot. Description of the costs in detail including investment, management and harvesting cost for 100 gaharu producing tree species is as follow Table 5.

Investment cost consists of cost for buying gaharu producing trees, inoculant material, chemical substance, depreciation of equipment used, fuel and cost of labor for inoculation process.

Table 5. Investment, management and harvesting cost of gaharu (Rp)

No.	Type of Cost	D = ≥15 - ≤25	D = >25 - ≤35	D = >.35 - 40
1	Trees buying	25, 000,000	30, 000,000	35, 000,000
2	Inoculant material	15, 000,000	30, 000,000	40, 000,000

No.	Type of Cost	D = ≥15 - ≤25	D = >25 - ≤35	D = >.35 - 40
3	Other chemical substance	5, 000,000	10, 000,000	15, 000,000
4	Equipment	1, 010,000	1, 010,000	1, 010,000
5	Fuel	450,000	450,000	450,000
6	Specialist technical labor	1, 500,000	1, 500,000	1, 500,000
	Technical assistant	1, 000,000	1, 000,000	1, 000,000
	Unskilled labor	1, 500,000	1, 500,000	1, 500,000
7	Transfer of inoculant	4, 650,000	9, 300,000	13, 950,000
	Total cost of inoculation (2-7)	30, 110,000	54, 760,000	74, 410,000
8	Cost for security	36, 000,000	36, 000,000	36, 000,000
9	Harvesting cost	153, 900,000	190, 350,000	220, 320,000

Source: Primary data analysis

1. Cost for buying trees is Rp 250,000,-; Rp 300,000,- and Rp 350,000,- for stem diameter ≥ 15 – ≤ 25 cm; > 25 – ≤ 35 cm and > 35 cm - 40 cm respectively.
2. Cost for buying inoculant material Rp 150,000,-;Rp 300,000,- and Rp 400,000,-. For stem diameter Ø ≥ 15 – ≤ 25 cm; Ø > 25 – ≤ 35 cm and Ø > 35 cm - 40 cm respectively.
3. Cost for buying other chemical substance Rp 5,000,000,-, Rp 10,000,000,- and Rp 15,000,000,- for stem diameter Ø ≥ 15 – ≤ 25 cm; Ø > 25 – ≤ 35 cm and Ø > 35 cm - 40 cm respectively.
4. Cost of equipment and cost of depreciation Rp 1,010,000 same for all three stem diameter class.
5. Fuel needed during inoculation process Rp 450,000,- same for all three stem diameter class.
6. Cost of labor for doing inoculation process (specialist, assistant and unskilled labor) Rp 4.000.000,- same for all three stem diameter class.

Maintenance cost after gaharu producing trees have been inoculated consists of cost for security and harvesting:

1. Cost for security, begins from period when inoculation process was carried out until the end of harvesting period (1 – 5 year after inoculation) is Rp 36 million, same for all three stem diameter class.
2. Cost of harvesting is Rp 153.9 million, Rp 190.35 million and 220.32 million for each stem diameter ≥15 – ≤25 cm; > 25 – ≤ 35 cm and > 35 cm - 40 cm respectively.

E. Feasibility of Gaharu Inoculation Bussiness

Based on assumption and restrictions mentioned above for inoculation of 100 gaharu producing trees with average stem diameter 15-20 cm, total investment cost needed is Rp 55.11 million consisting of cost for buying gaharu producing trees Rp 25 million and cost for inoculation Rp 30.11 million. Besides this, other cost for security of tree stands during 6 year period is Rp 36 million and harvesting cost is Rp 153.9 million. Based on those investment, maintenance and harvesting cost mentioned before, at 12.5 % interest rate, NPV obtained is Rp 329.4 million, IRR= 80.45 and B/C= 2.97 (Annex 1).

Next, inoculation of gaharu producing trees with 25-30 cm stem diameter, total investment cost needed is Rp 84.76 million consisting of cost for buying gaharu producing trees that is Rp 30 million and cost for inoculation process that is Rp 54.76 million. Besides this, other cost for security of tree stands during 6 year period is Rp 36 million and harvesting cost is Rp 190.35 million. Based on those investment, maintenance and harvesting cost mentioned before, at 12.5 % interest rate, NPV obtained is Rp 376.65 million, IRR= 72.66 and B/C= 2.75 (Annex 2).

Last, inoculation of gaharu producing trees with > 40 cm stem diameter, total investment cost needed is Rp Rp 109.41 million consisting of cost for buying gaharu producing trees that is Rp 35 million and cost for inoculation process that is Rp 74.41 million. Besides this, other cost for security of tree stands during 6 year period is Rp 36 milion and harvesting cost is Rp 220.32 million. Based on those investment, maintenance and harvesting cost mentioned before, at 12.5 % interest rate, NPV obtained is Rp Rp 393.56 million, IRR= 66.02 and B/C= 2.53 (Annex 3).

Financial analysis elaborated above showed that inoculation of gaharu producing trees need large amount of investment. However future benefit which is going to be obtained is also big and therefore it is very feasible to be developed. Level of feasibility would be much higher if harvesting period is postpone until five year of inoculation period (gaharu producing trees are 10 years old) (Table 6).

Table 6. Result of Financial Analysis of inoculation of 100 gaharu producing trees if harvested five years after inoculation

No.	Uraian	D=15-20 Cm	D=25-30 Cm	D=40 Cm
1.	NPV (DF 12.5%) (Rp)	859,63,865	934,500,351	987,837,607
2.	IRR (%)	94.93%	84.71%	78.94%
3.	B/C	6.0806	5.1683	4.7884

Source: Primary data analysis

From Table. 6 it can be seen that postponing of harvesting until five year after inoculation would produce NPV, IRR and B/C much higher than that of former analysis (Annex 1, 2 and 3). Postponing until five year after inoculation would produce gaharu with better quality product. However time of postponing is less preferred by many people who invest a lot of money in the business. People prefer to gain quick benefit even though total amount obtained would be less.

From the analysis above, it can be seen that gaharu agribusiness needs big amount of investment. Consequently only very limited people have the capability to establish the business. For forest surrounding people who mostly have very limited resources would not be able to afford it. Hence, in order to promote development of gaharu agribusiness wider, a partnership scheme should be initially introduced. Partnership model which is expected to be mutually advantages for both sides (investor and farmers or other parties) could endorse limited resources owner to develop gaharu agribusiness. Through partnership model, all risk, responsibilities and later benefit could be shared together among all parties involved.

IV. CONCLUSION AND RECOMMENDATION

Based on calculation and analysis described before, several conclusion remarks and recommendations can be presented as follow:

1. Gaharu is one of main non timber forest product export commodities. Its cultivation development and its artificial production of gaharu are very prospective to be developed in Indonesia.
2. Several supporting factors on the success of its cultivation development and its artificial gaharu production mainly lie on the availability of potential land for extensive gaharu cultivation, appropriate agro climate condition, cultivation technique which is relatively easy and has been well adopted by farmers, availability of necessary pathogen for gaharu inoculation and its demand that tends to increase with relatively high price.
3. Factors determining the success of gaharu business are inoculation technology, appropriateness/suitability between pathogen and tree species which is going to be inoculated and resistance of inoculated tree species.
4. Development of gaharu agribusiness at different stem diameter, (Ø $\geq$15 – $\leq$ 25 cm, Ø > 25 – $\leq$ 35 cm and Ø > 35 cm - 40 cm) and period of inoculation, would produce positive NPV, IRR much higher than interest rate on national market and B/C ratio > 1, therefore it is very feasible to be carried out.
5. In order to retain Indonesia as prominent gaharu production country, to increase export of non timber forest product commodity and to improve income of forest surrounding people, several efforts to induce development of gaharu production tree species cultivation and gaharu production through artificial inoculation should be widely developed.
6. As capital intensive agribusiness, only few people have the capability to afford it. Therefore, in order to develop gaharu agribusiness further, a partnership scheme between investor having enough capital with other parties having limited resources (farmers or other parties interested in gaharu development) should be initially introduced.

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Annex 1. Table Financial Analysis of inoculation on 100 gaharu producing tree species with stem diameter ≥ 15 - ≤ 25Cm

No.	Explanation	Year -					
		0	1	2	3	4	5
I.	Cash Inflow (Rp)						
	a. Output (Kg)						
	Super quality gaharu	0	10.80	13.50	16.20	18.90	21.60
	Low quality gaharu	0	54.00	72.00	90.00	108.00	126.00
	b. Output value	0	21,870,000	46,575,000	136,890,000	279,450,000	417,150,000
	Super quality gaharu	0	9,720,000	30,375,000	116,640,000	255,150,000	388,800,000
	Low quality gaharu	0	12,150,000	16,200,000	20,250,000	24,300,000	28,350,000
II.	Cash Outflow (Rp)						
	Investment						
	1. Buying trees	25,000,000	0	0	0	0	0
	2. Inoculation	30,110,000	0	0	0	0	0
	Cost of Security	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
	Cost for harvesting	0	19,440,000	25,650,000	31,860,000	38,070,000	38,880,000
	Total Cost	61,110,000	25,440,000	31,650,000	37,860,000	44,070,000	44,880,000
III.	Cash Flow	-61,110,000	-3,570,000	14,925,000	99,030,000	235,380,000	372,270,000
	Cumulative Cash Flow	-61,110,000	-64,680,000	-49,755,000	49,275,000	284,655,000	656,925,000
IV.	a. NPV (DF 12, 5%)	329,414,375					
	b. IRR (%)	80.45%					
	c. B/C	2.9740					

Annex 2. Teble Financial Analysis of inoculation on 100 gaharu producing tree species with stem diameter > 25 - ≤ 35Cm

No.	Explanation	Year -					
		0	1	2	3	4	5
I.	Cash Inflow (Rp)						
	a. Output (Kg)						
	Super quality gaharu	0	13.50	16.20	18.90	21.60	24.30
	Low quality gaharu	0	72.00	90.00	108.00	120.60	144.00
	b. Output value	0	28,350,000	56,700,000	194,400,000	318,735,000	469,800,000
	Super quality gaharu	0	12,150,000	36,450,000	170,100,000	291,600,000	437,400,000
	Low quality gaharu	0	16,200,000	20,250,000	24,300,000	27,135,000	32,400,000
II.	Cash Outflow (Rp)						
	Investment						
	1.Buying trees	30,000,000	0	0	0	0	0
	2. Inoculation	54,760,000	0	0	0	0	0
	Cost of security	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
	Cost for harvesting	0	25,650,000	31,860,000	38,070,000	44,280,000	50,490,000
	Total Cost	90,760,000	31,650,000	37,860,000	44,070,000	50,280,000	56,490,000
III.	Cash Flow	-90,760,000	-3,300,000	18,840,000	150,330,000	268,455,000	413,310,000
	Cumulative Cash Flow	-90,760,000	-94,060,000	-75,220,000	75,110,000	343,565,000	756,875,000
IV.	a. NPV (DF 12, 5%)	376,646,203					
	b. IRR (%)	72.66%					
	c. B/C	2.7474					

Annex 3. Table Financial Analysis of inoculation on 100 gaharu producing tree species with stem diameter > 35 cm – 40 cm

No.	Explanation	Year -					
		0	1	2	3	4	5
I.	Cash Inflow (Rp)						
	a. Output (Kg)						
	Super quality gaharu	0	16,20	18,00	20,70	23,40	26,10
	Low quality gaharu	0	90,00	108,00	126,00	144,00	162,00
	b. Output value	0	34,830,000	64,800,000	214,650,000	348,300,000	506,250,000
	Super quality gaharu	0	14,580,000	40,500,000	186,300,000	315,900,000	469,800,000
	Low quality gaharu	0	20,250,000	24,300,000	28,350,000	32,400,000	36,450,000
II.	Cash Outflow (Rp)						
	Investment						
	1. Buying trees	35,000,000	0	0	0	0	0
	2. Inoculation	74,410,000	0	0	0	0	0
	Cost of security	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000	6,000,000
	Cost for harvesting	0	31,860,000	37,800,000	44,010,000	50,220,000	56,430,000
	Total Cost	115,410,000	37,860,000	43,800,000	50,010,000	56,220,000	62,430,000
III.	Cash Flow	-115,410,000	-3,030,000	21,000,000	164,640,000	292,080,000	443,820,000
	Cumulative Cash Flow	-115,410,000	-118,440,000	-97,440,000	67,200,000	359,280,000	803,100,000
IV.	a. NPV (DF 12, 5%)	393,558,995					
	b. IRR (%)	66.02%					
	c. B/C	2.5345					

FINANCIAL ANALYSIS ON GAHARU (EAGLEWOOD) PLANTATION

By:

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ABSTRACT

There is a growing plantation area of gaharu (eaglewood), a potential non-timber forest products (NTFPs), planted either by government project or people initiative. The increasing gaharu planting trend is attributed mostly to the currently available of innoculant production and gaharu induction technology. ITTO PD425/06 Rev.1 (I) has planted 15.000 gaharu trees at Carita Banten and 30.000 trees at Kandangan-Barabai South Kalimantan. Planting gaharu is mostly done in mix planting with others commercial plants such as rubber trees and palm oil. This paper present gaharu planting cost calculation based on ITTO PD 425/06 Rev.1 (I) data on planting plot establishment at Carita, Banten and Kandangan-Barabai South Kalimantan. The planting cost calculation is presented in two planting schemes namely mono-culture and mix planting. Planting cost per hectare of gaharu in mono-culture at 3 x 3 and 4 x 4 meter spacing is Rp 12.452.000,- and Rp 8.460.500,- respectively. Planting cost per Hectare of gaharu in mix planting with palm oil at planting density of 278 trees per ha is Rp 9.303.000,-. Planting cost per hectare of gaharu in mix planting with rubber trees at planting density of 1.112 trees per ha is Rp 14.068.000,-.

Keywords : financial analysis, gaharu, plantation.

I. INTRODUCTION

Gaharu plantation area is recently expanding throughout Indonesia, planted either by government project or by private sectors. The growing trend of gaharu planting is triggered by the promising commercial prospect of gaharu commodity. Prior planting era of gaharu trees, gaharu resin was extracted by cutting of natural gaharu trees. In natural tropical forest, gaharu trees (*Aquilaria* spp. dan *Gyrinops* spp.) are not a dominant species or in other words the population of gaharu trees in natural forest is relatively few. The important value index of gaharu (*Aquilaria* spp.) at Bukit Tiga Puluh National Park is 2.27 (Antoko dan Kwatrina, 2006). The low important value index (1.03) of other gaharu

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species (*Gyrinops* spp.) is also recorded at Central Sulawesi (Sidiyasa, 1989.). Intensive exploitation of minor species or rare species from natural forest such as gaharu will speed up its disappearance from natural forest. Sharp declining of gaharu population has put the species onto Appendix II CITES (Siran, 2010). As a consequence, gaharu trading is limited by trade quota. However gaharu obtained from artificial cultivation is not include on trade quota.

Unlike other NTFP such as pine resin and damar which can be extracted from the trees after a certain age, to get gaharu resin the tree must first be innoculated by a particular microbes that induce gaharu resin production. Therefore, 5 – 6 years after planting, the gaharu trees must be innoculated by suitable microbes. The spending components for calculating gaharu planting cost are similar to other commercial trees. However, the price of gaharu planting stocks is relatively higher than other tree species. Depending on its size, the range of gaharu seedling price is between Rp 5,000 to Rp 20,000 per seedling. Other additional cost for gaharu planting and production is cost for gaharu induction by microbe inoculation. This paper however, only presented first year cost of gaharu planting, microbes inoculation cost is presented separately.

II. GAHARU PLANTING

Gaharu planting by local community can be observed in many parts of Indonesia Archipelagos. ITTO project PD 425/06 Rev.1 (I) has planted gaharu trees in Carita Banten and Kandangan-Barabai South Kalimantan. In the year of 2009 -2010 the project planted 15,000 gaharu seedlings in area of 24 Ha at Carita Banten. Planting was done under canopy of higher vegetation such as dipterocarps stand, clove trees, jackfruit trees, etc. Gaharu planting has also been done at Kandangan-Barabai South Kalimantan in area of 48 Ha with 30,000 gaharu seedlings.

Indonesia's indigenous trees that produced valuable gaharu resin such as *A. malaccensis, A. beccariana, A. crassna, A. microcarpa* dan *Gyrinops cumingiana,* naturally grown in Sumatera, Java, Kalimantan, Sulawesi, Moluccas and Papua (Siran, 2010). The suitable environment for planting gaharu is elevation between 0 – 750 m above sea level, clay mineral soil, rainfall above 2,000 mm/year for *Aquilaria* and above 1,500 mm/year for *Gyrinops* (Sitepu *et al*, 2010; Prosea, 1999). Other species of gaharu namely *Gonystylus* spp. (gaharu buaya) grow in peat land. Major pest of gaharu plantation is leaf eater green caterpilar *Heortia vitessoides* which attack gaharu plantation in Carita Banten, Sanggau West Kalimantan and Lombok NTB (Irianto *et al*., 2010).

Survival rate of gaharu planting in Carita Banten is 76%, mortality is mostly caused by leaf eater green caterpilar attack. Height of gaharu planted in Carita Banten at the end of 2010 (1,5 year old) is between 60 cm to 160 cm (Figure 1). Survival rate of gaharu at Kandangan South Kalimantan is above 80%.

Figure 1. One year and six months old of gaharu at Carita Banten (left) and planting activity at Kandangan South Kalimantan (right)

III. FINANCIAL ANALYSIS OF GAHARU PLANTATION

Planting cost study of gaharu planting is based on data from field planting plot ITTO PD425/06 Rev.1 (I) at Carita Banten and Kandangan-Barabai South Kalimantan. Calculation is presented on three planting schemes namely (1) monoculture planting of gaharu with two spacing variation i.e. 3 x 3 meter and 4 x 4 meter, (2) mix planting with palm oil at planting density of 278 trees per hectare, and (3) mix planting with rubber trees at planting density 1,112 trees per hectare.

Cost components for calculating planting cost are (1) seedling purchase, (2) stake purchase, (3) labor cost for Line clearing & staking (per diem), (4) labor cost for planting pit digging and planting (per diem), (5) fertilizer purchase, (6) labor cost for fertilizer application, (7) labor cost for first tending, and (8) labor cost for second tending. The differences planting cost among planting schemes are due to the difference purchase price of seedlings (gaharu, palm oil and rubber trees), and planting density (number of planted trees per hectare). The following table present calculation of planting cost based their planting schemes.

Table 1. Planting cost of gaharu in mono-culture with planting density 1.100 trees/Ha (3 x 3 m)

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
01	Gaharu seedlings	1.100	5.000,-	5.500.000,-
02	Stake	1.100	500,-	550.000,-
03	Line clearing & staking (per diem)	36	40.000,-	1.440.000,-
04	Planting pit & planting (per diem)	56	40.000,-	2.240.000,-
05	Fertilizer (Kg)	22	11.000,-	242.000,-
06	Fertilizer application (per diem)	36	40.000,-	1.440.000,-

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
07	First tending (per diem)	13	40.000,-	520.000,-
08	Second tending (per diem)	13	40.000,-	520.000,-
Total cost				12.452.000,-

Planting cost of gaharu planting for monoculture scheme at planting density of 1,100 plants/Ha is Rp 12.452.000,-. Monoculture planting of gaharu should not be interpreted as 100% pure planting of gaharu. Gaharu is tolerant tree, therefore planting gaharu should be done under canopy of other plants such as banana, papaya, etc. Two years after planting, when the height of gaharu trees about 1.5 – 2.0 meter, canopy trees should be cut off. However in many forest farms, the farmers do not cut the canopy trees such as clove, cacao and rubber, instead they provide wider spacing for gaharu trees to get sufficient sunlight.

Table 2. Planting cost of gaharu in mono-culture with planting density 625 trees/Ha (4 x 4 m)

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
01	Gaharu seedlings	625	5.000,-	3.125.000,-
02	Stake	625	500,-	312.500,-
03	Line clearing & staking (per diem)	36	40.000,-	1.200.000,-
04	Planting pit & planting (per diem)	56	40.000,-	1.680.000,-
05	Fertilizer (Kg)	22	11.000,-	143.000,-
06	Fertilizer application (per diem)	36	40.000,-	1.200.000,-
07	First tending (per diem)	13	40.000,-	400.000,-
08	Second tending (per diem)	13	40.000,-	400.000,-
Total cost				8.460.500,-

Planting cost of gaharu planting for monoculture scheme at planting density of 625 plants/Ha is Rp 8.460.500,-. Planting cost of this scheme is lower than at planting density 1,100 plants/ Ha. This cost discrepancy is mainly due to seedling purchase is less than with higher density.

Table 3. Planting cost of gaharu in mix planting with palm oil at planting density of **gaharu** plants 139 trees/Ha

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
01	gaharu seedlings	139	5.000,-	695.000,-
02	Stake	139	500,-	69.500,-
03	Line clearing & staking (per diem)	36	40.000,-	480.000,-

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
04	Planting pit & planting (per diem)	56	40.000,-	720.000,-
05	Fertilizer (Kg)	22	11.000,-	33.000,-
06	Fertilizer application (per diem)	36	40.000,-	480.000,-
07	First tending (per diem)	13	40.000,-	240.000,-
08	Second tending (per diem)	13	40.000,-	240.000,-
Total cost				2.957.500,-

Table 4. Planting cost of gaharu in mix planting with palm oil at planting density of **palm oil** plants 139 trees/Ha

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
01	palm oil seedlings	139	21.000,-	2.919.000,-
02	Stake	139	500,-	69.500,-
03	Line clearing & staking (per diem)	36	40.000,-	720.000,-
04	Planting pit & planting (per diem)	56	40.000,-	1.200.000,-
05	Fertilizer (Kg)	22	11.000,-	77.000,-
06	Fertilizer application (per diem)	36	40.000,-	720.000,-
07	First tending (per diem)	13	40.000,-	320.000,-
08	Second tending (per diem)	13	40.000,-	320.000,-
Total cost				6.345.500,-

Planting cost of gaharu on mix planting scheme is the sum of planting 139 gaharu seedlings (Table 3) and planting of 139 palm oil seedlings (Table 4). Total planting cost of planting gaharu in mix planting with palm oil at planting density of palm oil plants 278 trees/Ha is Rp 2.957.500,- + Rp 6.345.500,- = Rp 9.303.000,-.

In mix planting scheme of gaharu with palm oil, the planting of gaharu is done two years after planting the palm oil. This practice is done to allow palm tree grow at height level that suitable to provide shading for the gaharu trees. This scheme is implemented by forest farmer at Muara Jambi.

Table 5. Planting cost of gaharu in mix planting with rubber tree at planting density of **gaharu** plants 556 trees/Ha

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
01	Gaharu seedlings	556	5.000,-	2.780.000,-
02	Stake	556	500,-	278.500,-
03	Line clearing & staking (per diem)	26	40.000,-	1.040.000,-
04	Planting pit & planting (per diem)	38	40.000,-	1.520.000,-
05	Fertilizer (Kg)	12	11.000,-	132.000,-

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
06	Fertilizer application (per diem)	28	40.000,-	1.120.000,-
07	First tending (per diem)	9	40.000,-	360.000,-
08	Second tending (per diem)	9	40.000,-	360.000,-
Total cost				7.590.000,-

Table 6. Planting cost of gaharu in mix planting with rubber tree at planting density of **rubber trees** plants 556 trees/Ha

No	Cost component	No per Ha	Unit (Rp)	Total (Rp)
01	Rubber tree seedlings	556	3.000,-	1.668.000,-
02	Stakes	556	500,-	278.500,-
03	Line clearing & staking (per diem)	26	40.000,-	1.040.000,-
04	Planting pit & planting (per diem)	38	40.000,-	1.520.000,-
05	Fertilizer (Kg)	12	11.000,-	132.000,-
06	Fertilizer application (per diem)	28	40.000,-	1.120.000,-
07	First tending (per diem)	9	40.000,-	360.000,-
08	Second tending (per diem)	9	40.000,-	360.000,-
Total cost				6.478.000,-

Total planting cost of planting gaharu in mix planting with rubber trees at planting density of palm oil plants 1,112 trees/Ha is Rp 7,590,000,- + Rp 6,478,000.- = Rp 14,068,000.-. Mix-planting scheme of gaharu and rubber trees has been practiced by forest farmer in Sanggau, Kalimantan Barat dan Kandangan, Kalimantan Selatan.

Planting cost calculation presented on Table 1 to table 6 does not include other cost component such as (1) landscaping, (2) management cost, (2) second year tending and (4) inoculation cost of gaharu induced microbes. Per diem labor cost is based on 2010 standard labor cost in Banten and South Kalimantan. Planting site condition before planting is shrub land with few trees. Line clearing for planting pit arrangement is without cutting off the trees. The trees is needed to provides shading for newly planted gaharu seedlings. In mix planting schemes with palm oil and rubber trees, gaharu seedlings were planted 2 to 3 years after planting palm oil or rubber trees, at which canopy of palmoil and rubber trees can provide sufficient shading for gaharu seedlings.

IV. CONCLUDING REMARKS

The increasing popularity of planting gaharu occurs in many part of of Indonesia Archipelagos leads to growing business of other related sectors such as seedlings supply, growing variety gaharu products (perfume, cosmetic, aromatherapeutic product, etc.). Nowadays gaharu is considered as prospective and strategic commodity which will create variety of others business sectors as in palm oil on agriculture industry.

The financial analysis of gaharu plantation is presented in two planting schemes namely mono-culture and mix planting. Planting cost per Hectare of gaharu in monoculture at 3 x 3 and 4 x 4 meter spacing is Rp 12.452.000,- and Rp 8.460.500,- respectively. Planting cost per Hectare of gaharu in mix planting with palm oil at planting density of 278 trees per Ha is Rp 9.303.000,-. Planting cost per hectare of gaharu in mix planting with rubber trees at planting density of 1.112 trees per ha is Rp 14.068.000,-.

Leaf eater caterpillar *H. vitessoides* is now spreading in vast area of Java and Kalimantan, it is important therefore to keep highly alert for anticipating this problem. *H. vitessoides* attack can totally defoliate the trees of 30 cm in diameter and kill the trees. Planting cost calculation in this paper does not included eradication measures of caterpillar attacks.

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NUTRIENT AND ECONOMIC BALANCES OF GAHARU (EAGLEWOOD) GROWN IN A MIX FARMING SYSTEM

by :

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ABSTRACT

One of famers in Pulau Laut of Kotabaru Regency is growing gaharu with other plants (mix farming). Beside gaharu, this farmer also grows banana (*Musa* sp.), Jackfruit (*Artocarpus integra*), Rubber (*Hevea brassliensis*), Jati (*Tectona grandis*), Mahkota Dewa (*Phaleria papuana*), Cassava (*Manihot utilisima*), Durian (*Durio zibethinus*), and Langsat (*Lansium domesticum*). The advantage of growing Gaharu has never been evaluated. Using a NUTMON program, we take the opportunity to measure the economic performance of such system. The results showed that in the January to December 2009 period there were positive balances of nitrogen (N), phosphorus (P) and potassium (K) for the whole farm. In each commodity (compartment), there were positive and negative balances of nutrients. The positive balance occurred in compartments which has no yield yet. The negative balance occurred in the compartments that produced yield. It was also observed that the economic balance for the whole farm was positive. In each compartment, the positive balance of economy was noticed in the compartments that produced yield. On the other hand the negative economic balance was found in the compartments that had not produced yield. Over all, while waiting for the gaharu to produce, the farmer earned about 4.75 million rupiah per month from the mix farming system.

Keywords : nutrients flow, economic flow, nutmon

I. INTRODUCTION

Gaharu (eaglewood) may play an important role in gaining foreign exchange and as a source of income for people living in out- and in-side the forest in Indonesia. This is because, the gaharu export market remains open. Therefore there is a big opportunity

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for the Indonesian farmers to establish gaharu plantation (Purnomo, 2010).

Of the several study sites in South Kalimantan, one of them located in Pulau Laut Kotabaru regency. In this site, the gaharu was grown with other plants (mix farming system). There is a lack of information on the success of the Gaharu plantation using the mix farming system.

The present work focused on evaluating the sustainability of Gaharu plantation in the mix farming system by monitoring the balance of both nutrient and economy.

II. MATERIALS AND METHODS

Site. The study was taken place in Betung Village (3.271042 S; 116,144335 E), Berangas District, Kotabaru Regency, South Kalimantan. The soil in this site was classified as a red yellow podsolic. In the study site we found the gaharu (*Aquilaria microcarpa* and *Aquilaria beccariana*) trees were grown with other commercial plants such as banana (*Musa* sp), Jackfruit (*Arthocarpus integra*), Rubber (*Hevea brassiliensis*), Jati (*Tectona grandis*), Mahkota Dewa (*Phaleria macrocarpa*), Cassava (*Manihot utilisima*), Durian (*Durio zibethinus*), and Langsat (*Lansium domesticum*).

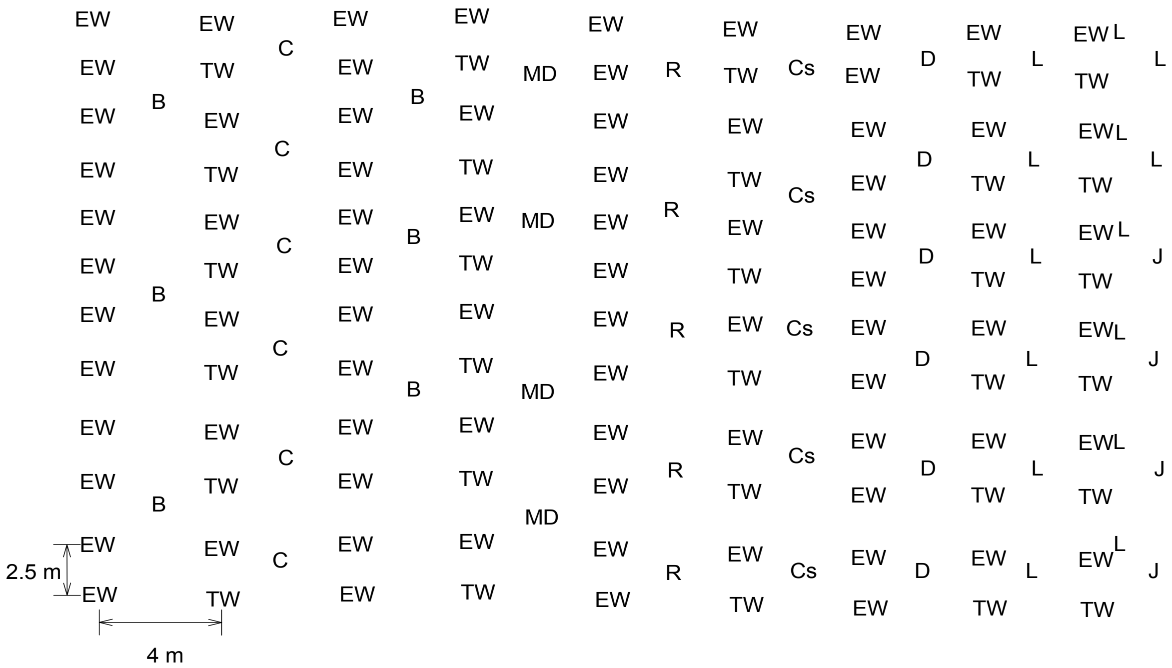

Figure 1. General plant arrahngement in the field. Notes: EW= Gaharu (70% of 5 ha) , TW= Teak Wood (17%); B= Banana (1%); C= Coconut (2%); MD= Mahkota Dewa (1%); R= Rubber (2%); C= Cassava (1%); D= Durian (2%); L= Langsat (2%); J= Jatropha (2%)

Data collection. Data were collected using two questionnaires for inventory and monitoring purposes. These data were needed to evaluate the mix farming system.

Data analysis. Data were analyzed using a software called NUTMON v 3.6. According to Vlaming *et al.* (2007) the software permits to carry out a quantitative analysis, which generates important indicators such as nutrient flows, nutrient balances, cash flows, gross margins and farm income. The evaluation was carried for the period of January to December 2009.

III. RESULTS AND DISCUSSION

The balances of nutrient and economy in the study area were calculated from the input to and output from the farm under study.

Nutrient balance. The input parameters included: mineral fertilizers (IN1), oranic input (IN2); atmospheric deposition (IN3), biological N-fixation (IN4) and sedimentation (IN5). While, the output parameters involved: farm product (OUT1), other organic product (OUT2), leaching (OUT3), gaseous losses (OUT4) and erosion (OUT5).

The full balance of N, P and K in the farm can be seen in Table 1. It was shown that the balance of P was positive and there were negative for the N and K balances. The positive balance indicates that the nutrient lost may be due to leaching, run off and or remove by harvest was less than fertilizers input as inorganic and organic form. It is well known that P is immobile, so lost to leaching would be small. The negative balances of N and K may be due to due to leaching, run off and or remove by harvest was less than fertilizers input as inorganic and organic form. The amount of N and K lost from the farm was 16.8 and 31.8 kg, respectively. The remaining P in the farm was 10.0 kg. The lost of N and K were mainly through harvest. It was 154.0 kg for N and 37.1 kg for K. The lost of P also occurred mainly due to harvest; however, the figure was lower than the input from fertilizer. In this compartment farmer grew vegetables.

Table 1. The nutrient balances in the general farm (kg)

Nutrient	Input		Output		Balance
	In1	In2	Out1	Out2	
N	140.5	3.5	154	6.8	-16.8
P	32.3	0.9	22.4	0.8	10
K	11.7	0.9	37.1	7.3	-31.8

Details of nutrient balances are demonstrated in Table 2. Positive nutrient balances were observed for commodities such as gaharu, teak, durian, langsat, coconut, jatropha, and mahkota dewa. The positive nutrient balances occurred because these commodities have not produced yield. Therefore, most of nutrients applied stay in the each compartment.

Table 2. Detail of nutrient balance in each commodity (kg)

Nutrient	Input		Output		Balance	Input		Output		Balance
	In1	In2	Out1	Out2		In1	In2	Out1	Out2	
Gaharu						Langsat				
N	97.3	2.5	6.4	0	93.4	2.8	0.1	0	0	2.9
P	22.5	0.6	0	0.7	22.4	0.6	0	0	0	0.6
K	8.3	0.6	5.8	0	3.1	0.2	0	0	0	0.2
Banana						Coconut				
N	2.8	0.1	0.4	0	2.5	2.8	0.1	0	0	2.9
P	0.6	0	0.1	0	0.5	0.6	0	0	0	0.6
K	0.2	0	1.5	0	-1.3	0.2	0	0	0	0.2
Cassava						Jatropha				
N	2.8	0.1	2.4	0	0.5	2.8	0.1	0	0	2.9
P	0.6	0	0.3	0	0.3	0.6	0	0	0	0.6
K	0.2	0	2.4	0	-2.2	0.2	0	0	0	0.2
Rubber						Mahkota Dewa				
N	2.8	0.1	151.2	0	-148.3	2.8	0.1	0	0	2.9
P	0.6	0	22.1	0	-21.5	0.6	0	0	0	0.6
K	0.2	0	34.7	0	-34.5	0.2	0	0	0	0.2
Teak						Chicken				
N	21.1	0.6	0	0	21.7	0	0	0.5	0	-0.5
P	4.9	0.1	0	0	5	0	0	0	0	0
K	1.8	0.1	0	0	1.9	0	0	0	0	0
Durian										
N	2.8	0.1	0	0	2.9					
P	0.6	0	0	0	0.6					
K	0.2	0	0	0	0.2					

Other commodities, namely, Rubber, Banana, Cassava and chicken have produced yield. Consequently, some amount nutrients were brought out from the farm. The highest lost of nutrients occurred for Rubber through latex production. For Banana and Cassava commodities, there were loss of K. The K lost was due to harvest of fruits and tuber, respectively.

Economy balance. The gross margins for all commodities are shown in Table 3. There were positive and negative margins. The positive margins were observed in the commodities of Gaharu, Rubber, Banana, Cassava and chicken. While, the negative margins were found in the Teak, Durian, Langsat, Coconut, Jatropha, and Mahkota Dewa.

Table 3. Economy balances (Rupiah)

Commodities	Cash in	Cash out
Gaharu	4.061.042	
Teak		2.202.027
Durian		296.027
Langsat		296.027
Coconut		56.027
Rubber	48.943.732	
Jatropha		276.005
Mahkota Dewa		276.005
Banana	5.739.994	
Cassava	1.589.995	
Chicken	120.000	
Sum	60.454.762	3.402.118
Profit per year	57.052.645	
Profit per month	4.754.387	

The positive margin indicates that the compartments had produced yields, in the other hand, the negative margin occurred in the compartments which had not produced any yield. It was estimated that growing Gaharu using the mix farming system gained profit Rp. 57.052.645 per year or Rp. 4.754.387 per month.

IV. CONCLUSION

It can be concluded that in the January to December 2009 period there were positive balances of nitrogen (N), phosphorus (P) and potassium (K) for the whole farm. In each commodity, there were positive and negative balances of nutrients. The positive balance occurred in compartments which has no yield yet. The negative balance occurred in the commodities that produced yield. It was also observed that the economic balance for the whole farm was positive. In each commodity, the positive balance of economy was noticed in the compartments that produced yield. On the other hand the negative economic balance was found in the compartments that had not produced yield. Over all, while waiting for the Gaharu to produce, the farmer earned about 4.75 million rupiah per month from the mix farming system.

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EXIT STRATEGY AND RECOMMENDATION ON GAHARU (EAGLEWOOD) DEVELOPMENT FOLLOWING THE ITTO PD 425/06 REV.1 (I) PROJECT

By

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ABSTRACT

The development of gaharu products as addressed in ITTO PD 425/06 Rev.1 (I) Project, entitled "Production and Utilization Technology for Sustainable Development of Eaglewood (Gaharu) in Indonesia" has significantly contributed to development of bio-induced gaharu, gaharu inoculum products, and its implementation in the demonstration plot for the gaharu-yielding trees owned by the farmer group who reside around the forests. The problems as encountered while these activities proceed are among others the pests brought about by the larvae that attack the leaves of gaharu-yielding trees, which have taken place in several regions. Another problem is that gaharu qualities varied depending on the gaharu-yielding species as induced; and also still other problems cover tree-genetic variation, bio-physic environments, community perception toward the technology of bio-induced gaharu, government policies on gaharu products that result from cultivation, market institution, etc which so far are not yet established. Development activities on gaharu in Indonesia deserve continuation by determining exit strategy with regard to research and development framework directed by the Forestry Research and Development Agency in cooperation with the related stakeholders. The addressing of these highlights intends to discuss in depth the exit strategy and recommendation on gaharu development following the ITTO project designated as PD 425/06 Rev.1 (1).

Keywords: Exit strategy, master plans, gaharu-yielding trees, bio-inducement

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I. INTRODUCTION

Activities on gaharu development has been conducted by the Forestry Research and Development Agency abbreviated as FORDA (under the Indonesia's Ministry of Forestry) in cooperation with the ITTO designated as PD 425/06 Rev.1 (1) has proceeded for three years. Such activities end up with fairly satisfactory results, particularly the advancement in bio-inducement technology on gaharu as an attempt to sustain gaharu products in Indonesia. The specific objectives regarding the activities of ITTO's PD 425/06 Rev.1 (1) are to introduce the bio-inducement technology to enhance gaharu production, and to conduct dissemination of such technology to the community who reside around the forests. The main gaharu-yielding tree species that responded favorably to gaharu formation through the bio-inducement technology covered *Aquilaria malaccensis*, *A. microcarpa*, *A. filaria*, *A. beccariana*, *A. hirta*, *A. cumingiana*, *A. crassna* dan *Gyrinops versteegii*. Still related, 54 fungi isolat regarded as dominant was *Fusarium solani* (Mart.) Sacc. (Sitepu *et al*., 2010). Unfortunately, the production of gaharu sapwood judged as genetically superior (exotic) so far has not been determined regarding such development activities. The activities regarding the breeding of gaharu-yielding trees did not belong to those of PD 425/06 Rev.1 (1).

Bio-inducement technology with solid media reveals the first generation technology the FORDA has ever developed using sawdust media added with nutrients and vitamins to enhance the growth of fungi *Fusarium* spp. (Santoso *et al*., 2010). Since the inoculum as used shapes as solid media, then the drill bit as employed to put the solid inoculum is 6-12 mm size (length), with the depth of holes reaching one third (1/3) inward of the stem diameter, and the resulting-drilling hole should be closed (sealed) with wax. This manner proves less effective, since the successful percentage rates only about 40-60%. Through the activity of ITTO's PD 425/06 Rev.1 (1), there have been conducted various modifications on bio-inducement technology. In this method, the media for fungi inoculation form as liquid, and consequently the diameter of holes becomes smaller. The volume of liquid put into the hole amounts to about 1 ml (wet origin). This method seems very effective, since the percentage of success reaches 100%. In addition, the drill bit enters into the holes also just as far inward as 1/3 of tree diameter. This intends to avoid the damage to the pit portion of stem. Another bio-inducement technology as used for the comparison is the so-called Taiwan technology. The technology used the injection needle that can enter inward the stem until 80% of the stem diameter. The injection needle contains 50-100 ml of liquid, and the inward movement of the liquid into the stem is assisted by the injection pressure. As a result, this Taiwan method causes the deterioration in the central portion of the stem, and consequently the amount of gaharu-sapwood as produced is still very limited.

Activities on the dissemination and training of gaharu bio-inducement technology have been conducted at the levels of consecutively province, regency, village, and farmer group around the forest. Several questions that arise during the discussion are among others how to acquire the appropriate bio-inducement (including the fungi inoculum) and how to market (commercialize) gaharu products that result from cultivation technique for domestic marker as well as for export. Further, it is essential to note that the aspects of national policies and institution for marketing of gaharu that result from the cultivation are not yet established. The traditional marketing of natural gaharu so far managed by the the ASGARIN (in English abbreviated from Association of Indonesia's Gaharu Enterprisers) is based on the quota as imposed by the CITES (in Appendix II), where its permits are released by PHKA (Authority dealing with Forest Protection and Nature Conservation, under the Indonesia's Ministry of Forestry) in cooperation with the LIPI (Indonesia's Scientific Authority). The aspects regarding the gaharu marketing that include product procurement, distribution system, and market intelligence either domestic or abroad are not yet accommodated in the activities of the ITTO's PD 425/06 Rev.1 (1). The ASGARIN so far still acts as a single organization to collect, distribute, and to market gaharu products categorized as the items stipulated by the CITES (in Appendix II), and oriented to the commodities of gaharu products originated from natural forests.

In activities of the ITTO's PD 425/06 Rev.1 (1), there has been attempted among others cultivation of gaharu in demonstration plots that each covered 40-hectare area situated at Carita's KHDTK (Forest Area For Special Purposes), Hulu Sungai Tengah's Regency, and Hulu Sungai Selatan's Regency (South Kalimantan). The community attention to conduct such planting activities is quite high. The patterns of cooperation in these activities have been realized for mutual benefits and reported by Suharti (2010). The sylviculture practice for the cultivation of gaharu-yielding tree seeds has been developed through the end-cutting technique that employs the KOFFCO method (Subiakto *et al*., 2010). Analysis on the growing sites of the gaharu-yielding trees done at two demonstration-plot locations revealed that such trees afforded high adaptation, covered wide-ranging growing sites, and did not require specific growing sites (Purnomo, 2010; Pratiwi, 2010).

Activities regarding chemical research on gaharu came up with finding numerous elements, but the key chemical compounds that trigger fragrant smell of the gaharu have not yet been found. Clearly, it is essential to develop more specific analysis methods (Novriyanti *et al*., 2010). Activities of PD 425/06 Rev. 1 (I) have worked out samples of downstream products from gaharu. This intends to impart added values of gaharu products, thereby enhancing their uses commercially. Several samples of downstream products which have been produced comprised among others solid soap, liquid soap, hand-cleaning soap, face whitener, and perfumes (Siran and Turjaman, 2010). In addition, one member of ASGARIN has developed the so-called gaharu-leaf tea and gahar-leaf syrup.

During the process of PD 425/06 Rev. 1 (I)'s activities, there have aroused fairly-serious threats, among which are pests and diseases that attacks gaharu-yielding trees (Irianto *et al*., 2010). There are several pests of larvae destroying gaharu leaves, already identified. One of those pasts known as the most dangerous is *Heortia vitessoides* (Moore, 1885). This pest attacks rapidly by eating-up the leaves of all gaharu-yielding trees within a short time. The control of this gaharu-larvae pest can be done biologically as the early prevention through the use of big-sized red-colored ants. This anticipation is essential by placing the colonies of those red-colored ants on the gaharu-yielding trees, thereby assisting the colony development. The use of the red-colored ants will be ineffective on gaharu trees, already under attack by such leaf-larvae pest.

Highlighting these gaharu-related aspects intends to discuss several possible exit strategies and recommendation on gaharu development following the ITTO's PD 425/06 Rev.1 (1) project

II. EXIT STRATEGY

A. The Role of Institution

Several institutions and stakeholders who possibly will participate in activities of gaharu development following the ITTO PD 425/06 Rev.1 (1) project are presented in Table 1. The FORDA serves as a central institution that has put on the move the activities of gaharu development by initiating the formation of the so-called Indonesia's Gaharu Forum (IGF), and communicating with Forestry Services at the levels of consecutively privince/regency, private sectors, and gaharu farmers.

The main key to the gaharu development is that intensity of cultivation and planting of gaharu-yielding tress should be socialized extensively in order that the availability of gaharu-yielding trees in the future becomes sustainable. Results of visits to several locations of natural-gaharu centers turned out that the knowledge of famers in gaharu-tree cultivation is still limited. Most of the farmers around the forests have not yet known the shape of fruits and seeds of gaharu trees. The distribution of gaharu trees as so far naturally scattered in Sumatera and Kalimantan is often encountered growing between the rubber trees owned by the community. Research results on the field revealed that the distribution of natural gaharu trees is assistad by mammalian creatures such as squirrels and forest mice, which assist the distribution (spreading) of gaharu-tree seeds. At the center of natural gaharu-yielding trees, there have been found such trees but it is uncertain whether or not they contain gaharu sapwood. In the initial sage, farmers are asked to make inventories on the nature shrubs that exist around their host trees which can be used as seed sources. The uprooting of gaharu-tree seeds still becomes the basis in the regeneration of gaharu-yielding trees. Results of survey conducted by the research team of the ITTO's PD 425/06 Rev.1 (1) found out gaharu-planting pattern done by the farmers who intercrop gaharu tress between rubber trees or oil-palm trees. The planting of gaharu trees as intercropped with rubber trees provides the favorable combined benefits for the related farmers. At present, the farmers obtained benefits from rubber harvest worth in price more than Rp. 20,000 per kg (of rubber). This daily revenue is regarded as the fixed daily income of the famers, and the gaharu-yielding trees as planted serve as the long-termed investment.

The production of gaharu resulting from the cultivation that will be sustainable through the bio-inducement technology is determined by the availability of gaharu inoculum. The gaharu-inoculum availability which is practical, efficient, and cheap implies that the technology products must reach the user hand. In the near future, the Institute for Forestry Research has been asked to assist the inoculum production in the gaharu-yielding centers. The Exit Strategy that will be initiated incorporates the technology transfer and establishment of "gaharu center" at the Institute for Forestry Research (IFR) in Mataram (West Nusa Tenggara). This institute owns the core researches about Non-Timber Forest Products (NTFPs), among others gaharu research. They have prepared laboratory facilities and capable-human resources. In the future, the Mataram's IFR will focus on endemic species of *Gyrinops* spp. and fungi for local-gaharu formation, which will be developed in Bali, West Nusa Tenggara, East Nusa Tenggara.

Table 1. Several institutions/*stakeholder* who will carry out the exit strategy following the ITTO's PD 425/06 Rev. 1 (I) project.

No	Institution	Exit strategy	Activities
1	Forestry Research and Development Agency (FORDA)	• Continuing strategy research on gaharu development • Arranging and organizing the master plans • Encouraging PHKA/LIPI (Forest Protection and Nature Conservation/Indonesia's Scientific Authority) to formulate special policies on gaharu resulting from the cultivation	• Allocation of researc funds • Empowerment of Forestry Research Institute
2	Indonesia's Gaharu Forum	Coordination among stakeholders and preparing action plans for gaharu development	IGF will prepare data base of gaharu tree plantation for each regency in Indonesia
3	Forestry Services at Province/Regency levels	Make action plans for gaharu plantation and inoculation program	Preparing gaharu seeds and inoculum from the regional-government budget
4	Private sectors	Cooperation regarding the investment in bio-inducement activities with farmer groups	Preparing capital for bio-inducement activities and planting of gaharu seeds
5	Farmer groups	Extending the planting activities with particular patterns	Preparing gaharu-yielding trees

Scrutinizing the proposal of ITTO's PD 425/06 Rev.1 (I), the exit strategy should deserve a thorough response or follow-up based on specific activities which have been done in three years, as follows (Table 2):

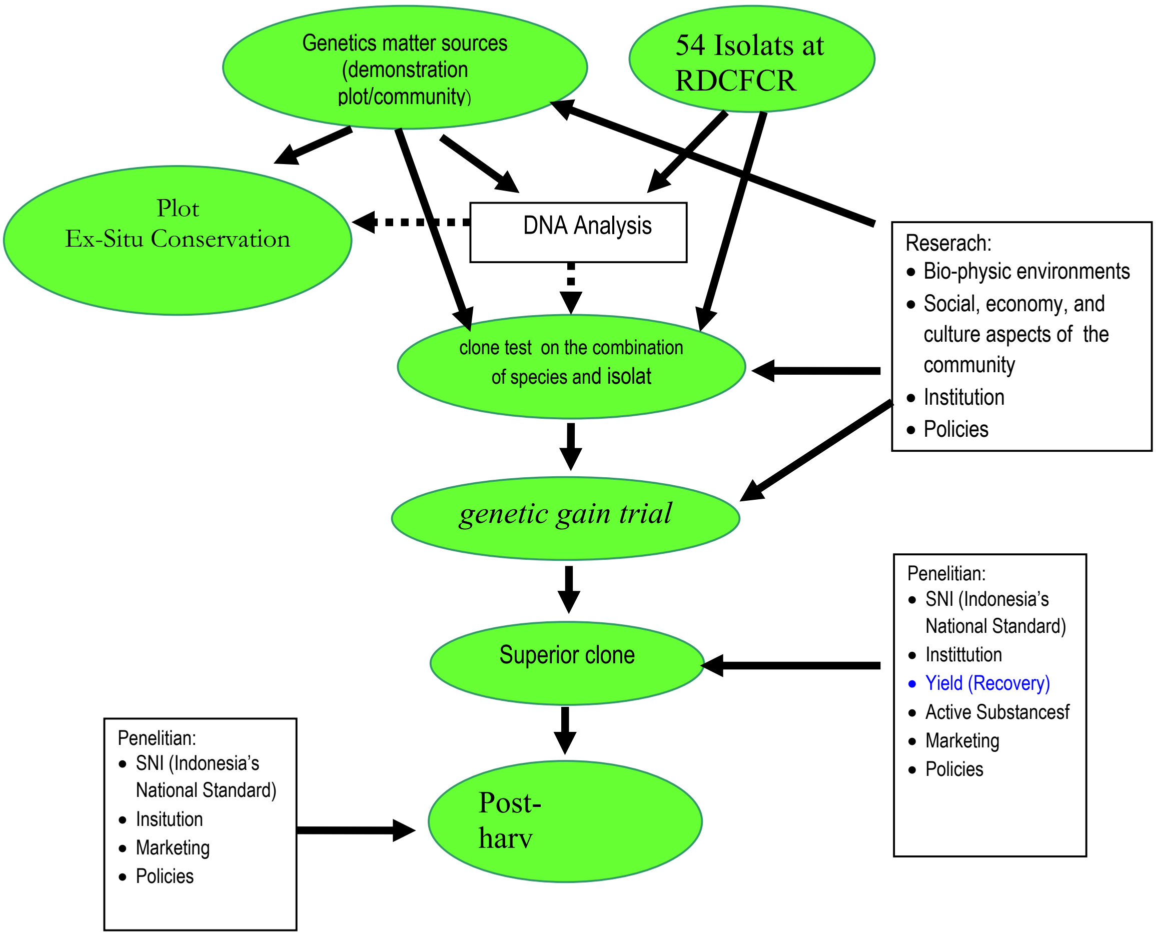
Table 2. *Exit strategy* based on activities of gaharu development at the ITTO's PD 425/06 Rev.1 (I)

No.	Activities	*Exit Strategy*
1.	Preparing the demonstration plot	ØForest area for special purposes at Carita (Province of Banten) · Cooperation between farmer groups and FORDA , which has been endorsed to manage 40-hectare area of gaharu-yielding trees. The forest farmer-group will manage and take care of gaharu-yielding trees, and concurrently the FORDA will prepare the gaharu inoculum together with the training. · The FORDA owns 300 trees which have been induced by the fungi *Fusarium* spp. The observation is conducted each year to measure the qualities of gaharu as formed. ØRegency of Kandangan/Barabai (South Kalimantan) · Agreement on the cooperation between gaharu-enterprise group (called Nanda Agribiz) and 44 members of farmer group who own over 800 trees which have been induced by the fungi *Fusarium* spp. ØSanggau (Kalbar) · The farmer group who has owned over 200 gaharu-yielding trees which have been induced. They have conducted cooperation with private sectors to induce 3,500 trees. In 2011, as many as 600 gaharu trees will be induced. ØLombok island (West Nusa Tenggara) · The Forestry Research Institute in Mataram focuses on research dealing with non-wood forest products (NWFP). In the early stage, this institute has owned over 180 gaharu trees already induced with the fungi *Fusarium* spp. Number of gaharu trees to be induced will increase, in cooperation pattern with farmer groups.
2	Development on the gaharu-inoculation techniques which is effective and efficient	· The inoculation techniques have been adopted by several stakeholders in regencies and forest farmer groups. The FORDA researchers have supervised these activities. The ASGARIN (Indonesia's Gaharu Enterprisers) will recommend its members in adopting this technology.
3	Development on inoculum which affords prospect for large-scale endeavor	· FORDA will conduct technology transfer to several Forestry Research Institutes (FRI). As of this occasion, the FRI of Mataram will be ready to accept this input technology, since the have already prepared laboratory facilities and capable-human resources.
4	The realization of training in gaharu-inoculation technology	· The FRI of Mataram is ready to continue the training for farmer groups in areas of West Nusa Tenggara. · Divisions of investment and research services will continue socializing the inoculation technology for several provinces.
5	Selection of effective inoculum	· The development on the selection of isolat *Fusarium* spp., which nowadays comprises 54 isolats, will be continued and trial-tested at the gaharu-yielding trees in several gaharu-production centers.

B. Master Plans

Activities regarding the development on the ITTO's PD 425/06 Rev.1 (I) has aroused some research ideas that deserves responses and follows-up, as addressed in organizing the Master Plans for Research and Development (R & D) on gaharu commodity. Several related R & D's which have not yet been conducted and are urgently needed comprise among others analysis on genetic variability using DNA analysis; and ex-situ conservation using representative genetic matter obtained from several populations which are separately designed between populations as an attempt to save them from extinction, and concurrently to support the breeding programs. Tree improvement that represents the test on the clone resulting from the combination of species and isolat should deserve a continuation using the so-called genetic-gain trial-test to look into the species as well as the isolat that afford the best qualities, and finally this ends up with finding the superior clone.

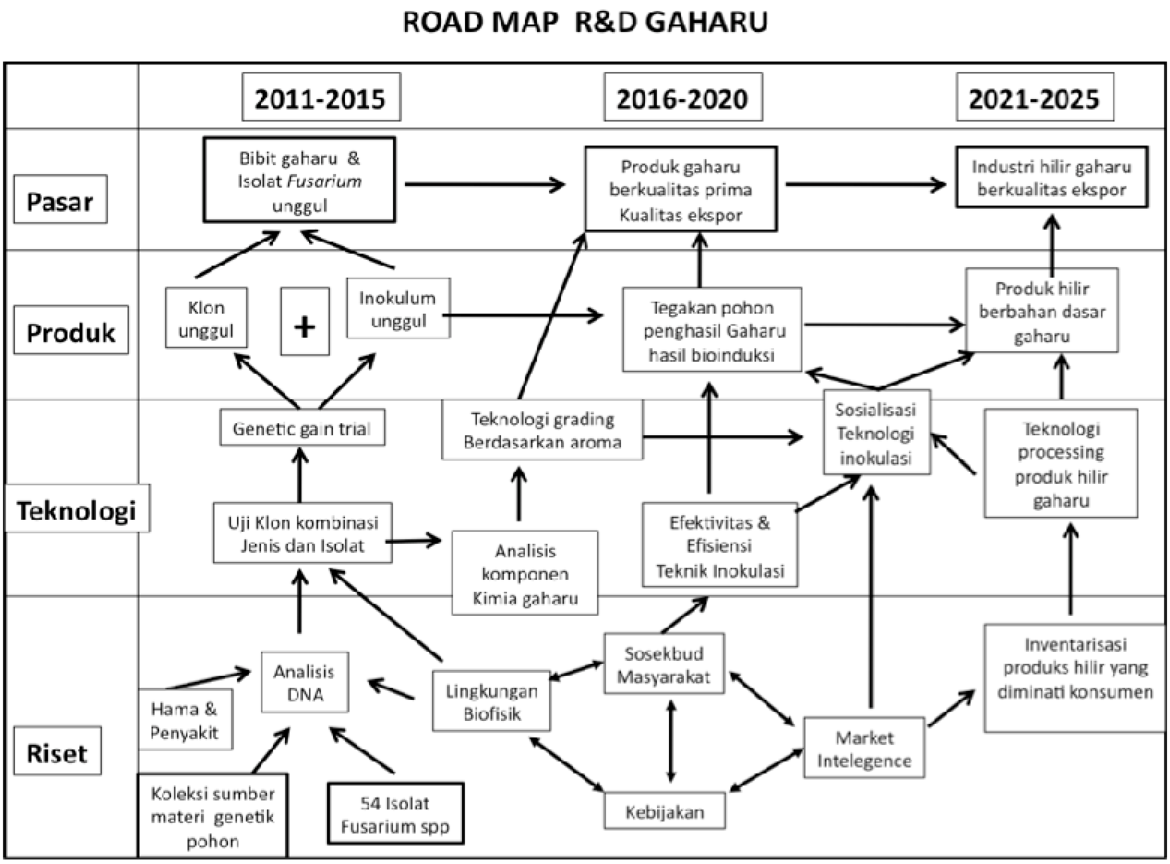
The Laboratory of Forest Microbiology (under the R&D Centre for Forest Conservation and Rehabiliation) has collected 54 isolats of fungi *Fusarium* spp. from the entire Indonesia, and so far only 8 isolats which have been trial-tested in the field. In activities of the ITTO's PD 425/06 Rev. 1 (I), there has been initiated the potency of pests that attack the gaharu-yielding tree species, particularly the leaf-eating larvae; and also research has been conducted to deal with those larvae using predators of red-colored ants and microbes. In addition, it is needed to conduct research with different bio-physic environments. Aspects about the grading of gaharu with the standard based on gaharu aroma are different for particular species and isolat origin, which differ from one another. Therefore, it is essential to conduct research to answer the interaction between genetic factors and environments (breeding/improvement). Besides, the key active substance that brings about gaharu aroma needs thorough identification particularly when linked to the derivative products such as oil, soap, cosmetics, drugs, etc. Standardization of product qualities comprising gaharu chips deserves a thorough determination, thereby not causing the loss to farmers. The strategy of research and development on gaharu is presented in the schemes as follows (Figure 1).



Remarks: FORDA = Forestry Research and Development Agency (under the Indonesia's Ministry of Forestry);
RDCFCR = R&D Centre for Forest Conservation and Rehabilitation (under the FORDA)

Figure 1. Flow-scheme regarding the exit strategy of gaharu development that will be conducted by the Research Team of FORDA

Multidisciplinary research on gaharu products beginning from the upstream until downstream should start right away. This research intends to yield gaharu products with high qualities, in which the markets take very-great interest. The integrated research as such refers to finding superior gaharu and the responsive fungi that induce gaharu formation, by scrutinizing in depth the chemical compounds that are formed based on biochemical analysis. Judging from the visit by the research team to Singapore, Taiwan, and Saudi Arabia, it tuned out that the gaharu samples that resulted from the inducement as implemented by the farmers using the technology developed by the FORDA could be accepted by markets, under the condition that the induced-gaharu should be synthesized in mass amount and continual manner. They will accept the induced-gaharu for grocery-scale (in tons of weight) with competitive prices.



Remarks (translation of words from Indonesian into English)

	2011-2015	2016-2020	2021-2025
Pasar = Market	Bibit gaharu & isolat Fusarium unggul = Gaharu seeds & superior Fusarium isolat	Produk gaharu berkualitas prima & kualitas ekspor = Gaharu products with prime qualities & export qualities	Industri hilir gaharu berkualitas ekspor = Gaharu downstream industries with export qualities
Produk = Products	Klon unggul = Superior clone Inokulum unggul = Superior inoculum	Tegakan pohon penghasul gaharu hasil bioinduksi = Stands of gaharu-yielding trees that result from bio-inducement	Produk hilir berbahan dasar gaharu = Downstream products based on gaharu origin
Teknologi = Technology	Genetic gain trial = OK Uji Klon kombinasi jenis dan isolat = Clone test on the combination of species and isolat	Efektifitas & Efisiensi Teknik Inokulasi = Effectiveness & Efficiency of Inoculation Techniques	Teknologi prosesing produk hilir gaharu = Processing technology for gaharu downstream products
Riset = Research	Analisis DNA = DNA Analysis Hama & Penyakit = Pests & Diseases Lingkungan Biofisik = Bio-physic environment Koleksi sumber materi genetic pohon = Collection of matter sources for tree genetics 54 isolat Fusarium spp. = 54 isolats of Fusarium spp.	Sosekbud Masyarakat = Social, Economy, and Culture Aspects of the Community Kebikakan = Policies	Inventarisasi produk hilir yang diminati konsumen = Inventories on downstream products, in which the consumers take great interest

Figure 2. The roadmap plan depicting research and development on gaharu (2011-2025)

The FORDA has planned to realize the Organizing-Team for Master Plans regarding Research and Development on the sustainable Gaharu in Indonesia. The organizing team has the members from the multidiscipline sciences such as sylviculture, tree improvement, forest microbiology, forest-soil science, wood chemistry, and forest pests and diseases. The Master Plans should be elaborated in "action plan" that exemplifies the research proposals submitted to obtain finances which are adequate and with multi-years conduct. The arranging of the master plans is depicted in the plan roadmap for gaharu research and development in the period 2011- 2025 (Figure 2). This roadmap is based on multi-years research and should be supported by technology, gaharu products that are yielded, and their marketing. The technologies as developed comprise the improvement of gaharu-yielding trees, biotechnology (DNA analysis for genetic variability, married system), seeds (vegetative and generative), gaharu inoculum (optimum inoculum dosage), inducement technology which is selective and effective, and post-harvest processing. The products as developed include technology (patent rights), clone of exotic tree species and superior isolat, gaharu-sapwood products, gaharu oil, cosmetics, and drugs. The marketing aspects as turned out cover locals (trade traffic in the province, harvesting farmers, collector, processor, trader/merchants), regional (trade traffic between provinces, harvesting farmers, collectors, processors, and traders/merchant), and marketing that includes market intelligence and export (overseas-trade traffic).

III. RECOMENDATION

In addressing the exit strategies regarding gaharu development following the ITTO's PD 425/06 Rev.1 (I) project, several recommendations can be drawn, as follows:

Socialization and dissemination of gaharu cultivation and gaharu bio-inducement technologies as realized by the ITTO's PD 425/06 Rev.1 (I) deserve a further dissemination as conducted by each of the stakeholders, in order that the gaharu development can proceed in the community around the forests in sustaining the gahru-yielding trees and gaharu production.

It is necessary to arrange immediately the multidisciplinary-research team who will organize Master Plans of Gaharu Development in the territory of FORDA (Forestry Research and Development Agency), in order that the continuity of gaharu production can be enhanced. Multidisciplinary research regarding gaharu should focus on genetic improvement of the gaharu-yielding trees, standardization of grading based on chemical content in gaharu, and gaharu marketing. This research should end-up with gaharu products which are measurable and standardized (SNI, as abbreviated from in English the Indonesian National Standard).

Demonstration plot regarding the cultivation and inducement of gaharu which have been developed by the ITTO's PD 425/06 Rev.1 (I) can be continued as the basic asset in the development of gaharu, whereby its Master plan will be arranged. The Master plan should be addressed in practical details by the research team, as articulated in the multi-years proposals supported by finance sources.

The policies on permits in cultivation of gaharu-yielding trees, distribution/

dissemination permits, and transportation as well as export particularly for the cultivation should be regulated chiefly by the Indonesia's Ministry of Forestry. The marketing institution for gaharu that results from the cultivation is not yet established. The marketing of gaharu resulting from the cultivation is still unknown by the traditional consumers/ users such as t hose in the Middle East and East Asia.

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