THE EXPERIMENTS

Experiment 1 :

Species and Spacing Trials

Introduction

Selection of suitable bamboo species to be planted and managed for sustainable production is a major concern in bamboo resource management. Five bamboo species commonly known for their utility, *i.e.*, Pai Tong (*Dendrocalamus asper*), Pai Sang (*Dendrocalamus strictus*), Pai See Suk (*Bambusa blumeana*), Pai Liang (*Bambusa* sp.), and Pai Rai (*Gigantachloa albociliata*) were selected for the species and spacing trials. Objective of the study was to find out the most suitable bamboo species and planting space as well as management practices leading to sustainable production of shoots and culms.

Materials and Methods

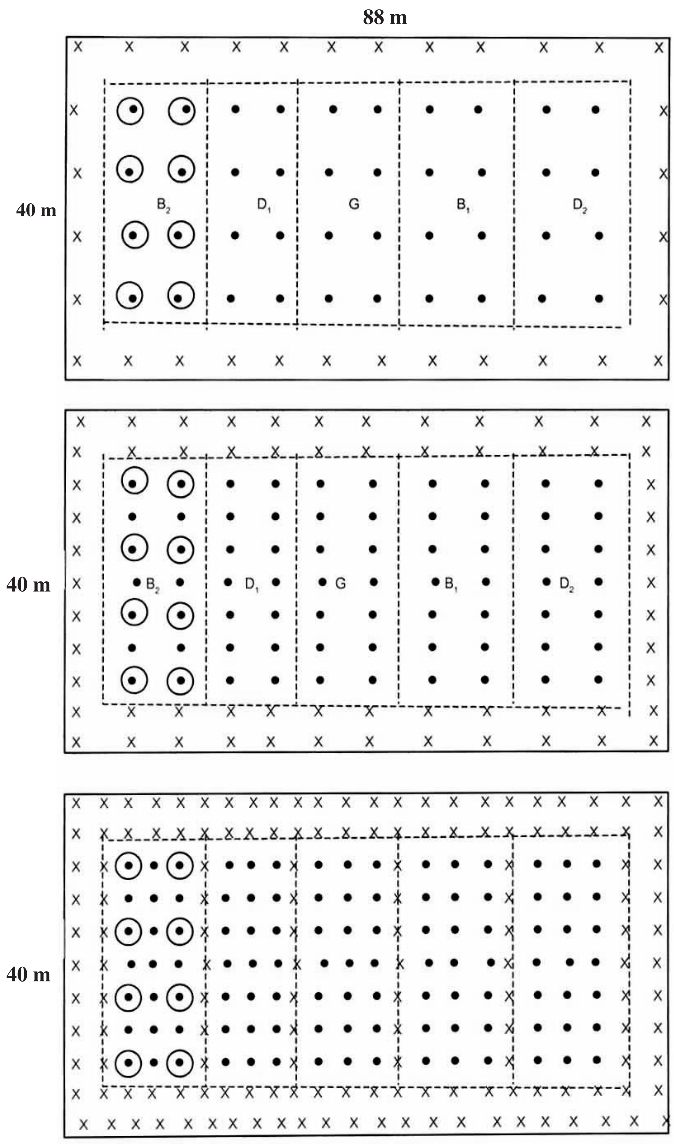
1) Experimental design

The experiment was taken place at Non Wood Forest Products Research Experimental Station in Pakchong district, Nakhon Ratchasima province, approximately 150 km northeast of Bangkok. The selected 5 bamboo species were planted with 3 planting spaces: 4 x 4 m, 4 x 8 m, and 8 x 8 m. The split plot design was employed comprising 3 blocks (replications), each of which included 3 main plots (of 3 planting spaces as treatments) with 5 subplots (bamboo species) each. The layouts of the experiment are presented in Figure 1. The size of the main plots was 40 x 88 m. Thus, the experimental site covered the total area of 31,680 m^2 or 19.8 rai (6.25 rai = 1 ha).

2) Site preparation

The planting site was cleared and ploughed prior to staking according to the spacing required. The planting pits of 30 x 30 x 30 cm were prepared with a farm tractor. The soil dug out from the planting pits was mixed with manure (chicken dung) and compost before putting back approximately half of the planting pit. The remaining mixed soil was used to cover the plant roots when planting was taken place. Chemical fertilizer, 15 –15 –15, was added to the mixed soil to improve fertility as well as to induce an early growth. An insecticide, such as carbofuran, was applied to protect bamboo from termite.

Split plot design : 3 main plots (spacing); 5 subplots (species)
Spacing : 4 x 4m, 4 x 8m, 8 x 8 m.
Bamboo species : *Dendrocalamus asper*, *D. strictus, Bambusa blumeana, Bambusa* sp, *Gigantochloa albociliata*
(D_1, D_2, B_1, B_2, G : subplot 1 2 3 4 5)



Main plot size = 40 x 88 m^2
Block size = 120 x 88 m^2
Total area = 19.8 rai

Plot 1 : spacing 8 x 8 m
Number : 72 clums/plot

Plot 2 : spacing 4 x 8 m
Number : 132 clumps/plot

Plot 3 : spacing 4x4 m
Number :253 clumps/plot

Total :457 clumps/block

Total :1,371 clumps/3 block

Total :274 clumps/species

Boundary clumps : 726

Block I – Block III
x border clump • clumps within plot for data collection ⊙ data-collection clumps

Figure 1. Layout of the experiment.

3) Planting

A total of 336 seedlings/cuttings of each species were planted soonest after the beginning of rainy season when soil moisture was suitable, *i.e.*, after an accumulative rainfall of 200 –300 mm (in July 2001). Watering was needed to help improve the survival and early growth. Two months after planting, chemical fertilizer (20-30 g of 15-15-15 fertilizer) and 1 kg of manure (chicken dung) were supplied to each bamboo plant.

4) Maintenance of the experiment

Maintenance was very important during the early period. During the first year, 3-4 times of spot weeding (weeding in the radius of 50-70 cm around the bamboo plant) were practiced, as well as 2 times of weeding for the whole area and few times of fertilizer and manure application.

5) Data collection

The survival percentage of bamboo in each subplot, number and quality of shoots in each subplot were recorded. Moreover, girth, height, and number of culms of 8 clumps in each subplot were recorded after the end of year 2. When the bamboo plants reached a production stage, the data on the number and quality of shoots, the number of culms in each clump, culm girth and height (length) were collected.

6) Data analysis

The Genstat 5 Release 3.2 (PC/Windows NT) application was employed in data analysis.

Results

1) Survival rate

The highest survival rate was found in Pai See Suk (*B. blumeana*), *viz.* 100%, the others being 93% in Pai Rai (*G. albociliata*), 74.9% in Pai Sang (*D. strictus*), 43.8% in Pai Tong (*D. asper*), and 21% in Pai Liang (*Bambusa* sp.). The results of the study are presented in Tables 1 and 2 and Figure 2 which can be concluded as follows.

a) The survival percentage was significantly different among bamboo species, but not among the planting spaces and the interactions (Table 1).

b) The performance of 5 bamboo species in terms of survival percentage under 3 different planting spaces was not significantly different, the average survival percentage being 68.6%, 66.7%, and 64.3% in case of 8 x 8 m, 8 x 4 m, and 4 x 4 m spacing, respectively (Table 2).

c) The results in Table 2 indicate that Pai See Suk, Pai Rai, and Pai Sang were suitable for reforestation. The survival rate of Pai Tong was very much lower than those of the farmers' plantations since the experiment was taken place in the area without irrigation. Thus, Pai Tong was not suitable for reforestation in dry areas.

Table 1. Results of ANOVA for survival rates

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	1397.5	698.7	1.96	
Rep. x Spacing					
Spacing	2	141.9	71.0	0.20	0.827
Residual	4	1423.0	355.7	1.01	
Rep. x Spacing x Species					
Species	4	40347.0	10086.7	28.60	<.001*
Spacing x Species	8	1037.6	129.7	0.37	0.926
Residual	21 (3)	7405.3	352.6		
Total	41(3)	41870.8			

* : non-significant difference at 0.05 level
(m.v.) : degree of freedom of missing value

Table 2. Survival percentage of bamboo planted in different spacing

Spacing	Bamboo species					Mean
	Bambusa sp.	*D. asper*	*G. albociliata*	*B. blumeana*	*D. strictus*	
8 x 8	22.4	41.7	91.7	100.0	87.5	68.6
8 x 4	23.8	40.5	100.0	100.0	69.0	66.7
4 x 4	16.7	49.2	87.3	100.0	68.3	64.3
Mean	21.0	43.8	93.0	100.0	74.9	65.8

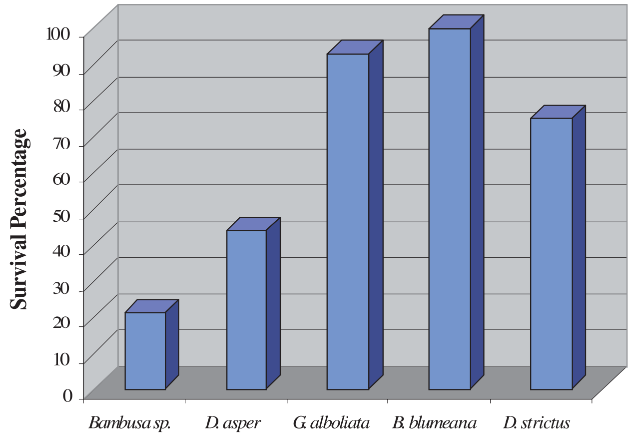


Figure 2. Survival percentage of bamboo.

2) Optimum spacing

The data on GBH, height (length), and number of culms per clump were recorded and used to calculate the volume with the following formula.

Simulated volume	=	A x H x N
A	=	basal area of culm
H	=	height (or length) of clump
N	=	number of culms

The results showed the significant difference in culm volume among bamboo species and interactions with the spacing. However, there was a non-significant difference with the spacing in this experiment. The overall results of the study can be summarized as follows.

a) According to results of ANOVA presented in Table 3, the significant difference in volume was found among species and interactions of species and spacing, but not spacing.

b) The significant differences in the production due to spacing indicated that each species must be planted with proper spacing (Table 3).

c) The results presented in Table 4 showed the proper spacing for each bamboo species in terms of volume production, *i.e.*, 4 x 8 m for Pai Liang (*Bambusa* sp.), Pai See Suk (*B. blumeana*), and Pai Sang (*D. strictus*), 8 x 8 m for Pai Tong (*D. asper*), and 4 x 4 m for Pai Rai (*G. albociliata*).

d) Pai See Suk (*B. blumeana*) developed from culm cuttings is the best species as far as survival and volume production are concerned, while Pai Rai (*G. albocialiata*) and Pai Sang (*D. strictus*) grown from seedlings and Pai Tong *(D. asper)* have lower volume production. Pai Liang *(Bambusa sp.)* has poor performance with low survival rate, low volume production, and flowering (Table 4 and Figure 3).

e) The results presented in Table 4 and Figure 4 show that the volume of the clumps under different spacing are different despite non-significant difference shown in Table 3. The results indicate that 4 x 8 m is the most suitable spacing.

Table 3. Results of ANOVA for the volume of bamboo

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	84746	42373	0.35	
Rep. x Spacing					
Spacing	2	537018	268509	2.19	0.228
Residual	4	490109	122527	4.70	
Rep. x Spacing x Species					
Species	4	1916688	479172	18.37	<.001*
Spacing x Species	5(3)	1151214	230243	8.83	0.006*
Residual	7(17)	182620	26089		
Total	24(20)	1102811			

* : non-significant difference at 0.05 level
(m.v.) : degree of freedom of missing value

Table 4. Volume of bamboo under different spacing

Spacing	Bamboo species					Mean
	Bambusa sp.	*D. asper*	*G. albociliata*	*B. blumeana*	*D. strictus*	
8 x 8	-210	504	273	655	341	313
8 x 4	600	235	647	917	472	574
4 x 4	244	248	784	834	349	492
Mean	211	329	568	802	387	460

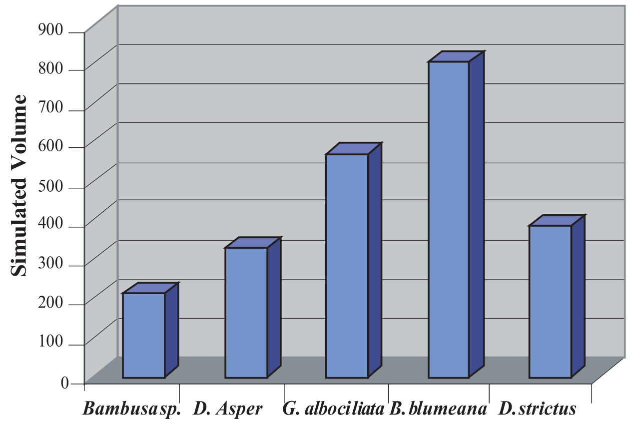


Figure 3. Volume of bamboo by species.

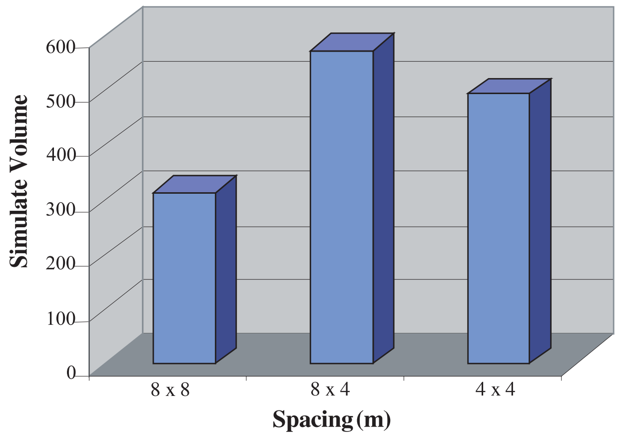


Figure 4. Volume of bamboo by spacing.

Experiment 2:

The Effects of Culm Harvesting on the Productivity

Introduction

The major concern in bamboo resource management is the impacts of culm harvesting on the productivity. A clump of sympodial bamboo composes of culms of different ages ranging from young shoots to young and old culms. Harvesting of culms will affect the production in the proceeding years. This study aims to investigate the effects of harvesting of the culms of different ages on productivity of the stands of Pai Sang (*Dendrocalamus strictus*), Pai Rai (*Gigantochloa albociliata*), and Pai See Suk (*Bambusa blumeana*).

Materials and Methods

1) Experimental design

The experimental design was Randomized Complete Block Design (RCBD). Natural stands of 2 bamboo species, Pai Sang (*D. strictus*) and Pai Rai (*G. albociliata*), in Mae-Mae village, Chiangmai province were selected for harvesting experiment under 4 treatments as follows.

Treatment 1 : Clear cutting (all culms were harvested)

Treatment 2 : Cutting of all culms older than 1year

Treatment 3 : Cutting of all culms older than 2 years

Treatment 4 : Cutting of all culms older than 3 years

There were 3 blocks (replications) of 12 clumps of each species. The block was divided into 4 plots (treatments) of 3 clumps each as shown in Figure 5.

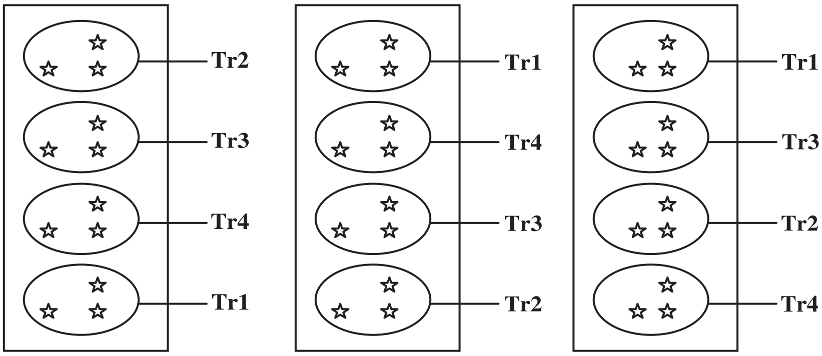


Figure 5. Layout of the experiment.

The experiment for Pai See Suk (*B. blumeana*) was taken place at the plantation of Non Wood Forest Products Research Experimental Station in Pakchong district, Nakhon Ratchasima province. Since there were a limit number of bamboo clumps in the area, the samples included only 12 clumps which were divided into 4 groups of 3 clumps per treatment with 4 harvesting schemes as in case of other 2 species.

The harvesting in Mae Mae village, Chiangmai province was taken place in December and that in Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima province in January.

After first year of the experiment, the data were collected again in the following year and the treatment was changed to:

Treatment 1 : Harvesting of all 1 year old culms;

Treatment 2 : Harvesting of 1 and 2 years old culms;

Treatment 3 : Harvesting of 1, 2, and 3 years old culms; and

Treatment 4 : Harvesting of 1, 2, 3, and 4 years old culms

2) Data collection and data analysis

The data on the number and size (culm girth and height/length) of harvested and remained culms were recorded at the end of growing season (rainy season). Genstat 5 Release 3.2 (PC/Windows NT) application was employed in data analysis.

Results

1) Pai Sang (Dendrocalamus strictus)

Table 5 presents the results of ANOVA for culm production of Pai Sang. There was a significant difference in culm production among the clumps of different culm ages. Higher production in terms of the number of new culms was found in the clumps of higher age class (*cf.* Table 6 and Figure 6). Thus, only culms older than 3 years should be harvested. This is relevant to the practice of the local people who usually harvest the culms older than 3 years for their uses.

Table 5. Results of ANOVA for culm production of Pai Sang

Source of variation	df	SS	MS	VR	F
Replication	2	6.724	3.362	0.89	
Age class	3	59.136	19.712	5.20	0.042*
Residual	6	22.739	3.790		
Total	11	88.599			

* Significant at 0.05 level

Table 6. Average culm production of Pai Sang

Clump age class	Number of new culms
1 = 0 year	2.44
2 = 0, 1 year	4.00
3 = 0, 1, 2 years	6.11
4 = 0, 1, 2, 3 years	8.33

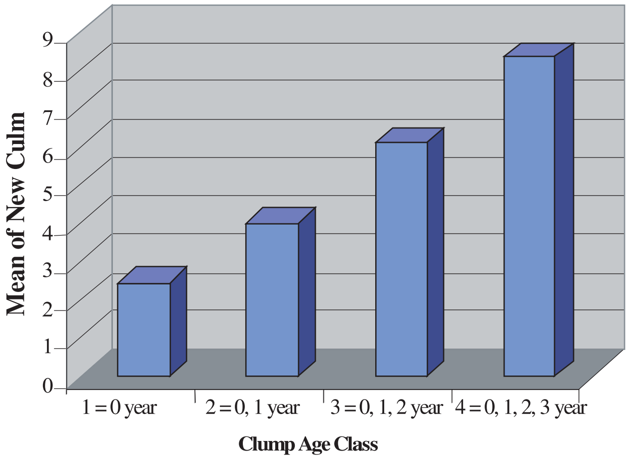


Figure 6. Average culm production of Pai Sang.

2) Pai Rai (Gigantochloa albociliata)

The results of ANOVA showed a non-significant difference among Pai Rai clumps of different culm ages (Table 7). The number of new culms of Pai Rai was found to be opposite to the case of Pai Sang, *i.e.*, more new culms were produced from the clumps of younger culms (Table 8 and Figure 7). Therefore, the culms younger than 2 years should be harvested so as to maintain high productivity of Pai Rai. This is also relevant to local practice where the people harvest young culms of Pai Rai for bamboo weaving and handicrafts.

Table 7. Results of ANOVA for culm production of Pai Rai

Source of variation	df	SS	MS	VR	F
Replication	2	0.898	0.449	0.24	
Age class	3	24.064	8.021	4.29	0.061
Residual	6	11.230	1.872		
Total	11	36.191			

Table 8. Average culm production of Pai Rai

Clump age class	Mean of new culm
1 = 0year	8.33
2 = 0, 1 year	7.89
3 = 0, 1, 2 years	7.11
4 = 0, 1, 2, 3 years	4.67

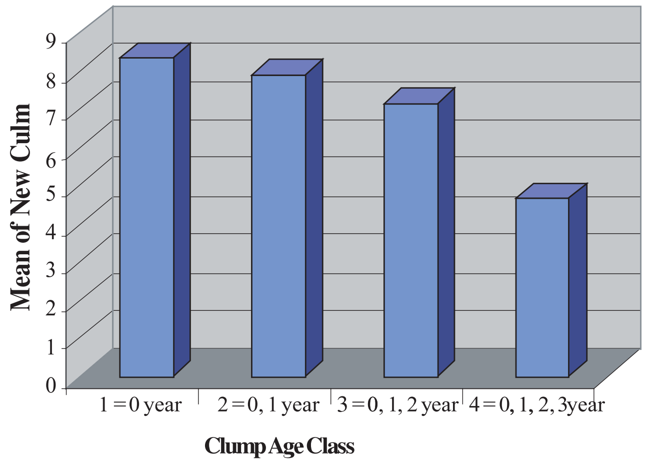


Figure 7. Average culm production of Pai Rai.

3) Pai See Suk (Bambusa blumeana)

The parameters taken into statistical analysis were culm production, culm girth, and culm length (or culm height) from the first and the second experiments. The significant difference was found only in culm production of the first experiment (Tables 9 and 11). In both experiments, more new culms were found in the clumps of higher age classes (Tables 10 and 12).

Table 9. Results of ANOVA for culm production of Pai See Suk (first experiment)

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	26.865	13.433	7.34	
Age class	3	51.118	17.039	9.31	0.017*
Residual	5 (1)	9.153	1.831		
Total	10 (1)	86.545			

* : non-significant difference at 0.05 level
(m.v.) : degree of freedom of missing value

Table 10. Average culm production of Pai See Suk (first experiment)

Clump age class	Number of new culms
1 = 0 year	7.94
2 = 0, 1 year	3.67
3 = 0, 1, 2 year	5.67
4 = 0, 1, 2, 3 year	9.00

Table 11. Results of ANOVA for culm production of Pai See Suk (second experiment)

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	51.68	25.84	1.33	
Age Class	3	225.22	75.07	3.86	0.090
Residual	5 (1)	97.28	19.46		
Total	10 (1)	334.18			

(m.v.) : degree of freedom of missing value

Table 12. Average culm production of Pai See Suk (second experiment)

Clump age class	Number of new culms
1 = 1 year	6.2
2 = 1, 2 years	6.7
3 = 1, 2, 3 years	9.0
4 = 1, 2, 3, 4 years	17.0

The results of ANOVA presented in Tables 13 and 15 revealed non-significant difference in the girth of culms of Pai See Suk in both experiments. Larger-sized culms were found in the clumps of higher age classes (Tables 14 and 16).

Table 13. Results of ANOVA for culm girth of Pai See Suk (first experiment)

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	142.12	71.06	2.19	
Age class	3	264.20	88.07	2.71	0.155
Residual	5 (1)	162.61	32.52		
Total	10 (1)	476.18			

(m.v.) : degree of freedom of missing value

Table 14. Average culm girth of Pai See Suk (first experiment)

Clump Age Class	Average culm girth
1 = 0 year	12.9
2 = 0, 1 year	18.3
3 = 0, 1, 2 years	24.3
4 = 0, 1, 2, 3 years	24.0

Table 15. Results of ANOVA for culm girth of Pai See Suk (second experiment)

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	26.79	13.39	1.22	
Age class	3	55.73	18.58	1.70	0.282
Residual	5 (1)	54.71	10.94		
Total	10 (1)	112.18			

(m.v.) : degree of freedom of missing value

Table 16. Average culm girth of Pai See Suk (second experiment)

Clump Age Class	Average culm girth
1 = 0 year	17.17
2 = 0, 1 year	21.33
3 = 0, 1, 2 years	19.67
4 = 0, 1, 2, 3 years	23.00

There was a non-significant difference in culm length of Pai See Suk in both experiments (Tables 17 and 19). However, it can be noticed that the culms in the second experiment were little longer than those in the first one (Tables 18 and 20).

Table 17. Results of ANOVA for culm length of Pai See Suk (first experiment)

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	7.125	3.562	2.31	
Age class	3	3.229	1.076	0.70	0.592
Residual	5 (1)	7.708	1.542		
Total	10 (1)	17.636			

(m.v.) : degree of freedom of missing value

Table 18. Average culm length of Pai See Suk (first experiment)

Clump Age Class	Average culm girth
1 = 0 year	27.50
2 = 0, 1 year	26.33
3 = 0, 1, 2 years	27.00
4 = 0, 1, 2, 3 years	27.67

Table 19. Results of ANOVA for culm length of Pai See Suk (second experiment)

Source of variation	df (m.v.)	SS	MS	VR	F
Replication	2	6.50	3.25	0.07	
Age class	3	254.90	84.97	1.94	0.241
Residual	5 (1)	218.83	43.77		
Total	10 (1)	414.73			

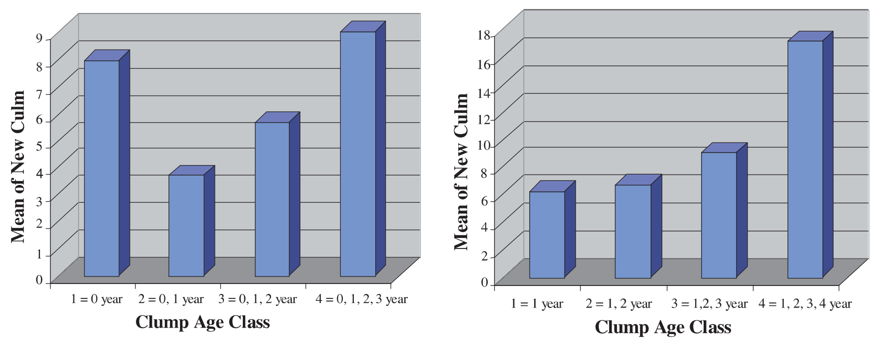
(m.v.) : degree of freedom of missing value

Table 20. Average culm length of Pai See Suk (second experiment)

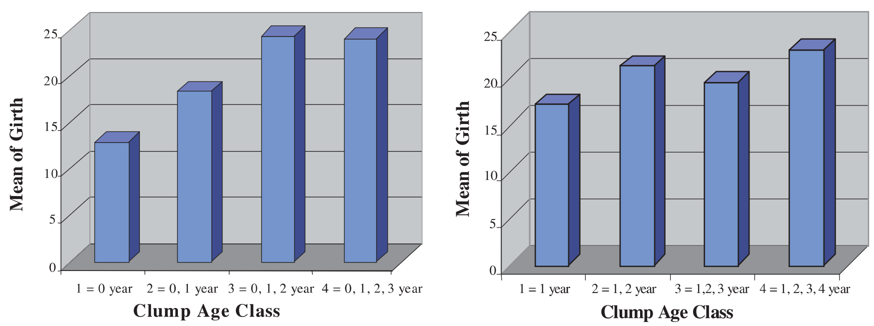
Clump Age Class	Average culm girth
1 = 0 year	28.0
2 = 0, 1 year	34.7
3 = 0, 1, 2 years	35.3
4 = 0, 1, 2, 3 years	41.0

Figure 8 illustrates the results from 2 experiments in terms of culm production, culm girth, and culm length.

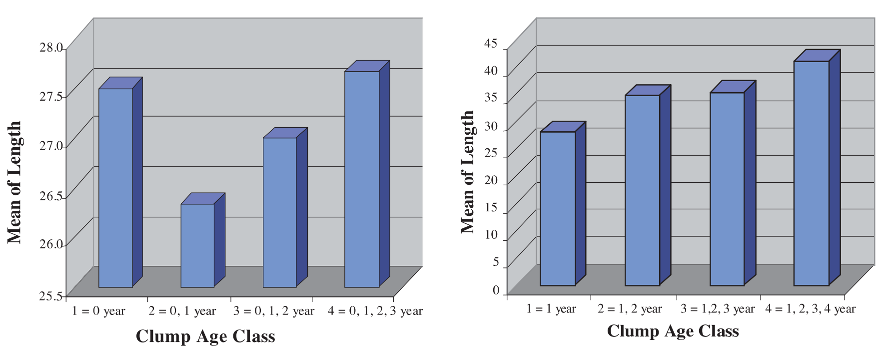
First Experiment **Second Experiment**



Number of new culms



Average culm girth



Average culm length

Average culm length

First Experiment:		**Second Experiment:**	
AGE 1 = 0 year	AGE 2 = 1 year	AGE 1 = 1 year	AGE 2 = 1, 2 years
AGE 3 = 1, 2 years	AGE 4 = 1, 2, 3 years	AGE 3 = 1, 2, 3 years	AGE 4 = 1, 2, 3, 4 years

Figure 8. Culm production, culm girth, and culm length of Pai See Suk.

Experiment 3 :
Management Trials for Shoot and Culm Production

Introduction

Bamboo shoots are very important local food supply and commercial products as well. The shoots of various species are consumed by the people of all income levels, particularly in southeast and east Asia. They are harvested from natural bamboo stands as well as from bamboo plantations. Rural people in Thailand harvest bamboo shoots from natural forest during rainy season for their household consumption and for an additional income. Culms are harvested and used as building material and various kinds of handicrafts which generate a substantial income in rural community. Some particular species are raised as commercial plantation from which shoots and culms are harvested for different purposes. Suitable methods and intensity of shoot and culm harvesting are the essential issues in sustainable management of bamboo forests and plantations. The methods and intensity of shoot harvesting will have the impacts on shoot and culm production. The objective of the experiment is to study the effect of clump size for a particular bamboo species on shoot production is the prime concern of this experiment.

Materials and Methods

This study was taken place at Pakchong district in Nakhon Ratchasima province. Pai Tong (*Dendrocalamus asper*), the most common species for commercial shoot production, was planted with 4 x 8 m spacing in 3 blocks of 9 clumps each (Figure 9). In each block, a row of 3 clumps was subject particular treatment. There were 3 treatments under which all shoots were harvested with different number of shoots remained in the clump as follows.

Treatment 1 : 3 shoots;

Treatment 2 : 6 shoots; and

Treatment 3 : 9 shoots.

It is important that the position or spacing of the shoots remained in each clump be arranged to avoid the congestion of new shoots and culms. Under this experiment, all culms older than 2 years will be harvested annually. The situation of the experiment can be summarized as follows.

Treatment	Number of culms in the clump less than 1 year old	Number of culms in the clump 1 to 2 years old	Clump size	Yearly harvest (culms/clump)
Treatment 1	3	3	6	3
Treatment 2	6	6	12	6
Treatment 3	9	9	18	9

With completely randomized block design, the layout of the experiment is illustrated in Figure 9.

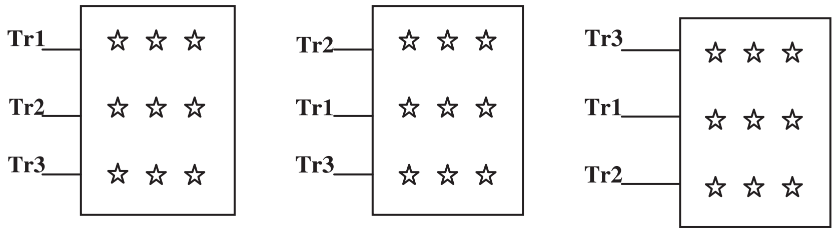


Figure 9. Layout of the experiment.

Each block covers an area of 32 x 16 m or 512 m^2, the total area of the experiment being 1,536 m^2 or approximately 1 rai. It is expected that the first harvest can be taken place when the bamboo plants are older than 2 years. The number and weight of shoots harvested will then be recorded for further statistical analysis.

Results

Since the bamboo plants are only 2 years old now, the first harvest can be started and the data collected during the next rainy season. The experiment must be extended for some years before the conclusion can be made.

Experiment 4 :
Trials on Bamboo in Agroforestry System

Introduction

To improve the sustainable production of bamboo for rural development, agroforestry is one of the alternatives to increase the biological diversity and reduce the adverse effects of land uses. Development of agroforestry systems for producing more commodities from the same piece of land deem to be in need in the tropical zone for more efficient production.

The incorporation of bamboo in the agroforestry system will be very beneficial as bamboo can generate quick annual returns with low investment. The bamboo production process is simple and the products can be used as food and raw material for a variety of products. Bamboo can play the role for both protection and production components at the same time and easy to manage for sustainable production. The success in using bamboo in the agroforestry systems will contribute a great deal to the well-being of the people in rural areas as well as to the economy of the country.

The objective of this study is to investigate the potentials of tree and crop species that can be grown together with bamboo in agroforestry systems.

Materials and Methods

The studies were taken place at 2 locations: Mae Mae village in Chiangmai province and NFPRC in Nakhon Ratchasima. Following are bamboo species and tree crops to be included in the trials on agroforestry systems.

Bamboo : Pai Sang (*Dendrocalamus strictus*), Pai See Suk (*Bambusa blumeana*), Pai Liang (*Bambusa* sp.), Pai Rai (*Gigantochloa albociliata*), Pai Tong (*Dendrocalamus asper*)

Trees : *Cedrela toona, Alstonia scholaris, Acacia auriculaeformis, Cassia siamea, Azadirachta indica, Ficus* sp., *Swietinia macrophylla, Leucaena* sp., *Hopea odorata, Dipterocarpus alatus, Pterocarpus macrocarpus, Tectona grandis*

Others : *Anona squamosa, Eugenia* sp., *Cinnamomum* sp.

Seedlings/cuttings of each bamboo species were planted with 8 x 8 m spacing in an area of 8 rai, the total area of experiment being 40 rai in each location. Seedlings of tree crops were planted between the rows of bamboo. The annual and perennial crops, *i.e.*, spices, vegetables were also planted under bamboo and trees with an inclusion of tea in Mae Mae village.

Results

1) Agroforestry system at Mae-Mae village

The results presented in Table 21 indicate that Pai See Suk (*Bambusa blumeana*) and Pai Sang (*Dendrocalamus strictus*) are the most suitable bamboo species to be planted in agroforestry system as far as survival rate, number of culms, and culm girth are concerned. Pai Liang (*Bambusa* sp.)

and Pai Rai (*Gigantochloa albociliata*) have lower survival rate. This means that intensive management is needed if these 2 species are to be included in agroforestry system. The data on Pai Tong (*Dendrocalamus asper*) are not presented in Table 21 due to its very poor performance, *i.e.*, very low survival rate. This also confirms the difficulty in planting this bamboo species in the upper northern part of Thailand.

Table 21. Survival rate, number of culms, and growth of bamboo at Mae Mae village

Species	Survival (%)	Number of culms	Girth (cm)	Height (m)
Bambusa sp.	82.50	2.18	5.561	2.18
Gigantochloa albociliata	75.00	2.97	2.933	1.45
Bambusa blumeana	100.00	2.28	2.963	1.19
Dendrocalamus strictus	100.00	3.28	3.075	2.01

2) Agroforestry system at NFPRC

Table 22 presents the results of the experiment at Nakhon Ratchasima Forest Product Research Center (NFPRC) in Nakhon Ratchasima. Pai See Suk showed 100% survival rate compared with 96.67% in case of Pai Rai and 86.67% of Pai Sang. Very low survival rate was found in case of Pai Tong due to poor site suitability, while many clumps of Pai Liang died because of flowering. It can be concluded that Pai See Suk, Pai Rai, and Pai Sang are suitable bamboo species for reforestation in Nakhon Ratchasima, selection of species being dependent on purpose of planting, utilization, and market.

Table 22. Survival rate, number of culm, and growth of bamboo at Nakhon Ratchasima Forest Product Research Center

Species	Survival (%)	Number of culms	GBH (cm)	Height (m)
Bambusa sp.	26.67	10.37	16.50	2.41
Dendrocalamus asper	20.00	7.50	15.50	2.97
Gigantochloa albociliata	96.67	30.00	9.45	1.81
Bambusa blumeana	100.00	14.33	21.00	3.60
Dendrocalamus strictus	86.67	30.31	7.73	3.42

Table 23 presents the survival rate and growth of 6 tree species intercropped with bamboo in agroforestry plots (see also Figure 10). Among

6 tree species, *Acacia auriculaeformis* and *Swietinia macrophylla* can be regarded as the most suitable tree species as far as survival rate and growth are concerned, followed by *Azadirachta indica*, *Cedrela toona*, *Anona squamosa*, and *Dipterocarpus alatus*. However, *Acacia auriculaeformis* may not be in good combination with bamboo because of its branchiness and rapid and widespread natural regeneration. Moreover, *Anona squamosa* is a light demanding fruit-bearing species, shading by bamboo will certainly affect the fruit yield. *Dipterocarpus alatus* has very poor growth performance and low survival rate. Thus, *Swietinia macrophylla*, *Azadirachta indica*, and *Cedrela toona* are more suitable to be intercropped with bamboo.

Table 23. Survival and growth of tree crops in agroforestry plots at Nakhon Ratchasima Forest Product Research Center

Species	Survival (%)	GBH (cm)	Height (cm)
Acacia auriculaeformis	93.83	21.67	2.90
Swietinia macrophylla	93.75	24.30	2.87
Azadirachta indica	84.38	13.96	1.75
Cedrela toona	68.75	12.05	1.70
Anona squamosa	56.25	5.56	1.41
Dipterocarpus alatus	9.38	6.33	0.87

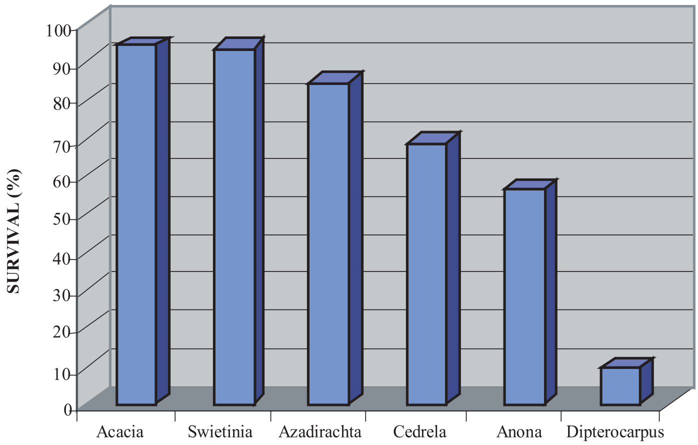


Figure 10. Survival of tree crops in agroforestry plots at NFPRC

CONCLUSIONS AND RECOMMENDATIONS

Pai See Suk (*Bambusa blumeana*) showed highest survival and volume production followed by Pai Rai (*Gigantochloa albociliata*) and Pai Sang (*Dendrocalamus strictus*). This means that Pai See Suk is the most suitable bamboo species for reforestation, while Pai Tong (*Dendrocalamus asper*) has the lowest potential for reforestation in dry areas despite its higher potential under intensive management in the areas with good supply of water.

Pai Liang (*Bambusa* sp.) showed the lowest survival rate due to gregarious flowering of some individual clumps. There should be a repeat of experiment with new planting stocks to ensure that a concrete solution can be drawn for this bamboo species.

The 4 x 8 m spacing is suitable for planting Pai Liang, Pai See Suk, and Pai Sang, while 8 x 8 m is for Pai Tong and 4 x 4 m for Pai Rai, as far as the productivity is concerned.

Harvesting of all culms of 3 years of age and older is the most suitable management measures for Pai See Suk and Pai Sang, whereas removal of 1- to 3-year-old culms is for Pai Rai. These management practices comply with the knowledge of the local people.

It is too early to draw a conclusion from the study on management for shoot and culm production, neither from that on bamboo in agroforestry systems. Further observations should be continued for some years before the conclusions can be made.

ACKNOWLEDGEMENT

We would like to extend our heartfelt gratitude to the International Tropical Timber Organization (ITTO) for providing financial support to the Royal Forest Department (RFD) to conduct this experiment. Special thanks are given to Mrs. Wanida Subansenee, Project Leader, for her hard work and good leadership, as well as to Mr.Kovit Sombun for his great contribution as a management consultant and Dr. Vitoon Luangviriyasaeng of Department of National Park, Wildlife and Plant Resources for his kind efforts for data analysis. We are also grateful to all project members for their assistance and cooperation during the entire course of the study.

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APPENDIX

Bamboo Plantation and Management

Five Economics Bamboo Species

Pai See Suk Culm Cuttings

Pai See Suk
(*Bambusa blumeana*)

Pai Liang
(*Bambusa* sp.)

Pai Liang Rhizome Cuttings

Pai Tong (*Dendrocalamus asper*)

Pai Tong Branch Cuttings

Pai Sang Seedlings

Pai Sang
(*Dendrocalamus strictus*)

Pai Rai
(Gigantachloa albociliata)

Pai Rai Seedlings

Demonstration Plot
Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima Province


Experimental plot without leveling


Site preparation by farm tractor


Transplant


Chicken dung manure


1-year-old plantation


1.5-year-old plantation


Effects of culm age on productivity


Flowering of Pai Liang

Demonstration Plot

Mae Mae Community Forest, Chiangmai Province

Manual transport of seedling

Bamboo seedlings damaged by cattle

Insect Attack

2-year-old plantation

A Case Study

WOMEN PARTICIPATION IN THE PROJECT SITE MAE MAE COMMUNITY FOREST, CHIANGMAI PROVINCE

Wanida Subansenee

Royal Forest Department, Chatuchak, Bangkok 10900

The project objectives, in consistent with article 1 of ITTO 1994, are to promote and support research and development of forest management, efficiency of wood utilization, and capacity to conserve and enhance non-wood forest products (NWFPs) value in timber producing tropical forest. This has peripheral beneficial effects on the attainment of the other project listed in ITTO since the project promotes the collection, processing, utilization, and marketing of NWFPs on a sustainable basis. Therefore, it has become an integral part of sustainable management in Thailand. Also, the project supports Thai National policies, especially for Thai National Economics and Social Development Plan VIII, in that it helps generate income in urban and rural areas from plantation, farm, community, forest, and tree farming programs which were launched in 1996.

Project Rationale and Background

The Royal Forest Department (RFD) and ITTO established the Pre Project PPD 4/98 Rev.1 (I) Potential Non Wood Forest Products in Thailand. The objective is to identify forest product potential by conducting a survey with local people, technicians, and government agencies from 4 community forests selected as representatives from different parts of Thailand, North/Northeast/South/West. The results can be summarized as follows.

- Bamboo can be utilized for value-added products such as furniture parts, charcoal, and weaving with appropriate technology.
- Bamboo shoot is a staple food and can be utilized for value-added products as well. A small scale industry in China is a good example for Thailand.

Consequently, RFD established the project PD 56/99 Rev, 1 (I): Promotion of Utilization of Bamboo from Sustainable Sources in Thailand.

A part of the project is the activity to establish women organization and a small bamboo co-operatives in Mae-Mae community forest in order to support bamboo cottage industry which was established in Mae-Mae community forest under the help of project.

Project Implementation

The Project PD 56/99 Rev. 1 (I) Promotion of the Utilization of Bamboo from Sustainable Sources in Thailand was started in October 1, 2000 and completed by September 30, 2004. Two project sites were selected at Mae Mae Community Forest in the north and the Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima, in the northeast. The objectives of the study are to develop and disseminate the knowledge on sustainable management of bamboo and technologies to promote efficient and diversified utilization of bamboo in Thailand in order to contribute to the socio-economic development of rural communities. It is expected that the knowledge gained from the project will also contribute to the conservation of tropical forest resources in Thailand.

Implementation Strategies

***Management* :**

The Project considers that bamboo planting is the key issue in sustainable bamboo resource management. Five economic bamboo species were selected to plant at 2 demonstration sites. The site at Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima province is for the study on planting and harvesting techniques, as well as demonstration plots for training activities. The other site at Mae Mae Community Forest, Chiangmai province serves as a pilot site with the people's participation in bamboo plantation establishment and management.

***Utilization* :**

The research includes the studies on physical and mechanical properties, chemical properties, preservation, dying techniques, processing, charcoal making, etc. The research results will be presented in special technical report.

***Training* :**

The project considers training as an important strategy to disseminate research results to communities and industries. Training courses on bamboo weaving and furniture parts, charcoal making were offered to Mae Mae

Community members, and local communities in Nakhon Ratchsima and Kanchanaburi provinces by the experts from Industrial Promotion Center, Rangsit University, and RFD. The aim is to help local people to understand the appropriate technology for bamboo utilization.

Implementation:

The following organizations have been established in Mae Mae community forest.

- A small scale bamboo industry
- Mae Mae Women's Bamboo Handicrafts Group
- Forest Cooperatives for Sustainable Utilization

Mae Mae Village

The Community Forest at Mae Mae village, Chiangdao district, Chiangmai province is located in the remote area with rather poor accessibility. The village is situated along the narrow gorge surrounded by steep mountains. There are 503 inhabitants, 271 men and 232 women, in 105 households. The local people harvest bamboo to make the basket as a container for vegetables and tea leaves. This labor-intensive bamboo product is priced at only 2-3 Baht per piece.

Social Impact on Women's Roles in Thailand

Thailand has achieved an impressive economic growth and diversification in nearly all sectors. The economic and production structures have increasingly transformed into manufacturing industry excluding agricultural sector. Rural population have still earned their living by farming and also spend their way of life under the agricultural society where the roles of women as a farmer have been overlooked. Women have less opportunities to participate in agricultural development due to social attitudes that women are suitable only for contributing to family farm production and house works. As a result, women have very limit access to training and participating in activities on new farming technology. In 1988, women's farming duties were regarded as household activities, not household economy. By the year 1990, the number of female household heads was 2,384,258 or 20 percent of the total household heads and they became the income earners because they have been left at home with the elderly and the children. The economic pressure drove the men to leave the village for urban employment. Thus, women have to take more responsibilities for the living of the whole family. Thai society feels proud of working women, but at the same time does not exempt from their household chores. Being mothers, wives, income earners and homemakers, therefore, they have eventually been frustrated. This burden creates stress and difficulties for women in fulfilling their roles. There is no exception for the women of Mae Mae village.

A Small Scale Bamboo industry

The Project has been introduced to the villagers with the objective to utilize local sources to increase the community income. The bamboo demonstration plots were established including agroforestry system at Mae Mae community forest followed by the training course on bamboo handicraft, furniture parts, and bamboo charcoal production techniques. After training, the Project helped set up a small-scale cottage industry for bamboo weaving and furniture parts.

Women Organization

The project also provided a basic knowledge in national and global socio-economic issues which helped them to improve their work and increase the decision making ability. (The women group in Mae Mae community forest was initiated in order to increase their bargaining power and to help develop occupational skills and other aspects which enhance the quality of life.) The group was named the Mae Mae Women's Bamboo Handicrafts Group, consisting of 27 members (22 women and 5 men). They elected the group members to work as a chairman and members of the group committee, other duties such as adviser, secretary, accountant, quality controller, saleswoman, etc. being distributed among the group members.

The Project provided USD 500 to the group as the revolving fund to initiate the group's activities and one kiln for drying to improve the quality of the products and enabled them to make the products during rainy season. The Project staff brought the expert from the Department of Industrial Promotion to teach the group how to make a variety of products with more attractive designs. This value-added could help them earning more income from using less raw material. When they could earn more, they would also participate in other social activities as well, for example, they organized the interest group of students in Mae Mae school and taught them how to make bamboo handicrafts to raise fund for the school.

Bamboo Co-operatives

There has already been the Hydro-Power Co-operatives at Mae Mae village. However, the co-operatives have not been active ever since. When the Project (Promotion of the Utilization of Bamboo from Sustainable Sources in Thailand) was introduced to the village, the co-operatives group and the Project members organized a meeting to discuss about future directions of the co-operatives. The meeting decided to widen the objectives and activities and changed the name of Hydro-Power Co-operatives to be registered as the Co-operatives for Sustainable Utilization from the Forest.

Outcome

The outcome and recommendation of the project are as follows.

Women Association : Mae Mae Women's Bamboo Handicraft Group

In Mae Mae community, local people rely on day-to-day income, the majority who harvest tea leaves for an income during the raining season, approximately 7 months a year. The income during the remaining 5 months comes from weaving and selling bamboo baskets. Although bamboo is a resource locally available without any cost to the local people, bamboo baskets are considered low value-added. The Women Association, called Mae Mae Women's Bamboo Handicraft Group, was established aiming to improve bamboo utilization and create long-term occupation for the local people.

The group members were trained to make high value-added products from bamboo, *e.g.* purse, bag. This is beneficial to the community in that they are educated on generating higher income from the local resource, as well as an efficient way of sustainable use of bamboo and skills improvement at the same time.

Since these products are not for local use, the members need to bring the products to the markets, e.g. local (food) market, department stores and shops in Chiangmai, exhibitions and fairs. Even though other products have higher market potentials, skill development is neglected by local people since they prefer to make a simple product like bamboo basket on the basis of "made-to-order". With location disadvantage of Mae Mae village, labor and transportation are the serious problems as far as large volume of more value-added products is concerned.

It is strongly recommended that the activities with local communities be continued. It is important that more budgets be provided to start up the pilot business, since the initial fund of USD 500 is for equipment only. Also, the association committee should be appointed to handle all relevant issues, i.e., marketing, supplying, and purchasing system of products from members to ensure theirs stable income.

ANNEX

PROJECT ACTIVITIES

Project Site

The North: *Mae Mae Community Forest, Chiang Mai province.*

The Northeast: *Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima province*

Women Participation

Activities

Study tour

Meeting and Field Visit

Project Steering Committee

Consultant

Study Tour

China :- *The International Training Workshop on Bamboo Handicraft Techniques, Its Tools and Small Machines*

Japan :- *Bamboo Charcoal Technique*

Training Course

Bamboo Furniture Parts and Handicrafts

Bamboo Charcoal Production Technique

Sustainable Management and Utilization of Bamboo

National Bamboo Conference

Bamboo 2004 : *Sustainable Development of Bamboo Resource*

Bamboo Products Development

Bamboo Products Design Contest for Young Generation

Bamboo Products

PROJECT SITE

Mae Mae Community Forest,
Chiang Mai Province

Bamboo Forest Survey

Demonstration Plot

Rural Community Participation on Bamboo Planting and Management

Bamboo Charcoal Kiln Construction

Bamboo House

PROJECT SITE

Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima Province

Demonstration Plot

Nursery

Propagation - grafting

Propagation - culm cutting

Spacing Plot

Agroforestry Plot

Shoot Harvest

Management

TRAINING COURSE

Bamboo Furniture Parts and Handicrafts

Bamboo Charcoal Technique

Sustainable Management and Utilization of Bamboo

WOMEN PARTICIPITATION

Mae-Mae Community Forest, Chiangmai Province

Mae Mae Village

Local Exhibition

Establishment of the Women Group and Co-operatives

Kiln Dryer for Bamboo Handicraft Products

Present Splitting Machines

Skill Development & Products

Study Tour

Visit Bangchaocha Group, Angthong Province

Visit Pabong Group, Chiangmai Province

MEETING AND FIELD VISIT

Project Steering Committee

1st Meeting at Marauy Garden Hotel, Bangkok Province

2nd Meeting at Chiangmai Regional Forest Office

Visit Project Site at Non Wood Forest Products Research Experimental Station, Nakhon Ratchasima Province

◀ Visit Mae Mae Community Forest, Chiangmai Province

Visit the Training Courses ▼

MEETING AND FIELD VISIT

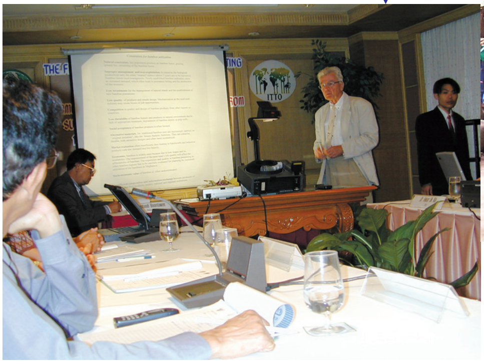
National Consultant

Bamboo Management

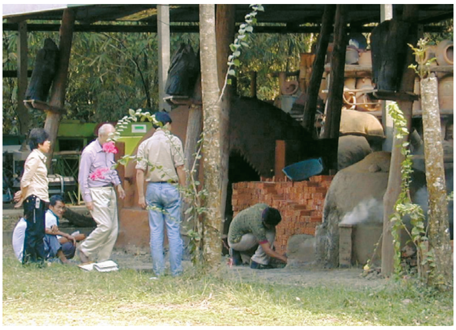
Bamboo Weaving

International Consultant

Bamboo Processing



Bamboo Charcoal



Bamboo Marketing

STUDY TOUR

The International Training Workshop on Bamboo Handicrafts Techniques, Its Tools and Small Machines in China

Visit Bamboo Factory

Mah-jong mat knitting

Bamboo Shoot Factory

STUDY TOUR

Bamboo Charcoal Technique in Japan


Visit Bamboo Plantation at Kamigamo Experimental Forest, KyotoUniversity


Visit Wood research Institute, KyotoUniversity, Uji city


Square Bamboo Making

Bamboo Shoot Production


Carbonizer


Stainless Steel Kiln


Sumiyaki Gama



Bamboo Charcoal Utilization

NATIONAL BAMBOO CONFERENCE

Bamboo 2004: Sustainable Development Of Bamboo Resource

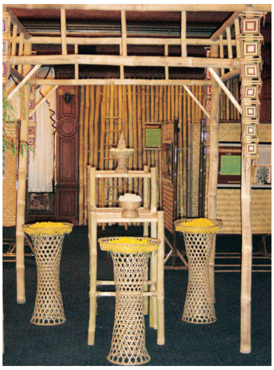
Opening Ceremony

Panel Discussion

Poster Presentation

Group Discussion

Exhibition & Fairs



Study Tour

BAMBOO PRODUCTS DEVELOPMENT

Bamboo Products Design Contest for Young Generation

Presents the awards to the winners

Student explains his product design

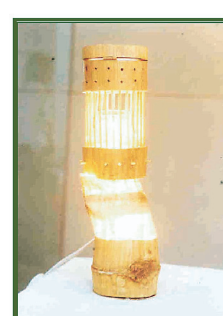
The Outstanding Awards

"Fork and Spoon and Chopstick"

"The Hand-Lace from Bamboo"

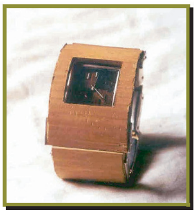
"The Wine Container"

"The Candle Sticks from Bamboo"



"The Lantern and the Aroma"

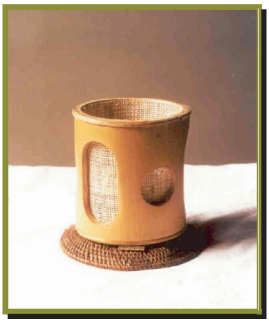
The Creative Awards



"A Bamboo Wrist Watch"

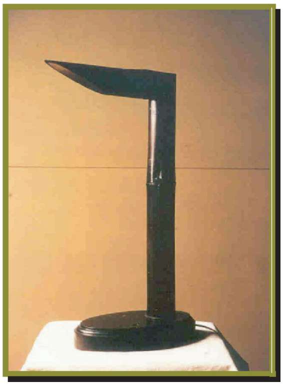
"Tray and Bowl for Japanese Food"

"Bamboo Bottle Opener"



"The Candle Lantern"

"Bamboo Lantern"

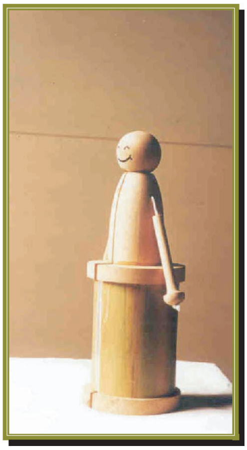


"The Bamboo Lantern"

"The Bamboo Pencil Container"

"A Bamboo Radio"

"The Bamboo Stationery Carrying Box"



"The Bamboo Singing Doll"

Bamboo Products

Project PD 56/99 Rev.1(I)

Promotion of the Utilization of Bamboo from Sustainable Sources in Thailand