Text Book Series No.27

REPORT OF TECHNICAL SERVICE AND RESEARCH WORK ON SILVICULTURE AND MANAGEMENT OF BAMBOO FOREST IN THAILAND

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OVERSEAS TECHNICAL COOPERATION AGENCY

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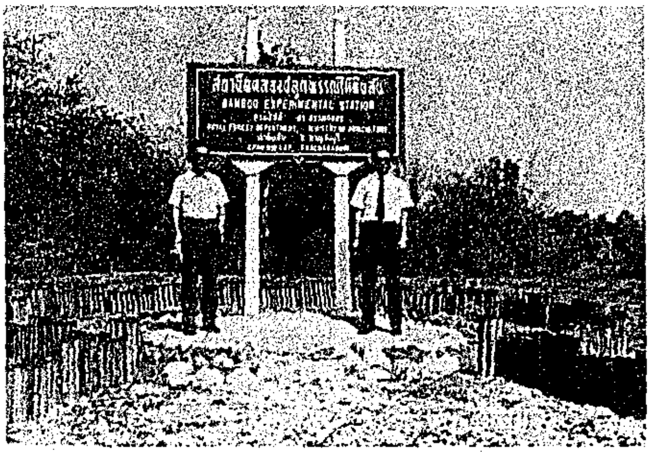

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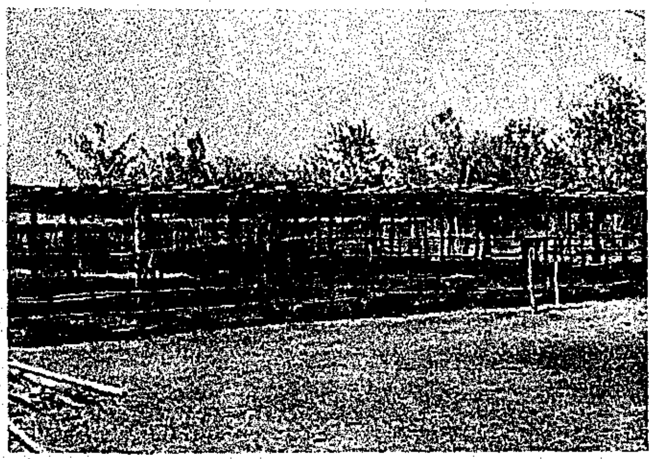
Khao Hin Lap Bamboo Experimental Station in a vast area of natural bamboo growth in Kanchanaburi. Left is previous Expert, Mr. T. Suzuki and the right is the reporter.



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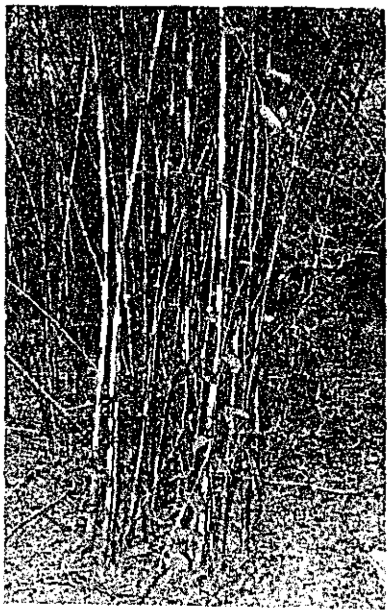

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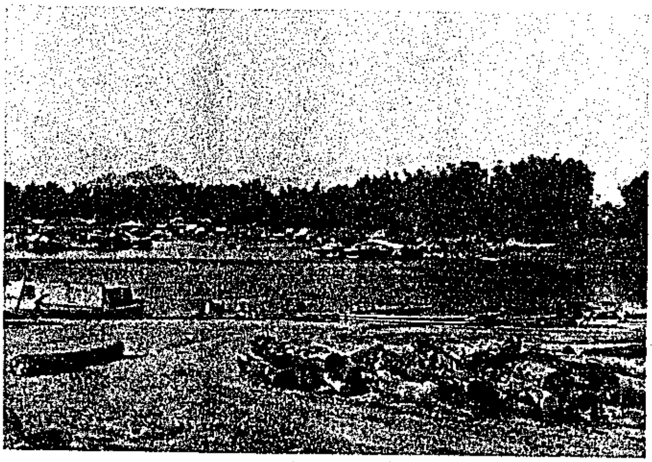

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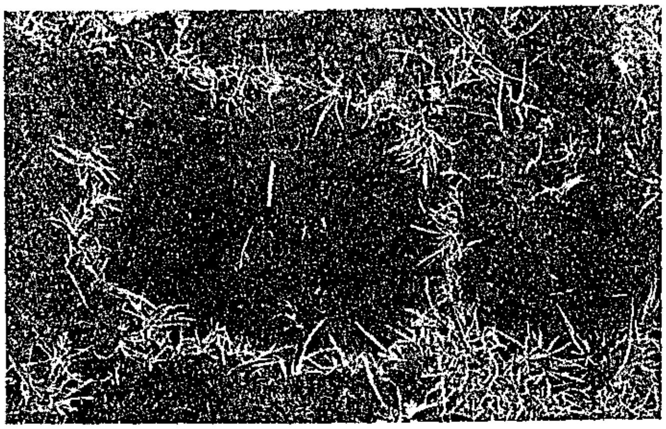

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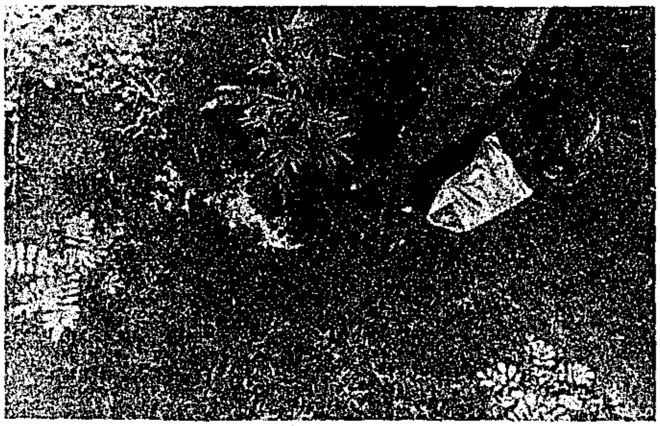

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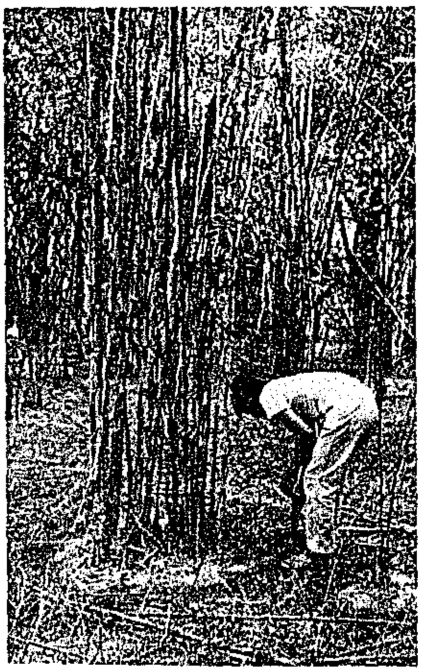

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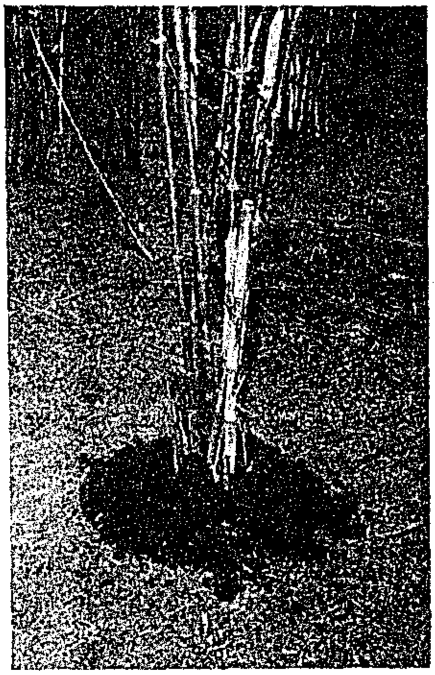

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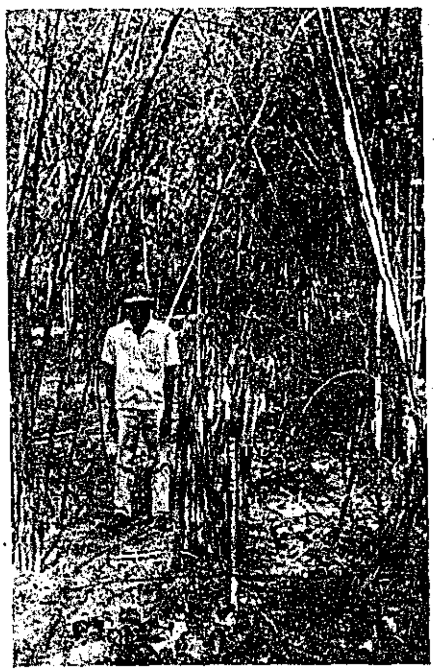

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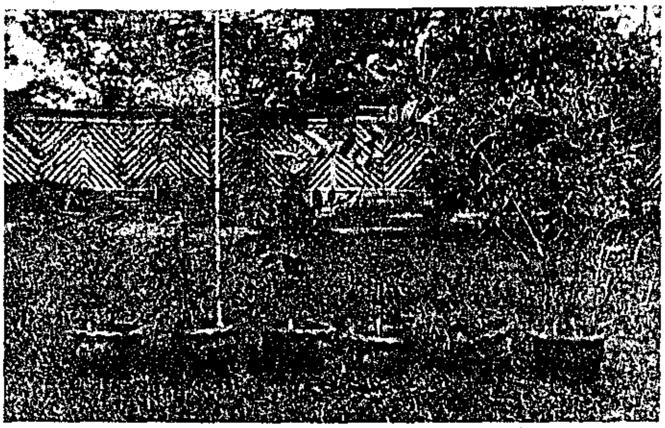

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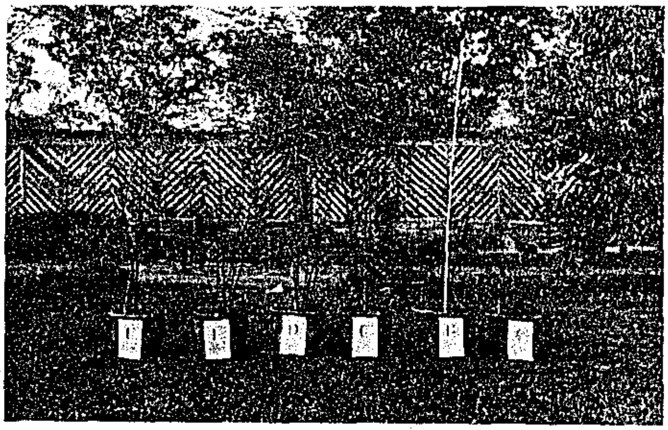

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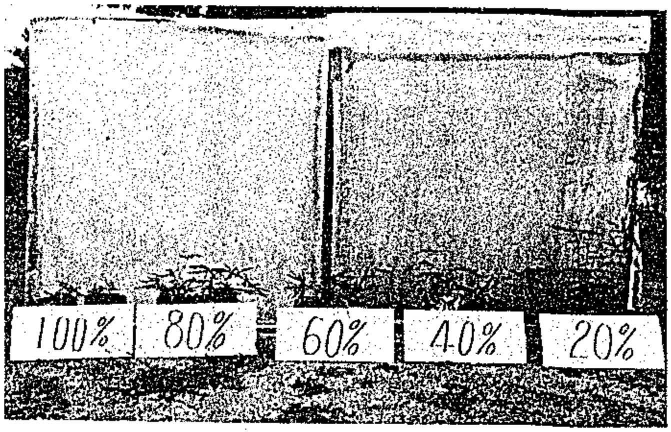

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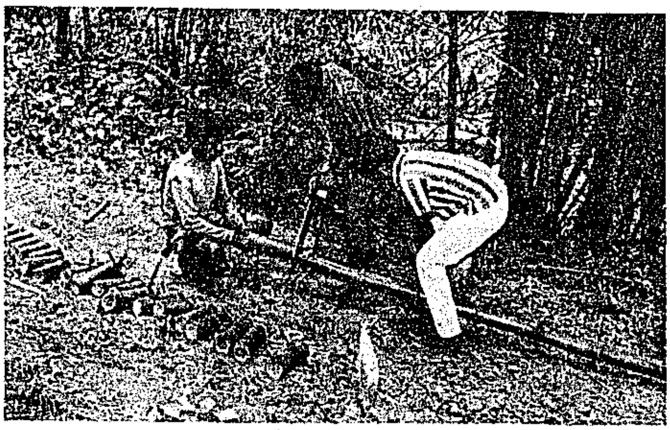

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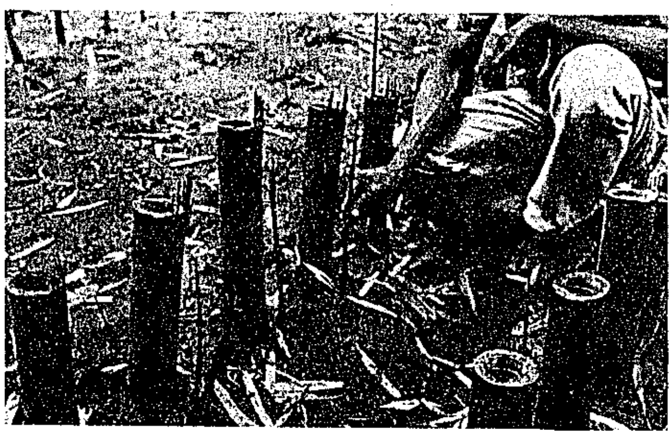

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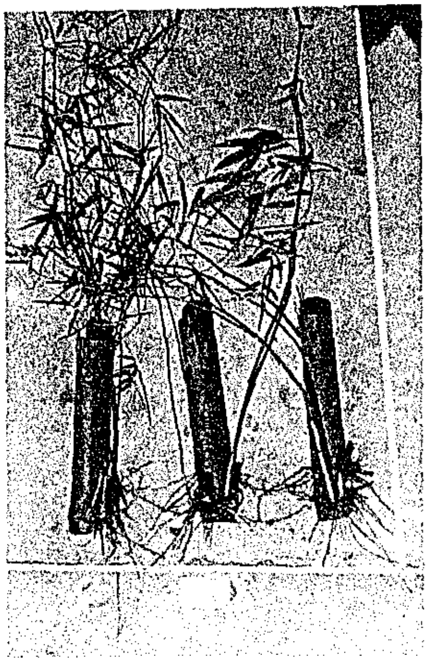

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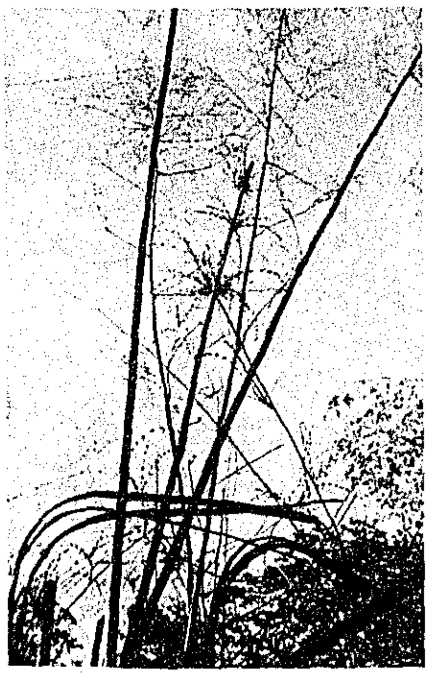

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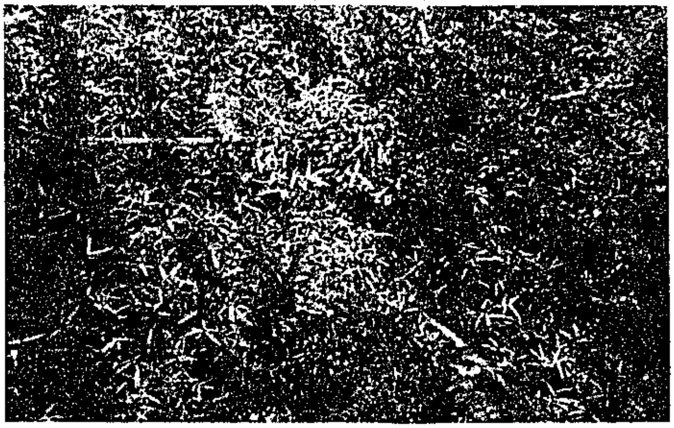

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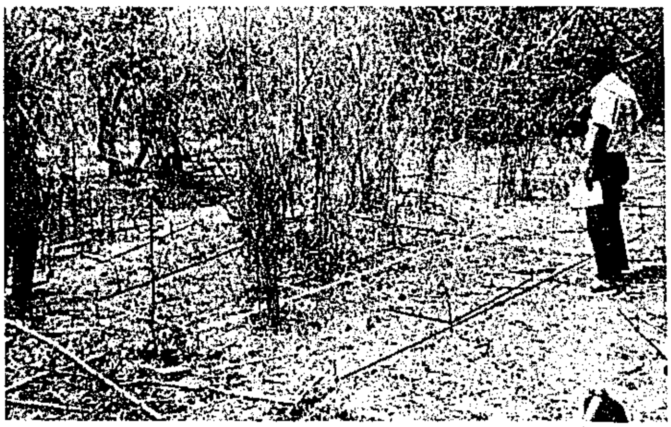

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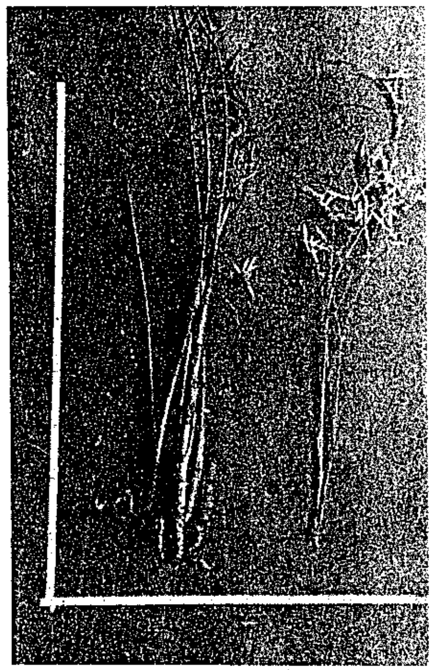

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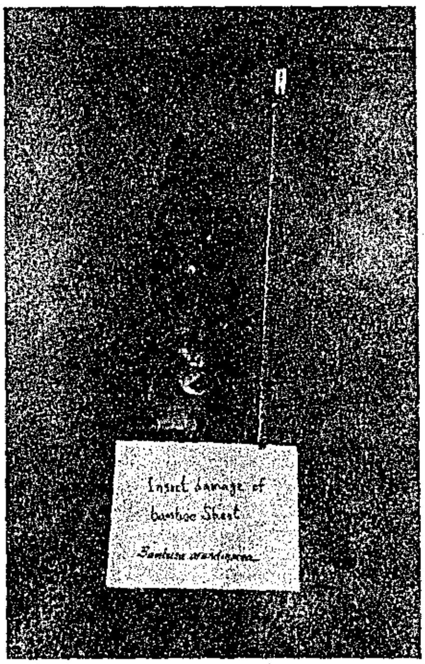

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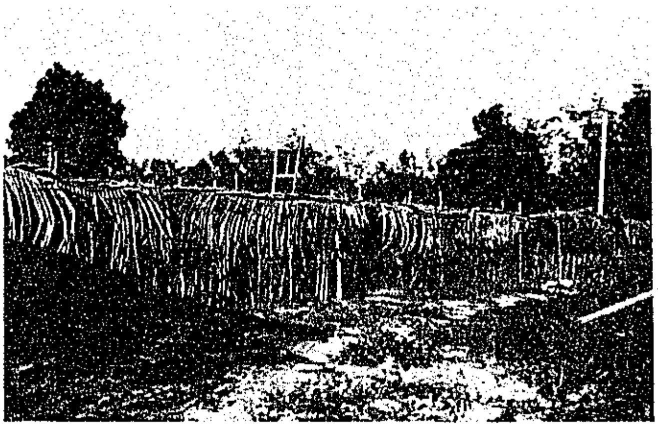

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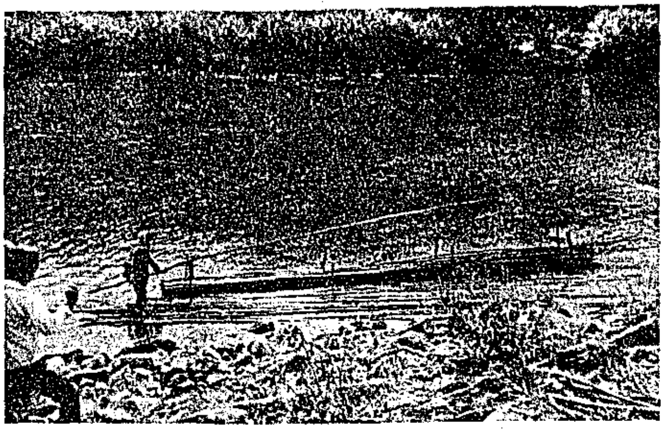

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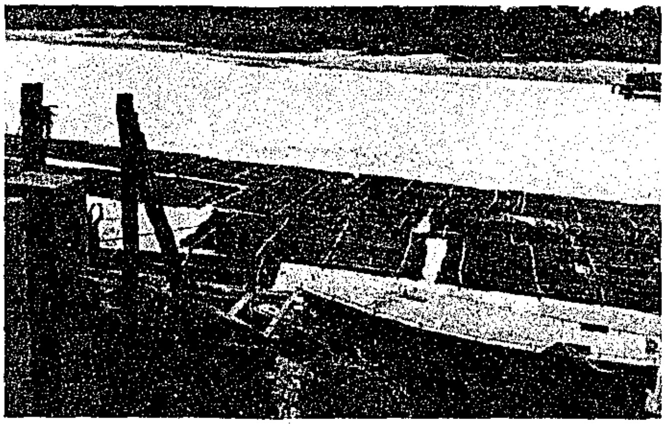

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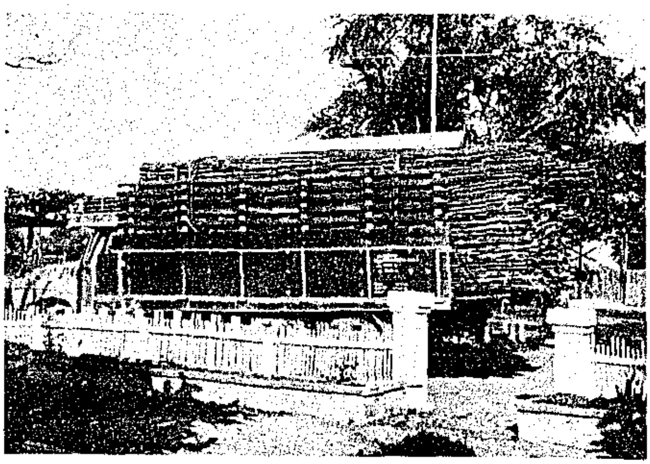

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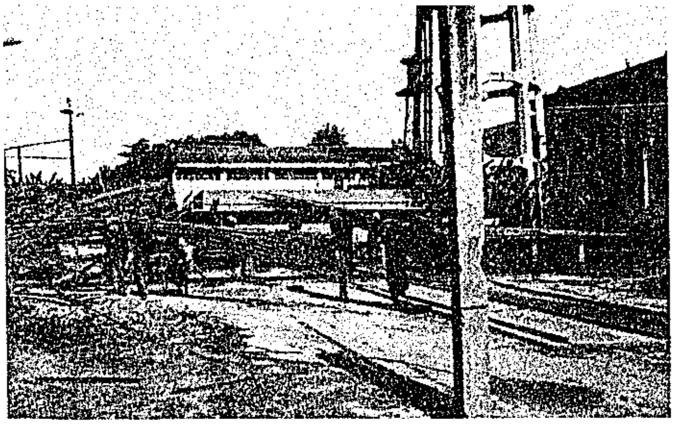

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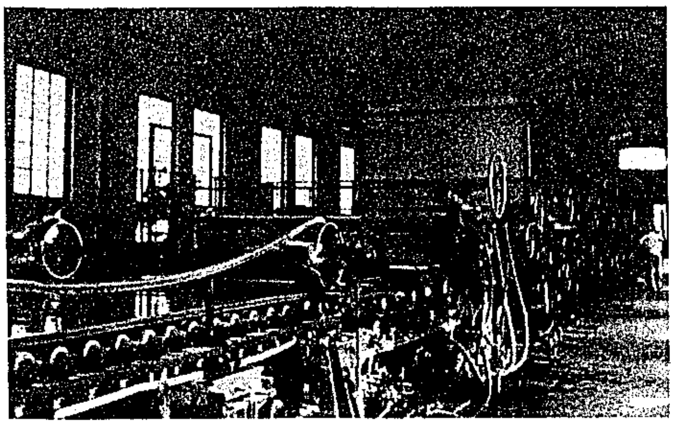

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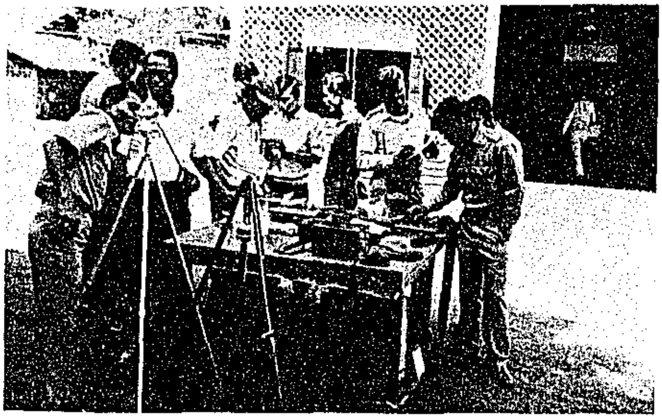

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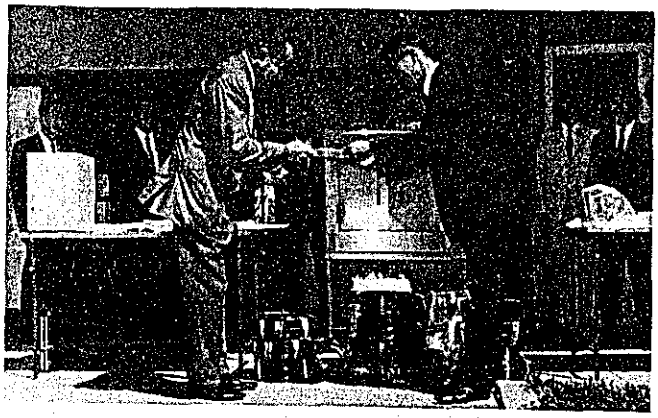

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Presentation Ceremony of the equipments and experimental articles for bamboo project under the technical cooperation between Japan and Thailand. Left is Former Director-General Mr. Dusit Banijbatana and right is Mr. Moriya Miyamoto, OTCA, Japan.

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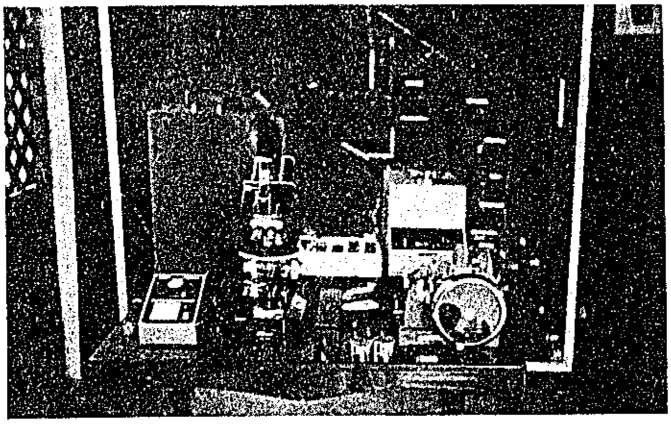

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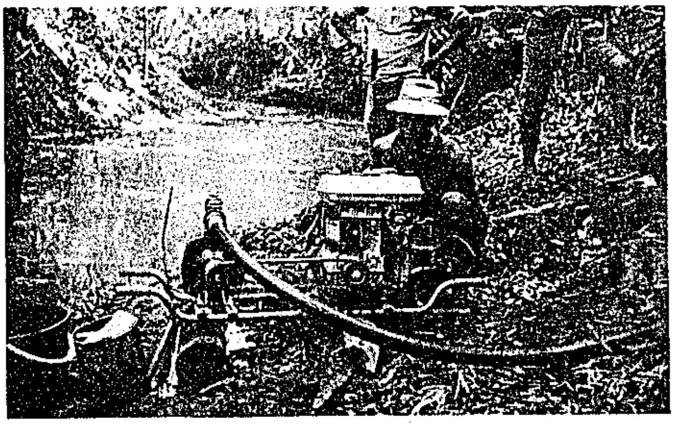

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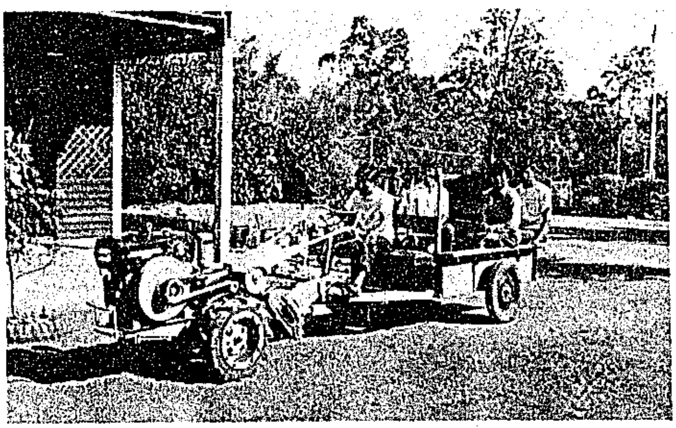

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I. INTRODUCTION

The bamboo forests in Thailand have an important role in furnishing the commodities necessary for a life of nation such as constructing materials, handicrafts, agricultural uses and for making pulp in particular. The areas of bamboo forests in Thailand have been estimated at about one million hectares[3], and over thirty-four species of ten families of bamboo occupy[1,12] mostly whole of the kingdom. The existing state of bamboo forest, while, is really natural without any case to be technically and economically dealt by the hands of peoples. It is because that a bamboo forest in Thailand is seemed to be nothing but only one of natural resources from which some necessaries for peoples can be supplied in any time when they need. When looking the present ways on their exploitation and utilization of such a vast area, it can be said that this may be really "a miser's gold buried in the ground" in Thailand.

On the other hand, the demand of paper in Thailand is exceedingly rapid. The consumption of paper and board in Thailand was 170,000 tons on an average for the last three years (1968 to 1970) in spite of 100,000 tons in 1965, and that was 1.7 times in an increasing rate for five years. The local produced paper in 1970 was, nevertheless, estimated at 62,000 tons included the productions by imported pulp and waste paper, because the two-thirds of the demand were dependent on the import from foreign countries. This should be the most worrisome problem for the economic development of Thailand.

As the result which the Government of Thailand had the anticipation of facing the recent trouble on pulp productions before about ten years ago, the Project of Paper and Pulp Material Survey was set up at Royal Forest Department by United Nation's Special Fund in 1964, and that had been finished with lots of fruits in 1967. After that, the project has been, as it is, succeeded to her hand of Thailand, then the technical cooperation between Thailand and Japan has been realized and continued under the Colombo Plan up to now. The present project on bamboo is, accordingly, being experienced for eight years.

The reporter was assigned at the Bamboo Project of Paper and Pulp Material Survey in Royal Forest Department by the Government of Japan under the Colombo Plan for two years from January 1970, for the purpose of technical service and research on silviculture and management of bamboo forests in Thailand.

At the completion of the reporter's assignment, this paper states about every concerned works attached the results of researches and presents some recommendations for the further development of the project as the final report, and this is submitted to the authorities of Royal Forest Department, The Ministry of Agriculture, Thailand.

II. ACKNOWLEDGEMENT

The strongest support and cordial cooperation of the Government of Thailand are gratefully acknowledged, especially those given by the authorities of Royal Forest Department and the Department of Technical and Economic Cooperation.

In Royal Forest Department the deepest understanding by the former Director-General Mr. Dusit Banijbatana, the present Director-General Mr. Tri Kokkumhang, Deputy Director-General Mr. Thanom Premrasmi and Mr. Tavesak Sriburi was real to be the greatest for well completing the reporter's objective. The cooperative help of Silvicultural Division, Mr. Rasmee Namwong and Mr. Somperm Kittinan, was the best for proceeding every research works concerned with the reporter.

The technical officials in Paper and Pulp Material Survey Project, Mr. Bunnalert Rushatakul, Mr. Prasarn Bamroongrasdt, Mr. Sakonsak Ramyarangsi and Mr. Sawai Thamdecha directly gave the best favourable assistance to the activities of the reporter. The general connection with the divisions of Forest Products Research and Working Plan, Dr. Tem Smitinand, Dr. Chumni Boonyophas, Mr. Pong Sono, Mr. Sansern Charernsri and Mr. Dumrong Chaiglom, was more efficient for getting the knowledge on their fields. The kindness given by several divisional forest offices and provincial forest offices, especially by Mr. Thep Siwasilp and Mr. Tiva Sapakit of Kanchanaburi Provincial Forest Office, led to reap the fruits of field works and inspections for the reporter.

For obtaining the figures and general informations, it was more convenient to have met F A O consultants Mr. K. Openshaw for Forestry Economic and Mr. W. E. Bullard for Watershed Management at Royal Forest Department.

On the other hand, the officials of the Embassy of Japan in Bangkok and Overseas Technical Cooperation Agency (OTCA) in particular could fulfil suitable measures to back up that the reporter's responsibility has been well discharged in Thailand. About the planning of research and technical service the best suggestions were offered by Emeritus Professor of Kyoto University, Dr. Koichiro Ueda and the previous expert of this project, Mr. Takeyoshi Suzuki.
Still more, the authorities of Kyoto University, especially the Director, researchers and Chief of Administration of Experimental Forest Station have favourably given support to the reporter to take one part of the bamboo project by the technical cooperation between Thailand and Japan under the Colombo plan.

Hereat, the reporter would like to express the greatest gratitude from the bottom of his heart to whole of the participators concerned with his scheme in Thailand.

III. BACK GROUND

III-1. General

Thailand has an area of 514,000 square kilometers. It extends from 5^{o} to 21^{o} north latitude while in longitude it streches from 97^{o} E to 106^{o} E. The country can be divided into four regions. The central region, a vast alluvial plain of developing agriculture, is the geographic and economic heart of about 100,000 square kilometers including Thailand's capital, the Greater Bangkok. The northern region is approximately 170,000 square kilometers with the mountainous and forest areas. The northeast is about same area of the north, but a plateau of poor soil and scanty rainfall. The southern region is a peninsular area being a narrow sliver of rugged mountains and low swampy lands of about 70,000 square kilometers.

The climate of Thailand is tropical as much affected by seasonal monsoon. The regular rainfall between June and October is brought by the southeast monsoon from the Indian Ocean, but a relatively cool and dry season caused by the northeast monsoon is the period from November to January. The summer is a hot and dry lasting from February to May, especially the hottest in April. The temperature is variant with the seasons and in regions, falling below 16^{o}C in cooler months, but usually ranging between 24^{o} - 35^{o} C for the greater part of the year.

The current figure for the population of Thailand is about 37 million. The population is growing rapidly as a result of the maintenance of a high level of fertility in the face of steady declines in mortality. The natural growing rate of population, however, is 3.1 percent a year, that the population may reach double in the next 21 years. The perpetuation of the present rapid rate of population growth will constitute on obstacle to the continued rapid economic development of Thailand.

By the end of 1970 the Gross Domestic Product of Thailand has gone up to US$6.37 billion on current market prices, from US$2.63 billion of 1960 and US$4.11 billion of 1965. These show a remarkable consistency despite fluctuating world prices in some of the principal contributing commodities. A number of recent events, both economic and political, have combined to make the next few years a significant period for Thailand. During the last ten years the performance of Thai economy has been, on the whole, satisfactory.

III-2. Circumstances of Paper and Board

It can be said that the circumstances on the demand and supply of paper and board in Thailand are needy. The total consumptions of paper and board in Thailand were 162,000, 188,000 and 160,000 tons in 1968, 1969 and 1970 respectively, because of 170,000 tons on the average in the past three years as shown at Table 1. The domestic production of paper by imported plus locally produced pulps and waste paper was, on the contrary, estimated at about 42,400 tons on the average of last three years, but about 37,000 tons of pulp and waste paper were imported for the manufacturing.

The imports of paper and board were major in supply for their demand as about 127,000 tons averaged those of 1968 to 1970, and both newsprint and print papers have shown the trend toward the bulking in every years, but decreasing the import of kraft paper after operated one large-scale factory of which its productive capacity is 51,000 tons a year. The local pulp production was extremely scanty to

Table 1. Trend on the circumstances of paper and board in Thailand

(tons)

	1968	1969	1970	Average
1. Paper & board imported				
Newsprint	42,700	36,314	64,101	47,705
Print	8,634	11,320	16,032	11,995
Kraft	70,243	72,086	27,844	56,724
Carbon	1,709	2,285	464	1,486
Cigarette	874	648	818	780
Paper board	11,423	17,688	17,630	15,570
Total	135,598	148,727	99,102	127,142
2. Pulp & waste paper imported				
Pulp	19,883	30,074	43,383	31,113
Wasted paper	1,651	5,141	11,651	6,147
Total	21,534	35,215	55,034	37,261
3. Local production of pulp				
Baggase pulp		2,325	9,132	5,729
Rice straw & grass pulps	6,779	6,168	6,664	6,537
Bamboo pulp	2,030	1,923	2,198	2,050
4. Local collection				
Total waste paper (estimated)	1,200	1,200	1,200	1,200
5. Total pulp production plus imports of pulp & waste paper and local waste paper collection (2+3+4)	31,543	46,831	74,228	50,867
6. Total paper production by imported plus locally produced pulps and waste paper (estimated)	26,286	39,026	61,857	42,390
7. Total paper & board of import plus local productions (1+6)	161,884	187,753	160,959	170,199
8. Exports of paper board & vulcanized	233	155	1,382	590
9. Total consumption (estimated) of paper and board (7-8)	161,651	187,598	159,577	169,609

be about 14,300 tons on average of the last three years, that occupied only one-tenths of the total demand even the tendency to increase its quantity could be slightly found year after year. Accordingly, about 37,000 tons of pulp and waste paper had to be imported so as to replenish the shortage of local pulp production.

Raw materials supplied to manufacture pulp are baggase, rice straw, bamboo and grass. Baggase is in demand rapidly to one private kraft paper mill producing of about 9,000 tons of pulp in 1970. Rice straw and grass are supplied for producing 6,700 tons of pulp a year at the state operated Bang-pa-in Paper Mill and the production of bamboo pulp is only 2,000 tons a year at also the state Kanchanaburi Paper Mill for making both printing and writing papers.

Table 2. Paper and board productions in Thailand

(tons)

Manufactures	1968	1969	1970	Average
Siam Kraft Paper Co.	-	8,293	31,930	25,112
Bang-pa-in Paper Mill	10,950	11,011	11,000	10,987
Bangkok Paper Mill	10,449	14,664	13,902	13,005
Kanchanaburi Paper Mill	2,708	2,982	2,838	2,843
Sam Sen Paper Mill	179	76	187	147
Others (17 factories)	2,000	2,000	2,000	2,000
Total (22 factories)	26,286	39,026	61,857	42,390

The capacities productive of paper and board in Thailand must, at present, be less than 80,000 tons a year by total 22 factories of the state and private. The productions, as shown at Table 2, were 26,300, 39,000 and 61,900 tons in 1968, 1969 and 1970 respectively, and 42,000 tons on the average of the three years. In the tendency to productive progression it could be noticed to be growing up the productivity as increasing it to about 1.8 times a year from 1968 to 1970. While, the present trend must be unexpected so long as the capacities of existing factories will not be extended or new factory can not be established in the near future.

III-3. Fibre Resources

About 60 percent, or approximately 265,000 square kilometers, out of the total area 514,000 square meters of Thailand are covered[5,6] by some forest vegetations as hardwood, bamboo and others, but only relatively small stands of pine. As fibre resources for making pulp and paper two species of pine, many kinds of bamboo, rice straw, baggase and rubberwood are expected.

The resources of pine, which consist of Pinus merkusii (91 per cent) and Pinus khasya (9 per cent), have been estimated at about 4.7 million cubic meters in 71,000 hectares.[11] Most of pine forests lie on slightly undulating site and stand mixing with some broad-leaved trees, mainly Depterocarpus species in the north. The density of the forests is low as 24 pine trees per hectare and at present 90 per cent of total volume belongs to the over mature class. So that, an annual loss has been estimated at 2.4 per cent of the total number of trees and of 3.5 per cent of the total pine volume. It goes without saying that pine is the most versatile and valuable fibre source in Thailand, as this reason pine plantations are essential for supplying the raw material of pulp-making in future.

Bamboo fibre is a good for making printing and writing papers. Total 34 species of 10 families of bamboo mostly cover whole regions of the country.[1,12] The main species is Thyrsostachys siamensis in poor and dry soils, sometimes mixed growing with deciduous trees, Bambusa arundinacea in rather fertile and moistured soils and Dendrocalamus species in mountainous areas. 850,000 hectares out of the total about one million hectares of bamboo distribution in Thailand concentrate upon the west.[11] As a large exploitation for pulp-making, the range around Kanchanaburi, Rajburi and Tak provinces had been focussed, and Kanchanaburi Paper Mill under the government which the productive capacity is 3,000 tons a year, has been operated. Nevertheless, about 85 per cent within the whole bamboo distribution areas in the west are inaccessible, because of 720,000 hectares out of 850,000 hectares. The growing stock in the west has been estimated at over 7 million (air day) tons, and 1.65 million tons of accessible area.

The hardwoods growing through the country are also suitable for producing short-fibre pulps. But, at present there is no possibility to use them for pulping economically, because most of them are in great demand for lumber and plywood which are principal in building materials, furnitures and other purposes in and out of Thailand.

The rubberwood of which the large quantity of waste rubberwood may be available to be supplied at the south of Thailand, is a good raw material for producing the bleached chemical pulp. The economic benefit on their utilization for pulping is now under consideration. Other fibre resources such as rice straw and baggase are being furnished for manufacturing pulps to some paper mills, but they can not compared favourably with other resources.

III-4. Progress of Bamboo Project

Before about ten years ago the newly-establishments of pulp and paper factories were noticeable as one of important targets for the Government of Thailand, due to the circumstances distressful on the unbalance of demand and supply of paper in Thailand. Accordingly, the government decided to exploit the fibrous resources with researching about the raw materials for pulping and to discuss the technical and economic feasibilities on the expansion of existing industries and of the possibility on establishing new ones.

In January 1964 the operation of Paper and Pulp Material Survey was started at Royal Forest Department of Thailand under United Nations Special Fund. The specific purpose of this survey was to assess the availability and suitability of existing and potential domestic fibrous raw materials for the manufactures of pulp, paper, paper board and wood based panel products through forestry surveys, plantation experiments and laboratory testing, to train local staff of concerned works and to assist the Government of Thailand to formulate a longterm plan for developing forestry and forest industries.

The concrete objective of the operation was to survey the inventory of growing stocks suitable for pulping by aerial photography, to test the plantation of native and exotic pines and some fast growing species, to investigate the growth state of bamboos and many kinds of experiments on silviculture and management of bamboo forests included plantation test, to conduct pulping tests on main species expectant for the raw material of pulp, and so on.

This operation by the department was once terminated in January 1967 with remarkable fruits that were reported by FAO, 1968.[11] For somewhat details of the results the inventory survey was completed by the Working Plan Division and several kinds of pulping tests were smoothly carried out at Forest Products Research Division of Royal Forest Department. On silvicultural research the five experimental stations of which each station has a character to proceed the experiments on the species available to grow in that location, have been set up at Chiang Mai (pine), Si-sa-ket (pine and eucalyptus), two in Kanchanaburi (bamboo, pine and fast growing species) and Surathani (pine and eucalyptus) provinces.

The Royal Forest Department of Thailand has succeeded the previous operation by herself just after it had completed under UNSF. At the same time, the co-operation of research works and diffusion of silvicultural technique in the sphere of facilitating the development for bamboo resources has been realized between Thailand and Japan under the Colombo Plan. Dr. Koichiro Ueda was dispatched by the Government of Japan as the first Japanese Expert on bamboo for many times during 1967 to 1969, then the second expert on this field was Mr. Takeyoshi Suzuki for one year assignment from March 1968 to March 1969. As mentioned-above, the reporter has succeeded the role of both previous experts since January 1970.

In accordance with technical convention between both governments, not only the Japanese experts have assumed the responsibility for servicing technical works, but also two technical officials of Royal Forest Department had an opportunity to train on bamboo in Japan as;

Mr. Sansern Charernsri, on "Technique on bamboo industry" from October 1966 to February 1967.

Mr. Prasarn Bamroongrasd, on "Silviculture and management of bamboo" from October to December 1966.

At present, Mr. Sansern Charernsri is carrying out the technological researches on bamboo and making an effort to establish the way available for industrial utilization of bamboo at Wood Research Institute of Royal Forest Department. And Mr. Prasarn Bamroongrasd is an important technician on silviculture and management of bamboo as well as the Thai-side counterpart of the reporter.

IV. PRODUCTION AND CONSUMPTION OF BAMBOO

IV-1. Production

It is extremely difficult to grasp the real situations of bamboo production and consumption. This must be due to the factors that there is no organized system on the lines between producer and consumer, especially on the supply for local demand, and that bamboo is unavailable for being controlled by the regulation applicable for important forest species like teak, yang and others. Accordingly, in the estimation of bamboo production there is only one way to check it by the registration at provincial forest offices on the occation when bamboo culms harvested are transported by rafts and vehicles through checking stations in each province.

The statistics[16] of annual produced culms which were summed up at Royal Forest Department in accordance with the figures reported from provincial forest offices, were shown at Table 3.

Table 3. Annual production of bamboo in Thailand

Year	Number of culm*	Air dry weight** (1,000 tons)
1966	16,428,088	49
1967	36,151,118	108
1968	51,996,620	156
1969	13,207,533	40
1970	61,838,603	186

Note * Included small and big sizes of culm
** Estimated at average 3 kg per culm

Total number by included small and big sizes of culm checked at the provincial checking stations were about 36 millions by the average of five years from 1966 to 1970. As shown, a definite tendency in their productions could not be found, because of somewhat a large variance year by year. If the numbers of produced culms were converted into air dry weight in case which an average weight per culm was estimated at 3 kg, the average of five years might be 108,000 tons. But the weight presumed must be insufficient in the confidence due to the large variance in weights by species and culm sizes. The figure indicated by air dry weight in the table has, at the utmost, to be regarded as an approximate reference.

Most of bamboo productions occur in the western provinces of Kanchanaburi, Rajburi and others, and relatively a small quantity in the north. It is said that no use of bamboo is seen in the south, despite the area of its distribution has been estimated at over 100,000 hectares.

IV-2. Consumption

A definite quantity of bamboo is consumed for only the raw material of pulp at present. About 6,000 tons or 4 million culms of bamboo per year are being demanded to Kanchanaburi Paper Mill which produces 2,000 tons of bamboo pulp. Because the demand for this factory must be about 10 per cent for the total consumption. Recently a few samll-scale factories which produce the dried and chemical treated culms for exporting are operating in Kanchanaburi province. Exporting commodities dealing with them are divided into a few classes in accordance with culm length, but trading only small size bamboo of Thyrsostachys siamensis. These commodities are exported to European countries for making fence, agricultural uses and ornamentation. Some million culms might be demanded by these exporters, even no figure could be proved. Local consumption for house construction, handicrafts, agricultural uses and other purposes is not cleared, but seems to be 70 to 80 per cent for the total consumption.

According to the local magazine[15], it is said that the Board of Investment, Thailand has given approval to a Thai investor for establishment of paper pulp processing factory in Kanchanaburi province. The production capacity of the factory may be preconcerted at 40,000 tons of bagasse pulp and 10,000 tons of bamboo pulp a year. By operating the factory of having such a scale, it seems that about 30,000 tons or 20 million culms of small size bamboo, probably Thyrsostachys siamensis, should be supplied.

At present surroundings extensive by the utilization of bamboo raw material it should be presupposed that the consumption of bamboo must be grown up rapidly after a few years due to the operation of new paper mills as well as being possible to expand the productive capacity by existing paper mills, and by increasing small-scale factories of exporting bamboo culms.

Still the bamboo consumptions in Asian countries have not been minutely investigated yet, the approximate circumstances on them would be summarized by the informal reports[17] by Mr. Partran in India and others as shown at Table 4.

Table 4. Bamboo consumption classified by uses in 1965

(1,000 tons)

Country	Estimated area of bamboo (1,000 ha)	House construction	Pulp	Handicrafts	Others	Total
India	4,000	500	800	100	100	1,800
China	?	200	100	300	400	1,000
Burma	2,200	300	20	100	380	800
Indonesia	50	300	10	20	170	500
Pakistan	100	300	90	20	80	490
Taiwan	110	20	60	250	20	350
Thailand	1,000	50	10	50	40	150
Japan	170	?	0	400	100	500?

The absolute quantity of bamboo consumption in Thailand was smallest in eight countries listed up to the table, despite the bamboo resources seemed not to be smaller than Taiwan, Pakistan and other countries except India and Burma. A demand for house construction might be generally large in southeast Asian countries. The consumption for making pulp in India[13] must be an eye-opening event and it could be understood how a bamboo is conductive to the economic development of India in the field of paper and board productions. Looking at the bamboo resources by its distribution, Thailand is potential more to utilize them for producing paper and board in near future.

V. FEASIBILITY OF IMPROVABLE PRODUCTIVITY IN NATURAL BAMBOO FORESTS

The west of Thailand has a great of bamboo resources, which have been assessed at over 7 million tons in 850,000 hectares.[11] About 15 per cent out of the total area is accessible to be economic in availability. The forest condition of accessible area is indicating at the nearly pure bamboo forest, but sometimes mixing with some emergent broad-leaved trees.

Bamboos distributing in the west have been divided into two categories of big and small bamboos by the survey of Paper and Pulp Materials. In accessible area the big bamboo occupies 65 per cent of bamboo ranging area and keeps 1.53 millions tons of the total growing stock. The growing stock of small bamboo is 114,000 tons that are only 7 per cent of the total as shown at Table 5.

Table 5. Accessible area and growing stock in the west

Category	Area (ha)	% of area	A.D.Wt. ton/ha	Total growing stock	
				A.D.Wt.	%
Small bamboo[1)]	46,350	34.8	2.46	114,000	7.0
Big bamboo[2)]	86,900	65.2	17.64	1,533,000	93.0
Total	133,250	100.0		1,647,000	100.0

Note: These figures were given by FAO, 1968.[11)]

1) Thyrsostachys siamensis

2) Bambusa arundinacea and other species comparatively large size culm.

Regarding to the bamboo inventory investigated in an accessible area of the west, the annual growth of bamboo and the quantity available for pulp productions have been discussed. In this case the annual growth means not only the quantity of new bamboo which sprouted and matured in a year, but also the yield expectant to be harvested. This is essentially characteristic and favorable points of bamboo, when compared with woody trees of which its annual growth means the annual increment totalled by the individual volume increased in a year.

Table 6. Presumptions of annual growth (yield) and the quantity of pulp available to be produced by its growth in the accessible area of the west.

Category	Area (ha)	Annual growth (A.D.ton/year)	Pulp expectant for producing (ton/year)
Big bamboo	86,900	191,180	63,700
Small bamboo	46,350	13,905	4,600
Total	133,250	209,085	68,300

Note: Annual growth was computed as 2.2 ton/ha for big bamboo, but only 0.3 ton/ha for small one in case which the surviving age of bamboo standing had been presumed at less than eight years old.

The estimation of annual growth was total 210,000 tons that must be possible by total 133,000 hectares of accessible area. About 91 per cent or 191,000 tons out of the total growth were estimated by the big bamboo in the category, because of only 9 per cent or 14,000 tons by the small bamboo. The quantity of pulp available to be produced by the annual growth of bamboo may be 68,300 tons by the total 63,700 tons of big bamboo and 4,600 tons of small bamboo.

At present, it is difficult to expect more than 0.3 tons per hectare of annual growth in natural Thyrsostachys siamensis forest. The importance, therefore, is to discuss urgently on the shift of forest condition from such a natural into managing. If this shift was realized, the productivity of bamboo forest accessible in the west as mentioned-above may be exactly heightened and increasing the pulp productions.

Table 7. The presumed annual yield of bamboo forest of small size culm in the accessible area of the west after converted into management forest from natural one, and the pulp production expectant by the yield.

Annual yield expectant by small bamboo (ton/ha)	Total yield by small and big bamboos (1,000 ton/ha)	Total pulp production (1,000 tons)
1.0	237.5	79.2
2.0	283.9	94.2
3.0	330.2	110.0

With regard to Table 7, if one ton per hectare of annual yield by small bamboo was assumed, the total anuual yields by small and big bamboos would be 240,000 tons, and 80,000 tons of pulp would be produced by the yield. In case of 2 tons per hectare expectant for the yield by small bamboo, the total annual yields and pulp productions would be 280,000 tons and 94,000 tons respectively. The annual growth of 3 tons per hectare must be an average in the pure type of natural Thyrsostachys siamensis forest. If the average annual growth of this species in accessible area could be kept to three tons per hectare, the total yields would be risen to be 330,000 tons, because 110,000 tons of pulp might be anticipated.

It is, by the way, said[3] that the productivity of Dendrocalamus strictus in India is 3 tons per hectare, and in Japan Phyllostachys reticulata is 7 tons in the average. It could be, therefore, of course said that the average growth of 3 tons per hectare by T. siamensis forest in Thailand should be possible.

The anticipation of productivity in inaccessible bamboo forest of the west is difficult, because of no detailed figure obtained. But, if it was successful to exploit a vast area of inaccessible bamboo forest, over 280,000 tons of pulp would be expected at least. The most potential of making bamboo pulp by the west may be over 700,000 tons per year.

The survey on bamboo growing in the north and south has not been completed. The type of bamboo forest[5] in the north is mostly forming the secondary story under the mixed deciduous forest and the species are Thyrsostachys siamensis, T. oliveri, Bambusa arundinacea, B. blumeana, Dendrocalamus species and others. Their growing areas have been inferred to over 100,000 hectares. Accordingly, the annual growth in total areas can be anticipated to be about 30,000 tons in case of 0.3 tons per hectare by natural production. Moreover, by the establishment of management way for such a forest the productivity must be possible to rise up to 2 or 3 times than the present.

In the south approximately 100,000 hectares of bamboo forests could be seen under mostly evergreen forests.[5] At present, most of bamboos are released from utilization, except for a few of making some kinds of furnitures and some agricultural uses. The exploitation of bamboo forest in the south should be more noticed in large scale. The present circumstance does not allow to estimate the productivity of bamboo forest in the south.

VI. ACHIEVEMENT OF RESEARCH WORK

VI-1. Progress of Research Work

Research work necessary for the exploitation and utilization of natural bamboo forests systematically has started with the operation of Paper and Pulp Material Survey in 1964. The beginning was depending on the trails designed by Mr. Green, Mr. Mason and others of FAO advisors. In 1965 Dr. Ueda dispatched to the project by FAO and advised in the way of investigation and research on silviculture and physiology of bamboo. Since the technical cooperation between Thailand and Japan under the Colombo Plan has been realized in 1967, the research work has been well proceeding by the technical service of Dr. Ueda, Mr. Suzuki and others and leading to get valuable fruits.

On the other hand, the effectiveness of research by the hands of technical officials in Royal Forest Department, Thailand has been a great in the significance. Khao Hin Lap Bamboo Experimental Station set up in 1964 under Paper and Pulp Material Survey became to be a pivot of all field research. The station is available to use thousands hectares for silvicultural and fundamental researches and its existing is an unigue in the world which could not be seen in other countries. In Forest Products Research Division of Royal Forest Department the characteristics of fibres, pulping test and technological research on bamboo have been satisfactory carried out. These fruits were reported in the publications issued by FAO,[11] Royal Forest Department[7] and through the several conferences on forestry in Thaialand.

Main subjects and their numbers of researches on bamboo conducted between 1964 to 1969 by the researchers in Thailand and with experts of FAO, Colombo Plan and others, have been extended to the whole of fields concerned that are shown at Table 8.

Table 8. Subjects and numbers of research on bamboo conducted between 1964-1969.

Subjects	Numbers
Management of natural bamboo forest	6
Propagation of bamboo	9
Artificial regeneration of bamboo forest	2
General fundamental research	7
Prevention against insect damage	A few
Utilization for pulping	Several

Some subjects on the management of natural bamboo forests and on the regeneration of bamboo are being carried out at present on account of the necessity of a long term for such a research. But, some problems economic and technical compelled a few research works to be suspended.

VI-2. Recent Research

Recently, the research works on silviculture and management of bamboo forests are well advancing under Paper and Pulp Material Survey in Royal Forest Department. Hereat, the subjects and objectives of the research being proceeded or just got worthy results by the technical cooperation between Thai researchers and the reporter are as following (see App. I).

VI-2-1. General Research

1) Bamboo sprouting

A knowledge on bamboo sprouting is a basic for progressing the studies on silviculturel and management. The performance of observation on bamboo sprouting was carried out at Pukae Botanical Garden and Khao Hin Lap Bamboo Experimental Station. The subjects investigated were on the period and number of sprouting, the occurrence of undeveloped sprouts, habitual elongation of shoots, relations between the phenomenon of sprouting and environmental factors such as precipitation, temperature, humidity and so on (see App. I-1-1).

2) Productivities of bamboo forests

The objective of research on the productivities of bamboo forests was to make clear the biomass and productive structure in the natural type of bamboo forests, as there had been a few of researches on this field in Thailand. The investigation of that on Thyrsostachys siamensis forest was carried out in 1970, though the discussion on its result must had been not enough owing to poor data (see App. I-1-2). Through this performance the approximate presumption of present stocks in the natural pure type of T. siamensis forest was possible to be done.

3) Natural regeneration of bamboo forests

It goes without saying that the development of natural bamboo forest is caused by natural regeneration. The natural regeneration can be, accordingly, seen anywhere in so far as bamboo growing range, especially T. siamensis species in Kanchanaburi. In order to clear the process of developing new community under natural environment, an investigation was conducted about young T. siamensis community which had been formed in Kanchanaburi (see App. I-1-3).

VI-2-2. Fundamental research

1) Physiological research

There are many kinds of physiological research that should be proceeded for the establishment of technique on silviculture and management of bamboo forests. During two years the research on water relations in bamboo culm (App. I-2-1) and environmental factors influencing to the growth of bamboo seedling (App. I-2-2) was attempted. Because, the observation on seasonal change of water content in bamboo culm was carried out in Khao Hin Lap Station, and a pot test on light intensity effective for the growth of bamboo seedling was performed for one of experiments on environmental factors.

2) Fundamental pot tests on fertilizing

So as to heighten the productivity of bamboo forest, the improvement of soil condition should be necessary. The application of some kinds of fertilizers must be ideal for improving a poor soil in a short time. There, nevertheless, is a problem requisite to be solved whether the economic management of forest is made up or not, when the chemical fertilizer was applied. It should be, accordingly, needed to test on the effectiveness of chemicals for the growth of bamboo basically.

By the hands of the reporter and Thai-side counterparts two pot tests on using chemical fertilizer were done at the nursery of Royal Forest Department. One was to find out the quantity of fertilizer proper for the growth of bamboo seedling (see App. I-2-3) and the other was to know the best season for adopting the fertilizing way (see App. I-2-4).

As one of ways to improve a poor soil condition, the adaptation of physiological function by root nodule bacteria existing in leguminous plant must be important. The pot test for discussing the effect on the growth of bamboo seedlings in case which they are planted by mixing with leguminous tree was carried out (see App. I-2-5).

VI-2-3. Applicable research

1) Experiment on the management of bamboo forest

The consideration on the choice of felling method, felling cycle and fertilization for soil must be the key for the purpose of shift from natural forest to management one. There are several felling methods which have to be desirably experimented. The question on felling cycle must be dissolved by the establishment of the felling methods which should be discussed through the experiments on adopting the way suitable for forest. The trials on fertilization to the forest soils in field which may be hard, compact and poor properties, should be needed abreast with fundamental pot tests on them.

Three kinds of experiments on the management have been conducted at Khao Hin Lap Station during two years. They were (1) Experiment on the management method of bamboo forest (App. I-3-1), (2) Preliminary test on the improvement of soil in poor T. siamensis forest and (3) Preliminary test on clear felling method. Unfortunately, the tests of (2) and (3) were unsatisfactory to get results, that mainly were due to the short term of testing.

2) Experiments on plantation

The success of bamboo plantation in the sporadic gap of bamboo growing area, naked land and some waste land should be expected as a potential of increasing the productions of bamboo. According to the results of previous trials on plantation in Khao Hin Lap Station, it was much difficult to succeed it. This root was attributable to severe drought in dry season, infertile soil and other factors.

By the reporter two experiments on plantation were designed and conducted at Khao Hin Lap Station. One was on planting mixed bamboo seedlings with leguminous tree seedlings in field and the other was on the planting method (see App. I-3-2). The mixed plantation had an objective to notice the function of root nodule bacteria by leguminous tree for the growth of bamboo in actual field applicably (App. I-2-5). This experiment planned in the field was practical to prove that function. Study on planting method is really an essential, especially under severe climatic condition. One of causes to fail such plantation in Khao Hin Lap, Kanchanaburi, must be due to the difficulty to discover the best planting method suitable for the field. So that, the experiment was tried to adopt the four kinds of methods, but which method might be best in the field could not be got yet.

3) Tests on vegetative propagation

About the species irrespective of either difficult to collect the seeds or necessary to take over the dominant character to another generation, the vegetative propagation is much important to produce new planting stocks. On bamboo it must be available to adopt the ways of branch and culm cuttings. Some tests were, therefore, carried out on cutting methods suitable for several useful species during two years (see App. I-3-3). But, it should have been recognized that the cutting ways must had been hard to look for.

VII. DIFFUSIVE ACTIVITY

VII-1. Third National Forestry Conference

The 3rd National Forestry Conference was held from 14th to 22nd of August 1970 at Chieng Mai University. The conference was characteristic at the same as the Annual Meeting of Japanese Forestry Society. It, so to speak, was a valuable opportunity to report and discuss the fruits of research and technical idea concerned with every fields in forestry.

In the conference the reporter was given an opportunity to appeal how bamboo growing in Thailand is important as titled "On the research works of bamboo forests in Thailand" (see App. III). It must have been believable that whole of participators in the conference may have understood the reporter's opinion in confirmation of its importance, by means of which the paper presented by the reporter had been completely translated into Thai by the hand of Thai-side counterpart.

It was a significant that some research papers on bamboo were also presented by the researchers of Thailand at the conference. Still it should be expectant for the papers more to be presented at such an opportunity in future. At the conference the authorities of Royal Forest Department were favourable to declare that the 2nd Bamboo Training Course on silviculture and management would be held recently.

VII-2. Second Bamboo Training Course

Following the 1st Bamboo Training Course that was held from 6th to 22nd of January 1969 performed by the authorities of Royal Forest Department jointed with previous experts Dr. K. Ueda and Mr. T. Suzuki, the 2nd Bamboo Training Course was held from 14th to 22nd of December 1970 at Khao Hin Lap Bamboo Experimental Station, Kanchanaburi. The 2nd Training Course was done for about forty participants composed by the technical officials of Royal Forest Department, business men concerned with bamboo pulp making and progressive farmers. The instructors were called from the expert and specialists on general forestry, botany, silviculture, soil survey, bamboo technology, ecology and practical researches in the department. The reporter, needless to say, took a part of instruction through whole term of the course.

The characteristic of 2nd Training Course was that it had been held at the place of the range concentrative of bamboo growing and that the farmers had attended as the representatives of the peoples taking the business concerned. The lectures and field training, accordingly, were practical in particular.

The main subjects taken for the training were as following;

1) National policy and economic concerned with bamboo.
2) Classification of bamboo species.
3) Improvement of natural bamboo forest.
4) Importance of soil fertility in bamboo forest.
5) Ecology of bamboo.
6) Utilization of bamboo for industry.
7) Insect damage and its prevention.
8) Cultivating method of Dendrocalamus asper species for edible shoots.
9) Practical works on bamboo forests.

10) Training of how to use the equipments for practical cultivation and research works.

11) Inspecting trip to paper mills, botanical garden and the cultivation of bamboo shoots.

The reporter made a lecture on "Improvement of natural bamboo forests in Thailand" included general knowledge on bamboo as in Appendix IV.

It could be found that all of participants were very behaving and enthusiastic in training on every subjects. It was, especially, thought to be much successful that Mr. A. Takahashi was invited to attend the opening ceremony by the authorities of Royal Forest Department as the representative of Japanese-side.

VIII. TENDER OF EQUIPMENTS AND EXPERIMENTAL ARTICLES BY JAPAN FOR TECHNICAL SERVICE ON BAMBOO

The Government of Japan has offered equipments and experimental articles necessary for accomplishing the works of experts dispatched for technical service on bamboo project of Thailand since 1968. From 1968 to 1969 the equipments provided for the duty of Mr. Suzuki were the boring and bush cutter machines, chain saw and others for field work and camera, drying-oven, calculator and others for experimental work, because of about US$2,900 summed up them by his recommendation. During 1970 to 1972, hand-tractor, irrigation pump and others were arranged for field research by the request of the reporter and microscope, chemical balance and others for indoor work, and the amount of them was about US$4,600 by totalled estimation. Accordingly, whole of equipments and articles offered by Japan under the cooperation have corresponded to about US$7,500.

It could be found that these were very effective to execute the service work of experts dispatched, but it would be desirable for Japan to tender more of equipments in order not only to make the program more progressive by Thailand, but also to accomplish the responsibilities of experts smoothly and satisfactorily. Besides, main equipments and articles offered in the past were listed up as shown at Table 9.

Table 9. Equipments and experimental articles tendered by Japan

Equipments and articles	Quantity	Amount (US$)
(1968 - 1969)		
Camera with telephoto lense	1 set	166.68
Binocular	1 pc.	47.23
Chain saw with accessories	1 set	120.80
Bush cutter device with accessories	1 set	50.60
Auger device with accessories	1 set	90.50
Scythe machine	2 sets	156.30
Boring & bush cutter machine with accessories	1 set	713.89
Calculator	1 pc.	94.45
Typewriter	1 pc.	63.89
Chemical fertilizer	200 bags	302.10
Soil sampling cylinder	20 pcs.	72.40
Drying oven	1 set	316.00
Other articles		682.10
Total		2,921.94
(1970 - 1972)		
Hand tractor with trailer and accessories	1 set	928.33
Microscope	1 set	495.50
Microtome	1 set	157.17
Chemical balance	1 set	569.44
pH meter	1 set	168.00
Irrigation pump with engine and accessories	1 set	591.60
Pocket compass with legs	1 set	65.00
Aspiration psychrometer with legs	1 set	61.10
Luxmeter	2 sets	272.40
Tension meter	3 pcs.	74.70
Steel footstool	1 pc.	43.20
Plant pot	55 pcs.	122.50
Chemicals		85.14
Other articles		945.38
Total		4,579.46
Ground total		7,501.40

IX. RECOMMENDATIONS

It is recommended that Thailand had better promote the fulfilment of scheme to exploit bamboo resources and the utilization of bamboo, in order to realize the self-sufficiency of pulp and paper, to heighten the level of standard living of farmer by taking a job concerned with a large-scale exploitation or a family industry of making bamboo commodities and to attempt increasing the national income by exporting pulp, paper and other bamboo products. When discussing the possibility to make materializing above plans, it should be pointed out to perform the following propositions.

IX-1. Survey and Research Works

1) Inventory surveys of bamboo stocks in the north and south as well as an inaccesssible area in the west.

2) The discussion on the quantitative feasibility of exploiting bamboo resources in the north and south for pulp making or a large-scale exploitation, and on the relationship between the heightening of the living level of farmer and the utilization of bamboo.

3) Economic survey on the flowing system of bamboo raw material from producer to consumer, marketing system, cost problems on industrial utilization and family scale.

4) On silvicultural and management techniques for natural bamboo forest;

   a) Research on the productivities of bamboo forest in accordance with the factors of species, forest type and site quality.
   b) Experiment on the management methods of bamboo forests, especially on which felling way is more economical and practical, selective felling or clear cutting.
   c) Establishment of felling cycle in both selective and clear fellings.
   d) Economic discussion on applying chemical fertilizer for the improvement of poor bamboo forest.
   e) Experiment on the planting methods in severe dry area, infertile soil and some waste lands which may not be useful for planting any tree under the commercial base.
   f) Investigation on the development of young natural commucity of bamboo, particularly environmental factors influenced to the natural germination, branching rhizome and growth of new shoots.

5) On the technique concerned with nursery;

   a) Test on the branch and culm cuttings for vegetative propagation of main species.
   b) Improvement of nursery technique, especially on seed preservation, promoting germination, prevention against pathogeny and insects.

6) On the utilization for pulp making;

   a) Discussion on the way for transporting bamboo raw material such as using special vehicles or chipping of bamboo culm in supplied place as well as rafting.
   b) Pulping test, especially in case of mixing bamboo pulp with some pulps of hardwoods, soft and rubber woods.

7) On operating small-scale industries and making bamboowares or handicrafts;

a) Fundamental test on making some kinds of laminated board for furniture and using for the decoration of house.
b) Introduction of technology on making bamboo handicrafts for exporting.
c) Establishment of pilot plant for producting bamboowares.

IX-2. Diffusive System of Technique on Bamboo

It is a matter of course that the diffusion of technique on silviculture and management of bamboo forest and on producing bamboowares or handicrafts should be extremely expected. In the past the bamboo training courses were significant and of avail for spreading the technique over the country. There might, while, be some problems on which to call for many participators simultaneously, on the season and term of the training course.

There will be various ways in holding the training course. If the training course could be attempted for farmer only, the practical technique would be preferable because of too hard to understand the theory for them. But, for the educated peoples the scientific theory would be more needed than the practice. According to this, as expecting a smooth diffusion, it should be needed to discuss somewhat a systematic way such as;

1) The authorities of Royal Forest Department may qualify for "Specialist" on bamboo, which the technical officials in the department must be available, through the special training on theoretical and practical knowledges by concerned instructors from home and abroad. The department may also entitle to "County Agent" on bamboo, which technical officials in divisional or provincial forest offices must be suitable.

2) The Specialist has a qualification to make plan of annual training course, to make lecture for County Agent and to advise farmer, dealer and other participants. on particular problems. And he has to get the concerned knowledges through proceeding the experimental works.

3) The County Agent has to be a usual consultant for all participators and to convene a meeting on practical works in the unit of village or district whenever the necessity of consultation is occurred.

IX-3. Establishment of "Bamboo Centre of Thailand"

1) For the purpose of propelling the exploitation and utilization of bamboo resources more progressively, it will be exceedingly expected to establish new bamboo project - "Bamboo Centre of Thailand" (BCT) which may be independent from present bamboo works in Paper and Pulp Material Survey in Royal Forest Department.

2) New bamboo project has following objectives;

a) Survey on bamboo resources in the north, west and south.
b) Experiment on the improvement of natural bamboo forest.
c) Diffusion of technique on silviculture and management of bamboo forest.
d) Research on making pulp from bamboo.
e) Installing of the pilot plant for producing bamboowares.
f) Training of making bamboo products.
g) Establishment of transporting and marketing systems.
h) Discussion on political problems concerned.

3) Project duration should be five years, but BCT must be expected to succeed for an indefinite period of time.

4) Headquarters office of the project should be settled in Royal Forest Department, and BCT has a stipulation on location to be chosen near bamboo resources, more facilities in transportation and communication.

5) The project may be organized as one Project Manager, one Assistant Manager, three Section Chiefs : Exploitation, Utilization and Administration, twelve technical officials, two clerks, two drivers and five hundred labourers.

6) Working proposal is as following;

a) Exploitation

a. Survey of bamboo resources - inventory survey, transportation, cost problems, marketing of raw material, etc.
b. Silvicultural experiments - productivities of bamboo forests, management methods, fundamental tests, artificial regeneration, making ornamental bamboo, cultivation of edible bamboo shoot, land and water-source conservations, etc.
c. Diffusion - training on general for forester and farmer.

b) Utilization

a. Research - fundamental analysis of bamboo characters, pulping tests, several technological researches, etc.
b. Pilot plant - introduction of mechanism, improvement of machinery, cost counting, investigation of marketing, etc.
c. Training - mechanism, operating machinery, etc.
d. Administration - general.

7) Project costs must be estimated at total US$240,200, because of;

	(US$)
Personnel	138,000
Fercilities	42,000
Motorized equipment	21,200
Pilot plant	36,000
Supplies and equipments	3,000
Total	240,200

8) The regular service by two foreign experts must be hopeful at least, then some experts or advisors with short term on special field. Eight technical officials of BCT may be allowed to apply for training on their field at developing countries. The economic co-operation with developing countries, especially on installing heavy equipments, will be more expected.

9) It must, at first, be hopeful to form "Preparatory Committee on BCT" in Thailand.

X. CONCLUSIONS

As mentioned-above, more than one million hectares of bamboo resources are much valuable for pulp making, small-scale industries of producing bamboowares and handicrafts and the preservation of land. Especially, a large-scale exploitation of the resources must be helpful for developing the country by an increase of national income to make up self-sufficient relation of paper and board and of expecting the feasibility to export them in future. Still more, there is a great expectation of rising up the standard living of farmer by the realization of synthetic utilization on it.

It is undoubted that there must be the possibilities to realize the ideas being by the scheme of the project. The first point of which it could by thought above, is that the bamboo resources are potential to be adequately kept, promptly improved, ideally exploited and utlized. The second is that the Government of Thailand is going to put her heart into this project, in order to open the way for the profitable exploitation of natural resources for the economic development by her hands and expecially to solve the present problem facing to the imbalance of production and consumption of paper.

When looking back to the reporter's service on standing at this point, it should be said that the works on himself could not be satisfactory. This was due to unfamiliar with research and diffusive works in Thailand, to missing the best time for some important experiments and had to meet with some unexpectant occations.

Finally, the reporter is confident of bamboo project which will be accomplished with great fruits by the technical cooperations between Thailand and Japan in near future.

APPENDEX

I. RESULTS OF RESEARCH

I-1. General Research

I-1-1. Bamboo sprouting

To know the habitual phenomenon on bamboo sprouting should be essential upon proceeding fundamental and applicable researches expecting at present. The main investigation on this subject was carried out at Pukae Botanical Garden under co-act with Silvicultural Division during the rainy season in 1970.

Species chosen in order to find out sprouting period, growing term and speed or amount of elongation of shoot were four which were Bambusa arundinacea, B. vulgaris, B. tulda and Thyrsostachys siamensis. The number of clump investigated was one to four that were different due to the number of specimen plantations by species in the garden.

Table I-1. Sprouting period of bamboo shoot

Species	Starting	Finished	Term
Bambusa arundinacea	May 10	June 25	46 days
B. vulgaris	May 1	June 22	52 "
B. tulda	May 25	June 27	33 "
Thyrsostachys siamensis	May 15	July 1	47 "

The beginning of sprouting was May in every species, and the sprouting finished at the end of June to the beginning of July. The term of sprouting differed a little by species, and that was 33 days in the shortest by B. tulda and 52 days in the longest by B. vulgaris. This was an unexpected result, because of very similar with large-size bamboos growing in Japan,[2] even different in species, growing habit and environmental factors between both countries.

There was a close relation between the numbers of bamboo sprouts emerged on the ground and the amount of rainfall as shown at Fig. I-1. The figure was made about the numbers of sprouts observed in 12 clumps of 4 species totalled and the precipitation during the sprouting term. The beginning of sprouting was apparent to the starting of rainy season in early May, then the number of sprout emerged was nearly in proportion to the precipitation. By the result it could be recognized that the sprouting should be extremely affected by the rainfall which was owing to give adequate moisture for making bamboo start to develop in soil.

Table I-2. Numbers of emerged, matured and undeveloped sprouts

(per clump)

Species	Number of emerged sprouts	Number of matured sprouts	Number of undeveloped sprouts	Rate of undeveloped sprouts
B. arundinacea	4.0	2.0	2.0	50.0 (%)
B. vulgaris	14.7	10.0	4.7	30.6
B. tulda	7.0	6.0	1.0	14.3
T. siamensis	4.8	2.6	2.2	45.8

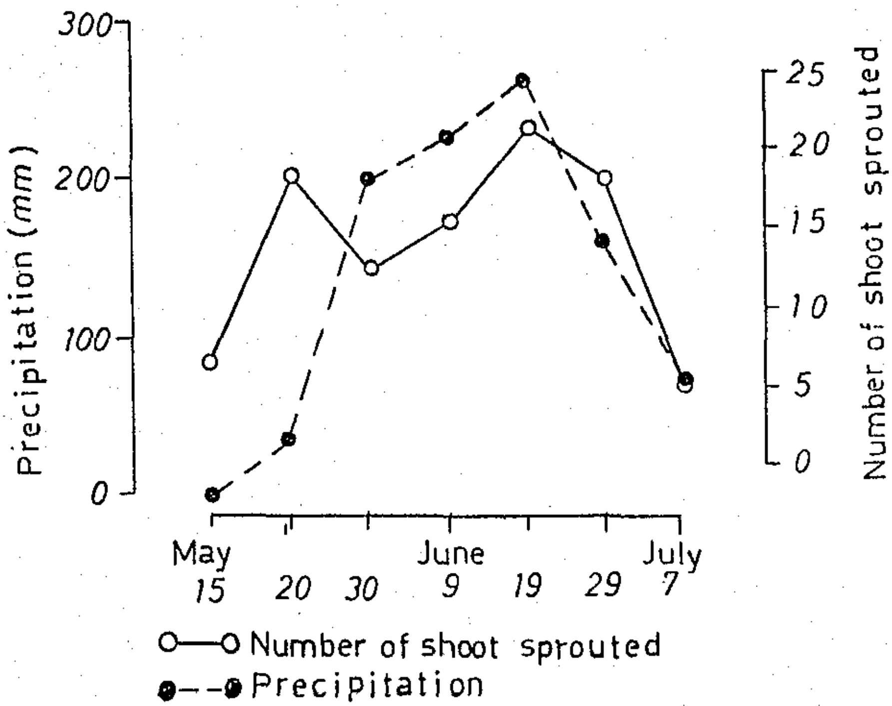


Fig. I-1. Relations between the number of bamboo sprouts emerged on the ground and the precipitation.

The number of bamboo sprouts just emerged on the ground was 4 to 14 per clump, but with remarkable different by species as shown at Table I-2. It means that the number of sprouts developing is exceedingly influenced by the factors such as soil condition, on-year or off-year of sprouting and management method that should be diversified by species.

Being noteworthy is that some of emerged sprouts have stopped their elongation, and then decayed. This phenomenon is not of rare, and they call the undeveloped sprout.[2,18] As for the occurrence of undeveloped sprout, the want of nutrition must be causative. This is because that nutrients may be lacking so as to make many sprouts grow in a short term. In case of the result investigated about 4 species in the garden, the per cent of appearing undeveloped sprouts for the total sprouts emerged in each species was in range of 15 to 50%. These rates seemed not to be high if compared with some large-size species growing in Japan, that they were 30 to 80% observed by the reporter.[18]

Table I-3. Elongation term of bamboo shoot

Species	Term
B. arundinacea*	69 - 72 days
B. vulgaris	72 - 84 "
B. tulda	54 - 82 "
T. siamensis	48 - 81 "

The elongation term of bamboo shoot was not much different in species, because of about 80 days in average as shown at Table I-3. Unfortunately, it was compelled to stop the observation on elongation term at the middle of August, by reason which most of bamboo sprouts of B. arundinacea and B. vulgaris measured had suffered the damage attacked by some insects. Because the result on term should be revised by which to add some more days for their complete elongation, despite it could not be cleared to estimate the necessary adding days. As the reference, clump forming species growing in Japan are generally 80 - 110 days[2] in their elongation term.

The daily growth of bamboo shoot was attractive as Fig. I-2. About 4 species the beginning of elongation was mostly less than 10 cm per day, then at 40 to 50 days after emerged on the ground the shoots showed their maximum which was 20 to 27 cm. The period of which they could reach to the most vigorous growth, might be equivalent to half to two-thirds of their whole growth term.

Table I-4. Bamboo elongation during the daytime and the nighttime on Bambusa arundinacea

(cm)

Date \ No.of sprout	1			2			3			Humidity (%)
	Day	Night	Total	Day	Night	Total	Day	Night	Total	
Aug. 29	11	-	-	8	-	-	15	-	-	82
30	6	13	19	8	15	23	7	11	18	71
31	7	21	28	6	15	21	8	30	38	71
Sep. 1	10	33	43	14	6	20	9	8	17	81
2	4	3	7	0	13	13	2	21	23	86
3	3	18	21	2	14	16	3	17	20	74
4	4	22	26	4	31	35	10	17	27	78

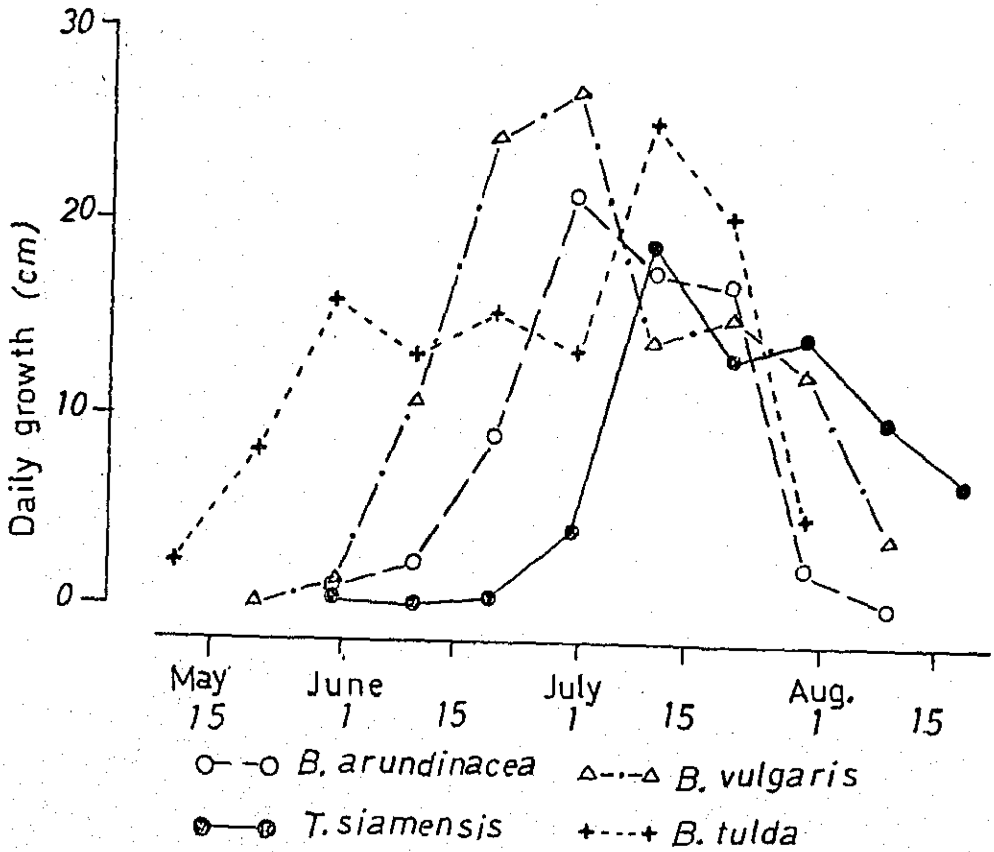


Fig. I-2. Daily growth of bamboo sprouts.

The heightening growth of bamboo shoot during the day'time and the night'time on Bambusa arundinacea was measured at Khao Hin Lap Station on August 29 to September 4, 1971. According to the result tabulated at Table I-4, the growth of sprout during the night'time was two to three times as much as those during the day' time. On monopodial type species growing in Japan which sprout in spring, usually a sprout grows more during the day'time than during the night'time. On the other hand, it is said that sympodial type species mostly growing in tropical countries show contrary to monopodial, even in Japan. The result in this case, therefore, was same that the observations in the past had pulled out. There has not been recognition about the relation between the growth of sprout and humidity, despite it is said that humidity is more effected to the growth of bamboo shoot than temperature.

I-1-2. Productivity of natural bamboo forest

It is needless to say that the analysing of productivity on natural bamboo forest is very important and fundamental to find out practical method for the management and the improvement of forest. Accordingly, at pure type forest of Thyrsostachys siamensis in Khao Hin Lap Station the investigation on the standing crop and the analysis of production structure of bamboo was conducted in October, 1970.

Table I-5. Composition of standing culm in pure type bamboo forest of Thyrsostachys siamensis in Kanchanaburi.

(per ha.)

Culm	Number	Average DBM	% for living	% for total
1 year old	3,054	1.96	12.6	9.4
Over 2 years old	21,112	1.90	87.4	64.9
Total living	24,166	1.91	100.0	74.3
Standing dead	8,354	1.54	-	25.7
Total standing	23,520	1.84	-	100.0

The quadrant plot of 750 square meters was selected, then the diameter measurement was done on all of standing culms in the plot. On the composition of standing culm the total numbers of them were 32,500 culm per hectare and their average diameter breast height (DBH) was 1.8 cm as shown at Table I-5. 24,200 culms or 74% out of total standing 32,500 culms were living, but 8,300 culms or 26% were mortal. 3,000 culms out of total living 24,200 culms could be surmised as one year old, and over two years old was 21,100 culms. Because the per cent of newly produced culm for total survivals was about 13 per cent. It was proved that the occurrence of high rate mortality and low rate new production are typical of natural bamboo forest, still the sampled area for investigated this T. siamensis forest was not an exception.

The distribution by DBH gradation of standing culms was in range of 0.4 to 3.7 cm as shown at Table I-6.

Table I-6. Numbers of living and dead culms classified by their DBH gradation in pure *T. siamensis* forest.

(per ha.)

DBH class (cm)	1 year old culm	Over 2 years culm	Total living culm	Standing dead culm	Total
0.4	20	20	40	40	80
0.7	120	598	718	479	1,197
1.0	133	878	1,011	918	1,929
1.3	206	2,494	2,700	1,756	4,456
1.6	406	4,515	4,921	2,381	7,302
1.9	712	4,754	5,466	1,663	7,129
2.2	805	3,531	4,336	771	5,107
2.5	412	2,501	2,913	226	3,139
2.8	193	1,230	1,423	80	1,503
3.1	20	352	372	40	412
3.4	27	186	213	0	213
3.7	0	53	53	0	53
Total	3,054	21,112	24,166	8,354	32,520

The vertex of DBH frequency by living culm was at 1.9 cm, but at 1.6 cm by standing mortalities. It means that small sized culms easily move to be more decandent than large-sized. One year old culm made its mode to be at 2.2 cm class of DBH. This indicates that the productivity of this stand may be going up.

Sixteen culms selected in accordance with DBH gradation were cut down and sampled, as shown at Table I-7, for measuring the standing crop, allometric relations between the volume of culm and the weights of leaves, branches and culm, and analysis of production structure.

Table I-7. Number of culms sampled

DBH (cm)	1.0-1.9	2.0-2.9	3.0-3.9	Total
Number of culm	6	6	4	16

The allometric relations of culm weight (w_S kg), branch weight (w_B kg), foliage weight (w_L kg) and the weight of above-ground parts (w_T kg) to D^2H (Dcm: diameter breast height; Hcm: culm height) were shown on logarithmic graphs of 3 and 4. But their weights were indicated to be oven-dry weight which was converted from fresh weight.

The regression formulas of them were bore a close resemblance to:

$$\log w_L = 0.9948 \log(D^2H) + 0.4393$$

$$\log w_B = 0.7804 \log(D^2H) + 1.0934$$

$$\log w_S = 0.9660 \log(D^2H) + 1.5541$$

$$\log w_T = 0.9199 \log(D^2H) + 1.7235$$

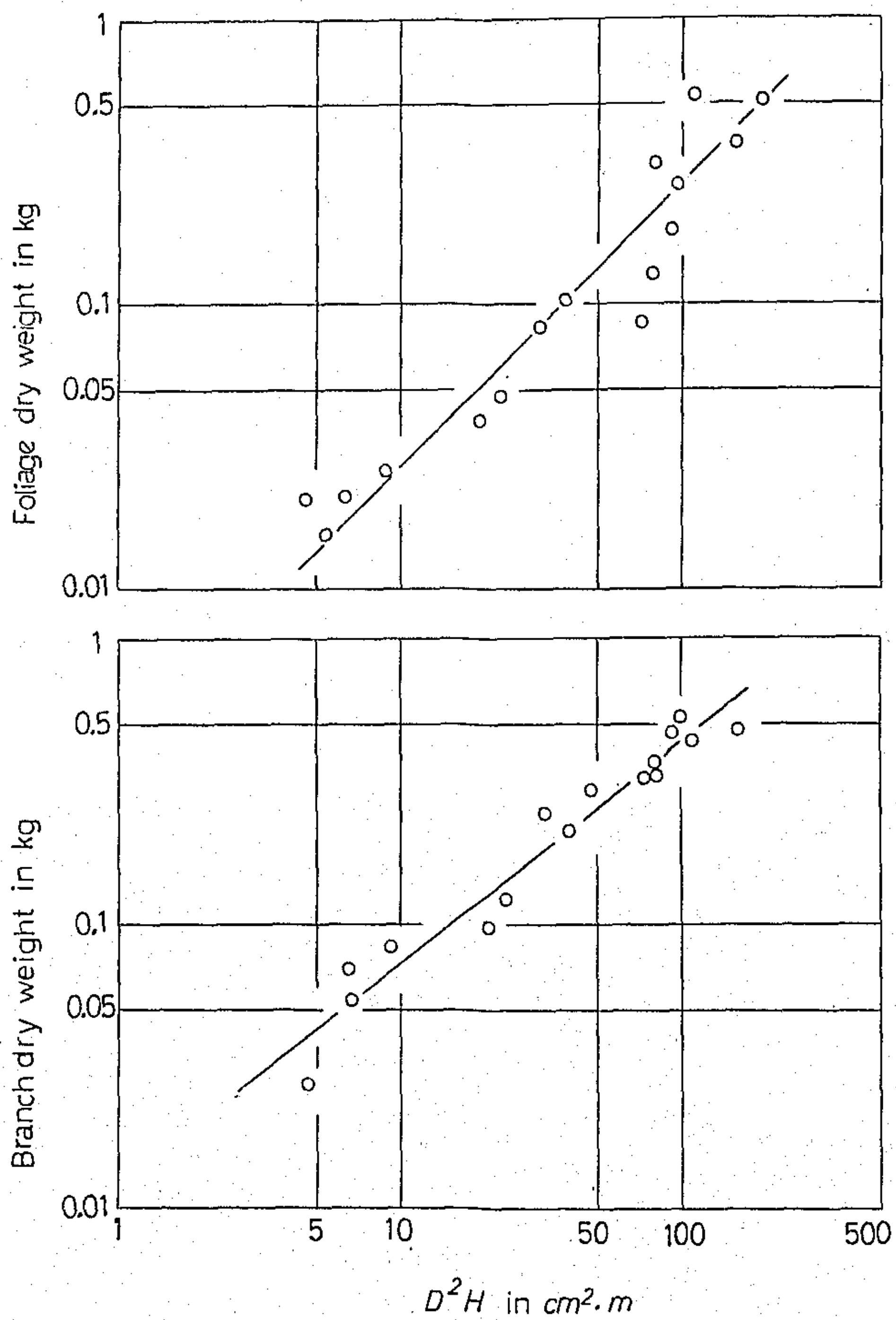


Fig. I-3. Allometric relations between the dry weights of foliage (w_L) in kg shown at upper and branch (w_B) in kg shown at lower and D^2H in $cm^2 \cdot m$.

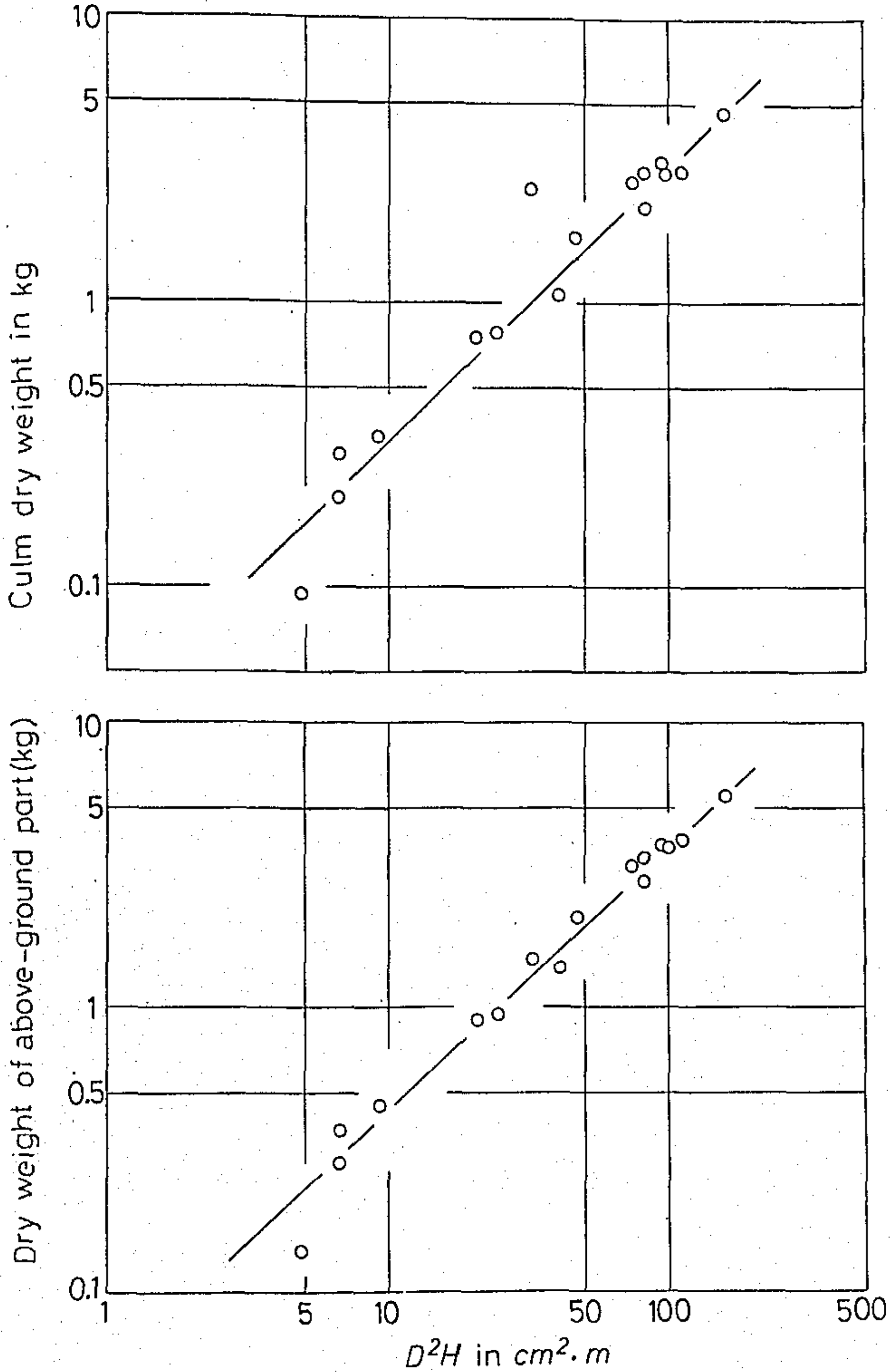


Fig. I-4. Allometric relations between the dry weights of culm (w_S) shown at upper and above-ground parts (w_T) shown at lower and D^2H in cm^2. m.

The standing crop or surviving bamboo in this forest was estimated at about 39.2 tons summed up with 2.1 tons of foliage, 6.8 tons of branch and 30.3 tons of culm. It would be interested in the tendency that the produced parts of non-assimilative parts of branch and culm were extremely augmentative, in spite which the weight of assimilative part or foliage was only 2.1 tons or 5.4 per cent for the total weights, as shown at Table I-8.

Table I-8. Standing crop of pure natural T. siamensis forest

(ton/ha)

Part	1 year old bamboo	Over 2 years old bamboo	Total
Foliage	0.280	1.854	2.134
Branch	0.698	6.112	6.811
Culm	4.022	26.257	30.279
Total	5.000	34.223	39.224

The weight totalled with foliage, branch and culm of one year old bamboo, which points out annual production or equivalent to annual increment in case of tree, was 5 tons and the production rate was calculated to be 12.7%.

In order to ascertain the production structure of this bamboo forest, the vertical distributions of dry weights in both assimilative; foliage and non-assimilative parts; culm and branch were measured by stratified clip technique, and the result was shown at Fig. I-5.

The vertical distribution of foliage on all standing bamboo exists in the strata of ranging 0.3 meters to the top of culm, and the vertex was at 7 meters high above the ground. But, the crown formed widely to distribute at the parts ranging about two-thirds height of culm length. It seems that this might be a kind of general broardleaved tree type.

I-1-3. Natural regeneration of bamboo forest

A natural regenerative process of which a bamboo starts to flower and to fructify, then the seeds begin to germinate and to form a new community, may be repeated with tens or hundreds years of regeneration cycle. A lot of such a advancing new natural community of Thyrsostachys siamensis is easy to be found at anywhere it is growing in Thailand. The investigation on the development of new regenerated community must be extremely important to get hint on the improvement of natural forest, the establishment of management way and the planting of fostered seedlings at field hereafter.

One of young natural communities of T. siamensis was observed at Khao Hin Lap Bamboo Experimental Station, Kanchanaburi in April, 1970. The forest around where the community formed was near the edge of gregarious type of bamboo forest and the area faced to bare land.

The plot of 8 x 4 meters in where the community was developing, was set up and divided into 32 blocks of 1 x 1 meter. The distribution of seedlings with forming their clumps was as shown at Fig. I-6. Seedlings observed in a few blocks were

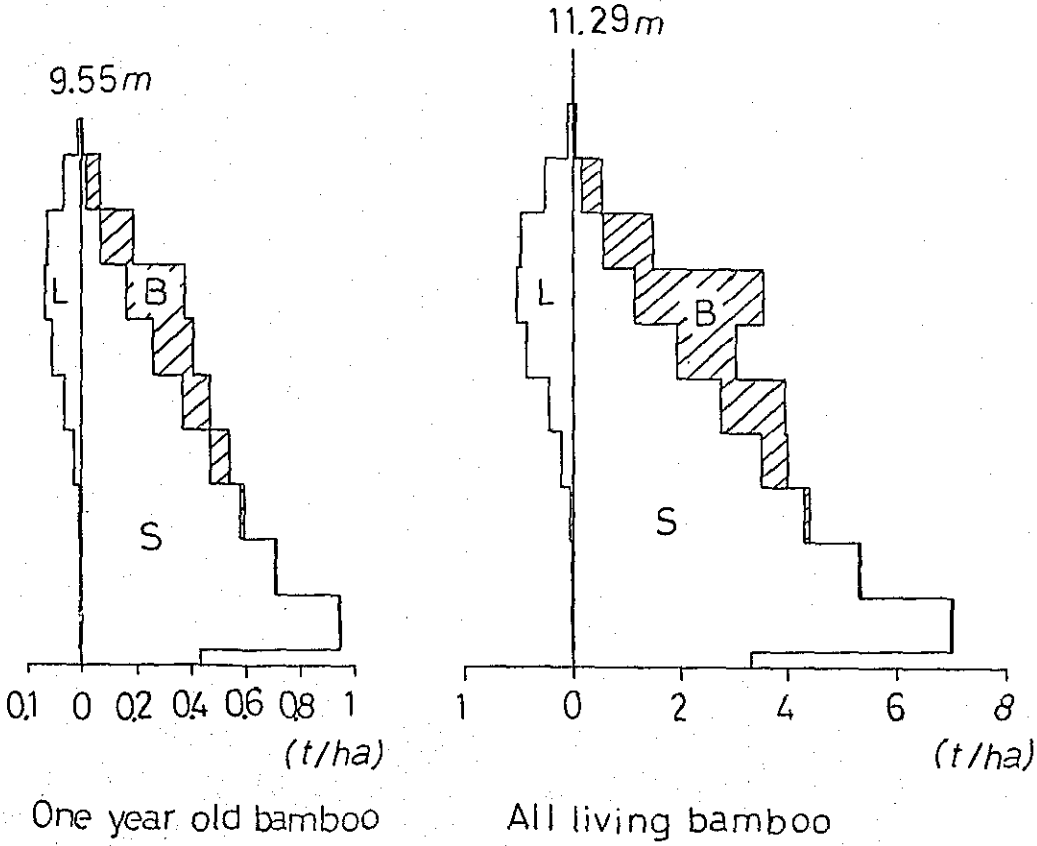
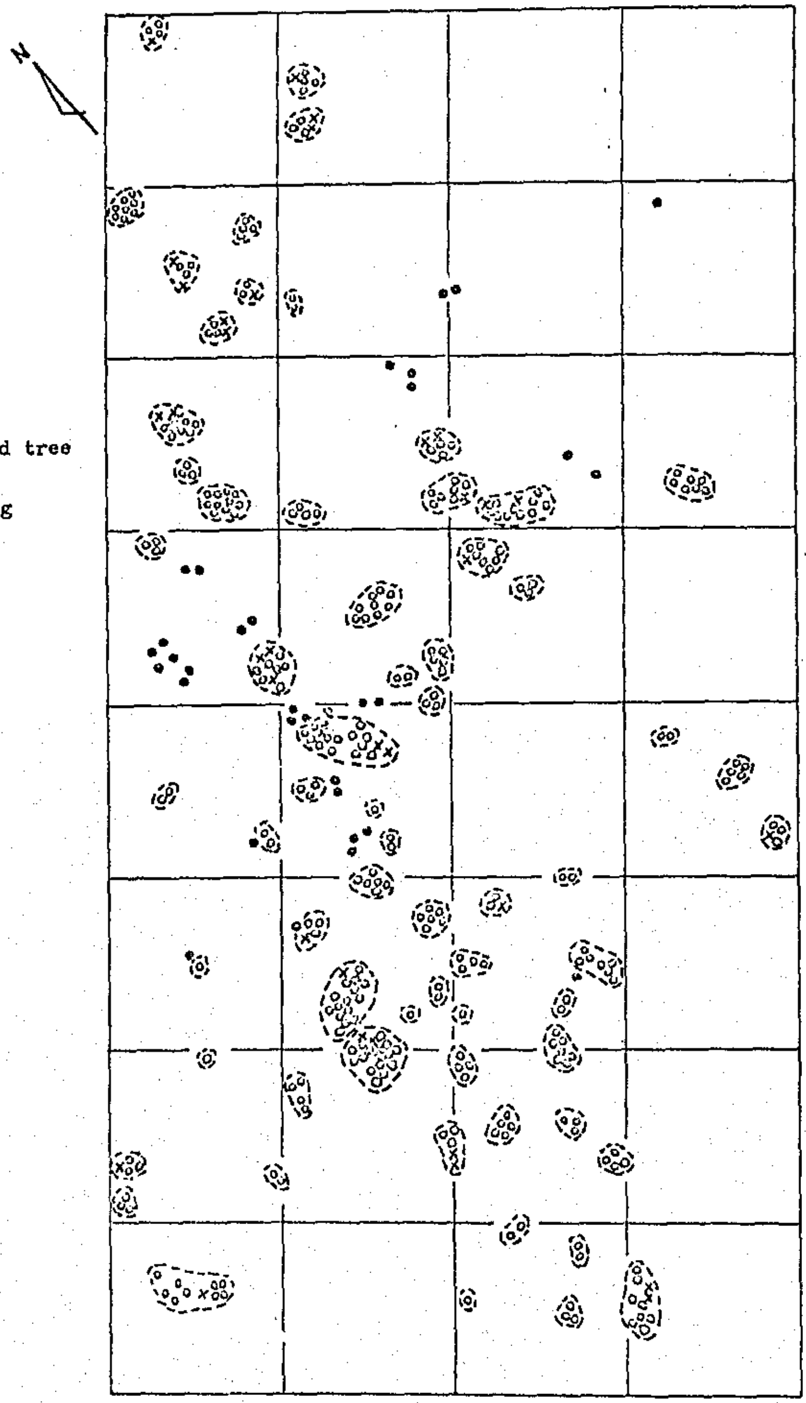


Fig. I-5. Production structure diagrams showing the vertical distributions of dry weight of culm (S), branch (B) and foliage (L) in ton per hectare.

Fig. I-6. Distribution map of standing culms and forming clumps in natural community of <u>Thyrsostachys siamensis</u> in Kanchanaburi.



o Survivals

x Mortalities

• Broard-leaved tree seedlings

Clump forming

(1 X 1 m. block)

forming the clump developed with high density of standing culm, but on some seedlings it was hard to ascertain the forming of clump, because of growing with a few of slender and short culms. In the plot about twenty seedlings of some tree which their species were not to be made clear, were scattering with poor growth. 329 culms of 66 clumps could be noticed in total 32 square meters of the investigated plot as shown at Table I-9.

Table I-9. Results of the observation on young natural community of Thyrsostachys siamensis in Khao Hin Lap, Kanchanaburi

(A) In 8 x 4 meters of plot

Number of clump	Number of culm	Frequency	Density of culm	Mean area
66	329	71.9%	$10.28/m^2$	0.099 m^2

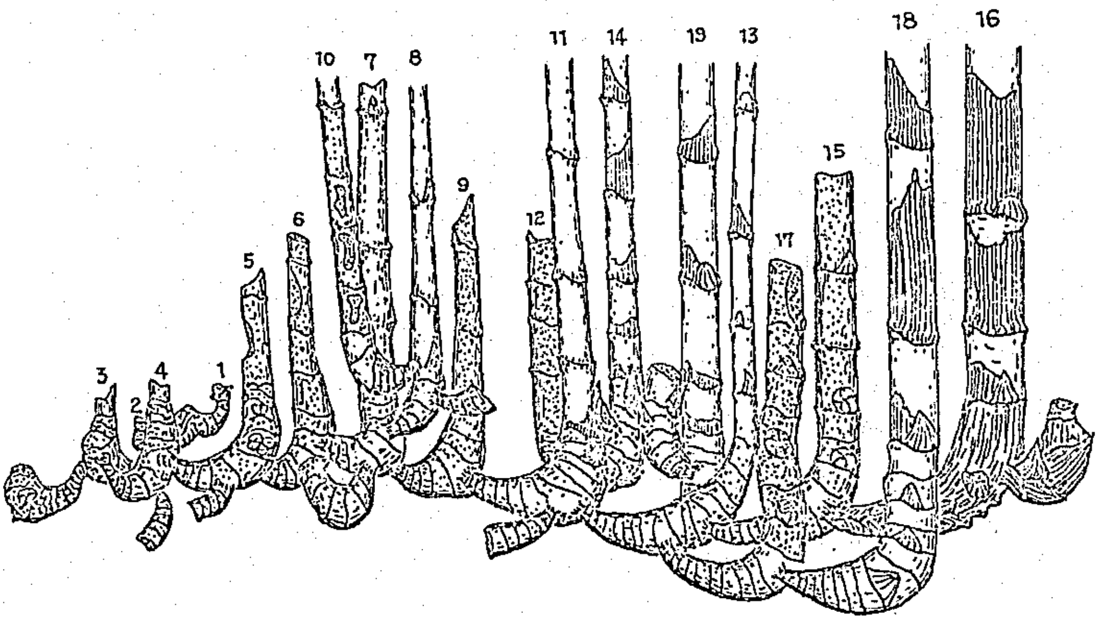
(B) In a sampled quadrant of 1 x 1 meter

Bamboo	Number of culm	Diameter of culm	Height of culm	Dry weight of culm
		(cm)	(m)	(g)
Survival	15	0.2 - 1.8	0.4 - 3.5	674
Mortality	5	0.2 - 1.2	0.4 - 2.4	133
Total	20			807

Culm No.	Presumed age	Diameter at base	Height	Remark
		(mm)	(cm)	
1	12			Dead
2	11			"
3	10			"
4	9			"
5	8	8		"
6	7	8		"
7	6	9	90	"
8	5	9	77	
9	5	11		Dead
10	4	9	56	Broken
11	4	14	52	"
12	3	9		Dead
13	3	10	95	
14	3	11	128	
15	2	13		Dead
16	1	19	281	
17	2	15		Dead
18	1	18	225	
19	2	17	215	

The frequency of number of surviving seedling in the area was about 72 per cent and the density of standing culm was 10 culms per square meter. Because the mean area per seedling was about 0.1 square meter. On the result investigated, the developing aspect of this community might be pointed to be poor. Besides, it could be found that there were twenty culms grown in one by one meter quadrant block sampled at random, despite five culms out of total twenty culms were mortal. The size of bamboo living in the sampled block had large variation as 0.2 to 1.8 cm in their dia-

Fig. I-7. A sketch of natural seedling grown in natural community of *Thyrsostachys siamensis* in Kanchanaburi.



Culm No.	Presumed age	Diameter at base (mm)	Height (cm)	Remark
1	12			Dead
2	11			"
3	10			"
4	9			"
5	8	8		"
6	7	8		"
7	6	9	90	"
8	5	9	77	
9	5	11		Dead
10	4	9	56	Broken
11	4	14	52	"
12	3	9		Dead
13	3	10	95	
14	3	11	128	
15	2	13		Dead
16	1	19	281	
17	2	15		Dead
18	1	18	225	
19	2	17	215	

meter and 0.4 to 3.5 meter in their height. The dry weight of above-ground parts was amounted to about 0.8 kg, but 0.7 kg by survivals and 0.1 kg by mortalities.

A sketch of culm formed clump and typical of natural seedling was as Fig. I-7. As to be depicted, total 19 culms included 8 survivals and 11 mortalities, that some culms of more than seven years old completely remained with their trace, were perceived on this sample. The oldest trace of culm which was not strict to presume its age, seemed to be twelve years old when it would be detected by the propagation system of rhizome. Because, from this fact the natural community might be formed before about twelve years ago at least.

On the advance of developing the community the size of culms produced in every years was considerably improved. This was to be observed that the diameter at the base part of culm was 1.8 cm by one year old culm, 1.5 cm by two years old's, 1.0 cm by three years old's and seven or eight years old culms were only 0.8 cm in diameter.

The natural regeneration of bamboo forest must be extremely affected by environmental factors such as fertility and moisture of soil, humidity, temperature, light and others. Because, it is a matter of course that the observation on these factors will have to be added hereafter.

I-2. Fundamental Research

I-2-1. Seasonal change of water content in bamboo culm.

The observation on seasonal change of water content in bamboo culm is important for discussing the presumption of growing stock or production, management technique such as the choice of harvesting time, fertilization and others. As one of species growing concentrative to spread over in Kanchanaburi, Thyrsostachys siamensis was dealt to be sampled for this investigation.

Two of one and two years old culms were sampled at random from the pure type of natural bamboo forest in Khao Hin Lap Station. The objective of this research was to know the seasonal change of reserved starch in major and water content in minor, but the preparation for microscopic observation on the starch was not to be available by reason of which suitable microscope for its observing had not been arranged in time. According to the first intention small pieces of samples obtained from base, middle and top parts of culm have been soaked into 70% alcohole solution after finished to sample some pieces of culm for balancing their weights. On the other hand, the sampling for measuring the water content in culm was done at the same time, then the samples were balanced at once. After they were dried out by 105°C in the oven for more than 24 hours, the dry weight of sample was balanced again.

The size of culm sampled and the water content shown by per cent for fresh matter (weight of water/ fresh matter) were as shown at Table I-10. Both of one and two years old culms were 2.3 - 3.0 cm in DBH and about 9 meters in height, because the size was considered to be even as far as possible. The water content of culm was extremely changeable according to the age of bamboo and the season of sampling. The culm of one year old was more in their moisture than that of two years old through all seasons sampled. The movement of moisture content in culm seemed to be in proportion to the rainfall.

Table I-10. Size of culm sampled and its water content of Thyrsostachys siamensis in Kanchanaburi

Month	1 year old culm			2 years old culm		
	DBH	Height	Water content	DBH	Height	Water content
	(cm)	(m)	(%)	(cm)	(m)	(%)
October	3.0	9.6	69.5*	2.4	8.3	41.2
January	2.3	8.7	20.1	2.7	9.3	19.2
April	2.5	8.9	43.0	2.5	9.6	35.2
July	2.6	9.5	32.0	2.5	8.6	31.3

* New culm matured at one month after sprouted.

In Kanchanaburi January is complete dry season that any precipitation may not be found. April is at the beginning of rainy season, this is also the hotest season, and that may affect to start the physiological activity of bamboo. July may usually continue to meet proper rainfall, and in October the precipitation may reach to the maximum in comparison with other months. It could be recognized that the seasonal change of water content in bamboo culm should be influenced by the climatic factors as rainfall in particular.

About 19% of water content in two years old culm taken in January must have been the surprized result. When inspecting T. siamensis forest around Kanchanaburi in dry season, the reason why most of their leaves have to be changed to yellowish brown color looked like mortal might be easily understood by this result. Anyhow, it can be said that T. siamensis may probably be one of strongest species against drought.

I-2-2. Experiment on light intensity effective for the growth of bamboo seedling.

The growth of seedling naturally regenerated in the field must be extremely influenced by the light value. Because it can be thought that the light may heavily affect to the transpiration of seedling when planted in bare land for the reforestation of bamboo forest, which must have so far been difficult to succeed it in Kanchanaburi when lacking in immense care of planted seedling. The success of natural or artificial regenerations may depend on the cause of overmuch or insufficient light intensity for the growth of seedling that must be one of important environmental factors.

This experiment had the objective to make clear the relation between the growth of seedling and the light intensity. On 24 April, 1971 one year old seedling and one month old seedling which was about one month after germinated, were prepared at Khao Hin Lap Station, Kanchanaburi. One year old seedlings were planted in 1/2,000 are pot and one month old seedlings were replaced to about 10 cm pot in diamenter. As the controlling of light intensity for the test, five kinds of plots on 100%, 80%, 60%, 40% and 20% of relative light intensity were provided. The light intensities expectant for each plot were obtained by using sun-shadow net which had been made by putting over one upon another to wooden frame.

Four 1/2,000 are pots of which one seedling of one year old had been planted and five 10 cm diameter pots with one seedling of one month old in each were placed in each frame of light intensity controlled by net. About five month these experimental materials of seedlings had been kept in the plots of several light intensities, they were dug out from pots and their growing states were measured. The result of growth aspect on one year old seedlings planted in 1/2,000 are pot was shown at Table I-11.

Table I-11. Growth aspect on one year old seedling of *Thyrsostachys siamensis* treated with several relative light intensities

(A) Growth of culm

Relative light intensity	Surviving culm planted			New culm sprouted		
	Number	Height	Diam.	Number	Height	Diam.
(%)		(cm)	(mm)		(cm)	(mm)
100	3.3	17.5	6.9	1.8	62.5	7.0
80	2.3	10.0	4.8	2.5	90.8	9.5
60	3.3	16.8	6.0	2.5	83.3	7.8
40	2.8	15.8	5.0	2.0	75.3	7.0
20	3.0	15.5	6.2	2.0	93.3	6.6

(B) Dry weight Growth

(g)

Relative light intensity	Above-ground parts			Under-ground parts			Total	T/R ratio
	Culm & branch	Foliage	Total	Rhizome	Root	Total		
(%)								
100	19.0	14.1	34.0	7.7	11.9	19.6	53.6	1.73
80	14.4	16.7	31.1	9.7	13.2	22.9	54.0	1.36
60	17.3	16.2	33.5	5.5	10.8	16.3	49.8	2.06
40	23.7	17.6	41.3	7.9	13.1	21.0	62.3	2.00
20	18.2	18.1	36.3	5.3	5.4	10.7	47.0	3.39

The state growing of culm was measured by dividing into the surviving planted stock and the new culm which had sprouted from the planted stock after treated. Although it would have been desirable that the growth of surviving culm planted had not been differed in their growing conditions, the standing number and the diameter of culms of planted stock were not exactely even, on account of the difficulty in unifying the testing materials. Under such a permissible condition the growth of new produced culm seemed to be responsive to increase more in 60 and 80% plots of relative light intensity, even in the tendency being indefinite. The discussion on dry weight growth was remarkable. On above-ground parts the weight of foliage was increasing in conformity to decreasing the light intensity. On the under-ground parts 20% plot was conspicuous to restrain the growth of rhizome and root. According to these results, it might be cleared that increasing darkness more might be a little to increase the weight of the above-ground parts but to reduce that of the under-ground parts. This was proved by T/R ratio which was gradually heightening in proportion to darkening.

There was also conspicuousness which had to be discussed on the influencial relation between light intensity and soil moisture. The water content of soil in the pots kept in each plot treated by several light values was as shown at Table I-12.

Table I-12. Water content of soil in the pots kept under several relative light intensities

(% for fresh soil)

Relative light intensity	Surface	20 cm in depth
100 (%)	12.9	14.9
80	12.4	17.3
60	14.3	15.2
40	15.0	17.0
20	17.6	18.3

The moisture in both surface and 20 cm in depth of soil was distinct to be more held in proportion to which the light value became to be weaken. The water content in soil was a tendency which had been contrary to the growth of the under-ground parts. It was, consequently, seemed that the growth of bamboo seedling might be more affected by light value than soil moisture, except for the open plot which might be slightly influenced to the development of the under-ground parts of one month old seedlings as following.

Table I-13. Growth of one month old seedling of T. siamensis planted under several relative light intensities

Relative light intensity (%)	Number of new culm	Height of new culm (cm)	Dry weight (g)					T/R ratio
			(A) Culm & branch	(B) Foliage	(A) + (B)	(C) Under-ground parts*	Total	
100	4.0	10.3	1.7	1.9	3.6	2.2	5.8	1.64
80	3.4	18.2	3.5	3.4	6.9	4.0	10.9	1.73
60	3.2	17.9	3.1	2.9	6.0	3.5	9.5	1.71
40	3.6	18.3	3.1	2.8	5.9	3.4	9.3	1.74
20	3.4	24.1	3.2	3.0	6.2	2.5	8.7	2.48

The growth state of one month old seedling planted in 10 cm diameter pot and kept under five kind plots of relative light intensity was as shown at Table I-13. The number of culm newly matured after the experimental stock had been moved into plots controlled light value was about four in each plot. There was the attention resulted more to heighten the height of new culm in accordance with decreasing light value. On dry weight the materials in 100% plot were remarkable to be lighter in every parts of culm, branch, leaves and the under-ground parts than these of other plots. The under-ground parts of bamboo in 20% plot were also undeveloped. The striking difference on weight growth was not observed in three plots of 40, 60 and 80%.

On the results of two different aged bamboo seedlings used for this experiment, the discussion could draw out a little notice. As a tendency 100% of relative light intensity that meant the free in light value, may restrain to produce the amount of leaves, this is because that the seedlings have to control violent transpiration from leaves. A low relative light intensity in case of 20% may also obstruct to develop the under-ground parts of rhizome and roots, even in progressing the production of the above-ground parts. And, in case of this experiment the soil moisture might not much influence to the growth condition of seedling planted in the plots controlled light value, but slightly affected to the seedlings in the uncontrolled light plot.

I-2-3. Pot test on the proper quantity of fertilizer effective for the growth of bamboo seedling.

As a fundamental test on bamboo growth progressive by applying chemical fertilizer, the first was a test what quantity of fertilizer is proper to encourage the physiological activity of bamboo seedling.

The clumps of one year old seedling of Thyrsostachys siamensis selected to use for this test, were composed of three types of culms, because of newly sprouted shoot (Type A), new matured culm which just finished its elongation (Type B) and the culm which was just one year old (Type C). Their growth state before began to test was as shown at Table I-14.

Table I-14. Growth state of one year old seedling of Thyrsostachys siamensis used for the fundamental pot tests

(per clump)

Type of culm	Number of culm	Diameter at base	Height	Total dry weight	Water content
		(mm)	(cm)	(g)	(%)
A	0.8	2.2	44	0.7	60.1
B	1.2	2.3	56	3.2	44.1
C	2.6	1.5	48	2.6	38.7
Root				3.9	
Total	4.6			10.4	
Mean		1.8	50		41.7

On the growth aspect of seedling for the test it could be said that their diameter, height, dry weight and water content were remarkably different among the types of culm which composed one clump. The dry weight of seedling which was most indicative of growth amount, was about 10 grammes.

One seedling which meant one clump was planted in 1/2,000 are pot on July 2, 1970 and kept at the nursery of Royal Forest Department. Total twenty-four pots with seedlings planted were arranged, then settled six kinds of treatments with four replications;

Treatment A - Non fertilizing.
" B - Applying 5 grammes of Chemical compoung fertilizer.
" C - " 10 "
" D - " 20 "
" E - " 40 "
" F - " 80 "

The rate of ingredient compounded in chemical fertilizer used for the application was T-N 10.0%, T-P_2O_5 6.0%, T-K_2O 7.0%, T-M_gO 2.5% and SiO_2 4.0%. Because the ingredient quantity in each treatment pot was as shown at Table I-15.

Table I-15. Ingredient quantity of chemical fertilizer applied in each treatment pot of the test on proper quantity of fertilizer

(g/pot)

Treatment	N	P_2O_5	K_2O	MgO	SiO_2
A	0	0	0	0	0
B	0.5	0.3	0.35	0.13	0.2
C	1.0	0.6	0.70	0.25	0.4
D	2.0	1.2	1.40	0.50	0.8
E	4.0	2.4	2.80	1.00	1.6
F	8.0	4.8	5.60	2.00	3.2

Twice of fertilizations were done on August 12, 1970 for the first growing season and on April 12, 1971 for the second. The developing process of seedlings after treated was investigated at the end of the first year and the final observation was done by digging up whole materials on October 19, 1971.

With regard to the investigation on the growth state of seedlings after finished their first growing season, all seedlings planted in pot were vigorously surviving. Some considerable difference in advancing their growth was, however, noticed among treatments as shown at Table I-16.

Table I-16. Development aspect of culms newly sprouted and matured in the first tested year.

(per seedling)

Treatment	Number of culm	Average diam. of culm	Total D^2H	Index number of D^2H
		(mm)	(cm^3)	
A	2.5	5.6	78	1.00
B	3.5	5.1	115	1.48
C	4.0	5.4	123	1.58
D	4.0	5.4	124	1.59
E	3.8	6.4	221	2.83
F	4.2	5.2	120	1.54

On the development of tested materials in the first growing season, the number of culm newly developed was more increasing in fertilized pots than that in the control, but there was not much variation among treatments. The diameter of the culm was about 5 mm except for the treatment E (40 g.) from which the maximum size of 6.4 mm had been obtained. Despite the volume of culm (D^2H) in four replications in each treatment was variant, their volume among treatments was also extended by

80 to 220 cm^3 that were clearly due to the response by the quantity of fertilizer applied. Because it showed to be lowest 80 cm^3 by non fertilizer, 120 cm^3 by 5, 10, 20 and 80 grammes of fertilizer and highest 220 cm^3 by 40 grammes. The index number by D^2H indicated difference on the efficient result among treatments clearly, because of 1.5 times of growth production by furnishing with 5 to 20 grammes of fertilizer and 2.8 times shown at the maximum by 40 grammes but 1.5 times in the plot of 80 grammes fertilized.

Furthermore, the final result which had been completed after finished two growing seasons, showed securely to prove above result as shown at Table I-17.

Table I-17. Final result of the test on proper quantity of fertilizer after finished two growing seasons

(A) Size and volume of the culm produced after treated.

(per pot)

Treatment	Number of culm	Diameter of culm	Height of culm	Total D^2H	Index no. of D^2H
		(mm)	(cm)	(cm^3)	
A	3.0	9.1	95	278.19	1.00
B	3.5	9.8	100	390.06	1.40
C	4.0	10.0	115	576.96	2.07
D	4.3	12.0	114	917.63	3.29
E	3.5	12.7	147	997.45	3.59
F	4.5	10.5	117	699.59	2.52

(B) Dry weight of new bamboo produced

(g) (per seedling)

Treatment	Foliage	Branch	Culm	Under-ground parts	Total	Index
A	15.4	17.9	48.8	58.9	141.0	1.00
B	14.4	27.4	68.3	70.8	180.9	1.28
C	31.1	35.3	114.8	147.3	328.5	2.33
D	27.9	42.2	144.3	169.9	384.3	2.73
E	31.7	57.5	171.4	202.3	462.9	3.28
F	33.6	44.5	122.6	135.4	336.1	2.38

After finished two growing seasons the size and volume of bamboo culms generally developed in every treatment plots, especially remarkable in the pots of fertilized treatments. The number of culm produced was not much different among the treatments, owing to the reason of which the surviving term of slender and short culms had been only a few or several months.

The diameter at the base of culm was 9 to 13 mm, and the treatments of D and E led to thicken their diameter as 12 to 13 mm. The height of culm in the treatment E was also pointing out the highest among the treatments. Accordingly, the volume

(D^2H) made definite to show the difference brought by the quantity of fertilizer applied. When looking at the index number of D^2H, the volume growth in treatment fertilized could promote to be 1.4 to 3.6 times than that of non fertilizer, extremely in the treatments D and E.

The measuring of dry weight is most important for discussing productivity. About the result of this test the dry weight of materials dealt specified part growth. There was a tendency to increase the weight of foliage in accordance with the increasing of fertilizer, but other parts as branch, culm and under-ground parts had to meet the peak of their production at the plot E or 40 grammes of compound fertilizer applied. In order to discuss the effectiveness among the plots in detail, the statistical analysis on them was done as shown at Table I-18.

Table I-18. Annalytical result of the test on the quantity of fertilizer effective for the weight growth among plots

Factor	Total square	Degree of freedom	Mean square	F ratio
Treatment	299,861.7	5	59,972.3	13.78**
Replication	26,925.8	3	8,975.3	2.06
Error	65,297.8	15	4,353.2	
Total	392,085.3	23		

** Significance at the 1 percent level.

(Significance among treatment plots)

Significance at the 1 percent level	A : C, A : D, A : E, A : F
Significance at the 5 percent level	C : E, E : F
No significance	A : B, C : D, C : F, D : E, D : F

As a result the variation among treatments was highly significant at the 1 per cent level, but there was an unnecessity to pay the attention on the variation in four replications because of no significant. The significance between non fertilizer and fertilizing plots was high and also the treatments B and D, E, F too. Accordingly, the response of fertilization for the growth of seedling was clear when applied more than 10 grammes of fertilizer.

The effectiveness was hightened by increasing its quantity from 20 to 40 grammes, but not rising by 80 grammes. Besides, 40 grammes of compound fertilizer used were equivalent to 8, 3 and 3 kg/ha of N, P_2O_5 and K_2D respectively.

I-2-4. Pot test on the season effective for applying fertilizer to bamboo seedling

This pot test had an objective of finding out the best season to apply chemical fertilizer for promoting the growth of bamboo seedling. Total twenty pots of 1/10,000 are which one seedling of one year old Thyrsostachys siamensis had been planted in each, were arranged at the nursery of Royal Forest Department on July 2, 1970. The design of seasonal fertilizing was as following;

Treatment A -	Non fertilizer.		
"	B - 20 grammers of compound fertilizer applying in		April.
"	C -	"	June.
"	D -	"	August.
"	E -	"	October.

Each treatment was with four replications and the quantity of fertilizer applied in each pot was 20 grammes. The rate of ingredient compounded was T-N, T-P_2O_5, T-K_2O, T-M_gO and SiO_2 of 10%, 6%, 7%, 2.5% and 4% respectively. The seasonal fertilization was done by the treatment applying in August and October of 1970 and April and June of 1971. Each treatment had one chance of fertilization being done during two growing seasons.

The growing state of seedling in each pot on October, 1971, when the final observation was done by digging up all materials tested, was as shown at Table I-19.

The number of culm developed after tested was in range of three to five per clump which meant one seedling tested in each pot, but a little increased by the treatments D and E. The culms in the pots of the treatments B and C pointed out a tendency more to develop their diameter growth than those of other treatments. A developing on the height was also similarly inclined to that of diameter. The volume of culm, of which D^2H took place, was large in the variation among treatments as shown by the index number. But, there was no significance in D^2H result among treatments and replications, on account of which the occasion to large error was recognized. According to this, a definite discussion on them might not be granted, even in observing somewhat differences on the average D^2H among treatments. Meanwhile, if the result on statistical analysis were done to be ignored, it could be said that there might be a tendency to increase the volume of culm by adopting the fertilization during April to August.

The dry weights of leaves and branches were increasing in the treatments B and C, but rather less progressing in the treatments A and E. There was the recognition of the same in the weight of culm. The most growth of culm was 26 grammes by the treatment B. The rhizome was nearly not strict to develop the weight among treatments, except for a little being restrained in the treatment A. The total weight was, accordingly, not much different by the treatments B, C and D, but their weight growth in the treatments A and E seemed to be reduced. In spite of which the attention was somewhat paid on the weight affected by seasonal application of fertilizer, the result of statistical analysis was also not significant just the same as the case of D^2H mentioned.

Through the discussion on the result of this pot test, it might be said that there would be a statistical distinction in the effectiveness by the seasons applied fertilizer when this test should have been continued for a few more years, due to decreasing the variation of samples among replications.

I-2-5. Pot test on the growth of bamboo seedling planted with leguminous tree seedling.

It was confident of the importance to know how to improve a poor soil in case

Table I-19. Result tested on the season for the fertilization effective for the growth of bamboo seedling

(A) Size and volume of new bamboo culm

(per seedling)

Treatment	Number of culm	Diameter of culm	Height of culm	Total D^2H	Index number
		(mm)	(cm)	(cm^3)	
A	3.8	4.4	30	40.63	1.00
B	2.5	7.5	67	177.01	4.36
C	3.2	6.2	73	151.37	3.73
D	4.8	4.7	48	122.49	3.01
E	4.8	4.6	38	79.86	1.97

(B) Analysis on D^2H

Factor	Total Square	Degree of freedom	Mean square	F ratio
Treatment	28,040.8	4	7,010.2	1.62
Replication	4,968.2	3	1,656.07	0.38
Error	51,876.8	12	4,323.07	
Total	84,885.8	19		

(C) Dry weight of seedling

(g/pot)

Treatment	Leaves	Branch	Culm	Under-ground parts	Total	Index number
A	4.4	6.1	9.0	20.1	39.6	1.00
B	7.6	13.4	25.6	36.2	82.8	2.09
C	9.1	13.8	22.1	31.6	76.6	1.93
D	5.0	10.7	21.1	39.9	76.7	1.94
E	4.5	6.5	14.3	29.1	54.4	1.37

(D) Analysis on total dry weight

Factor	Total square	Degree of freedom	Mean square	F ratio
Treatment	5,355	4	1,338.75	1.20
Replication	449	3	149.67	0.13
Error	13,361	12	1,113.42	
Total	19,165	19		

of succeeding the bamboo plantation in field for the afforestation. The objective of this pot test was fundamental to make clear the effectiveness which would be brought by the plantation of bamboo seedling mixed with leguminous tree seedling, that the root nodule bacteria of leguminous tree might be helpful to support the surviving of bamboo seedling planted and to progress its growth in particular.

The materials used for this test was one year old seedling of Thyrsostachys siamensis and also the same age of Cassia fistula seedling chosen from one of leguminous species. The reason why C. fistula had been selected for the material, was due to be no enough time to discuss the species suitable for such a test in those days.

Total eighteen pots of 1/10,000 are in area were set in the nursery of Royal Forest Department on July 9, 1970. As the design for the test six kinds of treatments were arranged with three replications, because of;

Treatment A - Planting of T. siamensis.
" B - Planting of C. Fistula.
" C - Fertilizing in addition to the treatment A.
" D - Fertilizing in addition to the treatment B.
" E - Planting mixed T. siamensis with C. fistula.
" F - Fertilizing in addition to the treatment E.

The chemical fertilizer used for the treatments C, D and F was a kind of compound fertilizers and twenty grammes were applied to one pot, that was the same rate of ingredient as that used for the pot test on seasonal application as abovementioned. The first fertilization was conducted on August 11, 1970 and April 12, 1971 for the second.

The result of investigation on this test after finished the first growing season was indefinite tendency among the treatments. The cause might be due to some hult by plantation into pot and the attack by some insect.

After completing the second growing season, the result noticeable of the affecting by treatments was drawn out and the growth aspect of bamboo newly developed was as shown at Table I-20.

Table I-20. Growth state of bamboo culm newly developed after treated for two growing seasons in the pot test on the mixed plantation with C. fistula (per pot)

Treatment	Number of culm	Diameter of culm	Height of culm	Total D^2H	Index number
		(mm)	(cm)	(cm^3)	
A	2.3	6.6	61	232.18	1.00
C	6.7	7.2	64	531.78	2.29
E	2.7	5.6	48	193.90	0.84
F	4.7	9.1	85	1,098.49	4.73

The number of new bamboo matured after the treatment was two to seven culms that were varied by the treatment plots, especially the treatment C produced about seven culms. New culm by the treatment F was well increasing its diameter as 9 mm in average, but nearly no influence in those of other treatments. The treatment F could also heighten new culms to 85 cm tall, in spite of which others were 50 to 60 cm. The volume of culms developed as proving by D^2H, in consequence, was a large in difference among treatments such as remarking 4.7 times by the treatment F for the control plot or the treatment A, 2.3 times by the treatment C and 0.8 times by the treatment E.

Table I-21. Dry weight growth of seedling in the pot test on mixed plantation with leguminous tree

(A) Dry weight

(g) (per seedling)

Treatment	Leaves	Branches	Culms	Under-ground parts	Total	Index number
A	5.1	9.1	17.3	38.5	69.8	1.00
C	14.4	24.1	53.2	105.8	197.4	2.83
E	4.9	6.3	14.2	20.9	46.3	0.66
F	18.9	26.1	65.7	126.7	237.4	3.40

(B) Analysis of the result on total dry weight

Factor	Total square	Degree of freedom	Mean square	F ratio
Treatment	79,600.5	3	26,533.5	25.82**
Replication	543.4	2	271.7	0.26
Error	6,166.5	6	1,027.8	
Total	86,310.4	11		

** Significance at the 1 percent level.

(C) Significance among treatments

Significance at the 1 percent level	A : F, C : E, E : F
Significance at the 5 percent level	A : C
No significance	A : E, C : F

The dry weight of seedling was a graphic to indicate its developing state as shown at Table I-21. A seedling in the treatment F was most extreme in the production of each part, and the growth similar with the treatment F was also found in that of the treatment C. The treatment E, on the contrary, reduced a little of the growth than the treatment A. This was clearly approved by the total dry weight and its index number. In order to discuss the relationship between the treatment and the productivity of seedling, the result on total dry weight was statistically analyzed. The production of seedling among treatments was high significant, but not significant in replications which meant that there was no variation in samples.

According to the result of analysis, the bamboo seedling in case of the plantation mixed with Cassia seedling must have reduced its production, and the reason might be on account of which the dominance of bamboo growing had been plundered by Cassia tree. In case of the fertilization to such a mixed plantation, the result was confirmable to incline the dominant condition to the help of bamboo growth. And yet, the analyzed results on the growth of bamboos between the plantation mixed with Cassia seedling and the individual plantation of bamboo were not significant, because of no confirmation on the effectiveness of adopting the trial of mixed plantation. But, it might be tending that there would be somewhat a satisfactory condition to promote bamboo growth by the mixed plantation method as recognized by a little more increased dry weight of the treatment F than the treatment C.

On the other hand, the growth of Cassia fistula seedling planted with bamboo seedling showed an interesting result as shown at Table I-22.

Table I-22. Growth aspect of Cassia fistula planted with bamboo seedling in the mixed plantation pot test

(A) Growth

(per seedling)

Treatment	Diameter of stem (mm)	Height of stem (cm)	Dry weight (g)			
			Foliage	Branch & stem	Under-ground parts	Total
B	6.8	60	4.5	10.1	62.2	76.8
D	9.8	57	4.4	12.2	71.1	87.7
E	4.8	54	1.2	3.6	21.6	26.4
F	5.6	41	0.5	3.6	9.3	23.4

(B) Analysis of the result on total weight

Factor	Total square	Degree of freedom	Mean square	F ratio
Treatment	10,094	3	3,363.7	9.59*
Replication	1,769	2	898.0	2.56
Error	2,105	6	350.9	
Total	13,995	11		

As being found by synthetic state of the growth of Cassia seedling and the analyzed result on weight growth, the production of Cassia was peculiar to indicate the result of growing competitive with bamboo seedling. Cassia in case of mixed plantation was extreme in its production to be repressed when compared with that in case of individual plantation, especially in the treatment of mixed plantation with fertilization. This was because that the domination of advancing the growth of Cassia may had been controlled by the accelerating of bamboo growth. Besides, the effectiveness of fertilization for Cassia was noticed in the increase of diameter and weights of the under-ground parts.

I-3. Applicable Research

I-3-1. Experiment on the management method of bamboo forest.

As to improve poor natural bamboo forest, the experiment on the management method for various types of bamboo forest must be first necessary. This experiment, accordingly, had an objective for getting knowledge on the selection of felling method and the effect of fertilization.

In two different sites of pure Thyrsostachys siamensis forest in Khao Hin Lap, Kanchanaburi, two experiment plots in each site were set up in June 1970. The reason of which two site classes were chosen, was due to the recognition that the condition of bamboo growth in both areas had been somewhat different and the factor must not had been also neglected for conducting the experiment, as shown at Table I-23.

Table I-23. The growth states of both sites chosen for the management trial of pure bamboo forest

(per ha.)

Site	Number of clump	Living culm		Number of standing mortality	Total standing culm
		Number	DBH (cm)		
I	3,867	25,573	1.8	6,693	32,266
II	3,307	23,327	2.0	10,053	33,380

Total areas of 750 square meters were chosen for the trial plots in two sites, then divided into 375 square meters of two sites. On the site consisted of 15 blocks which were 5 X 5 meters quadrant in each. Five kinds of treatments on which two felling methods and the effect of fertilization had been combined, were adopted as following;

Treatment A - Control (no treatment).
" B - Felling of the culms standing in a half area of each clump.
" C - Fertilization in addition to the treatment B.
" D - Felling of more than four years old culm in each clump.
" E - Fertilization in addition to the treatment D.

Each treatment had three replication blocks designed by the randomized system. Four kilogrammes of chemical compound fertilizer, which was the same as used for the pot tests mentioned-above, were applied into each block designed for the treatment of fertilization. The quantity of ingredient giving for this experiment was programmed as T-N, T-P_2O_5, T-K_2O, T-M_gO and SiO_2 of 160, 120, 140, 50 and 80 kilogrammes per hectare respectively.

The composition of standing clump in all blocks and the number of living culms in clumps were completely investigated, then drawn the distribution map as shown at Fig. I-8. As being understandable by the map, clumps were generally scattering to distribute in each block. Some blocks were rather close in the standing density of small clumps like forming a group, to the contrary that there were somewhat large gaps in which the crown cover was opened in a few blocks. A large clump was composed of more than thirty culms living, but of only one culm in the smallest clump. Such a composing condition seemed to be typical of pure natural forest which could be easily found in Kanchanaburi.

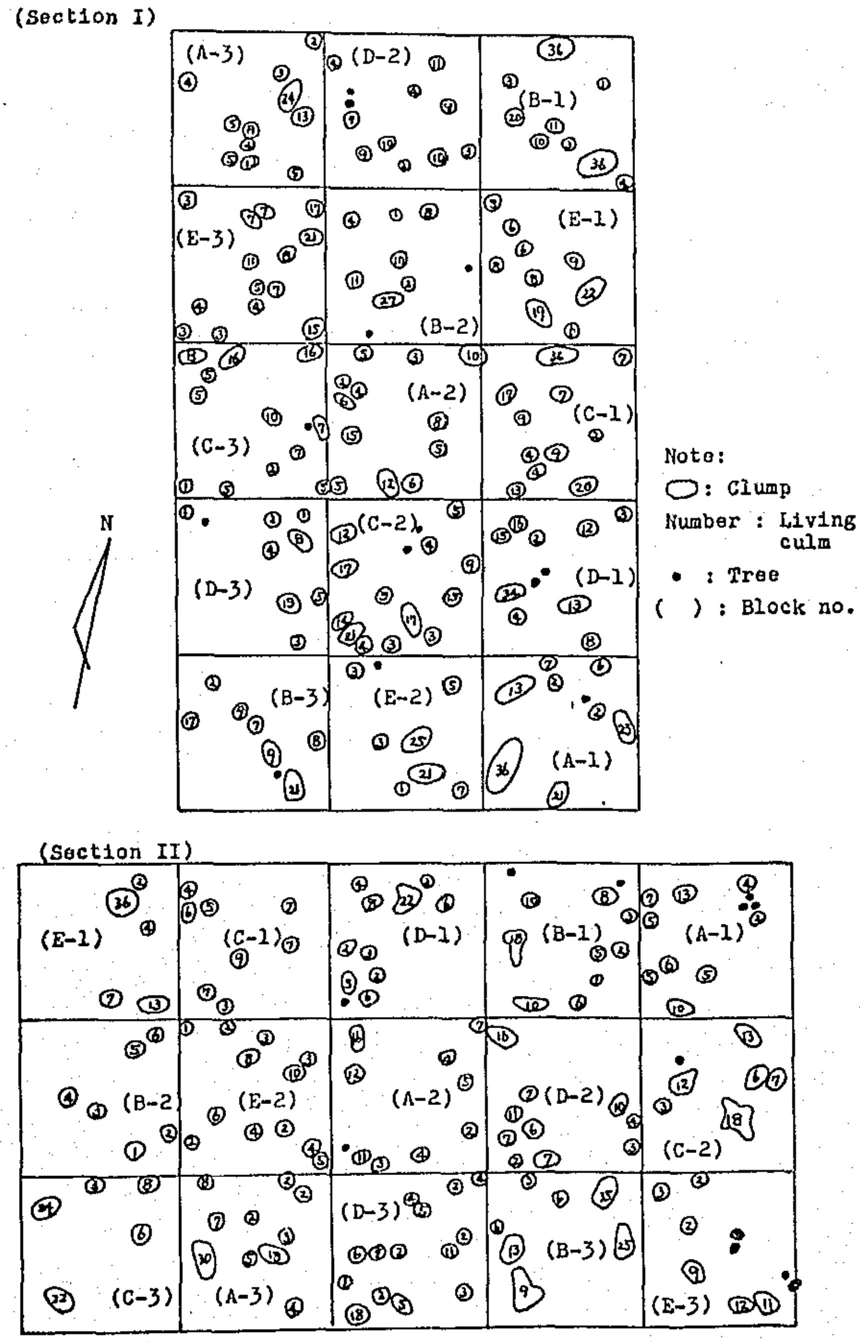


Fig. I-8. Distribution map of clump and number of standing culm in the blocks of management experiment for pure *Thyrsostachys siamensis* forest in Kanchanaburi.

The first felling treatment in accordance with the trial designed was done in November, 1970. The standing stock just before the culms were removed, and the first harvest by the felling treatment were shown at Table I-24.

Table I-24. Standing stock before the culms were removed and the first harvest by the management experiment in pure T. siamensis forest

(per block : 25 m^2)

Site	Treatment	Standing stock				Harvest	
		Number of clump	Number of culm	DBH	D^2	Number of culm	D^2
				(cm)	(cm^2)		(cm^2)
I	A	11	76	1.9	286	0	-
	B	8	72	1.8	236	29	78
	C	11	72	1.9	295	24	37
	D	9	51	1.9	193	14	26
	E	10	60	1.8	213	18	30
II	A	9	77	2.1	364	0	-
	B	7	53	1.9	214	16	49
	C	6	56	2.1	277	18	80
	D	11	67	1.9	256	17	33
	E	7	48	2.0	209	12	31

The aspect of standing stock in the treatment plots before the first felling was not alike. The number of clump and culm living in blocks were somewhat a variant as 8 to 11 clumps and 51 to 76 culms in the site I, then 6 to 11 clumps and 48 to 77 culms in the site II. Average DBH was nearly resembling among blocks, but that in the site II was a little thicker than that of the site I. The diameter square (D^2), which must be convenient to know approximate volume, was also variant among blocks as 200 to 290 cm^2 and 210 to 360 cm^2 in the sites I and II respectively.

The harvest by the first felling treatment differed in its quantity according to the treatment method and the growing condition of standing stock. The number of culm removed for harvest was much more in the treatments B and C than those in the treatments D and E. The result on D^2 pointed out to be also similar in its tendency with which to be shown by the number of culm.

The rate of the quantity of harvest for the standing stock was clear to guide the profitableness on choosing the felling method as shown at Table I-25.

In both sites the harvest rate in the treatments B and C of which the culms standing in a half area of clump had been removed, was 30 to 40 per cent by the total number of culm standed and 13 to 33 per cent by the total D^2 of stock. While, the rate in the treatments D and E of which the culms of more over four years old had been removed, was about 26 per cent by the total number and about 14 per cent by the total D^2.

Table I-25. Rate of the quantity of harvest for the standing stock by the experiment on management method

(%)

Treatment	Site I		Site II	
	No. of culm	Total D^2	No. of culm	Total D^2
A	0	0	0	0
B	40	33	30	23
C	33	13	32	29
D	27	13	25	13
E	30	14	25	15

When considering a suitable felling method depending upon above result, it seemed that the harvest by the felling of the culms standed in a half area of clump would be available by the three years cycle and in case of felling more than three years old culms it might be four years cycle expected.

As a reference, the yield by this first felling treatment was presumed as shown at Table I-26.

Table I-26. Yield per hectare by the first felling treatment in the experiment plots on the management method for pure *T. siamensis* forest

Treatment	Site I		Site II	
	No. of culm	A.D.weight	No. of culm	A.D.weight
		(ton)		(ton)
A	0	0	0	0
B	11,470	17.2	6,400	9.6
C	9,470	14.4	7,470	11.2
D	5,470	8.2	6,530	9.8
E	7,200	10.8	4,930	7.4

Despite the above result was very rough to be calculated, it was a noteworthy to be understood that the felling of culms in the half area of clump could give a lead to gain 10 to 17 tons in the site I and 7 to 11 tons in the site II by the cutting of more than three years old culms.

The productivity of bamboo forest must be comprehensible by the quantity of new bamboo culms grown. New bamboo sprouted at the first growing season after treated were very varying in the number of culm matured and the total D^2 among plots as shown at Table I-27.

On the site I the number of new bamboo sprouted and matured in the fist growing season was 17 to 20 culms in each block and their diameter was about 21. cm in average. The square of diameter (D^2), which could give a suggestion for the thinking of volume growth, was 70 to 100 cm^2 per block. When these figures were converted

Table I-27. New bamboos sprouted at the first growing season in the plots on the managemant experiment for pure *T. siamensis* forest.

Site	Treatment	per block			per hectare	
		Number of culm	DBH (cm)	D^2 (cm^2)	Number of culm	A.D.weight (ton)
I	A	15	2.2	79	5,867	8.8
	B	15	2.2	78	6,133	9.2
	C	20	2.2	105	8,133	12.2
	D	13	2.1	67	5,200	7.8
	E	17	2.0	77	6,800	10.2
II	A	11	3.0	84	4,533	8.3
	B	9	2.2	49	3,733	5.6
	C	10	2.7	77	4,000	6.0
	D	9	2.4	61	3,733	5.6
	E	8	2.4	49	3,200	4.8

(Analysis of the result on D^2)

Site I

Factor	Total square	Degree of freedom	Mean square	F ratio
Treatment	2,385.7	4	596.43	1.19
Replication	741.7	2	370.85	0.74
Error	3,995.3	8	499.41	
Total	7,122.7	14		

Site II

Factor	Total square	Degree of freedom	Mean square	F ratio
Treatment	3,187.33	4	796.8	1.64
Replication	163.63	2	81.8	0.17
Error	3,892.04	8	486.5	
Total	7,243.00	14		

into per hectare, the new bamboo produced might be 5,200 to 8,100 culms and 8 to 12 tons by air dry weight. The plots in the site II were a little poor in their growth as 8 to 11 culms and 50 to 80 cm^2 by the square diameter per block, even the thickness was averaged to about 2.5 cm at DBH. Because the culm production per hectare in the site II was calculated to 3,200 to 4,500 in the number and 5 to 8 tons of the air dry weight.

Through the results obtained, the statistical analysis was done for discussing the effect on new production affected by the management treatments. But, as shown at the table, the difference of growth indicated by D^2 among treatment plots in both sites was not significant at the five percent level. This must not have been expected to obtain satisfactory results only by the course of one year testing.

I-3-2. Practicable experiment on planting mixed bamboo seedling with leguminous tree seedling in the field.

The importance is to know how to improve a poor natural bamboo forest, and one of the ways might be to experiment on the effect of root nodule bacteria by some leguminous plants for the growing activity of bamboo seedling planted in such a field. The pot test for this objective was also done fundamentally as above-mentioned in App. I-2-5. The experiment was, accordingly, planned up for its application on the practicability in field.

In April 1970, one year old seedling of Thyrsostachys siamensis fostered at the nursery of Khao Hin Lap, Kanchanaburi, was used for this plan as bamboo material for plantation and also one year old Cassia fistula seedling as leguminous species chosen. It was a real on the species of leguminous tree that there had been no reference which species was more to effect for promoting the growth of bamboo.

In one of sporadic growth fields of T. siamensis at Khao Hin Lap, the area of 450 square meters where were somewhat a large gap without any bamboo found like a bare land, was prepared for the experiment plotted in June 1970. The area provided was divided into 18 blocks of 5 X 5 meters for six kinds of treatments with three replications by the randomized block system. The treatments were as following;

Treatment A - Planting of T. siamensis seedling.
" B - Planting of C. fistula seedling.
" C - Fertilizing in addition to the treatment A.
" D - Fertilizing in addition to the treatment B.
" E - Planting mixed T. siamensis with C. fistula seedling.
" F - Fertilizing in addition to the treatment E.

For the fertilizing plots the eighty grammes of chemical compound fertilizer, of which its ingredient was T-N : 10%, T-P_2O_5 : 6%, T-K_2O : 7%, T-MgO : 2.5% and SiO_2 : 4%, were given into one hole planted one seedling or mixed one bamboo seedling with one Cassia seedling. The fertilization was done in September 1970 for the first growing season and in April 1971 for the second.

Table I-28. Growth state of both bamboo and Cassia seedlings after finished the first growing season on the experiment of mixed plantation

Treatment	Bamboo			Cassia		
	Survival	Number of new culm	Average diameter	Survival	Diameter	Height
	(%)		(mm)	(%)	(mm)	(cm)
A	92	0.5	4.2	-	-	-
B	-	-	-	93	4.6	31
C	85	1.6	6.3	-	-	-
D	-	-	-	100	9.4	57
E	92	1.1	4.2	100	3.6	24
F	75	1.4	6.9	92	5.6	44

The growth states of both bamboo and Cassia seedlings planted at the field after finished the first growing season were not much clear to point out the effectiveness of mixed plantation as shown at Table I-28. Bamboo seedlings planted in every treatment plots seemed to be slightly involved in planting damage, despite the complete watering was done for a few weeks after planted. Cassia might be more stronger in drought hardiness than bamboo as indicated high survival percent. The number of new culm produced after planted was less than two culms and their diameter was 4 to 7 millimeters. There was the cognizance of a little disparity in the growth of bamboos between the fertilizer plots and non-fertilizer plot, because the effect of fertilization was already appeared in progressing the growth of bamboo at the first year. The growth of Cassia was also similar in its tendency to be affected by the treatments with that of bamboo seedlings.

Table I-29. Growth aspect of bamboo and Cassia seedlings by mixed plantation after the second growing season

Treatment	Bamboo					Cassia			
	Survival rate	Bamboo newly produced				Survival rate	Average diam.	Average height	Total D^2H
		Number per hole	Average diam.	Average height	Total D^2H				
	(%)		(mm)	(cm)	(cm^3)	(%)	(mm)	(cm)	(cm^3)
A	95.8	1.2	3.9	49	11	-	-	-	-
B	-	-	-	-	-	91.7	9.2	49	54
C	83.3	3.5	6.6	84	243	-	-	-	-
D	-	-	-	-	-	100.0	17.9	98	378
E	87.5	1.9	4.2	54	23	95.8	5.8	37	19
F	72.9	3.4	7.9	110	374	95.8	9.9	66	129

After the second growing season the survival rate of bamboo was more going down than that of the previous year, but nearly changeless in Cassia seedlings as shown at Table I-29. The productive state of new bamboo was extremely progressive in the plots C and F that showed at 10 to 20 times in the increment of D^2H than those of the plots A and E. It was, hereupon, clearly noticed that the fertilization could make to enlarge the volume growth of bamboo so much. There, nevertheless, was no significant in the difference on the development of bamboo seedling in the plots A and E. This was because that the efficiency by the plantation mixed bamboo with leguminous tree seedlings expected for this experiment had not been strictly observed. The large difference of the growth of Cassia seedling was also found as well as bamboo. There was a noteworthy tendency on the development of Cassia seedling recognized among treatment plots. This was why the growth of seedling in the mixed plantation plot (E) had been more scanty than that in the individual planting plot (A) and also the growth of the fertilized with the mixed plantation plot (F) had been less than that of the plot of only fertilization (E). The cause might be due to the reason for which the preferential competition of dominancy between bamboo and Cassia took place and the result seemed to be a tendency of which bamboo was going to take its preference.

When looking at the fruits of more progressive trend of the bamboo growing in mixed plantation plot than that of individual planting plot, it could be inferred to bring on the effect for developing the propagation of bamboo in several years after the plantation mixed with some leguminous tree.

I-3-3. Tests on bamboo cuttings used for propagation.

The vegetative propagation of bamboo is important to produce the planting stocks when the collection of seed may not be expected and in case of which the dominant character shoudl be inherited to another generation. There are several ways in the vegetative propagation, but on bamboo the both of branch and culm cuttings must be available. Accordingly, during two years three cutting tests were conducted, because of two branch cutting tests and one culm cutting test.

a) Test I

The test of branch cutting on five species of Bambusa arundinacea, B. Blumeana, Thyrsostachys siamensis, Dendrocalamus strictus and D. longispathus was carried out in September 1970. Sandy soil was prepared for the medium of rooting in small wooden boxed being usually used for sowing. The cuttings of 15 - 20 cm in length were taken from the branches of mother bamboos. Three kinds of treatment for cutting were applied before cuttings were planted;

Treatment A - Control, immediately planted just after cuttings were collected.
" B - The base part of cuttings was wrapped with clayey soil ball, then planted.
" C - The base part of cuttings was wrapped by clayey soil ball which had kneaded by chemical solution for promoting their growth, then planted.

The age of mother bamboo selected for this test was two years old in every species, except for B. blumeana that was fostering at nursery. The growth condition of mother bamboo and the cuttings collected were as shown at Table I-30.

Table I-30. Growth state of mother bamboo and the size of cutting used for the Test I.

Species	Mother bamboo			Size of cutting	
	Age	Height	DBH	Length	Diameter
		(m)	(cm)	(cm)	(mm)
Bambusa arundinacea	2	12.0	5.5	15.7 ± 1.9	2.9 ± 1.1
B. blumeana	1	8.5	6.5	15.4 ± 0.8	6.1 ± 1.7
Dendrocalamus strictus	2	6.0	3.0	19.6 ± 3.7	2.7 ± 0.4
D. longispathus	2	8.0	4.5	17.9 ± 2.8	6.3 ± 1.5
Thyrsostachys siamensis	2	8.7	2.1	21.7 ± 1.8	2.7 ± 0.5

The height and DBH of mother bamboo were natural to be variant by their growing condition. The size of cutting was 16 to 22 cm in length and their diameter was differed owing to the thickness of branch.

The result of the Test I which was taken at the fourth month after planted, was worse as shown at Table I-31.

Table I-31. Result of cutting Test I.

Treatment / Species	Surviving rate (%)			Rooting rate (%)		
	A	B	C	A	B	C
B. arundinacea	-	10.0	3.3	-	-	3.3
B. blumeana	5.0	15.0	10.0	5.0	15.0	-
D. strictus	-	-	-	-	-	-
D. longispathus	5.9	5.9	11.8	-	-	-
T. siamensis	-	-	-	-	-	-

Survivals through all species were a few as less than 15 per cent at three months after planted, moreover no survival in D. strictus and T. siamensis. A few rootings were found in two species of genus Bambusa only. No rooting was in D. longispathus, despite some survivals had been noticed. There, accordingly, was no figure to be able to discuss the effect on treatment. As these results, it should be said that the test was unsuccessful. The reason why it was failed might be due to unsuitable for selecting the season to test and not enough to control the environmental factors such as soil moisture and light.

b) Test II.

In July 1971 the second test about branch cutting was arranged about four species of Bambusa arundinacea, B. blumeana, Dendrocalamus longispathus and D. strictus at Khao Hin Lap Station. The plant pots of which the area was 1/2,000 are, were used for planting the cuttings after the sandy soil as a medium for rooting had been filled up into pots.

Table I-32. Growth state of mother bamboo for the Test II and size of cutting arranged

Species	Mother bamboo				Size of cutting	
	Age	Height	DBH	Node	Length	Diameter
		(m)	(cm)		(cm)	(mm)
B. arundinacea	2	20.01	8.45	87	11.2 ± 1.6	5.2 ± 0.8
B. blumeana	2	14.21	6.80	51	11.9 ± 7.0	8.7 ± 1.3
D. longispathus	2 .	11.40	4.70	44	17.3 ± 3.7	8.3 ± 0.9
D. strictus	2	12.41	4.70	49	13.2 ± 1.7	4.4 ± 1.0

As Table I-32, all mother bamboos chosen to collect the cuttings were two years old and their growth condition was about average in the size among the culms standing in the clump. The branch cuttings were 11 to 17 cm in length, but varied due to the length of each internode by species. This was because that one branch scion for planting had to take two nodes. The diameter of cutting was differed by the size of branch chosen from mother bamboo. Four kinds of treatments for cuttings, which should be soaked into four kinds of plant-hormone for 24 hours before they were planted into medium, were designed for this test, because of;

Treatment A - Control; into pure water
" B - IAA; into 0.1% indole acetic acid.
" C - IBA ; into 0.1% indole butyric acid.
" D - NAA; into 0.1% naphthalene acetic acid.

The result at four months after planted was also poor in surviving like previous test, particularly in rooting, except for D. longispathus which could keep rather high surviving rate as shown at Table I-33.

Table I-33. Result of cutting Test II.

Treatment / Species	Survival rate (%)				Rooting rate (%)			
	A	B	C	D	A	B	C	D
B. arundinacea	11.0	-	-	-	-	-	-	-
B. blumeana	7.7	7.7	15.4	-	7.7	7.7	15.4	-
D. longispathus	53.3	46.7	86.7	74.4	-	-	-	-
D. strictus	6.7	6.7	6.7	6.7	-	-	-	-

From above result the surviving of branch cutting seemed to be hard in general, but somewhat a satisfactory rate of surviving could be watched by only D. longispathus which pointed out more than 50 per cent expectantly. The treatment for cutting soaked into plant-hormone solutions might not be effective. A few cuttings rooted were recognized at B. blumeana only, and its rate was less than 15 per cent. Another species could not make to root at all. There might, nevertheless, be some hopes to be able to notice the rooting of D. longispathus cutting by reason to last comparatively good surviving.

c) Test III.

In the past some tests on vegetative propagation used by a part of culm which was about fifty centimeters long in length with two nodes, have been carried out by the hands of Thai researchers. By this method only a few species were successful for which to be able to apply in practical. The Test III, accordingly, had an objective to clear what part of culm would be vigourous to root.

The materials used for the test were four species that were Bambusa arundinacea, B. blumeana, Dendrocalamus longispathus and D. strictus. Whole culm in each species was cut at about one-thids of the length in each internode. The number of cutting tested was 44 to 86 parts which one node was included in each, because one node had been arranged to be one cutting. But the number of material for one species varied due to the number of total nodes in whole culm length.

In July 1971, the culm cuttings were vertically planted in the sandy soil of the nursery of Khao Hin Lap Station and watered into cyrindrical cavity of culm to keep moisture everyday. They were dug up as the final observation in November because of four months after planted.

Table I-34. Result of culm cutting test

Species	Part of culm	Number of cutting	Number of shooted	Number of rooted	Rooting state	Rooting percent (%)
B. arundinacea	Low	28	12	4	*	14.3
	Middle	26	14	13	*	50.0
	Top	32	1	5	*	15.6
	Total	86	27	22		25.6
B. blumeana	Low	17	10	10	***	58.8
	Middle	12	12	12	***	100.0
	Top	22	6	9	**	40.9
	Total	51	28	31		60.8
D. longispathus	Low	13	11	0		
	Middle	12	7	0		
	Top	19	7	0		
	Total	44	25	0		
D. strictus	Low	14	0	7	**	50.0
	Middle	13	0	3	*	23.1
	Top	22	0	0		
	Total	49	0	10		20.4

Note : * a few roots ** several roots *** heavy rooting

The result on shooting and rooting was discussed in accordance with the three parts of culm, because of lower, middle and top parts divided with each one-thirds of culm length. Bambusa arundinacea was well shooting in lower and middle parts. The rooting of cutting was about 25 percent in average, but 50 percent by middle part. The state of development of rooting was not enough as finding out only a few roots.

A hfgh rooting rate was noticed in B. blumeana which showed about 61 percent in the rate for total cuttings planted. The development of rooting by this species was extreme in lower and middle parts, especially in middle part that the cuttings were complete to make rooting as shown 100 per cent of rooting rate. No rooted cutting was found in the cuttings of D. longispathus, despite the half of them was shooting. On the other hand, there was no shooted cutting of D. strictus, but some of them taken from lower and middle parts of culm were rooted.

According to above results, the possibility of rooting might be expected easily by genus Bambusa, but a little hard to be looked by genus Dendrocalamus. The rootability of culm cuttings seemed to be more promoted by the cuttings taken from the lower and middle parts of culm than those of top part.

II. AN IDEA ON THE ESTABLISHMENT OF NEW BAMBOO PROJECT "BAMBOO CENTRE OF THAILAND" IN ROYAL FOREST DEPARTMENT, MINISTRY OF AGRICULTURE, THAILAND

II-1. Base of Idea

A bamboo repeats sextual regeneration with the long term of cycle. During the cycle it can, nevertheless, produce new bamboo culms by the way of unsextural propagation every years. Bamboo species of sympodial type as growing in Thailand are also an identical with its propagation way. Because, after removing some bamboo culms from their clump for harvest, there is no necessity to plant complemental planting stock. This is a profitable point on the exploitation of bamboo resources and is also conclusive different point from trees. In Thailand a bamboo must be extremely suitable for raw material of pulp, because the constant quantity of supply may be satisfied. There must, furthermore, be potential to make for increasing the productivity of bamboo forest by the shift of forest aspect from natural to managing.

Bamboo resources in Thailand are not an inexhaustible, even one million hectares of her land are covered by bamboos. It must, therefore, be anxious about making them spoil if the right way on exploitation may not be taken. Owing to this, we should discuss our ideas how to keep and develop these worthy resources with doing all over again.

Works in present bamboo project as one part of Paper and Pulp Material Survey in Royal Forest Department have so far been progressive. Especially, Khao Hin Lap Bamboo Experimental Station in Kanchanaburi province, which was set up in 1964 under UNSF project, is an unique in the world. Most of field researches on bamboo have been concentrated on the station. The only defect, if the reporter imphasizes, is that the scale of the station is a small as for satisfying the completion of important researches on which the development of vast economic resources in near future must be depended.

An idea on the establishment of new bamboo project "Bamboo Centre of Thailand" (BCT) has been based on synthesizing, renoving and evolving the every fields of investigations and researches, diffusion and training of technique on the exploitation and utilization of bamboo resources by dint of adopting the centre system.

II-2. Objective and Reason

The BCT project advocated by the reporter strongly is to achieve following objectives which are due to each reason.

a) Survey on bamboo resources.

This work should be important for developing the resources as to give the course of action. The inventory survey of inaccessible area in the west should be at first needed to start because of the largest distribution area of bamboo in Thailand, but that of accessible area was done by the first task of the present project.

The bamboo growing stock, which forms the second-story under the mixed deciduous and the evergreen forests in the north and south, has to be measure due to the effectiveness for increasing the income of farmer by its ideal utilization.

b) Experiment on the improvement of natural bamboo forest.

The productivity of bamboo forest in Thailand is remarkably low as mentioned at the chapter V. An available productiveness by natural Thyrsostachys siamensis forest was conjectured for less than one-thirds of that of managing bamboo forest in Japan. There will, while, be a real possibility that the productiveness of such a natural forest in Thailand may be heighten by which to find out considerable way on the development. This way should be, accordingly, led by the fruits of fundamental and applicable researches such as on growth habit, biomas, regeneration, genetics, propagation, plantation, fertilization, thinning, etc. In addition to the research, it should be needed to proceed the study on insect damage, cultivation of edible shoots, making ornamental culms and land or water-source conservations.

c) Diffusion of technique on the silviculture and management of bamboo forest.

An actual management for bamboo forest may probably be carried through the hands of farmer under the instruction by technical officials concerned. Accordingly, the diffusive way should be planned up for each of farmer and technical officials. The salient points for the way are of techniques on practice for farmer, but on scientific knowledge for technical officials in addition. Since the bamboo training courses held in twice so far were much successful, the BCT must be better to construct the training curriculum of short term in accordance with regular schedule so that more trainees may be easily and more accepted.

d) Research on making pulp from bamboo.

The major problem on the exploitation of bamboo resources in how to utilize them for making pulp. In India[8] the total production of bamboo pulp may, for instance, be 256,000 ton/year at the end of 1971. In case of Thailand it may not dream to produce over 200,000 ton/year of bamboo pulp by which to develop about one million hectares of resources, even if only 3,000 ton/year are being made at present.

There will be many research subjects taken at the BCT, and they must be on structure, and properties of fibre, pulping tests and others on main species expectant for the large-scale industrial utilization of bamboo. The research on making pulp mixed with some species of tree, grass and other raw materials will be necessary in case of which sufficient bamboo raw material may not be supplied in the north and south.

e) Installing of pilot plant for making bamboowares.

It goes without saying that the present Paper and Pulp Material Survey could take neither part nor lot in the production of bamboowares. This is only a field which can be thought under the BCT project and much hopeful in both conditions of sufficient raw material and producing cost, but a few problems in their qualities.

The construction of pilot plant must, in consequence, be indispensable for the development of small-scale industries on which the counter-plan to heighten the economic living level of farmer should be based. When looking at some growth habits on bamboo, the machinary processing for making bamboo screen or blind would be selected as major products and fish trap, mat and tooth-pick as minor for the plant. Then, several problems as suitable species, operating process, improvement of machines, costs and others should be discussed.

f) Training of making bamboo products.

Simultaneously with the operation of pilot plant, regular training course for producing bamboowares should be planned up. This must be important to foster producers and mechanicians, due to foreseeable observation that such machines may probably be introduced under commercial base in near future.

g) Establishment of flowing system of bamboo material.

Bamboo raw material is generally flowing like as producer : Royal Forest Department → felling farmer or employee of dealer → dealer : agent of transportation → consumer : paper mill and others. On the feasibility of exploitation scheme for bamboo resources the necessary relation between producer and consumer has been really alight owing that the harvest of bamboo has done by farmer and dealer to this way. This may call on unexpected conjucture on the development of bamboo resources in future.

The system, accordingly, which defines the ideal relation between producer and consumer and keeps or controls the balance of demand and supply of bamboo, should be needed to establish. For the purpose of realizing this, the deep consideration on transportation and marketing systems should be paid through the joint committee organized with producer, dealer and consumer.

h) Discussion on political problems concerned.

On the improvement of natural bamboo forest the influential factors are of indiscriminate harvest, digging up bamboo shoots for sale and grazing cattles in bamboo growing area, but these are serious affairs which should involve the living of farmer. On the utilization the most importance may be seemed to solve the problems on giving the concession of bamboo forest land which may be clamored by industrial massive consumers with increasing the construction plan of new bamboo pulp processing companies henceforth.

These political problems must also be discussed at the BCT project and some solvable ideas may be offered to the authorities concerned in Thailand.

II-3. Feasible Condition

a) Project duration.

The BCT project must be enough to set up for a period of five years, except for the activity of the BCT, which may be succeeded for an indefinite period of time.

The first year is for constructing the headquarters of the project in Royal Forest Department, reconsidering the project organization and making the base discussion of the BCT' establishment. Inventory survey on bamboo forest should be started at the first year. Several experiments being carried out under the present project in Khao Hin Lap station have to be continued to the BCT project as before.

The second year is for progressing every schedules which may be on silvicultural experiments included previous those by present scheme, diffusion work on the management of bamboo forest and all researches on utilization.

Pilot plant proposed in the BCT should be completed at the third year and begun to operate. Training curriculum on making bamboowares will be founded at the same time. The fourth and fifth years are for giving full scope to its function satisfactorily.

Project generalization should be made at the second half of the fifth year and led the final conclusion on further activity of the BCT.

b) Choice of location.

The headquarters of the BCT project has to be set up in Royal Forest Department. The location of the BCT' establishment is expectant near vast bamboo resources and the conveniency in transportation and communication.

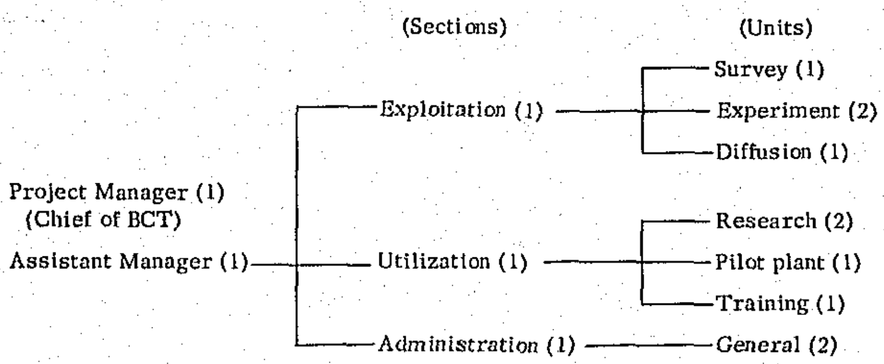
The area of bamboo forest for experiments and training planned by the BCT should be required to more than 1,000 hectares. For laboratory, pilot plant, training and other works in the BCT, the necessity of electrical installation is absolute.

Owing to above condition, Kanchanaburi or Rajburi province must be considerable. Khao Hin Lap station under the present project may, furthermore, be possible to think of the conversion into the field of the BCT if some indispensable problems such as trafic facilities, establishment of communication and lasting generation of electricity are completely solved.

Technological and chemical analysisses will, however, be conducted with using research facilities in Wood Research Institute of Royal Forest Department.

c) Organization.

One project manager and one assistant manager will be engaged to be the forestry expert, specialist or on a par. Both sections of exploitation and utilization consist of each three units which concerned with technical work only, because of requiring total twelve technical officials. One administrative official and two clerical staffs must be enough, and others may be more than two drivers and five hundred labourers. Because the organization is;



( ) : Shows the numbers of staff.

II-4. Working Proposal

a) Exploitation

1) Survey of bamboo resources (1st to 2nd year)

* Inventory survey of inaccessible area in the west.
* Inventory survey of bamboo forest formed-the under-story of natural forest in the north and south.
* Solution on transporting system, cost problems and marketing.

2) Silvicultural experiments (2nd to 5th year)

* Investigation on the productivity of natural bamboo forest.
* Experiment on felling cycle and method, fertilization and irrigation.
* Fundamental research on natural regeneration, biomas, genetics, flowering and other physiological and ecological subjects.
* Experiments on plantation, vegetative propagation, seed preservation, germination and nursery techniques.
* Trials on making artificial ornamental bamboo culms.
* Experiment on the cultivation of edible bamboo shoot.
* Investigation on land and water-source cons ervations of bamboo forest.

3) Diffusion (2nd to 5th year)

* Training on fundamental and applicable studies for forest technical officials.
* Training on practical technique for farmer and consumer.

b) Utilization

1) Research (2nd to 5th year)

* Fundamental analysis of physical and chemical properties of bamboo.
* Pulping tests of bamboo including the tests mixed with grass and tree fibres.
* Technological tests for making bamboowares.

2) Pilot plant

* Introduction of mechanical engineering on the bamboo machines.
* Improvement of mechanism and operating system upon the suitability for Thai bamboos.
* Cost counting on the productions of bamboowares.
* Investigation on market.

3) Training (3rd to 5th year)

* General mechanism.
* Practical operation.

c) Administration (1st to 5th year)

General administrative works, planning of training course, spreading activity of general knowledge on bamboo and exchanging the informations including references on bamboo.

II-5. Project Costs

a) Cost table

Items	Cost
1) Personnel	US$
Government officials (15)	36,800
Drivers (2)	1,200
Labourers (500)	100,000
Total	138,000
2) Land and buildings	
Headquarters	(Royal Forest Dept.)
Land for BCT	(National area)
Buildings	
BCT office (300 m^2)	18,000
Pilot plant (200 m^2)	9,000
Strage and garage (100 m^2)	3,000
Incidental expenses	5,000
Total	35,000
3) Facilities of transportation and communication	5,000
4) Installing electrical system	2,000
5) Motorized equipments	
Jeep (2)	8,000
Truck for two-tons (1)	5,000
Tractor (1)	7,000
Farm tractor (1)	1,200
Total	21,200
6) Pilot plant	
Machinery (18 sets)	30,000
Operation	6,000
Total	36,000
7) Supplies and equipment	3,000
Grand total	240,200

b) Explanation on cost

The grand total of project costs must be expected at US$240,200. About the half of personnel expense may probably be lightened if the present bamboo works may be shifted to the BCT project. Aggregate three hundred square meters of wooden two-storied BCT office may be enough for three office rooms, one laboratory, one specimen-room and one lecture-room. A building for pilot plant should be proposed to about two hundred square meters for setting eighteen machines. Incidental expenses for buildings are to fit with accessory equipments, furnitures, water-works and others.

The estimable foundation for facilities of transportation and communication may not be sound because of alterable in depending on the choice of location for the BCT.

It is needless to say that the municipal electric power is much ideal to supply for the BCT, but the installation of generating electricity is not always unwieldy.

Eighteen sets of machines for pilot plant are full of scale for the process of producing bamboo screen, fish trap, mat and tooth-pick. The expenses for consuming bamboo raw material and operating machinery for the pilot have been included into the operation costs.

The total valuation should be contributed by the Government of Thailand, due to be still premature to anticipate the cooperation with foreign countries as affairs now stand.

II-6. Cooperation with Foreign Countries.

There is a little of the bounds of possibility to revolutionize the present scheme and to establish new BCT project by only Thailand herself, in view of the fact that she needs to solve technical and financial problems in order to realize these ideas. The present situation on both problems in Royal Forest Department must, however, not be satisfactory in spite which there is a necessity more to extend the target of present works. By means of above, it is much expected that Thailand offers the cooperation in technical and economic to make the progression for exploitation and utilization of bamboo resources to some foreign countries.

On technical development two foreign experts, who have to be regularly proposed to serve for both sections of Exploitation and Utilization of the BCT, should be necessary. Some of experts or advicers with short term, a few months, should be also considerable in special fields such as on dendrology, ecology, genetics, chemical analysis, soil improvement and others.

At least eight technical officials in the BCT project should be desirable to attend at technical training for acquiring general knowledge and their specialities on bamboo to foreign countries. Four of them, who are being engaged at the present bamboo works, must be urgent to need the training for their fields, on account of which they should be expected to advance the starting of the BCT project. Another four technical officials, who have to be newly posted of the BCT project, must be more lacking in the experience, because they would be exceedingly supported to obtain the general knowledge through the training in foreign countries.

About financial problems it is hopeful that Thailand may contribute the costs for personnel, land and buildings, facilities of transportation and communication, installing electrical system and supplies and equipments. Because most of heavy equipments as motorized equipments and machineries of pilot plant will be requested to the cooperated countries.

It can be possible to mention that the countries which will be able to cooperate for the BCT project in Thailand, may be Japan, Taiwan and USA.

II-7. Conclusion

There is no doubt that the establishment of the BCT project can render Thailand to further her social and economic developments. The knotty problem on this realization, nevertheless, is not a few, especially about forming the connection on technical and economic cooperations with foreign countries. There must, accordingly, be necessity to concretize the best course to be chosen, and to proceed its preparation urgently.

As above-mentioned the reporter believes that Royal Forest Department may need to form like a committee for investigating the establishment of the BCT project, that may be called "Preparatory Committee on Bamboo Centre of Thailand".

III. REPORT AT THE THIRD NATIONAL FORESTRY CONFERENCE IN THAILAND ON 14 - 22 AUGUST 1970

(Title : On the Research Works of Bamboo Forests in Thailand)

III-1. Fundamental Researches

III-1-1. Bamboo species and propagation forms.

A bamboo is spontaneously growing in the world except for Europe and the North American Continent. 1,250 species of 47 genera have been found[3] in the world as shown at Table III-1.

Table III-1. The number of genera and species of bamboo in Japan, Southeast Asia and the world

Distribution	Genera	Species
World	47*	1,250*
Japan	13	662
Thailand	10	42
India	13	136
Taiwan	11	28
Burma	?	42*
Malaysia	?	52*
Philippines	8	30*
Indonesia	9	31*

* Approximate number

A bamboo, generally, continues to propagate asexually in full vigor by branching rhizome. Then it can produce new culms every years. Accordingly, it would be more effective if a bamboo forest could be cultivated and managed by suitable method fitted with the propagation way in each species. So that, Dr. Ueda[2] classified the propagation forms of bamboo into three types, because of monopodial, sympodial and intermediate types as shown at Fig. III-1.

The monopodial type is typically found in Phyllostachys species ranging in Japan mainly, and the sympodial type which is spontaneously distributed in Southeast Asia, is noticed in Bambusa species, Dendrocalamus species, etc. But the intermediate type is recognized by Sasa and Pleioblastus species, and sometimes found in the abnormal growth of Phyllostachys species in Japan.

The management technique on bamboo forest in Japan is nearly all well established, in particular about the useful species such as Phyllostachys edulis, P. reticulata and other. In order to propel the management technique of bamboo forest in Thailand, it should be necessary to study fundamentally on physiological and ecological charactors of useful species of sympodial type such as Bambusa, Thyrsostachys, Dendrocalamus and other genera.

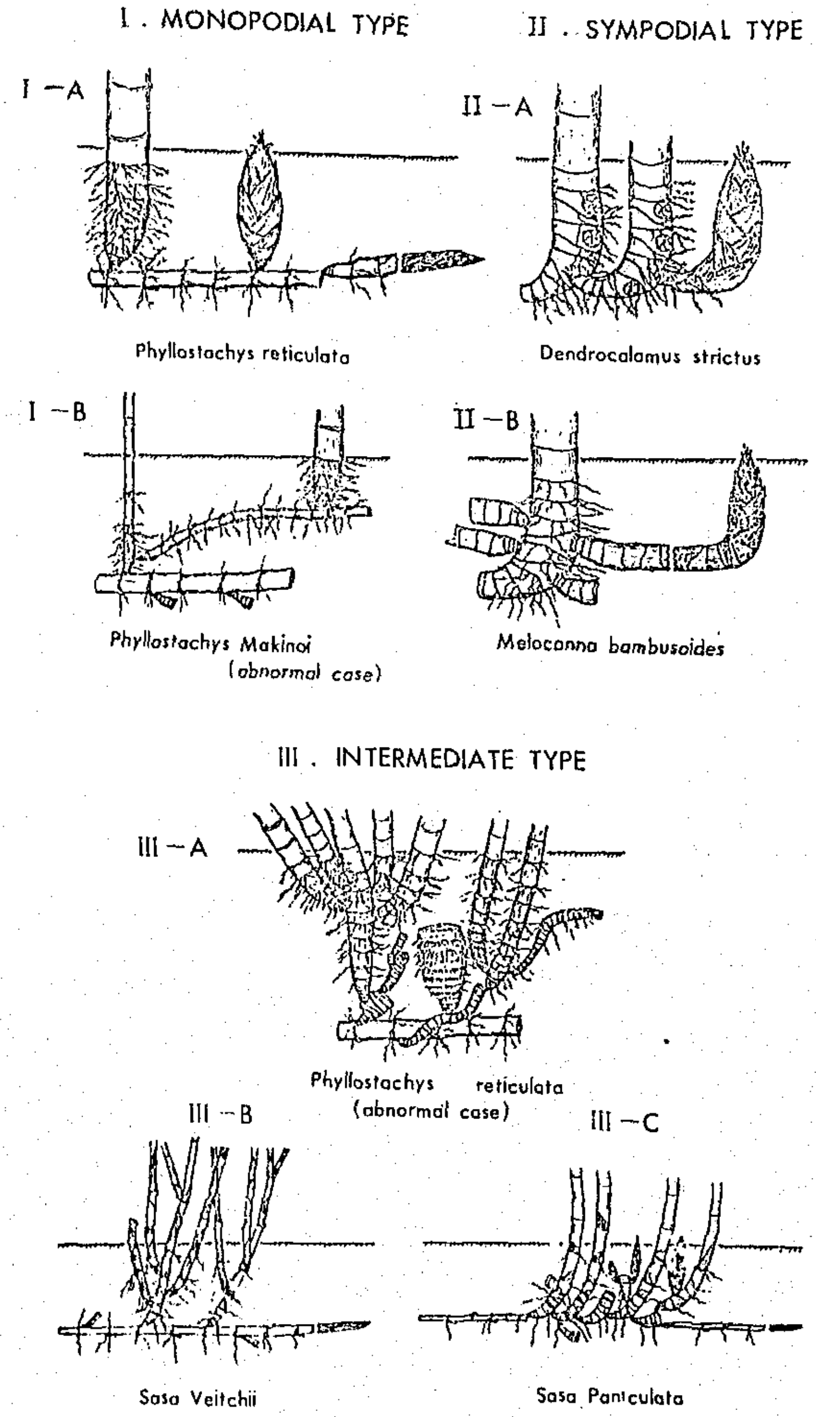


Fig. III-1. Branching system of rhizome

III-1-2. Growth of Bamboo

Bamboos ranging in Southeast Asian countries usually make their sprouts grow at the beginning of rainy season in May or June, then new sprouts reach the maximum growth in June or August, and they finish completely their daily elongation in October or November. But, after reaching their full diameter and full length for five to seven months, new culms never increase in diameter and height at all.

The growth of bamboo is exceedingly affected by various environmental factors as soil and climate in particular. Although throughout, the influences of severe drought in dry season and infertile lateritic soils are extreme.

Generally, there are unfavourable factors in the tropical region that the plant growth should be extremely reduced by violent ranspiration from leaves as well as consuming its growth energy intensely. But, a bamboo has surpassing adaptability to natural circumstances. Because, a bamboo is able to complete its growth in short term during the rainy season, then it keeps a halt of growth in dry season. At the starting of the rainy season, a bamboo has to consume its reserved nutriment for producing new culms, while the requisite nutrition for the elongation of new sprouts is swiftly replenished by the prompt decomposition of dead things and litter in the soil by high temperature. This is a favourable point of bamboo in the tropical region.

Consequently, it should be necessary from now on to carry out the physiological studies such as the relation between the photosynthesis and the respiration of bamboo, seasonal changes of reserved nutriments in bamboo culm and rhizome, etc.

III-1-3. Productivity of bamboo forest.

The productivity of bamboo forest is closely related with the quantity of fresh leaves that can do assimilation. However, the quantity of leaves differs more or less by species, age and size of bamboo culm, soil condition, etc. Generally, there is a tendency that the more bamboo has fresh leaves, the more diameter of culm is increasing. Namely, assimilatory products made by green leaves are consumed not so much for own growth as the growth of new sprouts, because they are sent to new sprout growing through rhizome system. Therefore, the relation between the amount of fresh leaves and diameter of new culm is varied by the age of rhizome, growing conditions of root and other factors, and this result becomes the cause that produces remarkable individuality.

The productivity of bamboo forest is unable to be presumed by only the present stock of forest. That is to say, the annual yield is not always much in the abundant forest of present stock. The annual felling quantity of bamboo culm can be estimated by the quantity of new culm yearly produced. About the forest of general woody plant the annual increment is measured from the total of individual annual increment of present stock, but about bamboo forest the total quantity of new culm appeared yearly is equal to the annual increment of woody forest. In consequence, the annual volume producting in bamboo forest corresponds to annual felling volume too.

The annual yield is differed conspicuously by species, growth condition and the management technique of bamboo forests as shown at Table III-2.

Table III-2. Annual yield of bamboo forest

Distribution	Species	Forest condition	Annual Yield
			(A.D.ton/ha)
Japan	Phyllostachys reticulata	Cultivation	4.0 - 9.5
"	P. edulis	"	5.0 - 14.5
Taiwan	Bambusa stenostachya	"	About 3.0
India	Dendrocalamus strictus	Natural	2.8 - 3.4
Thailand	Thyrsostachys siamensis	"	1.5 - 2.5

The mean annual yield of cultivated bamboo forests in Japan is about 7 tons in Phyllostachys reticulata and about 11 tons in P. edulis forests per hectare. This is a match for the increment of broad-leved and coniferous trees that are being utilized for pulp making in Japan. However, the productivity of natural bamboo forest in Southeastern countries is comparatively low. It should be contrived to increase it by the conversion from natural forest to management forest in future.

III-1-4. *Bamboo flowering and the appearance of natural seedling community.*

Generally, a bamboo repeats the asexual propagation by rhizome branching, then it has to finish its life if the flowering takes place in time. The flowering is not disease but physiological phenomenon, because bamboo is a perennial plant. Some of useful species which are Phyllostachys reticulata, P. nigra var. henonis, etc., die in groups within a few years after the flowering took place. In consequence of it, various studies on the counter-measure for this are being proceeded now.

It must be necessary to consider about the counter-measure when the group flowering will take place in Thailand. The author saw some clumps of Thyrsostachys siamensis flowered at Kanchanaburi many times, and recognized that lots of natural seedlings are growing around the dead clump after it flowered.

The author investigated the natural seedling community of T. siamensis that may have elapsed about twelve years ago after flowered in Khao Hin Lap, Kanchanaburi. Namely, 32 m^2 of investigated area was naturally regenerated with 72% in frequency and 10.3 seedlings per square meter in density. Besides, there were 20 seedlings grown with 0.4 to 3.5 meter tall in 1 X 1 meter quadrant sampling plot, and their dry weight were 807 grammes. Because, it was able to understand that T. siamensis is easy to propagate sexually with vigour, so that the natural forest in the district may have repeated the regeneration by natural seedlings.

Various climatic factors in Thailand must have considerably arrested the regeneration by sexual propagation. This is undoubtedly shown in the aspect noticed in Kanchanaburi. Because T. siamensis forests in the region can be divided into two types that one is sporadic mixed bamboo forests with some deciduous or other trees and other is nearly pure or gregarious bamboo forest. It is considered that the former may have been formed under the trees by natural germination from the seeds that came flying from some flowered clump, and the latter may have developed from the sporadic mixed bamboo forest. However, the naked lands could not grow only bamboo due to both reasons of strict drought in the dry season and surface erosion in the rainy season.

Accordingly, as becoming clear by above inspection, it should be necessary to research efficiently on the developing process, environmental factors and management method of various natural bamboo seedling communities. And the results taken from them will practically give pertinent guide to plantation and management of bamboo forests.

III-2. Practical Research.

III-2-1. Felling

The bamboo stock supplies the nourishment needful for the growth of new sprouts by its photosynthesis. Generally, the supplying energy is more powerful in young stock as one to three years old culms than more older culms, so that the old stock more than five years old culm is not effective for producing new culms. Moreover, the bamboo stock of good quality which is young and burly, is able to bear, exellent new culms with keeping high productivity, though slender or old stock are unproductive. Namely, the age and the quality of bamboo stock have an important effect upon the production of new culms, and also the quality of the stock is markedly influenced by the felling method.

There are two methods in the felling, because of selective and clear cuttings. The selective cutting is the method that the culms reached to their cutting period are yearly removed by thinning, and this is commonly used in the monopidial type species. On Thyrsostachys siamensis Mr. P. Bhodthipuks & Mr. P. Bamroongrasd,[7] Royal Forest Department, have recognized that the thinning of three and over three years old culms was the most practical with increasing yields and improving the clump. In case of applying this method into practice, age of selected culm for cutting should be taken every possible cares, because the mistaken selection for young culm is nothing but an indiscriminate cutting that does not make efficient use of the merits of selective cutting, and this attended with far-reaching consequences. Further it is to be regretted to have been found lots of young culms gathered in bamboo yards beside the River of Khwae when the reporter inspected there. Accordingly, the important points and the method of selective cutting should be spread over to whole of participators.

The clear cutting of bamboo forests reduces the productivity of forest, but it has the merit that the felling work is very easy. With thorny of close standing bamboo of sympodial type, it should be obliged to introduce this method. In fact, this method is already in force on some Bambusa stenostachya forests applied the rotation of seven or eight years in Taiwan.[3] The productivity of clear cutting is considerably differed by season and method. The reporter[20] has confirmed that the productivity was more affected by clear cutting in vegatative season than that in dormant season by Phyllostachys reticulata in Japan. The results showed that there might be only slight damage by clear felling in the dormant season by reason which the reserved nutrients had been kept abundant in the rhizome. Accordingly, the effect of clear cutting in Thailand should be also tested in several seasons and method on main species from now on if it would be adopted under the theoretical plan in future.

Still, the culms of T. siamensis in Thailand are usually cut off from about one meter high above the ground, and the weight of this part memained is about 20 percent of the total weight. This cutting method must be available for easy sprouting of new shoots from the remained part of culm in case of clear cutting, but in selective cutting the culm included this part should be preferably cut for the utilization.

II-2-2. *Management*

The growth and yield of bamboos are conspicuously affected by soil condition. The soil of poor T. siamensis forest is generally infertile with lateritic and compact, so that the organic carbon content is wanting with high acidity. Hence, the fertilizing for such a forest must be more effective for the growth of bamboo. On the other hand, as to improve poor bamboo forest in Thailand, it is a question whether the economic relations between the growth increasing by fertilizing and the fertilizer cost will be made up or not. But, the fertilizing test is very important for getting the knowledge on the physiological effects of verious elements influenced upon the growth of bamboo and moreover, applying to the fostering of nursery stock.

In Thailand, the supply of green and stable manures is easily obtained and it must be effective so as not only to increase the organic matters in soil, but to improve the physical properties of soil.

The intense drought in the dry season remarkably reduces the assimilation of growth materials, and this phenomenon exerts an important influence upon shoot growth at the beginning of next rainy season. Aslo, the decomposition of litter is extremely checked by drought, and the soil micro-organism must also find it difficult to survive. Accordingly, the irrigation in dry season must have the most effect it is possible in economic terms. But the tests on irrigation for bamboo forest and nursery is necessary in order to make clear the water relations of bamboo and soil.

The therophyte leguminous plant shown in bamboo forest fixes the free nitrogen by root nodule bacteria as well as protecting the surface erosion from heavy rain. In consequence, the effects of leguminous plant should be sufficiently investigated at low productive forest, especially in poor T. siamensis forest.

III-2-3. Plantation

As to devise the production increase of bamboo, the needs of afforestation and reforestation of bamboo have become pressing. For instance, if the plantation of naked lands in Kanchanaburi were successful, the productivity of bamboo forest would increase at least double. But there will be not much chance to succeed the plantation in open field, because of the influence by severe climatic conditions. The success of bamboo plantation depends on whether the planted stock can endure under the heavy drought or not. In order to succeed, it must be necessary to conduct the research on age and size of planting stock, shading method after planted, planting depth, planting density, mixed plantation with tree, soil improvement, etc. Moreover, an important key to the successful plantation will be given by the results of the investigation on the relations between the development of natural seedling community and the environmental factors as above-mentioned.

III-2-4. Propagation

Cutting for propagation is an important as the means of multiplying the planting stock as well as selective breeding. Cutting test to propagate bamboo culms have been tentatively carried out on several species in the past. However, the rootability differs considerably among species. For instance, genus Leleba and Bambusa are more easy to root than the monopidial type species such as Phyllostachys species and others. In general, the rooting of cuttings is affected by the collecting period, the part of scions taken from parent bamboo, and the several conditions of planting beds, etc. The rootability of cuttings will also be promoted by the treatment with the plant hormones. Accordingly, it should be expected to examine the above-mentioned tests on difficult rooting species.

The propagation by the stock with roots and rhizome that is called "offset stock" for plantation, is the most common method for monopodial type species in Japan. And this method has been recently put in practice at Khao Hin Lap station. But, the fostering of offset stock is not easy to be applied to every species in Thailand successfully. So that, in order to adopt the method practically, it should be tried to design such tests as age and size of stocks, collecting season, nursing technique, etc.

There are many species that are able to easily fructify the fertile seeds in the tropical region, namely T. siamensis, Bambusa arundinacea and other some species in Thailand. The cultivation of bamboo seedlings is likewise available for preparing the planting stock in Thailand. For the sake of this, it is necessary to conduct the tests on the promotion of seed germination, preservation method of seeds and others.

IV. OUTLINE OF THE LECTURE FOR THE SECOND BAMBOO TRAINING COURSE ON 14 - 22 DECEMBER 1970.

IV-1. General Knowledge on Bamboo Forest.

IV-1-1. Human being and bamboo.

For many thousand years there has been a deep and inseparatable relations between human beings and bamboos. There are some of old legends and tales about bamboo in Japan. One of very famous legend is "The Bamboo-Cutter and the Moon-Child"[19] which has been handed down from one generation to another. The reporter is proud to present you this legend and hoping that you will enjoy it at the beginning of the lecture.

Long, long ago, there was an old bamboo-cutter. He earned their living by selling bamboos and the products, but very poor and sad for no child. One morning as usual he had gone out to grove of bamboos and saw a bamboo which was flooded with a bright soft light, as if the full moon had risen over the spot. The old man, full of wonder, had cut the bamboo that the brilliance was streaming. Suddenly, a tiny human being, only three inches in height and exquisitely beautiful in appearance, was born from this soft splendour of green bamboo culm. A little creature was brought up with exceeding love of old couple.

From this time on, the old couple were very happy and often found gold in the notches of the bamboos when he cut down the culms, then became to be rich. The day come for the naming of their new found child, so old couple called in a celebrated name giver, and he gave her the name of Princess Moonlight, because her body gave so much soft bright that she might have been a daughter of the Moon God.

Many suitors from far and near posted themselves outside the house in the hope of catching a glimpse of the Princess. But most of the men seeing how hopeless their quest was, lost heart and hope both, and returned to their homes.

By this time the fame of Princess Moonlight's beauty had reached the ears of the Emperor, and he sent one of the Court ladies to see if she were really as lovely as report said; if so he would summon her to the Palace and make her one of the ladies-in-waiting. But Princess Moonlight refused to see her. The next day the Emperor set out with his retinue, which he soon managed to outride, and he cought her and begged her to listen to what he had to say.

The Emperor fell deeply in love with her, and begged her to come to the Court. But the Princess stopped him. She said if she were forced to go to the Palace she would turn at once into a shadow, and even as she spoke she began to lose her form. He left the house with a sad heart.

At this time her foster-parents noticed that night after night the Princess would sit on her balcony and gaze for hours at the moon with a burst of tears. One night the old man asked her the reason of her sorrow. With many tears she told him that on the fifteenth day of that very month of August her friends from the moon would come to fetch her, and she would have to return. The Emperor, as soon as the news was carried to him, sent a guard of two thousand warriors to watch the house.

The night wore on! The yellow harvest moon rose high in the heavens, then the night grew grey towards the dawn and all hoped that the danger was over - that Princess Moonlight would not have to leave the thousand men-at-arms after all. Then suddenly the watchers saw a cloud form round the moon - and while they looked this cloud began to roll earthwards. Nearner and nearer it came, and everyone saw with dimay that its course lay towards the house. In a short time, at last the cloud lay over the dwelling only ten feet off the ground. In the midst of the cloud there stood a flying chariot, and in the chariot a band of luminous beings. One amongst them who looked like a king called aloud, saying; "Princess Moonlight, come out from this lowly dwelling. Rest not here another moment." The messenger led her forth and placed her in the chariot. She looked back, and saw with pity the deep sorrow of the old man.

One of the moon beings in the chariot held a wonderful coat of wings, another had a phial full of the Elixir of Life. She swallowed a little and was about to give the rest to the old man, but she was prevented from doing so. The Princess said, "Wait a little. I must not forget my good friend the Emperor. I must write him once more to say good-bye." After she wrote, she placed the phial of the Elixir of Life with the letter. Then the chariot began to roll heavenwards towards the moon.

Princess Moonlight's letter was carried to the Palace. His Majesty was afraid to touch the Elixir of Life, so he sent it with the letter to the top of Mount Fuji, and there the Royal emissaries burnt it on the summit at sunrise. So to this day people say there is smoke to be seen rising from the top of Mt. Fuji to the clouds.

It is not clear how such an interesting legend was born in Japan. So this legend explains not only the relation between the life of human beings and bamboos, but also the pleasure of cutting, harvest, bamboo culms. And it is pictured to ourselves that the bamboo forest mentioned in the story might be a wonder site condition.

It is doubtful to the reporter either there are some legends and tales on bamboo in Thailand or not. But most of bamboo forests in the kingdom may not be such a forest as a beautiful Princess may be born from the stand. This would be due to different factors such as environmental conditions, bamboo species, living custom of people and others. Anyhow we should pay our greatest efforts, in order to make whole of bamboo forests bear such brilliant Princess by improving the natural bamboo forests in Thailand.

IV-1-2. Similarity in human lives and bamboos.

A filial piety in human is to show their great appreciation for their parents. This is very common in human society. Now, very similar thing to the above relationship is also found in the life of bamboo.

All of bamboo species in Thailand grow to be forming the clump. A bamboo culm has six to fourteen buds at its lower part under the ground and produce new bamboo culms. When they are fully growth, they become to be parent bamboos, then they give new buds for new bamboos again, as we know that a clump is formed by repeating such phenomena. And, most of young culms tend to grow around the clump and leave old-aged culms inside. Therefore, young culms which grow around the clumps look like to watch over the old culms. Its nature is similar to children who show great devotion to their parent. Now, we call this clump forming "Sympodial type species".

Why are there lots of sympodial type species of bamboo in the tropical regions? Because, the tropical region is severe in the dry season and heavy rainy season causes by monsoon. A bamboo in such a region has to conquer hard natural conditions, by means of stopping its growth, reducing leaves in the dry season, and produce new bamboo sprouts which could be grown into culms within a few months after renewing leaves at the beginning of rainy season. So this repeating phenomena might be the factor of forming bamboo culms into a clump.

Most species of bamboos grown in Japan have long stretch rhizome which expand like a net. The rhizome of these species has nodes, buds and roots. The bud of rhizome will grow up and then becomes to be new bamboo culm by the nutrients of parent bamboos. Because the standing feature of bamboo culm is scattering in its condition, so we call this single culm forming "Monopodial type species".

IV-1-3. Marvellous growth of bamboo shoot.

One day, the reporter took a European tourist out to bamboo forest in Kyoto, Japan. When he saw a big culm which was about 17 cm in diameter, "How old is this bamboo?" he asked. The reporter replied that it was only one year old. Then he gave the same question with fingering at the culm of about 7 cm in diameter. The reporter said to him that this culm might be five years old. Immediately, he threw the question again, "Why is the one year old bamboo bigger than the five years old?"

It seemed to be quite a proper question for him whom never saw any bamboo in his own country. At that time the reporter had to explain some reason that bamboo is monocotyledon as the rice plant, because of the scattering of vascular bundles in culm which has no cambium. Accordingly, when the bamboo sprouts are in full growth, they can not do thickening and lengthening again.

The daily growth of bamboo shoot was measured on Phyllostachys edulis in Kyoto, Japan[2]. The maximum amount of elongation per day (24 hours) was 119 cm, even though the sample shoot was fairly big. Such a growth power of bamboo shoot is in a great speed and could never be seen in any other plants. How bamboo shoot can grow up such a great speed is due to these reason;

A bamboo shoot has few roots, and no green leaves at the beginning stage of sprouting. At the beginning of growth the shoot will gradually increase its growth by the help of the reserved and additional nutrients from parent bamboos. Later, the bamboo shoot will produce a lot of roots, then new branches and leaves open. As a result of these function the bamboo shoot will get more absorption of nutrients by new roots and more assimilation by new leaves. This is due to the elongation amount of bamboo shoot suddenly increase.

IV-1-4. Nature of sympodial type species

As the nature of human, parents will try with a great effort to make their children happy. This is a duty of parents. But, how to fulfil the parent's responsibility is varying depends on circumstances and surroundings. Some parent will bring up their children with their own efforts, but some will depend on the others.

This is the same in the case of sympodial type species. New sprouts can start to grow by nutrients from parent bamboos which are mostly one to three years old. But, this function must be remarkably influenced by several factors such as soil, precipitation, temperature, light and others. Therefore, in some forests where above-mentioned conditions are inadequate, some bamboo shoots can not satisfactorily complete their growth through the help of parent bamboos. So that, it will need artificial help for their growth. This help is what we called "The management technique of bamboo forest".

In Thailand, useful Thyrsostachys siamensis is distributed over the worst soils that are dry, compact and infertile conditions. On the other hand, Bambusa arundinacea is mostly growing at comparatively good soil along the stream and river. The culm of T. siamensis is smaller and shorter than that of B. arundinacea as shown at Table IV-1.

Table IV-1. Culm size of Thyrsostachys siamensis and Bambusa arundinacea

Species	Length of culm	DBH	Length of internode	Thickness of wall
	(m)	(cm)	(cm)	
T. siamensis	13 - 17	2 - 6	13 - 30	Very thick
B. arundinacea	10 - 20	5 - 15	15 - 50	Thick

T. siamensis is small culm, that might be the result of threatened drought, and close density of culms which are growing in small area's clump. But, B. arundinacea can grow generally well only in fertile soil, and can not survive under severe dry condition of poor soil.

In general, the quality of parent bamboo culms will inherit to that of new culms sprouted. There is also no exception in sympodial type species. This could be found that T. siamensis in Erawan district, Kanchanaburi, where it is suitable for bamboo growth, could be able to produce more superior culms than those in Khao Hin Lap, where the land is extremely infertile.

There are various sizes of standing culms in every bamboo forests of sympodial type species. And it must be aware of superior quality culms in large clumps which are always better than those in small clumps. This is also found in monopodial type species in Japan. It is because of the close relationship between the diameters of rhizomes and culms as shown at Table IV-2.

Table IV-2. Relation between the diameters of rhizome and culm of Phyllostachys reticulata

	Good site	Poor site
(A) Diameter of rhizome (cm)	2.3	1.5
(B) Diameter of new culm (cm)	6.2	1.7
(B) / (A)	2.7	1.1

The table shows that both culms and rhizomes are larger in size in fertile soil (good site) than that in the poor. And the ratio of both rhizome and culm is increasing according to the fertility of soil. From this point, parent bamboos of good quality can bear good quality of new bamboo culm also. However, this relationship should be understood thoroughly for improving natural bamboo forest.

IV-1-5. Outlay and outcome

Most of peoples prefer to deposit their own money in the bank for their economic living, and want high interest from their saving money. Still more, nobody does not expect the rise of interest rate as well as increasing the amount of saving.

The management of bamboo forest is like depositing money in the bank. It can be assumed that the number, volume or weight of present stock per unit area are equal to the amount of deposit, and annual yield also must be equal to the annual interest. However, we have to take an account of two problems that one is how to increase the yield and the other is how much amount of present stock is the best to get high rate interest.

The annual yield of bamboo can be estimated by that of new culms produced yearly. So, if we want to cut them, the annual quantity of felling must be equal to that of increment. But, the annual yield is different in each species, growth condition and the management technique of bamboo forests. The average annual yield of cultivated bamboo forests in Japan is about 7 tons by Phyllostachys reticulata and about 11 tons by P. edulis per hectare. This is comparing with the increment of coniferous and broad-leaved trees that are being utilized for pulp-making in Japan.

The productivity of bamboo forest is unable to be presumed by only present stock. It is to say that the annual yield is not always related with the quantity of present stock. The reporter would like to confirm this tendency by the result of

Table IV-3. Numbers of living and dead standing culms per hectare in poor Thyrsostachys siamensis forest

Plot	Number of living culm			(B) Number of dead culm	(C) Total standing culm	A/C %	B/C %
	(A) 1-year-old	Over 2-year-old	Total				
I	3,300	22,300	25,600	6,700	32,300	10.1	20.7
II	2,800	20,500	23,300	10,100	33,400	8.5	30.1

experiment in poor T. siamensis forest, Kanchanaburi as shown in Table IV-3. With regard to the table the rate of annual growth or one year old culms sprouted for the quantity of present stock is 8 - 10% in the plots I and II, additionally the rates of dead culms for present stock in both plots are 20%, and 30% respectively. From the result, the rate of annual yield in these plots is less than 10%, still the yield of more than 20% should have been removed as they are useless. This is because the natural bamboo forest mostly contain with lots of old-aged, dead bamboos or low quality bamboos and the productivity is extremely low.

IV-2. *Improvement of Natural Bamboo Forest*

IV-2-1. *Importance of young bamboo.*

Going up Kwae Yai river in May of this year, we had to look over a lot of young culms which might be cruelly cut down, piled up at the riverside and rafted. This was a matter of really regrettable. Although the distribution area of bamboo forest in the west has been measured at 850,000 hectares,[11] the productivity of such a vast bamboo forest must be extremely decreased in the near future if such indiscriminate method of cutting still being continued.

Considering the improvement of natural bamboo forest, it should be thought over how to breed young bamboos. Because the productivity must be able to increase by means of giving such condition as they are apt to produce new bamboos. The necessity of this condition should take a great consideration, especially in poor forests.

IV-2-2. Cutting method for yield

In order to convert natural bamboo forest into cultivation one with high productivity expectant, the harvest or felling method should be urgently discussed. It must be able to be divided into two ways, they are clear cutting and selecting.

The clear cutting is the easiest method of which all of standing culms are cut down with no technical consideration for giving yield. This method which often found in the west, give an abundant yield for a specific period of time. Clear cutting as to cut off the whole of parent bamboos, is not the right way. Although a few clumps may produce new bamboo sprouted from remained stumps, but it should take more than ten years to get what the forest was like before. Several tests on clear cutting have been done many times in Japan. For instance, the test on Phyllostachys reticulata, that the result was shown at Table IV-4, was experimented by the reporter.[20]

Table IV-4. Deteriotation rate of production by clear cutting method on Phyllostachys reticulata

(%)

Month of clear cut	February	August	November	Average
Culm length	52	37	48	46
DBH	59	47	60	55
Fresh weight of culm	28	18	27	24

From the result the fresh weight of new bamboos matured after clear cut was reduced to 24% in consequence, also the quality of bamboo culms was extremely becoming to be poor. Such a result was also found in the test on Pleioblastus pubescens. On the other hand, Mr. P. Bhodthipuks & Mr. P. Bamroongrasd[7] have recognized by the thinning test on T. siamensis that the clear cutting would decrease the annual yield drastically, and the remained stumps would be extinct in final.

It might be hopeful if the felling cycle, season of cutting, way of taking care for the forests and other problems are discussed. But, now there is no profitable result by this clear cutting method on natural bamboo forest in Thailand.

A selective cutting means in a few words, to be thinning. This method is the most efficient for improving poor stand and shifting from natural stand to management one, by means of using vigorous rhizome propagation of bamboo. The knowledges and techniques on the management are greatly in need for selective cutting.

There are various methods in selective cutting. Each method differs according to species, soil condition and stand grade, etc. The most important thing is to understand the relation between the density of bamboo standing and productivity as well. Now this relation will be explain by Table IV-5 that shows the result on Phyllostachys reticulata.[21]

Table IV-5. Relation between the density of bamboo forest and the productivity of Phyllostachys reticulata

(per ha)

(A) Number of Standing culm	12,000	9,000	7,500
Number of felling culm (B)	1,650	1,790	2,180
DBH of felling culm (cm)	7.0	6.6	6.2
Annual yield (Air dry wt. ton)	6.5	7.5	7.5
Yielding rate (%) (B)/(A)	11.8	17.9	23.7

From Table IV-5, the plot which gave the highest production among three kinds of density pattern, was 7,500 culms per hectare in standing density. It must not have been said that higher density of present stock, the greater yield would increase. The production of bamboo ought to increase in regard to the effective circulation of nutrient. However, old-aged, dead and low qualitative bamboos composed are obstacle in increasing the productivity.

For instance, by Table IV-3 mentioned at the paragraph IV-1-5, if all dead and old culms ages around three and over in the plots I and II were removed away, the productions in both plots would be increase more than the present state, as shown at Table IV-6.

Table IV-6. Presumption of annual yield by the management expectant for poor T. siamensis forest mentioned at Table IV-3.

(per ha)

	Plot I	Plot II
Present density (culms)	32,300	33,400
Present annual yield (culms)	3,300	2,800
(A) Expectant density (culms)	20,500	18,700
(B) Expectant annual yield (culms)	4,900	4,200
(B)/(A) Expectant yielding rate (%)	23.9	22.9
Air dry weight of expectant yield (ton)	7.3	6.3

On the table the standing densities of bamboos in both plots would become to be about 20,000 culms, that the rate of expectant standing bamboos for the number of present standing bamboo might be reduced at a rate of 40%, in case that the sampled area should have been shifted from natural forest to management one. By contraries, the expectant annual yield after converted to management forest would be more than 4,000 culms or 6 to 7 tons, and the rate of yield for expectant present stock would show about 23%.

Next, it is necessary to discuss how many years old culms should be cut for uses and to be remained as parent bamboos. In order to solve these problems, we have to understand the relation between the physiological functions of young bamboos and forestry felling cycle. Generally, bamboos of the sympodial type over four years old become weak as the effect of rising the productivity. Therefore, ages of bamboos suitable for cutting must be at least more than four years old.

But, there may be many problems in cutting in roder to get the regular annual yield. In such a case, it is proper to adopt the effective cutting cycle. For reasons of bamboo nature as mentioned above, effective felling cycle should be three or four years. If the cycle of three years is adopted, four, five and six years old culms will be removed with every three years. Otherwise, in case of the cycle by four years, five, six, seven and eight years old culms will be cut off in every other years.

According to above-mentioned, the important points of selective cutting work can be summarized as following;

1) On standing parent bamboos.

   a) One, two and three years old bamboos
   b) High quality culms as far as possible

2) On cutting culms for harvest

   a) Dead, broken and low quality bamboos
   b) Four and over four years lod bamboos

IV-2-3. Manuring

Fallen leaves and branches or dead culms in bamboo forest will be decay and become to be nutrient in soil. The nutrient is absorbed by roots of living bamboos, then consumed for the growth of new bamboos and for respirating by parent bamboos. As time gone these bamboos died after their full lifes, then become to be the nutrient again. This circulation is repeating in natural bamboo forest.

Accordingly, the getting of the yield of bamboo culms removed from the forest is to take the nutrient from the forest. Because, by continuous harvest without replenishment of the nutrients, the systimatical circulation of nutriment should be gradually destoyed year and year.

On the other hand, the nutrient is produced by green leaves of plants. The more amount of green leaves increase, the more nutrient is produced. Generally, large sized and tall bamboos produce more green leaves than the small and short size. Accordingly, in order to improve poor bamboo forest, it is very important to produce large sized culms.

Adding up the nutrient for soil by the way for increasing green leaves of bamboos and large sized parent bamboo culms, the manure and manuring method should be discussed. There are many kinds of chemical fertilizers, stable manures, green manures, etc. Which kind is the most effective is due to various conditions of bamboo forests, and economical reasons. Unfortunately using the method of applying chemical fertilizer which is swift to go into effect easily, might be an economic problem in Thailand. Because, the reporter would like to recommend to use stable manure as it is easy to obtain. Now, the supply of such method has been already adopted in cultivating edible bamboo shoots in Prachinburi province.

The effect of manuring in bamboo forest is generally remarkable, especially in poor soil. According to the results of fertilizing on monopodial type species in Japan, it was reported[21)] that there was a possibility to increase the yield of 3 tons per hectare by supplying N : 81 kg, P : 55 kg and K : 54 kg per hectare. On the fertilization for bamboo forest in Thailand, it seems to be possible to increase 3 tons per hectare in yield more than present, by applying 16 tons per hectare of stable manure. During the season when is the best for manuring, it will be a good idea to apply such method twice, because of the beginning and the middle of rainy season.

Table IV-7. Effect of the seasonal supplies of fertilizer to Leleba multiplex clumps

(per clump : about 4 m^2)

	Cont.	Feb.	Apr.	June	July	Aug.	Oct.	Dec.
Number of sprouted new culms	30	48	64	67	101	89	69	60
Total fresh weight (kg)	6.0	7.8	15.7	27.0	42.2	38.1	24.8	14.7
Index number for fresh weight	1.0	1.3	2.6	4.5	7.0	6.4	4.1	2.5

The reporter[20] has experimented the effect of fertilizing on Leleba multiplex clumps in Japan and got result from the test as shown at Table IV-7. The fertilizer was very effective in the plots applied in June, July and August, as the total weight of new culms produced was 4 to 7 times for that of non fertilizer plot. Now, if the best record of the production increased by this test had been estimated as per hectare, the total produced weights of new culms would be equal to 15 tons. It could be said that such a productivity is tremendous.

IV-2-4. Bamboo forest control

One of many problems on the management of bamboo forest in Thailand is the method of picking out bamboo shoots thoughtlessly. Looking over some greengrocers in daily market, it is easy to find a lot of edible bamboo shoots. Otherwise, we could see thousands of bamboo shoots loaded on trucks and transported to maket too. But, the reporter has never heard of cultivating such shoots of useful species except Dendrocalamus asper in Prechinburi. As we have seen in daily market, these shoots might have been picked out unmethodically.

The harvesting of bamboo shoots is the same meaning as destroying young bamboo, and it is definitely the cause of deceasing the productivity of bamboo forest. It is easy to destroy, as the young bamboo shoots is likely to destroy national resources.

If the demand of edible bamboo shoots is increasing, suitable bamboo forests for this purpose will have to be prepared intensively as in Prachinburi.

Next suggestion may be the cattle pasturage that new sprouts, leaves and branches have been grazing by hundreds of cattles. On this problem the particular consideration on not only protecting way to pasturage but also the future development of pasturage should be paid, because it relates remarkably with the living of farmer. The reporter has an idea on it, that under the decision of the government some forest lands should be given to farmer for only pasturage and suitable pasture plants for cattle should be cultivated.

IV-2-5. Plantation

It is reported that the distribution area of bamboo forests in the west is more than 850,000 hectares, but the pure bamboo forests are estimated at over 130,000 hectares.[11] According to the observation of the reporter, the distribution type can be roughly divided into two types, one is developed in a small area among the tall deciduous or evergreen trees, and other is nearly pure forest as bamboo is as dominant species. Still more, the pure bamboo forest might have developed from the former type. Accordingly, in order to increase substantial area for distribution and increasing bamboo products, it is necessary to plant bamboo stocks in bare lands spreading over the range.

But, there will be not much chance of successful plantation in open field, because of severe climatic condition, especially threatened by drought. From the observation at Khao Hin Lap, Kanchanaburi a few months ago, if the reporter give some suggestion on these problems, it will be effective that soil must be plowed in planting holes a year in advance before planting, the plantation should be done during rainy season, especially within rainy days for a few weeks. If possible watering and shading should be done a few weeks after planted.

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VI. REFERENCE FIGURES

VI.-1. Bamboo Species in Thailand
(by Dr. Tem Smitinand, Royal Forest Department)

No.	Local name	Botanical name	Diameter (cm)	Locality
1	Jote	Arudinaria ciliata A. Camus	0.50 - 1.0	South and east
2	Yah pet	A. pusilla A. Chev. et A. Camus	0.50 - 0.70	Northeast
3	Pai pah	Bambusa arundinacea	10 - 15	Throughout Thailand
4	Pai sisook	B. blumeana Schult.	7 - 10	Generally cultivated
5	Pai bongnam	B. burmarica Gamble	10 - 12	North
6	Pai lamalog	B. ongispriculta Gamble	7 - 9	Throughout Thailand
7	Pai lieng	B. nana Roxb.	2 - 3	Generally cultivated
8	Pai sangkum	B. pallida Munro.	5.5 - 7.5	North and northeast
9	Pai hom	B. polymorpha Munro.	7.5 - 15	Chiengrai, north
10	Pai bong	B. tulda Roxb.	6 - 18	Throughout Thailand
11	Pai loung	B. vulgaris Schrad.	5 - 10	Throughout Thailand
12	Pai loung	B. wamin G. Camus	10 - 12	Chiengmai, north
13	Pai loung	B. nutans Wall	4 - 8	North
14	Pai kaolarm	Cephalostachyum pergracile Munro.	5 - 7.5	North
15	Pai hiar	C. virgatum Kurz.	4 - 4.5	North
16	Pai bongyai	Dendrocalamus brandissii Durz.	12 - 20	Throughout Thailand
17	Pai hok	D. giganteus Munro.	15 - 20	Throughout Thailand
18	Pai nuanyai	D. hamiltonii Ness b Arn	10 - 17	North
19	Pai sangkum	D. latiflorus Munro.	10 - 12	North
20	Pai lamalog	D. longispathus	7.5 - 10	Throughout Thailand except south
21	Pai snag or Pai nuan	Dendrocalamus membranaceus Munro.	3 - 12	Throughout Thailand
22	Pai sang	D. strictus Nees.	3 - 8	North
23	Pai khlan	Dinochloa macclellandi Kurz.	2.5 - 5.0	North and south
24	Pai luai	D. scandens O. Kuntze.	2.5	Throughout Thailand
25	Pai takwang	Gigantochloa kurzii Camble	7.5	South
26	Pai hangchang	Melocanna compactiforms Benth & Hook	2.5 - 4.5	Throughout Thailand
27	Pai rai	Oxtenanthera albociliata	1.5 - 2.5	Throughout Thailand
28	Pai rai	O. hosseusii Pilger	1.5 - 2.5	Throughout Thailand
29	Pai phak	O. nigrociliata Munro	5 - 10	South
30	Pai phak	O. densa A Camus	4 - 6	South
31	Pai lowt	Schizostachyum aciculare Gamble	1 - 1.5	South
32	Pai po	S. zollingeri Steud.	4 - 6	South
33	Pai ruak	Thyrsostachys siamensis Gamble	4 - 6	Throughout Thailand
34	Pai ruak	T. oliveri Gamble	5 - 7.5	North

VI-2. Import and Export of Paper and Pulp in Thailand

(by Mr. Keith Openshow, FAO Forestry Economist)

VI-2-1. *Net imports of paper (and pulp)to Thailand (tons)*

SF=Semi Finished F=Finished	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Newsprint	17,807	24,459	15,458	26,608	21,360	25,914	34,980	32,712	42,710	42,700	36,314
Print & W.SF	13,822	16,023	15,268	17,553	7,716	6,068	11,267	8,953	6,908	6,952	12,933
F	438	578	925	-77	454	743	1,198	889	1,645	4,324	2,333
Total P&W	14,260	16,601	16,193	17,476	8,170	6,811	12,465	9,942	8,562	11,276	15,266
Kraft SF	19,520	20,494	26,012	32,085	36,186	39,593	50,951	57,235	65,658	66,481	23,481
F	2,535	3,595	4,688	3,582	4,615	6,055	8,326	5,897	4,440	5,496	3,757
Total K.	22,055	24,089	30,700	35,667	40,801	45,648	59,277	63,132	70,098	71,977	27,238
Carbon ECT SF	281	332	466	574	431	695	597	762	797	1,177	
F	192	291	298	444	372	561	625	897	913	1,108	464
Total Carbon	473	623	764	1,018	803	1,256	1,222	1,659	1,709	2,285	464
Cigarette SF	480	483	500	358	520	407	553	672	600	622	739
F	2	0	0	1	0	11	4	165	274	26	79
Total CIG	482	483	500	359	520	418	557	837	874	648	818
Paper Board & Vulcanished	1,098	1,167	1,944	1,881	3,043	3,397	4,995	10,278	11,421	17,686	17,620
Grand Total	56,175	67,422	65,559	83,009	74,697	83,444	113,496	118,560	135,365	146,572	97,720
Mechanical Pulp	4	662	209	NIL	2,799	1,559	NIL	3,285	10,003	26,386	15,546
Total Pulp & Waste Paper	4	1,850	1,909	1,997	8,582	9,139	8,936	10,317	14,476	35,400	48,293

* NOTE IN 1970 The Customs and Excise Department of the Government of Thailand change the classification system from thestandard international trade system (SITC) to the Brussels Tariff Nomenclature (B.T.N.). Therefore, some groups in 1970 may not be strictly comparable with the previous years.

VI-2-2. Value of paper (and pulp) net imports (import-export) of Thailand (million baht)

SF=Semi Finished F=Finished	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Newspring	48.1	70.5	43.6	71.8	58.1	66.9	93.7	94.6	111.7	125.0	108.0
Write & Print SF	72.4	79.2	15.3	64.0	41.4	35.6	64.5	55.9	42.6	51.0	84.4
" " " F	7.9	9.2	9.4	8.3	9.0	10.8	16.2	14.3	20.1	20.2	32.5
Total	80.3	88.4	24.7	72.3	50.4	46.4	80.7	70.2	62.7	71.2	116.9
Kraft SF	84.1	84.8	96.8	112.4	134.9	140.2	177.8	204.2	228.7	233.6	123.5
" F	25.6	31.7	40.3	40.1	45.4	56.7	130.9	59.6	44.9	48.2	44.2
Total	109.7	116.5	137.1	152.5	180.3	196.9	308.7	263.8	273.6	281.8	167.7
Carbon SF	1.7	2.1	2.9	4.0	3.0	4.5	3.7	4.7	5.6	7.0	
" F	6.8	7.9	8.2	10.1	9.6	13.7	17.2	19.7	20.4	22.8	17.5
Total	8.5	10.0	11.1	14.1	12.6	18.2	20.9	24.4	26.0	29.8	17.5
Cigarette SF	8.0	1.8	9.2	6.6	9.0	7.8	10.7	13.6	11.7	13.7	11.6
F	0.1	0.0	0.0	0.0	0.0	0.4	0.1	3.2	4.9	0.5	1.7
Total	8.1	1.8	9.2	6.6	9.0	8.2	10.8	26.8	16.6	14.2	13.3
Vulcanized	7.5	7.0	10.3	12.2	20.2	26.8	29.3	63.4	77.9	97.7	94.9
Grand Total	262.9	264.2	236.0	329.5	331.2	363.4	564.1	533.2	573.9	619.7	519.1
Mechanical Pulp	0.1	1.8	0.6		9.4	5.2		10.5	29.0	80.0	23.5
Total Pulp & Waste Paper	0.1	5.3	5.7	6.6	27.4	29.7	26.3	30.9	43.5	114.0	124.6

VI-2-3. Export of paper (tons)

SF=Semi Finished F=Finished	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	SITC
Newsprint (Total)						34			5			641.01
Print & W SF	1	22	24	5	34	399	34	35	54	43	763	641-02, 1907 & 1998
" " " "	13	24	37	578	120	132	10	4	27	1	3	642-02 & 03
Total P&W	14	46	61	583	154	531	44	39	81	44	766	
Kraft SF	1	5	179	189	48	179	6	38	58	4	452	641-03, 04 0702 0701 641-08, 19
" F	4	29	45	107	119	114	2	16	87	105	154	642, 01, 0903-14
Total Kraft	5	34	224	296	167	293	8	54	145	109	606	
Carbon ETC SF		0	0									641-0704/5/6 -1201, 1901
" " F												6420902/5/8/9
Total		0	0			0						
Cigarette SF					1							641-1100, 1202/3
" F						3						6420901
Total					1	3						
Paper Board & Vulcanized (Total)	0	0	0	1								641-05, 06, 0703 0707/8/9-99
Grand Total	19	80	285	880	332	861	52	93	231	153	1,372	

VI-2-4. Value of paper exports of Thailand (million baht)

SF = Semi Finished F = Finished	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	B.T.N.
Newsprint						0.1			0.0			480-14
W & P SF	0.0	0.1	0.1	0.0	0.3	3.2	0.1	0.1	0.1	0.1	0.6	480-151, 161, 200, 600, 721/22/23, 739
" F	0.1	0.1	0.4	0.5	1.3	1.4	0.0	0.0	0.0	0.0	0.0	481-401-9, 51, 522, 801-9, 482-123
Total W	0.1	0.2	0.5	0.5	1.6	4.6	0.1	0.1	0.1	0.1	0.1	
Kraft SF	0.0	0.0	0.1	1.3	0.6	2.3	0.0	0.4	0.7	0.1	1.2	480-110, 12, 301-9,400 501-9, *
" F	0.0	0.2	0.3	0.9	1.3	1.3	0.1	0.4	0.2	2.3	4.1	481, -521, 601-9, 700, 900, 482-000
Total	0.0	0.2	0.4	2.2	1.9	3.6	0.1	0.8	0.9	2.4	5.3	
Carbon SF		0.0	0.0			0.0						
" F			0.0								0.0	481-301-9,
Total			0.0									
Cigarette SF					0.0							480-130, 800 481-523
" F						0.0						481-000
Total					0.0	0.0						
Vulcanized	0.0	0.0	0.0	0.0			0.0		0.1	0.0	0.0	480-71, 725/6, 738 481-200
Grand Total	0.1	0.4	0.9	2.7	3.5	8.3	0.2	0.9	1.0	2.5	5.9	
Mechanical Pulp								0.0				
Total Pulp & Waste P.												

* Kraft SF Cont. 480-724, 481, 100, 480-159, 169, 724
" F " 482-12

VI-2-5 Imports of paper to Thailand (tons)

SF=Semi Finished F=Finished	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	SITC
Newsprint	17,807	24,459	15,458	26,608	21,360	25,948	34,980	32,712	42,715	42,700	36,314	641.01
Print & W.S.F.	13,823	16,045	15,292	17,558	7,750	6,467	11,301	8,988	6,962	6,995	13,696	641.02 :<1998 1907
" " F	451	602	962	501	574	875	1,208	993	1,672	4,325	2,336	642.02 ; 03
Total	14,274	16,647	16,254	18,059	8,324	7,342	12,509	9,981	3,634	11,320	16,032	
Kraft. SF	19,521	20,499	26,191	32,274	36,234	39,772	50,957	57,273	65,716	66,485	23,933	641.03 (19) ; 04,07;08
" F	2,539	3,624	4,733	3,689	4,734	6,169	8,328	5,913	4,527	5,601	3,911	642.01 ; 09
Total	22,060	24,123	30,924	35,963	40,968	45,941	59,285	63,186	70,243	72,086	27,844	
Carbon ETC SF	281	332	466	574	431	695	597	762	797	1,177		641.07, 12, 19
F	192	291	298	444	372	561	625	897	913	1,177	464	6420902/5/8/9
Total	473	623	764	1,018	803	1,256	1,222	1,659	1,709	2,285	464	
Cigarette SF	480	483	500	358	521	407	553	672	600	622	739	641.11.120
ETC F	2	0	0	1	0	14	4	165	274	26	79	6420901
Total	482	483	500	359	521	421	557	837	874	648	818	
Paper Board & Vulcanized	1,098	1,167	1,944	1,882	3,043	3,397	4,995	10,278	11,423	17,688	17,630	641.0500 0600 0703 0707/8/9
Total	56,194	67,502	65,844	83,889	75,019	84,305	113,548	118,653	135,598	146,727	99,102	
Mechanical Pulp	4	602	209	NIL	2,799	1,559	NIL	3,285	10,003	26,386	15,546	
Total Pulp Waste Paper	4	1,850	1,909	1,997	8,582	9,139	8,936	10,317	14,476	35,400	48,293	

VI-2-6. Value of imports of paper (and pulp) Thailand unit million baht

SF=Semi Finished F=Finished	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Newsprint	48.8	70.5	43.6	71.8	58.1	67.0	93.7	94.6	117.6	125.0	108.8
Write & Print SF	72.4	79.3	15.4	64.0	41.7	38.8	64.6	56.0	42.7	51.1	85.0
" " " F	8.0	9.3	9.8	8.8	10.3	12.2	16.2	14.3	20.1	20.2	32.5
Total	80.4	88.6	25.2	72.8	52.0	51.0	80.8	70.3	62.8	71.3	117.5
Kraft SF	84.1	84.8	96.9	113.7	135.5	142.5	177.8	204.6	229.4	233.7	124.7
" F	25.6	31.9	40.6	41.0	46.7	58.0	131.0	60.0	45.1	50.5	48.3
Total	109.7	116.7	137.5	154.7	182.2	200.5	308.8	264.6	274.5	284.2	173.0
Carbon SF	1.7	2.1	2.9	4.0	3.0	4.5	3.7	4.7	5.6	7.0	
F	6.8	7.9	8.2	10.1	9.6	13.7	17.2	19.7	20.4	22.8	17.5
Total	8.5	10.0	11.1	14.1	12.6	18.2	20.9	24.4	26.0	29.8	17.5
Cigarette SF	8.0	1.8	9.2	6.6	9.0	7.8	10.7	13.6	11.7	13.7	11.6
F	0.1	0.0	0.0	0.0	0.0	0.4	0.1	3.2	4.9	0.5	1.7
Total	8.1	1.8	9.2	6.6	9.0	8.2	10.8	16.8	16.6	14.2	13.3
Vulcanized	7.5	7.0	10.3	12.2	20.8	26.8	49.3	63.4	78.0	97.7	94.9
Grad Total	263.0	294.6	236.9	332.2	334.7	371.7	564.3	534.1	574.9	622.2	525.0
Mechanical Pulp	0.1	1.8	0.6		9.4	5.2		10.5	29.0	80.0	23.5
Total Pulp & Waste Paper	0.1	5.3	5.7	6.6	27.4	29.7	26.3	30.9	43.5	114.4	124.6

VI-3. Lists of Insects on Bamboo

(by Mr. Dumrong Chaiglom, Royal Forest Department)

VI-3-1. Insects attacking culms and foliage of living bamboos.

Scientific name	Family	Host plats	Types of damage
1. Cyrtotrachelus longipes	Curculionidac	Dendroctonus strictus Gigantoohloa albociliata Thyrsostachys oloveri	Culm borer
2. C. dux	"	Dendrocalamus hamiltonii D. strictus	Culm borer
3. C. birmanicus		Melocanna bambusoides	Culm borer
4. Myocalandra exarata	"	Bambusa polymorpha Dendrocalamus strictus	Culm borer
5. Estigma chinensis	Chrysomelidae	Bambusa arundinacea B. birmanica Cephalostachyum pergracile Dendrocalamus strictus	Culm borer
6. *Calamochrous pentasaris*	*Pyralidae*	*Dendrocalamus strictus*	*Defoliator*
7. Messepha absolutalis	"	Dendrocalamus strictus	"
8. Lethe drypetis	Nymphalidae	Bambusa arundinacea	"
9. L. incana	"	Arundinaria falcata	"
10. Stenadonta radialis	Notodontidae	Dendrocalamus strictus	"
11. Hieroglyphus banian	Acrididae	Dendrocalamus strictus	"
12. Pyrausta bambucivora	Pyralidae	Cephalostachyum pergracile	Leaf roller
13. P. coclesalis	"	Dendrocalamus strictus	"
14. Matapa aria	Hesperidae	Bambusa arundinacea	"
15. Cosmopteryx bambusac	Cosmopterygidae	Many species of bamboo	Leaf miner

VI-3-2. Wood borers of seasoned bamboos.

Scientific name	Family	Host plants
1. Bostrychopsis bengalensis	Bostrychidae	Dendrocalamus strictus
2. B. parallele	"	Bambusa arundinacea
3. Dinoderus brevis	"	Dendrocalamus strictus
4. D. minutus	"	D. strictus D. giganteus D. hamiltonii Gigantochloa nigrociliata Bambusa arundinacea Thyrsostachys spp.
5. Heterobostrychus ocsualis	"	Bambusa arundinacea Dendrocalamus strictus
6. H. hamati pennis	"	Dendrocalamus strictus
7. Lyctoxylon convictor	"	
8. Lyctus africanus	Lyctidae	Bambusa arundinacea Dendrocalamus strictus
9. Minthea rugicollis	"	D. strictus
10. Phonepate stridula	"	D. strictus
11. Rhizopertha dominica	Bostrychidae	D. strictus
12. Sinoxylon anale	"	D. strictus
13. S. crassum	"	D. strictus
14. Trogoxylon auriculatum	"	D. strictus
15. T. spinifrons	"	D. strictus
16. Anamera albo-guttata	Cerambycidae	Bambusa tulda
17. Chlorophorus annualaris	"	Dendrocalamus strictus
18. Merionoda nigriceps	"	D. strictus
19. Pterolophia bambusae	"	Bambusa polymorpha
20. Phloebius alternans	Anthribidae	B. polymorpha