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JSPS Core University Program in the Field of Wood Science

Development of Optimum Machining and Drying Methods for Fast Grown Species and Lesser Used Species

Prof. Kazuo Hayashi, Ehime Univ.

Wood machining and wood drying are essential processing to use wood effectively in a solid state. Moreover, they decide the yield of sawn lumber and wood products. There are about 4000 tree species in Indonesia. However, there are very few species for which processing technologies have been optimized. The reason is seemed that it is difficult to collect a sufficient quantity, the wood quality is not good enough for utilization and/or there are problems in the processing. Fast grown species are very important as a sustainable resource and for the prevention of deforestation. There is a need to convert lesser used raw materials into valuable resources through the essential processing such as the wood machining and drying. Unfortunately, I am not qualified to explain the results of the wood machining research. So, in this article, I will introduce only the results obtained by the wood drying division of this project.

The aims of this wood drying research are as follows;

1) To establish a basic drying schedule by the quick decision method,

2) To identify the wood qualities which modify the drying schedule through the practical trial.

3) To obtain a variety of drying schedules by the juvenile wood of fast-grown species.

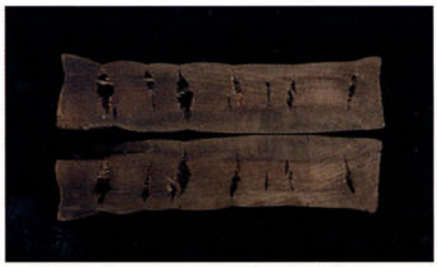
4) To classify lesser used species based on optimum drying schedules.

It is of course impossible to achieve all of this in only three years. Rather, we want to point out the direction of the program. As we must continue to make an effort for a long time, we expect the support of this program and others in JSPS.

The final seminar of this project at IPB

The conclusions of our research so for are as follows:

1) The optimum drying schedules for ten lesser used species differed but five of the ten could be suitable for the same drying schedule. We would like to try a common method using these five species and adopt a suitable classification based on wood quality.



Honeycombs of Acacia manguim, a quick test of 100℃

Total utilization of forest products; a wooden desk, a wooden wall and coconuts.

2) It has become apparent that

Acacia manguim has serious defects such as collapse, honeycomb and discoloration. To solve these problems, we developed a shed drying system on a laboratory scale and obtained good results, namely no collapse, no discoloration and a large yield. At the moment, an industrial trial of the shed drying technique for *Acacia manguium* is being carryied out in Indonesia. I hear that the first trial was successful and the industry is happy with the good results. I would like to see the system by myself.

3) Juvenile wood which is usually contained in the lumber from fast grown species, affects closely drying defects and is the main reason of the variety for the optimum drying schedules even for lumber taken from the same log.

Although, in Japan, the main subject of wood drying is to develop the rapid drying method of planted sugi, Indonesian fast grown species and lesser used species made me recognize anew the complex of wood properties and the importance of wood not only as the sustainable resources but also the social resources. From this view point, this project was very useful to me.

I have explained the outline of the wood drying project in this article. I expect that the results of the wood machining division will be given in the near future.

Development of Integrated Technology for the High-performance Utilization of Tropical Forest Resources

Prof. Yuji Imamura, WRI, Kyoto Univ.

Extending the life-span of wood is a highly effective way of saving natural forest resources and preventing global warming. Environmentally friendly technologies to provide wood of the high-performance will be established through the integration of research on the durability of tropical forest resources and the factors causing biological, physical and weathering-related deterioration, as well as their prevention. In this cooperative study, the resistance of tropical wood to weathering was evaluated after exposure testing under a tropical climate of heavy rain, high temperature and strong sunshine. Furthermore, the distribution and identification of Indonesian termite species were examined through field investigations in tropical forests. The extractives contained in tropical trees and responsible for the durability of wood, were also chemically analyzed.

Demonstration of AE monitoring for the detection of termites activities

1) Chemical and biological characterization of the surfaces of tropical woods deteriorated by weathering

Fourier transform infrared photoacoustic spectroscopic analysis revealed that the combinated effects of water and UV irradiation play an important role in destroying the lignin-hemicellulose matrix of cell walls. Of the genera identified, *Aureobasidium*, *Cladosporium*, and *Penicillium* were the dominant moulds on wood exposed to the Indonesian climate.

2) Identification of termite species in Indonesia and the detection of attack by acoustic emission (AE) monitoring

Coptotermes is perhaps the most economically important termite in South East Asia. Field surveys in Indonesia have showed that *Coptotermes* sp. are distributed on the islands of Java, Sulawesi and Sumatra Is. Their identification has been undertaken by using cuticular hydrocarbon analysis and DNA analysis as well as by examining termite body morphology. Meanwhile, an AE monitoring method was applied to Japanese and Indonesian termite species to detect their feeding activities at different RH and temperatures.

3) Chemical characterization of tropical wood extractives responsible for durability

Exposure of wood samples to the Indonesian climate

The screening of wood extractives by the direct use of cellulose TLC plates was conducted to evaluate the active components in the crude extract of Nangka (*Artocarpus heterophyllus*). A strong biocidal effect against termites and fungi was observed in the band with the highest polarity.

4) Improvement of liquid penetration into tropical wood by precompression treatment

Collection of subterranean termites in soil around the felled tree

When precompression treatment was applied to refractory tropical hardwoods, the penetration of liquid into the heartwood of Nangka and Sengon (*Paraserienthes falcataria*) was markedly enhanced. However, little compression deformation for improving the liquid uptake of Kiguru (*Girroniera subaequalis*) was attained due to high density.

Composting of Biomass Wastes into Multifunctional Recyclates

Prof. Minoru Terazawa, Hokkaido Univ.

This project started in April 1999 and will finish at the end of March 2002. Its aim was to promote the bio-conversion of biomass wastes such as garbage (food-related wastes) by GADE (garbage automatic degradatorextinguisher) systems, human excretion by BT (bio-toilet) systems, and livestock manure by LMF (livestock manure fermentor) systems into valuable compost, to form multifunctional recyclates and use them effectively establishing forestry, agriculture and fishery biomass recycling systems (FAFBRCS).

It should be emphasized that sawdust plays a key role as an artificial soil matrix in the systems and the biomass wastes are biodegraded into carbon dioxide and water and extinguished without the formation of odor. Testing the applicability of sawdust from tropical wood species as an artificial soil matrix for FAFBRCS is the main theme of this project.

Artificial Soil Matrix

The key material for the GADE, BT, and LMF systems is sawdust, used as an artificial soil matrix. The physical properties of the sawdust including its high porosity, excellent water retention, and good water drainage provide an efficient aerobic environment for the multiplication of aerobic soil bacteria, which bio-convert organic wastes into carbon dioxide and water without the formation of odor. The moisture content and temperature of the matrix are also important. The effective evaporation of water is vital to the maintenance of the system and the surface area of sawdust facilitates evaporation from mixtures of waste and sawdust matrix, maintaining aerobic conditions.

Multifunctional Recyclates

The compost obtained after operation of the systems was formed into multifunctional recyclates: ①Beds for mushroom cultivation, ②Boards for agricultural and industrial use, ③ Packing for exporting goods, ④ Molding pellets for road sides and gardens in parks, ⑤Planting pots for seedlings, ⑥ Fertilizers or soil conditioners, etc.

Biologically active substances

Extractives of sawdust from tropical wood species can inhibit bacterial and fungal growth. In such cases, the utilization of sawdust as an artificial soil matrix negatively affects the multiplication of bacteria in the systems. Pre-extraction and the utilization of the biologically active substances in sawdust should be the first target for the effective utilization of local low quality wood species which are not usable for lumber production. After extraction of the biological substances, the residual sawdust is turned into an effective artificial soil matrix for the GADE, BT, and LMF systems.

The inspectors and press men were confirming the odorless operation of the livestock manure fermenters (LMFs), containing 8m³ sawdust as an artificial soil matrix. Pig manure (0.5 t/day) has been composted without formation of odor for 20 days.

Dr. Neni Sintawardani visited Kyushu University in 1999 and screened tropical wood species for anti-oxidant (anti-tyrosinase) activity. She found 5 species showing strong anti-tyrosinase activity.

Dr. Antonius Subiyatno stayed at Gifu University in 2000 and attempted to specify the wood species inhibiting the growth of fungi and bacteria. He found active substances in Merbau (*Intsia* sp.) wood including 3,5,3',4'-tetrahydroxystylbene that inhibit fugal and bacterial growth.

Mr. Tapa Darma visited at Ehime University in 2001 and screened the tropical wood species for fungal growth inhibitors. His report is entitled "Wood extractive substances inhibiting growth of wood rotting fungi". Using the fungi such as *Lentinus edodes*, *L. edodes* var. Indonesia, *Pleurotus promonalius*, *P. ostreatus*, and *Ganoderma* sp. and the wood species Kempas (*Koompassia malccensis* Maing. et Benth.), Angasa (*Pterocarpus indicus*), and Amboyna (*Pterocarpus* sp.) and he found that Amboyna wood strongly inhibited fungal growth.

Effect of Silvicultural Conditions on the Wood Quality of Plantation Teak

Prof. Takashi Okuyama, Nagoya Univ.

Since 1999, we have been conducting a joint study on the effect of silvicultural treatments on the wood quality of planted teak with Prof. Usuf Sudo Hadi in IPB. This project arouses interest among the graduate students in my laboratory in tropical man-made forests as well as helps them to understand the background and importance of wood science from a global point of view.

90-year-old planted teak

In the 21st century the forest industry will have to balance sustainability in the supply of material resources with the maintenance of the global environment through carbon sinks as well as energy conservation. In order to achieve this, it is essential to achieve the economical cycling of forest products between producers and consumers by raising the value of the finished products.

Teak is a common timber marketed from tropical forests. In Japan, teak is quite popular and even people who know little about timber are familiar with the name. Nevertheless, few know what it looks like. Moreover, even people who deal with timber have no idea that it comes from man-made forests. Nowadays, only the teak from such forests is available on the market.

There are two species of Teak, *Tectona garndis* and *T. hamiltonian*, originating from India, Thailand, Myanmar and Laos. The oldest planted teaks date back to 1846 and are found in Kerala, India, where the largest has a girth of 4.2m and a height of 46m.

Mass plantings of teak started in the 1980s and as of now occupy over three million ha in tropical countries. Trees will be available in the market only after rigorous forest management at a cutting cycle of 30 years and 150 years. Because of the value of the wood, when tropical man-made species are discussed, teak cannot be ignored.

Investigations on teak have been continued since the 1980s, however, their main focus has been silviculture and forest management. Studies dealing with wood quality tend to be limited to moisture content, shrinkage and extractives.

A common perception is that in quality, planted or fast-growing teaks are inferior to natural or slow-growing teaks. However, this is yet to be proven for only a few studies have been carried out on the relationship between wood quality and growth rates. Increasing the growth rate of the species by applying several silvicultural treatments is essential to raise the supply of cheap teak timber on the market. Thus, knowing the effect of growth rates on the quality of the wood will play an important role in improving the species.

Girdling treated two years prior to harvesting

The results of our study of teak quality are as follows: 1) The basic qualities of the wood, such as density, microfibril angle and growth stress, were not affected by the growth rate similar to other fast-growing species. 2) The formation of mature wood starts in the 11th - 12th year of growth;

and 3) The heart wood ratio, the radius of heart wood / the total radius of the trunk, does not depend on the age of the tree but on the diameter of the trunk. With this, the faster the growth rate, the higher the tree volume, and the larger the profit to be derived from teak plantations.

Regarding the effect of stem girdling, teak girdled for two years prior to harvesting showed that the moisture content of the trunk was more or less evenly distributed across the diameter at felling and approximately 20%. Consequently, a sophisticated drying process is not necessary to obtain air-dry teak lumber. Moreover, a reduction in residual stress inside the trunk was predicted during the two-year period.

In fast growing hardwoods, their wood quality is expected to be related to provenance and growing conditions. Wood quality assessments combined with silviculture involving forest soil, chemical components, wood processing and improved tree breeding technology are essential to raising the value of timber as well as the production of man-made forests.

We can not reduce the pressure on tropical forests nor can we establish a valuable forestry industry by merely discussing the ecology of the forest. To maintain the global environment, establishing forestry practices based on economics is indispensable. Wood science, being an effective tool in producing timber of high value, should be further improved by joining together the producers and consumers of different countries.

=New=

New Strategies for Controlling Tropical Biodegradation of Woody Composite Materials

Prof. Ikuo Furukawa, Tottori Univ.

Features of this Project

This research project (FY2002-2004) is similar in concept to a previous project conducted by Dr. Y. Imamura (FY1999-2001), however it aims to develop and establish new strategies for controlling both tropical biodegradation caused by termites and tropical deterioration due to weathering conditions by means of newly developed technologies for the improvement of the durability of woody composite materials.

The new strategies used for controlling tropical deterioration in this project are; first, assessments of the actual applicability of newly developed environmentally friendly preservatives, such as Chitosan Copper Complex (CCC) or non-organic chemicals, for protecting woody composite materials against termites and weathering and also as fire-retardants, will be carried out on the basis of morphological (anatomical) indicators and weight-loss; second, the effectiveness of non-chemical (that is, ecological) methods such as the newly developed "baiting system" for controlling tropical termite's attack will be assessed on-site under tropical conditions; third, a new concept for termite control associated with the ecological behavior of individual termites and the characteristics of their society, will be proposed.

This research project hopes to make a great contribution to reducing soil and water pollution produced by the wood preserving process in tropical regions, and also to extend the life-span (durability) of tropical woody composite materials for housing construction in order to save natural resources.

Objectives

(1) To assess the performance (effectiveness vs. product cost) of newly developed preservatives (post-CCA preservatives) under tropical conditions at different test-sites in Indonesia.

(2) To evaluate the morphological changes to woody composite materials caused by weathering or by termites of deterioration and to clarify features of the process so as to demonstrate the criteria for evaluating the post-CCA preservatives and new "baiting system".

(3) To propose guidelines for controlling tropical termites and the durability of tropical woody materials using a non-chemical method (new baiting system) and environmentally friendly preservatives (post-CCA preservatives).

Expected Results

(1) In tropical Southeast Asia, it is important to apply environmental friendly wood preservatives such as post-CCA to prevent wood degradation by termites and weathering. Environmental friendly methods are still not well known in Indonesia, therefore, it is necessary to establish them as soon as possible to reduce and stop the pollution caused by the wood preserving process.

Field test for wood degradation at a site infested with termites

Project members photographed in front of a wooden building on the campus of the Indonesia Forest Products Research Institute

(2) Micro morphological changes in woody composite materials affected by termites and/or weathering will be clarified by optical and electron microscopy, and the information obtained on the characteristics of biodegradation for various woody materials will be used as indices (indicators) for assessing both the degree of degradation and the effectiveness of the newly developed preserving methods.

(3) After clarifying the ecological behavior of tropical termites, features of their life style will be exploited to control their activity and to prevent expansion of the colony, using a new "baiting" system. It is hoped that this system will prove the ideal methods of controlling termites from the viewpoint of human safety and the conservation of tropical environments.

= New =

Development of Structural LVL from Tropical Wood and Evaluation of Performance as the Structural Components of Wooden Houses

Dr. Paridah Md. Tahir[*1], Dr. Wong Ee Ding[*2] and Prof. Kohei Komatsu[*3].

Laminated veneer lumber (LVL) was introduced into Malaysia in the early 1990's. However, current LVL production in Malaysia is limited to non-structural or furniture grade. Among the major obstacles to the utilization of LVL in this part of the world are a lack of scientific data on the performance of tropical hardwood LVL, and the unfamiliarity of local architects and designers with this material. Production of LVL from tropical hardwoods in Malaysia is expected to reduce the pressure on natural forests, via optimum utilization of low-grade logs from both natural and plantation forests. Diversification into LVL production is also expected to ensure survival of the existing plywood industry in Malaysia (photo.1).

This international collaborative research project under the JSPS Core University Program, which encompasses Japan, Indonesia and Malaysia, covers a total duration of 3 years (2002 to 2005). Attempts will be made to determine the fundamental properties of structural LVL produced from selected tropical timber species: keruing (*Dipterocarpus* sp.), kedondong (*Santiria* sp.), white meranti (Shorea spp.), yellow meranti (*Shorea* sp.) and bintangor (*Calophyllum* sp.). The mechanical strength retention and glue bond integrity in LVL under tropical and temperate weathering conditions will be evaluated. The effectiveness of property enhancement by surface coating and preservative treatments will also be examined. Subsequent evaluations will focus on the estimation of basic working stresses of LVL and the performance of frame structures of wooden dwellings composed of these LVL. Portal frames made of LVL will be also tested as shown in photo.2, with a detailed analysis of their lateral deformations.

The members involved in this co-operative research project are as follows;

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Takuro Mori (Kyoto Univ.)
Takanori Arima (The Univ. of Tokyo)
Naoto Andou (The Univ. of Tokyo)
Noboru Sekino (Iwate Univ.)

(Indonesian Side)
Anis Saggaff** (Univ. of Sriwjaya.)
Yakni Idris (Univ. of Sriwjaya.)
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Zaidon Ashaari (Univ. Putra Malaysia)
*2 Wong Ee Ding (Univ. Putra Malaysia)

(*: Project Leader)
(**: Vice Project Leader)

Veneer clipping in LVL manufacturing (Courtesy: CHG Industries Ltd., Malaysia) (Photo. 1)

An image of the portal frame made of LVL subjected to a push-pull cyclic lateral loading for evaluating structural performance of beam-column joints. (Photo. 2)

= New =

The Total Utilization *of Acacia mangium*

Dr. Hiroyuki Yano, WRI, Kyoto Univ.

In Indonesia, *Acacia mangium* is one of the most important fast growing trees, and at present its annual growth is 2.4 million m^3. Originally, *Acacia mangium* was planted as a resource for the pulp industry. However, due to the cost required for pulp processing, most trees are not effectively utilized. In consideration of increasing social demand for sustainable forest management, new directions for the effective utilization of *Acacia mangium* should be investigated.

Recently, the bark of *Acacia mangium* was found to contain more than 50% tannin that can be converted into high quality waterproof wood adhesives. Our preliminary observation showed that a 3 year old tree of 23 cm in diameter and 12 meters height provides about 120 kg of dried wood from the trunk, 40 kg of dried wood from the branches, and 20 kg of dried bark. Thus, it is estimated that if 50% of the wood from the trunk can be converted into sawn timber, the other 50% and the wood from the branches can be reconstituted as glued laminated lumber, particleboard or other composites by using tannin adhesives derived from the same tree.

To realize the total utilization of

Acacia mangium, nine researchers each having a different expertise will be engaged in this cooperative project. By exchanging ideas and experimental data regarding wood drying, non-destructive testing and grading, bark glue preparation and composites it is hoped that appropriate techniques and technologies for the total utilization of this species will be developed.

Acasia mangium plantation, Borneo

Bark waste at the MDF factory, Borneo, mainly consisting of Acasia mangium bark

The project group is divided into four subgroups with different functions, that is: Drying by Prof. Kazuo Hayashi, Ehime Univ. and Mr. Yustinus Suranto, Gadjah Mada Univ.; Non-destructive testing and Grading by Ms. Anita Firmanti, Research Center for Human Settlements Technology; Bark glue preparation by Dr. Hiroyuki Yano, Kyoto Univ. and Ms. Erna Susanti, Univ. of Papua; and Production of composites by Prof. Shuichi Kawai, Kyoto Univ., Mr. Subyakto and Dr. Bambang Subiyanto, Research Center for Physics, LIPI.

The project will commence in April 2002.

= New =

Novel Physiologically Active Substances from Medicinal Plants and Fancy Woods in Indonesia

Prof. Koichi Ogiyama, Yamagata Univ.

The need for wood products has increased with the rise in population. Usable forest resources have decreased yet industrial and personal demands continues to increase. However, half of all the wood consumed in the world is used for fuel as a raw energy source. The sustainable development of forest resources which are economically, ecologically and environmentally indispensable, will only be achieved by improving the utilization of forest products compatible with maintaining sound forests.

Several wood species have been reported to cause sickness and severe illness in those who come into contact with the saw dust and shavings created during processing . General symptoms include headaches, severe stomach-aches, nose bleeds, nausea, cramps and irritation of mucous membranes. Certain wood species cause dermatitis, general irritation and asthma. Wood workers in room with poor ventilation occasionally suffer pneumonia, and may develop cancer of the nasopharynx after several decades of steady contact with fine saw dust. Some users are particularly sensitive to house dust and show allergic symptoms, so-called sick-house disease, which are most likely to occur in the confined spaces of modern cities. The factors responsible for most cases of allergic contact dermatitis and also asthma are extractives, mainly phenolics including benzo- and naphtha-quinones. These sensitizing compounds are particularly found in tropical wood species used for fancy plywoods because of their graceful grains. Teak (*Tectona grandis*), rosewood (*Dalbergia* and *Machaerium* spp.), black ebony (*Diospyros ebenum*) and black walnut (*Juglans nigra*) are representative of these woods. The identification of extractives from tropical wood species grown in Indonesia, which affect human health, is one of the main aims of this project.

A snapshot in front of the black ebony tree (Diospyros spp., Japanese name ; KOKUTAN) in Bogor Agr. Univ.

A kind of medicinal tree, Ginkgo bilova (Japanese name ; ITYO)

Useful medicines have long been obtained from organisms living in the deep forest, particularly from plants and microbes. Looking back over the centuries, many important drugs were first found as poisons and only converted to medicines after much trial and effort. Aspirin (acetylsalicylic acid) from willow (*Salix spp.*) bark as an anti-inflammatory, analgesic, and antifebrile, as well as for the prevention of heart attack, Berberine from the KIHADA (*Phellodendron amurense*) bark for stomachache, and Quinine from *Cinchona* spp. bark as an anti-malarial are among the most famous drugs obtained from forest trees.

Recently, Taxol (pacritaxel) from *Taxus* spp. Heartwood, Podophyllotoxin (etoposide) from *Podophyllum* spp. and Vinblastine from *Catharanthus roseus* as anti- cancer agents as well as several plant extracts as anti-HIV (anti-human immunodeficiency virus) agents are expected to become important drugs. Plants and microbes are also expected to serve as complementary sources of chemical diversity for drug discovery. However, forested areas are rapidly disappearing only to be replaced with a limited number of plant species in the form of crops or fruit trees. This artificial selection has advanced to such an extent that many organisms and ecosystems are disappearing before their true value can be recognized. Much effort is needed to ascertain the true value of forest resources before they are lost. Looking at to the traditional folk medicines of Indonesia, investigating their bio-activity, and chemically characterizing the essence of these drugs is the second aim of this project.

Tough these investigations, we hope to establish a base for computer investigations of plants/trees detrimental to human health and information about novel agrochemicals or medicines. This Cooperative Research Project as part of the JSPS-LIPI Core University Program will provide a new insight into sustaining forest resources and the utilization of forest products in Indonesia and Japan.

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= New =

Characterization of Main Wood Species and Development of Novel Methods of Utilizing Unused and Unvalued Wood Species Grown in Indonesia

Prof. Kazuya Minato, Kyoto Prefectural Univ.

Dr. Wahyu and I formed a group, which has 4 Japanese and 6 Indonesian members, and proposed a research theme. Fortunately, our proposal was adopted as part of the new project, which will start in 2002. At first I would like to express my sincere thanks to the parties concerned. I am aware of our responsibilities, and will attempt to fulfil our obligations. Our objectives and expecttations are as follows:

Author in tropical forest.

A great number of wood species, which vary widely in anatomical structure, physical and mechanical properties, chemical components and so on, are distributed in tropical forests including those of Indonesia. Given such diversity, there are many distinctive wood species, with excellent dimensional stability, durability against biological attack and photo degradation, permeability, mechanical strength etc. However, not all species are best used according to their characteristics. Moreover, an abundance of wood resources remains unused, irrespective of their potential medical or economic value. Therefore, by studying the characteristics of various wood species from several viewpoints, we may find their optimum use, and enhance the utility of tropical wood species.

First we will clarify the correlation between conventional (or traditional) forms of utilization in Indonesia and the characteristics of major tropical wood species. For this purpose, the cooperation of Indonesian members in collecting information as well as wood samples is indispensable. The items to be evaluated are mechanical strength for construction, visco-elastic properties for the mat-forming of wood-based composites such as particleboards and fiberboards, compressibility for consolidated wood, vibrational properties for sound facilities, penetrability to chemical reagents for preservation treatment, resistibility to biodegradation and weathering for outdoor use, and so on. These properties will be examined also in unused or fast-growing wood species.

Through the course of the work, we intend to propose more appropriate and high performance uses of major tropical wood species than the conventional ones, as well as novel and effective ways to utilize of unused wood species.

Finally, I hope that the fruits of this work will equally benefit both countries and contribute to the effective use and protection of tropical forest resources.

The Committee of International Academic Exchange
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目次にもどる