Rattan in Thailand

Promotion of Sustainable Utilization of Rattan from Plantations in Thailand

PD 24/00 Rev. 1(I)

Royal Forest Department
and
International Tropical Timber Organization

Rattan in Thailand

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PREFACE

Rattan, is the name for the roughly six hundred species of palms in the tribe Calameae, native to tropical regions of Africa, Asia and Australia. It is superficially similar to bamboo, but distinct in that the stem is solid, rather than hollow, and also needs for some sort of support; while bamboo can grow on its own. It has become symbolic of the importance of non-wood forest product. Generally, rattan is processed into several products to be used as materials in weaving and furniture making. The value of rattan is increasing significantly. However, with the more advantage of rattan utilizing, the problems faced are the over exploitation and diminishing of supply.

In recognition to the importance of rattan, with strong desire to provide necessary information about rattan and situation of rattan in Thailand, the International Tropical Timber Organization (ITTO) had supported the project on "Promotion of Sustainable Utilization of Rattan from Plantation in Thailand" to prepare this guideline to share almost all aspects about rattan in Thailand from past upto present to those who interested in this field.

Special thanks to Dr. Hwan Ok Ma, ITTO Project Manager, for his constant support along the entire project. The strong effort and experiences shared of all project staff to produce this fruitful outcome also deserve special acknowledgment.

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Introduction

Thailand locates at the central part of Indochina Peninsula between the latitudes of 5°37′ N and 20° 27′ N and the longitudes of 97° 22′ E and 105° 37′ E with a total land area of 513,115.02 km^2. The vegetations in Thailand are classified into 7 types including tropical evergreen forest, mixed deciduous forest, dry dipterocarp forest, mangrove forest, pine forest, beach forest, and plantations area. Areas of each type of forest based on the regions are shown in Table 1. A total forest area was 170,110.78 km^2 or about 33.15 % of total land area (Royal Forest Department, 2003).

Rattans are found in peat swamp, evergreen, dry evergreen and mixed deciduous forests at elevations up to 1,000 m above mean sea level (Dransfield, 1985). They are important as commercial and subsistence sources of canes obtaining from their stems. The stems of rattan, after stripping off its sheaths and leaf-sheaths, provide uniquely light, flexible and durable canes as structural materials for furniture industry. In addition to furniture making, split canes and peeled skins are the major raw materials for handicraft and cottage weaving industries for making baskets, mats, bags, hats, fish traps and any other useful products. Rattan skins are also employed as cordage for tying and binding. Rattan products are definitely symbols of the tropical regions. As of its unique characters, rattan world consumption in the mid-19th Century has jumped from the local to international trades without any suitable plans for sustainable resources management. In the 1980s Indonesia, Malaysia, the Philippines and Thailand had become major exporters of rattan and rattan products, while Singapore and Hong Kong, which has no harvestable rattan resources are the major re-exporters.

Table 1 Forest Area by type and Region (RFD, 2002)

ype of Forest	North		North-East		East		Central		South		Total	
	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%	Sq.km.	%
1.Tropical evergreen forest	19,887.60	37.75	7,666.4	14.55	6,190.0	11.75	4,306.8	8.17	14,628.2	27.77	52,679.0	30.97
2.Mixed deciduous forest	63,498.60	72.62	8,351.8	9.55	1,226.0	1.4	14,365.6	16.43	2.7	0.03	87,444.7	51.40
3.Dry dipterocarp forest	9,655.40	51.99	8,185.5	44.08	24.5	0.13	704.1	3.79	0.00	0.00	18,569.5	10.92
4. Mangrove Forest	0.00	0.00	0.00	0.00	233.9	9.53	125.5	5.12	2,093.1	85.83	2,452.5	1.44
5. Pine forest	331.40	71.72	130.7	28.28	0.00	0.00	0.00	0.00	0.00	0.00	462.1	0.27
6. Beach forest	0.00	0.00	0.00	0.00	3.60	2.88	1.60	1.28	119.8	95.84	125.00	0.07
7. Bamboo forest	200.80	13.36	397.30	26.42	156.60	10.41	733.60	48.79	15.10	1.00	1,503.50	0.88
9. Swamp forest	4.90	1.61	0.00	0.00	1.80	0.59	1.40	0.46	295.90	97.33	304.00	0.18
10. Others	2,691.50	40.96	1,795.20	27.32	601.90	9.16	1,223.10	18.62	258.60	3.94	6,570.40	3.86
Total	73,057.32	48.93	21,438.12	14.36	9,892.78	6.63	16,088.58	10.78	28,806.75	19.29	149,283.5	100.00

Source: Royal Forest Department

Origin and geographic distribution

Rattans are mostly present in humid tropical forests especially in forests with high humidity and precipitation. They are spiny climbing palms in the family Palmae. There are approximately 13-14 genera and 600 species of rattan in the world (Dransfield 1979), with the two genera *Calamus* and *Daemonorops* representing the bulk of the species, 370-400 and 115 species respectively (Uhl and Dransfield, 1987 after Dransfield and Manokaran, 1994). The major distribution ranges of rattans are in the Old World tropics and subtropics: in equatorial Africa, the Indian subcontinent, Sri Lanka, the foothills of the Himalayas, southern China through the Malay Archipelago to Australia and the western Pacific as far as Fiji where the greatest diversity of genera and species are found in the western part of Malaysia (Dransfield and Manokaran, 1994). About nine genera are found in South-East Asia; *Calamus, Daemonorops, Korthalsia, Plectocomia, Ceratolobus, Plectocomiopsis, Myrialepis, Calospatha and Bejaudia* (IDRC 1980; Dransfield 1979). The genus *Calamus* is the most diverse genus that contains about 370-400 rattan species (Moore 1973; Dransfield and Manokaran, 1994) and is also the most economically importance. Eight genera of rattans are found in Borneo, 7 in Sumatra, 5 in Java, 4 in the Philippines, 3 in New Guinea and 1 in Fiji (IDRC, 1980). In Thailand, the exact numbers and lists of rattan species have never been thoroughly investigated and confirmed. Smitinand (year not available) and Smitinand (2001) reported of 6 genera, 74 and 70 species respectively, while Vongkaluang (2000) quoted in his report as "an unpublished list by J. Dransfield (pers. Comm.)" accounted for 7 genera, 81 species (synonymous species were counted as one specie). Comparison of the genera and species of rattans in Thailand as listed in the three reports: (1) Smitinand (year not available), (2) Smitinand (2001) and (3) Vongkaluang (2000), is shown in Table 2.

Very little information is available on the eco-geographic distribution of rattans in Thailand and also in other regions. The positive side of this situation

Table 2 List of rattan species recorded in Thailand

No.	Botanical name	Local Thai name (s)	Location	Smitinand, year not available	Smitinand, 2001	Vongkaluang, 2000
	Genus: *Calamus*			**50 species**	**47 species**	**54 species**
1	*C. acanthophyllus* Becc.	Wai Nang	NE, S	✓	✓	✓
2	*C. acanthospathus* Griff.	-	-			✓
3	*C. arborescens* Griff.	Wai Pang, Wai Tanong	S, E	✓	✓	✓
4	*C. aquatilis* Ridley	Wai Hin		✓		
5	*C. axillaris* Becc.	Wai Ta Kha Nam	S	✓	✓	✓
6	*C. balingensis* Furtado	Wai Lue Bae	S	✓	✓	✓
7	*C. blumei* Becc.	Wai Keepung, Wai Hin, Wai Kanun	S, E	✓	✓	✓
8	*C. bousigonii* Becc.	Wai Sae Ma, Wai Hin	S	✓	✓	
9	*C. bousigonii* Becc. var. *bousigonii*	-	-			✓
10	*C. bousigonii* Becc. var. *smittinandii* J. Dransf.	-	-			✓
11	*C. burkillianus* Becc. ex Ridley	Wai Krada, Ro-Tae-Kri-Ya	S		✓	✓
12	*C. caesius* BI.	Wai Takha Thong	S	✓	✓	✓
13	*C. cambojensis* Becc.	Wai Preed	E	✓	✓	

14	*C. castaneus* Griff.	Wai Chark Kao, Wai Chark	S	✓	✓	✓
15	*C. concinnus* Mart.	Wai Nang	S	✓	✓	✓
16	*C. densiflorus* Becc.	Wai Khae Re	S	✓	✓	✓
17	*C. diepenhorstii* Miq.	Wai Chom Kao, Wai Khom	S, N, C	✓	✓	
18	*C. diepenhorstii* Miq. var. *diepenhorstii* Miq.	-	-			✓
19	*C. erectus* Roxb.	Wai Khom, Wai Khae Sian	S	✓	✓	✓
20	*C. erinaceus* (Becc.) Dransfield	Wai Pang Kaa	S	✓	✓	
21	*C. erinaceus* var. erinaceus (Becc.) J. Dransf.	-	-			✓
22	*C. exillis* Griff.	Wai Phra Ram	S		✓	✓
23	*C. flagellus*	-	S	✓		
24	*C. flagellum* Griff.	-	-			✓
25	*C. floribundus* Griff	Wai Nam Khao	NW, N	✓	✓	
26	*C. godefroyi* Becc.	Wai Dao Tuk, Wai Num	NE	✓	✓	✓
27	*C. gracilis* Roxb.	Wai Sambai Toa	C, N	✓	✓	
28	*C. griseus* J. Dransf.	-	-			✓
29	*C. guruba* Ham.	-	NE	✓		
30	*C. guruba* Buch. Ham. ex. Mart.	-	-			✓

31	*C. harmandii* Pierre ex Becc.	-	NE	✓		
32	*C. henryanus* Becc.	-	-			✓
33	*C. insignis* Griff.	Wai Hin, Korte Batu	S	✓	✓	
34	*C. insignis* var. *insignis* Griff.	-	-			✓
35	*C. insignis* var. *longispinosus* J. Dransf.	Wai Hin	S	✓		✓
36	*C. insignis* var. *robustus* (Becc.) J. Drandsf.	-	S	✓		✓
37	*C. javensis* BIume	Wai Lek, Wai sai	S, E	✓	✓	✓
38	*C. kerrii* Becc.	Wai Saikai, Wai Rai, Kor Kae	NW, NE	✓	✓	
39	*C. Kerrianus* Becc.	Wai Phew Bao, Wai Sai Kai	N		✓	
40	*C. laevigatus* var. *laevigatus* Mart.	Wai Khao, Wai Kriya	S		✓	✓
41	*C. largesitus*	-	-	✓		
42	*C. latifolius* Roxb.	Wai Pong	C, N	✓	✓	✓
43	*C. leucotes* Becc.	-	-			✓
44	*C. longisetus* Griff.	Wai Kampuan	S	✓	✓	✓
45	*C. luridus* Becc.	Wai Sai	S	✓	✓	✓
46	*C. manan* Miq.	Wai Khor Dam	S	✓	✓	✓
47	*C. micranthus* BI.	Wai Sai	S	✓	✓	

48	*C. multirameus* Ridley	Wai Khi Kai	S	✓	✓	
49	*C. myrianthus* Becc.	Wai Kaekai, Wai Khom Kaekai	E, S	✓	✓	
50	*C. nambariensis* Becc.	-	-			✓
51	*C. oligostachys* Evans *et al.*	-	-			✓
52	*C. ornatus* BIume	Wai Chang	E, S	✓	✓	
53	*C. ornatus* Blume var. *ornatus*	-	-			✓
54	*C. oxleyanus* Teijsm.&Binn.var. *montanus* Furtado	Wai Dum	S	✓	✓	✓
55	*C. oxleysnus* var. *oxleyanus* Teijsm. & Binn. ex Miq.	-	-			✓
56	*C. palustris* Griff.	Wai Namhaa, Wai Kring	S	✓	✓	✓
57	*C. pandanosmus* Furtado	Wai Horm	S	✓	✓	✓
58	*C. pauciflorus* T.Evans et.al.	Wai Krahing	NE		✓	
59	*C. peregrinus* Furtado	Wai Nguay, Wai Hua Daew	S	✓	✓	✓
60	*C. poilanei* Conrard	-	-			✓
61	*C. rotang* Linn.	Wai Khom	NW, N	✓	✓	
62	*C. rudentum* Roxb.	Wai Kaesean, Wai Yae	NW, S	✓	✓	
63	*C. rudentum* Lour.	-	-			✓

64	*C. scipionum* Lour.	Wai Mai Tao, Wai Kam	S	✓	✓	✓
65	*C. sedens* J. Dransf.	-	-			✓
66	*C. setulosus* J. Dransf.	-	-			✓
67	*C. siamensis* Becc.	-	C, S, NE	✓	✓	✓
68	*C. siamens* var. *malaionus* Furtado	-	S	✓		
69	*C. solitarius* Evans *e.t al.*	-	-			✓
70	*C. speciosissimus* Furtado	Wai Teng	S		✓	✓
71	*C. spectatissimus* Furtado	Wai Krae	S	✓	✓	✓
72	*C. tenuis* Roxb.	Wai Khom, Wai Chumporn, Wai Nam	C, S	✓	✓	✓
73	*C. tetradactulus* Hance	-	-			✓
74	*C. thwaithesii* Becc. var. *canarus* Becc.	Wai Nam Rob	NW	✓	✓	
75	*C. trigrinus* King	Wai Takha	C, S	✓	✓	
76	*C. viminalis* Willd.	Wai Khom Na, Wai Dong	C, NW, S	✓	✓	✓
77	*C. viridispinus* Becc.	Wai Sai	S	✓		
78	*C. viridispinus* Becc. var *viridispinus*	-	-			✓
79	*C. wailing* Pei and Chen	-	-			✓

	Genus: *Ceratolobus*			**0 specie**	**0 specie**	**1 species**
80	*C. subangulatus* (Miq.) Becc.	-	-			✓
	Genus: *Daemonorops*			**14 species**	**14 species**	**15 species**
81	*D. angustifolia* (Griff.) Mart.	Wai Num	S	✓	✓	✓
82	*D. brachystachys* Furtado	Wai KaeKai	S	✓	✓	
83	*D. calicarpus* (Griff.) Mart	Chark Chum, Wai Chum	S	✓	✓	
84	*D. didymophylla* Becc.	Wai Kaeped, Wai Pon Kaeped	S	✓	✓	✓
85	*D. elongatus* BI.	Wai Puan	S	✓	✓	
86	*D. geniculatus* (Griff.) Mart.	Wai Ta No	S	✓	✓	✓
87	*D. grandis* (Griff.) Mart.	Wai Chark	S	✓	✓	✓
88	*D. jenkinsiana* (Griff.) Mart.	-	-			✓
89	*D. kunstleri* Becc.	Wai Kaerei, Wai Nang	S	✓	✓	✓
90	*D. leptopus* (Griff.) Mart.	-	-			✓
91	*D. lewisiana* (Griff.) Mart.	Wai Kheam, Chark Keam	S	✓		✓
92	*D. macrophylla* Becc.	Wai Loe Bae Lek	S		✓	✓
93	*D. melanochaetes* Blume	-	-			✓
94	*D. monticola* (Griff.) Mart.	-	S	✓		✓

95	*D. periacantha* Miq.	Wai Lano	S		✓	
96	*D. propinqua* Becc.	-	-			✓
97	*D. sabut* Becc.	Wai Pon, Wai Pon Khonnon	S	✓	✓	✓
98	*D. schmidtii* Becc.	Wai Soam Khao	E	✓	✓	
99	*D. sepal* Becc.	-	-			✓
100	*D. tabacina* Becc.	Wai Kheam	S	✓	✓	
101	*D. verticillaris* (Griff.) Mart.	Wai Ta Pla	S	✓	✓	✓
	Genus: *Korthalsia*			**3 species**	**4 species**	**5 species**
102	*K. flagellaris* Miq.	-	-		✓	✓
103	*K. laciniosa* **(Griff.) Mart.**	Wai Dao Baiyai	S	✓	✓	✓
104	*K. rigida* BIume	Wai Dao Nuu, Wai Dao Lekk	S	✓	✓	✓
105	*K. rostrata* Blume	-				✓
106	*K. scortechinii* Becc.	Wai Kung	S	✓	✓	✓
	Genus: *Myrialepis*			**1 species**	**1 species**	**1 species**
107	*M. scortechinii* Becc.	Wai Kung	S	✓	✓	✓

	Genus: *Plectocomia*			**5 species**	**2 species**	**3 species**
108	*P. elongata* Mart. ex Blume	Wai Kam Phot, Wai Tao Phro	S		✓	✓
109	*P. griffithii* Becc.	Wai Tong Plong, Watae Madalong	S	✓	✓	
110	*P. kerrana* Becc.	Wai Daeng	W, NE	✓		✓
111	*P. khasiyana*	-	-	✓		
112	*P. macrostachya* Kurz.	Wai Kampod, Wai Taoproh	S	✓		
113	*P. pierreana* Burret	Wai Daeng	E, S	✓		✓
	Genus: *Plectocomiopsis*			**1 species**	**2 species**	**2 species**
114	*P. geminiflorus* (Griff.) Becc.	Wai Kung Numprai	S	✓	✓	✓
115	*P. wrayi* Becc.	-	-		✓	✓

Source: (1) Smitinand, T. year not available. Knowing Rattan. Technical paper. Royal Forest Department. Bangkok. Thailand. 9 p.
(2) Smitnand, 2001 (3) Vongkaluang, 2000

offers great scopes for further study. Ninety five percent of the rattan species so far known are present in South and South-East Asia. The centre of distribution of rattans is in South-East Asia such as Indonesia, Malaysia, Philippines, and Thailand which are the most abundant sources for rattans in the world. The distribution ranges of rattans depend on several factors. These factors are:

Elevation

There are approximately 600 rattan species in the world. Some species can grow in areas up to 2,900 m above mean sea level while some species are particularly found from 1,000 – 1,400 m such as common species that belong to the genera *Calamus*, for example *C. viminalis, C. siamensis, C. caesius, C. manan,* and *Daemonorops,* e.g. *D. kunsteri, D. sabut, D. sepal,* and *D. geniculata.* Some species such as *Plectocomia griffithii* are always found in the low land forest.

The number and species of rattans found also depend on the forest types. *Korthalsia flagellaris* and *C. scabridulus* are always found in peat swamp forest. *C. insignis* var. *longispinosus* and *C.longispathus* are always found along the slope of the upper part of mountain ridges mixed with highland Dipterocarp forest. *Daemonorops didymophylla, D. lasiospatha* and *C. axillaris* are always present close to or along river banks. However, many species have a wide range of distribution and can grow in different areas.

Light

Rattan species can be grouped into those that grow well under shade with moderate light intensity (most of rattan species) and those that grow well in the open under full sun light. Species such as *C. manan* which grows in primary forest requires light gaps for further growth and development. Those growing in secondary or disturbed forest such as *Plectocomiopsis geminiflora* and *Myrialepis paradoxa* need very high light intensity for maximum growth while *D. calicarpa*

and *D. didymophylla* are slowly grow to maturity under shade in the undergrowth forest (Dransfield and Manokaran, 1994). For the edible shoot rattan species such as *C. viminalis* will produce high shoot production whenever they are grown under full sunlight (Kangkarn *et al.*, 2005). Moreover, light intensity is also important for the growth of rattan seedling. Diloksamphan *et al.* (2005) found that seedlings of *C. viminalis* showed best performance on growth when grown under 50% of light intensity.

Soil

Most rattan species prefer to grow in sandy soil containing decayed leaves and humus. However, they can grow in various soil conditions, even in the low fertility and very strong acid soil (Janmahasatien, 2005). The soil that rattans grow well typically has 2 layers, a black colour layer on the top and a rather rough sandy layer below (Sansern and Winai, 1977). For instance, *C. caesius,* which grown in variety of soils but performs best on rich alluvial soil while *C. manan* performs best on well-drained soils (Rao *et al.*, 1998).

Commercially important species

Not all rattans are equally useful, and not all have potential for commercial applications. Depending on the species, diameter of canes ranges from 3 mm to 60 mm or more. In rattan industry, canes are graded based on seven basic factors, namely diameter, length, color, hardness, defects and blemishes, node length, and thickness uniformity.

Some tend to characterize rattans based solely on their diameter because species of different diameters are used for different purposes. Canes with a diameter >18 mm are referred to as "large"" while those that are <18 mm are "small" canes. Large canes are wholly used to make the frames of furniture, but more often that they are split and used to weave the chair back (Dransfield 1988).

However, within a size class, not all species are of equal quality (Dransfield and Manokaran, 1994; Sunderland, 1998).

There are three desirable properties that characterize rattan canes; namely their solid nature, ability to be bent, and amenable to application of lacquer or paint. Unlike bamboos that are typically hollow rattan is very strong and most of them can be bent. After bending, by the application of heat, rattan canes will hold the shapes without deformation. Rattan canes can be lacquered to preserve their natural light colour or painted depending on designs.

In 1998, Rao et al. had published a list of 21 priority species based on available information on utilization, cultivation, products and processing, germplasm and genetic resources, and agro-ecology. However, in Thailand, the sizes together with the quality of rattans are concerned and recognized for commercial.

The most important species of large stem rattans in Thailand used for furniture are Wai Kho Dam (*C. manan*), Wai Kumpuan (*Calamus longisetus*), Wai Namphung (*C.* sp.), Wai Khi Sean (*C. rudentum*), and Wai Nguay (*C. peregrinus*). The most important species of small stem rattans are Wai Takha Thong (*C. caesius*), Wai Khi Phung (*C. blumei*), Wai Lek *(C. javensis),* Wai Horm *(C. pandanosmus*) and Wai Khi Re (*C. densiflorus*) (Vongkaluang 1986). However, concerning international trading, Nainggolan (2003) recommended that the topography and climate of Thailand is suitable to grow world economic rattan species such as *C. manan* and *C. caesius*. Therefore, it is necessary to give priority to these 2 species for plantation that will support sustainable rattan raw materials in the future.

Rattan Trade and Uses

Trade and uses of rattan canes

In Thailand, rattan canes have been extensively utilized for centuries. Rattan resources that used to be plenty and enough for utilizing locally has now being depleted. As of their advantage characteristics in strength, flexibility, uniformity and durability over other plants, in recent decades rattans have become major demanded raw materials/products in international markets. Rattan that used to be "minor forest products" has completely turned itself to "major forest products" in the mid-19th Century.

The development of rattan arts and crafts with the combinations of recent technology and the Thai unique designs has brought Thai rattan arts and crafts to the worldwide standard. However, it is unfortunately that Thailand still facing the problems in producing its own rattan raw materials.

Nowadays, Thailand imports substantial quantities of raw rattans from Indonesia, Laos, Hong Kong, Malaysia, Myanmar, Singapore, Vietnam, and elsewhere. The quantity of imported raw rattan has increased due to the promising rattan furniture exporting. In 1987, 18,433 tons of raw materials valued at 142 million baths were imported. In 1988, the quantity went up to 29,390 tons valued at 224 million baths. Subsequently, imports have declined. Exports of raw rattan from Thailand have generally been very low, peaking in 1989 at 331 tons, valued at 4.8 million baths. Recent exports and imports are given in Table 5. Chuntanaparb *et al.* (1985) estimated that local production of about 5,000 - 6,000 tons per year would generate employment, in harvesting and transportation, of about 35,000 person-days and, for furniture production, about 400,000 person-days per year.

Trade and uses of rattan shoots

When people talk about rattan, most of them think about the baskets, armchairs and other hand-made decorative items. Unknown to many people, the

inner core of some rattan species is edible. People in the north-eastern of Thailand such as Sakon Nakhon, Udon Thani, Kalasin, Nong Khai, Mookdaharn, Nakhorn Phanom and also those in the Lao People's Democratic Republic (Evans, 2001), who live nearby the forest have used rattan as food for many generations. They use rattan as an ingredient in many delicious and nutritious dishes.

Off all rattan species that grow in Thailand, shoots of six species are recorded edible and all of them belong to genus *Calamus*. In fact, shoots of some rattans other than the six mentioned edible species are not poisonous. They are not suitable for eating as of their excessively bitter taste. Part of the rattan used for cooking is its young shoot or "tiller", which is still white and soft. Only the upper part of the stem can be eaten because the lower part is too tough. After the sheath, leaf-sheath, spines and skin are removed; the inner core should be boiled to reduce bitterness. The Thai people typically cook rattan shoots with tropical herbs or add them to other preparation (Sricharatchanya, 2000).

With the increasing rate of depletion of natural forests, wild rattan is becoming scarce while the demand is becoming higher. Therefore, the price of shoots is tending to be higher than other vegetable crops. This based on the belief that rattan shoot is a kind of medicinal plant and contained no chemical or any toxic substances. Therefore, the cultivation of this rattan specie for shoot harvesting purpose should be promoted to the farmers.

Recently, the farmers are now starting to plant rattan for shoots. Over a decade ago, villagers in the northeastern of Thailand began to cultivate edible rattans to harvest their shoots. Sakon Nakhon province has the largest area of plantations, with over 1,280 ha in total. The most popular species planted for shoots in Thailand is Wai Dong (*Calamus viminalis*) as it grows fast and provides big clumps with high shoots productivity. Moreover, the shoot cultivation can be done for more than 30 years in each clump (Apinantaworachai *et al.*, 1995).

At present, domestic markets for rattan shoots in Thailand and Lao People's Democratic Republic are tending to be expanded. Rattan plantation for shoot production is becoming much better than that for cane production. Furthermore, planting is spreading rapidly without the need of special policy support. Shoots of *C. viminalis* offer a rapid and proven return on the open market. This will also upgrade living standard of the farmer and create income for the rural people.

Calamus viminalis locally called Wai Dong, Wai Kom, Wai Nham or Wai Nham Khao (Sangkaew *et al.* 1997). At present, *C. viminalis* plantations are popularly practiced at Varijphum district, Sakon Nakhon province. The plantation was carried out by a family in the traditional way which means no fertilizer or pesticides are used. The discussion of rattan utilization would be incomplete without mentioning other uses of rattans. Examples of other uses or products from rattan are summarized in Table 3.

Table 3 Secondary uses of some rattan species (except cane)

Product/Use	Genus and Species
Fruit used for food	*Calamus dongnaiensis, C. longisetus, C. ornatus, C. viminalis*
Young shoot used for food	*Calamus javensis, C. siamensis, C. tenuis, C. viminalis, Daemonorops schmidtiana, Plectocomiopsis geminiflorus*
Fruit used in traditional medicine	*C. castaneus, D. didymophylla*
Young shoot used in traditional medicine	*D. grandis, Korthalsia rigida*

Fruit as source for red dye (dragon's blood)	*D. didymophylla*
Leaflet used for thatching	*C. castaneus, C. longisetus, D. elongatus, D. grandis*
Rachis used for fishing pole	*D. grandis*

Threatened Rattan

In Thailand, three major threaten activities that are harmful to rattan natural resources and drag them to nearly extinction are as follow:

1) Over harvesting rattan canes and diminishing forest covers.

2) Changing rattan habitats into other land uses.

3) Cutting down rattans' reproductive cycles by changing ratio of male and female plants and eating their fruits.

Economic aspects

Annual quantities extracted and their value

In the past, all rattans, except *C. caesius*, were not protected. However, in 1987, all rattans were brought under protection because over-exploitation had depleted the resource. Permits from the Royal Forest Department (RFD) are required for harvesting rattan from natural sources. Table 4 and Table 5 show the quantity of rattan officially extracted from forests and the export / import values in the past.

Table 4 Thailand's annual licensed rattan production and value in the past

Year	Production (tonnes)	Value (million US$)
1980	2,320	0.10
1981	205	0.03
1982	385	0.07
1983	2,924	0.78
1984	1,405	0.34
1985	2,588	0.67
1986	3,147	0.83
1987	5,960	1.65
1988	3,558	1.02
*1989	1,235	0.37
1990	1,098	0.33
1991	868	0.29
1992	417	0.14

Source: Forest Statistic of Thailand

* Logging permits closed

Table 5 Exports and imports of rattans

	Exports		Imports	
Year	**Quantity (tons)**	**Value (million US$)**	**Quantity (tons)**	**Value (million US$)**
1993	0.25	0.011	11.83	2.05
1994	0.72	0.005	12.07	2.49
1995	0.39	0.004	10.53	2.44
1996	1.73	0.004	10.52	2.56
1997	0	0	9.66	1.82
1998	36.01	0.025	6.16	1.53
1999	28.02	0.048	7.92	1.92
2000	4.40	0.038	4.85	1.91
2001	4.97	0.010	6.10	2.29
2002	10.32	0.007	4.21	1.96
2003	4.99	0.032	5.26	2.21
2004	2.45	0.011	4.68	2.34

Source: Forest Statistic of Thailand

Harvesting and processing of rattan cane

The Ministry of Agriculture and Co-operatives has established regulations for rattan harvesting, even though data on growth rates, harvestable age and cutting regimens of Thai species are very limited. Therefore, the regulations that are roughly used as temporary guidelines are cutting only mature canes, retaining half of the number of stems in each clump, clearing the areas under the clumps after harvesting and let felling rotation of at least 5 years.

Generally, mature canes are recognized by the fallen of leaf sheaths. The best time for cutting rattan is from November to March. After harvesting, there are several methods of treatment including:

- Sun-drying until the moisture content is about 5-10 percent;
- Washing the canes in water, rubbing them with sand and coconut husk, and then leaving them to dry in the sun (as above);
- Washing the canes in water, fumigating them with SO_2, sun-drying, washing in water again, and rubbing them with sand and coconut husks;
- Immersing in a solution of sodium hypo-chlorite for one hour, then washing them in water, followed by fumigating with SO_2 and sun-drying;
- Boiling the canes in a mixture of diesel and coconut or palm oil for 30-40 minutes and sun-drying.

General management of rattan

In Thailand, wild rattan resources are rarely managed. Even if rattan can be planted in different types of environment, suitable sites still have to be selected in each region. The site selected should have sufficient humidity especially in moist evergreen forest that contains fertile soil and well drained. An annual rainfall should not less than 1,500 mm. The areas that can grow rattan as plantation in

Thailand can be classified into 4 types, namely natural forest, forest plantation, rubber plantation and general land areas.

Two out of four areas mentioned above, namely forest plantation and rubber plantation are the suitable areas for most rattan species. In these areas, optimum sunlight can pass through the crown covered as suggested by Dransfield and Manokaran (1994) that about 50% overhead light appears to be optimum for good growth of rattan seedlings. However, selective tree felling and removal of overhead branches is also necessary and this should be done soon after transplanting has been carried out. Some rattan species such as *Calamus viminalis*, which is popularly planted in northeastern of Thailand, need more sunlight and will give more shoots when planted in open area.

In general, management of rattan plantation should begin soon after planting. This involves replacing planted seedlings that died and those growing very poorly. This process should be completed within 3-6 months after planting. During the early stage, weeding is carried out to remove climbers that twine around the seedlings. This process is best carried out once in 6 months in the early years after planting.

Plantation, seed banks and seed production areas

In Thailand, *Calamus caesius* plantation was established in 1968 at Istear peat swamp forest, Rangea District, Narathiwat province and reached a total of 213 ha by 1978 (Bhodthipuk & Ramyarangsi, 1989). In 1979, Royal Forest Department had initiated 16 ha of cultivation trials of *C. caesius* each at Ngoa waterfall, Ranong province; Khoa Tha Petch, Surathani province; and Kapoh waterfall, Chumporn province. Between 1980-1987 *C. manan* and *C. caesius* were planted on an area of 930 ha in Sukirin district of Narathiwat province (Dransfield and Manokaran, 1994).

In 1989, Royal Forest Department together with Department of Agricultural Extension had started 2 projects on planting programme namely, rattan seed orchard and rattan plantation. Seed orchard were set up at Khao Soi Dao (48 ha), Chantaburi province and Naichong (184 ha), Krabi province. Rattan plantation were set up at Kao Sok (368 ha), Surattani province, Kao Bunthat (240 ha), Trang province and Sakaerat (32 ha), Nakorn Rachasima province (Vongkhaluang, 2000). Seed production stands of *Calamus caesius*, *C. latifolius*, *C. longisetus* and *C. manan* were also established in 12.8 ha at Trang Botanical Garden, Trang Province. A Thai rattan arboretum was established with 24 species at Trang province. A demonstration plantation has also been set up in 3.2 ha. at Trang Botanical Garden. Rattan plantation techniques had been applied in the government pilot plantations both in the southern and north-eastern regions in order to improve and upgrade the technology on watering and fertilizing. Species trials and selection trials were also carried out to determine their suitability to the plantation sites (Bhodthipuk & Ramyarangsi, 1989). At present, due to the awareness of the shortage in supply of rattan canes, other cultivation trials of various rattan species have been initiated in several regions.

Propagation and seedling production

Rattans are generally propagated by 2 ways, natural propagation and propagation by planting.

1. Natural propagation: Rattans can be propagated from the seed or sucker. In nature, propagation by seed is carried out by man or animal. The germination rate of rattan seeds in nature is quite low and it also takes long time to germinate. The initial growth of rattan is slow. Therefore, propagation of rattan from seeds in natural forest is not so successful. Propagation from sucker is better as the growth and survival rates are higher, However, the new suckers or new shoots usually distributed close to the mother sucker. The growth rate of new sucker depends on

the mother sucker. A big and strong mother sucker usually produces good off-springs in the next generation.

2. Propagation by planting: In Thailand, rattan plantations were started in 1968 in peat swamp forests at Tambon Istear, Rangea District, Naratiwat province. The species that was planted was Wai Takathong (*Calamus caesius*). In general, propagation methods can be done as follows;

a. Using vegetative parts

Actually, rattan can be vegetatively propagated by suckers, and whole rhizomes. Suckers with some intact roots from rattan cluster can be separated from the clump, potted immediately in a suitable soil mixture and transplanted to the field after a period of stabilization in the nursery.

The rhizome systems of clustering species can support numerous suckers that will be developed into stems. For propagation purposes, stem can be cut off and the rhizome dug up and transplanted to the planting site. The clump can develop very quickly from the sucker left intact.

The benefit of this method is the genetically characteristic of the parent can be transferred completely to the next generation. These include growth characteristic, strength, and resistance to pest and decease. In Thailand, this method of propagation is feasible only with clustering species, when it is difficult to obtain seeds, and when small-scale of plantation is needed.

b. Using seeds

At present, cultivation of rattans in Thailand is based on seedlings raised in nursery. The germinated seeds and seedlings in a nursery are protected from pests and are shielded from strong sunlight. The direct sowing of seed in soil at the planting site is unlikely to be successful as the seeds and newly germinated plants always damaged by animals or birds, by drying out in hot weather, and by disease. It is also recommended that the outer scaly pericarp of the fruit and the freshly

sarcotesta be removed before the seed is sown, as seed sown with the intact pericarp and sarcotesta showed poor germination rates (Manokaran, 1978).

c. Tissue culture

The tissue culture technique have been introduced as a vegetative propagation method to promote seedling production of the economic rattan species such as Wai Takathong (*Calamus caesius*), Wai Kamphuan (*C. longisetus*), and Wai Pong (*C. latifolius*), Wai Kor Dum (*C. manan*) and Wai Num Pung (*C.* sp.). At present, tissue culture methods have been developed for mass production and in conservation of genetic variability of rattan in Thailand.

Growth and yield

The growth and yield of rattan varies according to planting areas and factors affected such as humidity, nutrients, light intensity, management and species of rattan. Small sized rattan can be harvested within 7-10 years after planting while large sized rattan can be harvested within 10-15 years after planting.

Generally, clump rattans can give highest yield at about 19 years old and can be harvested every 2-3 years. After the fourth harvest, replanting is needed because the yield will decrease rapidly. In Thailand, there is little research on yield or productivity of rattan. The data of Wai Takha Thong from Istear rattan plantation were collected and analysed. Results showed that growth rate during the first 5 years were very slow. The average growth of rattan cane was about 0.6-1.0 m/year. Each clump produced at least 10 canes. The big clump produced up to 50-100 canes. The length of each cane was not less than 20 meters (Kuldilok *et al.*, 1993). It was noticed that *C. caesius* gave high productivity and should be one of the promising species to be promoted.

Kuldilok *et al.*(2000) had studied the production of *C. longisetus* and *C. latifolius* in *Azadirachta excelsa* plantation. It was found that an average growth rate of *C. longisetus* is 4.61 m/year with the cane production 78, 189, and 456 m/rai

at 8, 9,and 10 years old. For *C. latifolius,* an average growth rate is 5.48 m/y with the cane production 212, 466, and 724 m/rai at 8, 9,and 10 years old.

Pest and disease

Vongkaluang (1986) studied about pest and disease that destroy rattan and found that several pests and diseases attacked all stages of growth of rattans from the seeds, seedlings, mature plant or even the cane that is already utilized. The common pests and diseases that are found attacking rattans are:

Seeds: Seeds of rattan that were kept for propagation were prone to damage by beetles and fungi. The beetles that normally attack rattan seeds are *Xyleborus formicatus* and *Pocilips* sp. that cause the seed to lose viability. The common fungi that were found attacking rattan seeds were *Penicillum* sp., *Trhichoderma* sp. and *Botrytis* sp. which caused seed rot disease.

Seedlings: Shoots and leaves of rattan seedlings in the seed–bed are attacked by the grasshopper (*Tetris* sp.) and cricket (*Gryllus* sp.). Some diseases that damage rattan seedlings include *Colletotrichum glocosporiodes* that caused leave spot and leave bright disease, and *Rhizoctonia solani* that caused damping off disease. Other fungi that were always found but did not cause serious damage include *Cercospora* sp., *Fusarium* sp., *Curvularia* sp., *Botryodiplodia theobrome*, and *Helminthosporium* sp.

Stems: Insects that attack rattan stems are weevils and long horn beetles. These insects attack the stem at the base close to the soil and cause long black scars on the stem.

Cane: The cane is composed of cellulose and carbohydrate-based materials and is susceptible to attack by several kinds of weevils and beetles namely, *Dinoderus minutus, Sinoxylon anale, Heterobostrychus aequalis,* and *Minthea rugicollis.* Rattans are also attacked by stain fungi such as *Trichoderma* sp., *Botrytis* sp., *Aspergillus niger, Penicillium* spp., and *Fusarium* spp. as reported by

Jittkaew (2005). These fungi cause discoloration or grey or dark grey colour of the cane that decreases the quality and price of rattans.

Factors affecting rattan planting

Kuldilok *et al.* (1993) recommended that for the successful planting of rattans the following factors need to be considered:

1. Site: The sites suitable for each rattan species should be selected. This will be based on adequate moisture, fertile soil, and not too dense forest.

2. Species: The species of rattan should be selected based on market needs, priority and price.

3. Seedling preparation: Seedling should be well prepared. Process of hardening should be carried out before planting.

4. Budget: Sufficient amount of budget should be prepared.

5. Experience: Manager should have knowledge or experience on nursery technique, how to plant and harvest rattan or pre-studied or training in the rattan related fields before starting the project.

Conservation, genetic diversity and improvement

Generally, most of the rattans in Thailand are harvested from the wild where there is little or no genetic improvement within the species. Scientist has proved that broad base population is essential in any living organisms in order to be able to capture as much genetic gain as possible for future generation (Alloysius & Claude Bon, 1995). Therefore, *in situ* and *ex situ* gene conservation of rattan is necessary and should be set up to use as a base population in the rattan genetic improvement program. However, rattan conservation is exceedingly difficult to generalise, as many poor villagers still depend on non-wood forest product such as rattan. Conservation efforts should not interfere with the use of resources for daily needs and income-generating activities of these people or other forest dwellers.

In the coming years, rattan plantations along with some form of rattan management will play an increasing role in providing the raw canes and in turn relieving some of the pressures on threatened wild populations.

For genetic diversity of rattan, it has just begun to interest among researchers. Therefore, only a few studies are available on genetic diversity of rattan. In Thailand, there is a research on studying of 13 populations of *C. palustris* from seven provenances. Results showed that approximately 18 % of the total diversity resulted from differences in the form and location of the isozymes. This indicated that isozyme analysis can be used as one of the tools to assess intra-specific genetic diversity in *C. palustris* (Hong, *et al.*, 2001)

Status of rattan species in Thailand and Asian countries

In Thailand, most of the rattans being used nowadays have been harvested from natural tropical forests. Being one of the most important trade commodities for forest dwellers, rattan has been severely over-exploited to the extent that is now in very short supply. Deforestation, traditional harvesting of rattan shoots and fruits for food as well as the lack of suitable harvesting methods have also accelerated its rate of extinction. Some rattan species are disappearing since people use up every part of their life cycle or breaking their ability in regeneration. Many rattan trades, especially those that own by local communities, are trend to breakdown because they lack of sustainable raw materials. Some medium size factories for rattan furniture in the cities can still maintain their activities but their raw material supply depends mostly on the imported rattans. The major rattan canes exporters such as Indonesia and Malaysia have now announced the banning of some rattan canes exportation. To solve this problem, activities relevant to the promotion on rattan plantation for sustainable utilization should be done in urgent. However, sustainable utilization of natural rattan will never be employed unless cultivation is extended to meet the demand.

The status of threatened, non-threatened rattans and their conservation status in Thailand and other neighbouring countries are shown in Table 6.

Policies on conservation of rattan

Diminishing forest cover and uncontrolled exploitation have seriously depleted wild population of rattan throughout Thailand. Pressure on wild rattan has increased dramatically and some species are nearly extinction. Even if logging operation was banned in Thailand, the ban is unlikely to have much effect on the rate of exploitation of the wild stock of rattans. At present, Thailand has to import raw rattan from other countries such as Indonesia and Malaysia because wild rattan is almost depleted from Thai forests. Most of them are found only in national parks where they are sometimes illegally collected (Dransfield, 1989).

It is unfortunately that we do not know much about the conservation status of wild rattans to identify which areas should be the focus of priority conservation actions. However, strategy for rattan conservation and management in Thailand is generally based on the need to develop and disseminate appropriate technologies of management and utilization in order to facilitate the sustainable management and utilization practices and including conservation of rattan resources.

Table 6 Status of Asian rattans

Threatened Asian Rattans

Scientific Names	Selected Local Names	Distribution
Calamus densiflorus	Wai Khi Re	Malaysia: Peninsular; Singapore; Thailand; Vietnam
Calamus godefroyi	Wai Nam	Thailand
Calamus manan	Wai Kho Dam	Malaysia: Peninsular; Indonesia: Sumatra; Borneo; Thailand
Calamus multirameus	Wai Khi Kai	Malaysia: Peninsular (endimic); Thailand
Calamus spectatissimus	Wai Krae	Malaysia: Peninsular; Indonesia: Kalimantan, Sumatra; Thailand

Non-threatened Asian Rattans

Scientific Names	Selected Local Names	Distribution
Calamus javensis	Wai Lek	Malaysia: Peninsular, Sarawak, Sabah; Brunei; Singapore; Indonesia: Kalimantan, Java, Sumatra; Philippines: Palawan; Thailand
Daemonorops calicarpa	Chark Cham	Malaysia: Peninsular; Indonesia: Sumatra; Thailand
Daemonorops didymophylla	Wai Khi Pet	Malaysia: Peninsular, Sarawak, Sabah; Brunei; Singapore; Indonesia: Kalimantan, Sumatra; Thailand
Daemonorops grandis	Wai Chark	Malaysia: Peninsular; Singapore; Thailand
Korthalsia laciniosa	Wai Sadao Yai	Malaysia: Peninsular; Singapore; Indonesia: Java, Sumatra; Philippines; Vietnam; Thailand; Myanmar; India: Andaman & Nicobar Islands
Plectocomiopsis geminiflora	Wai Kung Nam Prai	Malaysia: Peninsular, Sarawak, Sabah; Indonesia: Kalimantan, Sumatra; Brunei; Thailand

Asian Rattans with Unknow Conservation Status and Reported Uses

Scientific Names	Selected Local Names	Distribution
Calamus axillaris	Wai Takha Nah	Malaysia: Peninsular, Sarawak; Brunei; Indonesia: Sumatra; Thailand
Calamus blumei	Wai Khi Phung	Malaysia: Peninsular, Sarawak, Sabah; Brunei; Indonesia: Kalimantan, Sumatra; Thailand
Calamus caesius	Wai Takha Thong	Malaysia: Peninsular, Sarawak, Sabah; Indonesia: Kalimantan,Sumatra; Philippines: Palawan; Thailand
Calamus castaneus	Wai Chark Kao	Malaysia: Peninsular; Indonesia: Sumatra; Thailand
Calamus diepenhorstii	Wai Khom	Singapore; Indonesia: Sumatra; Philippines Palawan; Thailand
Calamus insignis	Wai Hin	Malaysia: Peninsular; Singapore; indonesia: Sumatra; Thailand
Calamus longisetus	Wai Kumpuan	Myanmar; Thailand; Malaysia: Peninsular
Calamus luridus	Wai Sai	Malaysia: Peninsular; indonesia: Sumatra; Thailand
Calamus ornatus	Wai Chang	Brunei; Indonesia: Java, Sumatra, Sulawesi; Philippines; Thailand
Calamus oxleyanus	Wai Dam	Brunei; Sumatra; Thailand
Calamus palustris	Wai Khring	Peninsular Malaysia; Myanmar; Thailand; Vietnam Chaina; India: Nicobar and Andaman Islands
Calamus peregrinus	Wai Nguai	Thailand; Peninsular Malaysia
Calamus scipionum	Wai Mai Thao	Malaysia: Peninsular, Surawak; Sabah; Brunei; Singapore; Indonesia: Kalimantan, Sumatra; Philippines: Palawan; Thailand
Calamus viminalis	Wai Dong	Indonesia: Java, Bali, Sumatra; Malaysia: Peninsular; Kampuchea; Thailand; Myanmar; Bangladesh; Sikkim; India Andaman Islands, West Bengal, Bihar, Orissa, Pradesh, Maharastra
Daemonorops angustifolia	Wai Nam	Malaysia: Peninsular; Thailand
Daemonorops elongatus	Wai Phuan	Indonesia: Sumatra; Malaysia: Peninsular, Sarawak; Singapore
Daemonorops sabut	Wai Pon Khon Non	Malaysia: Peninsular, Sarawak, Sabah; Singapore; Brunei; Indonesia: Kalimantan; Thailand
Kothalsia rigida	Wai Dao Nu	Malaysia: Peninsular, Sarawak, Sabah; Brunei; Indonesia: Kalimantan, Sumatra; Philippines: Palawan; Thailand

Research and Development

Rattan Research in the past

In 1968, the first rattan plantation was established in swamp forest, tambon Istear, Rangea district, Naratiwat province. Wai Takha Thong (*Calamus caesius*) seedlings were planted at a spacing of 4 x 4 m spacing until 1978 to a total of 213 ha. The growth was slow for the first five years at a rate of 0.6 – 1 m/year. However, it is expected that growth at 10 –15 years will reach approximately an average of 2 – 3 m/year (Bhodthipuks and Ramyarangsi 1987).

In 1979, the Silvicultural Research Sub–division of Royal Forest Department undertook the planning of rattan silvicultural research throughout Thailand. This work included several sites namely, Wangsapung district, Khonkhaen province; Kantang district, Trang province; Hinlap district, Kanchanaburi province; Prachai district, Saraburi province; Sakaerat district, Nakhorn Ratchasima province; and at Kamphangphet province. These plantings were mostly done as species trials; however, the results were not so satisfactory. In the same year, establishment of field trials of 16 ha each at Ranong province, Suratthani province and amphur Thasea, Chumporn province were carried out.

In 1980, under the King's project, the second rattan plantation was established at Sukirin, Naratiwat province. In 1987, the total area of plantation was 930 ha planted with *Calamus caesius* and *C. manan*. The suitable sites for rattan plantations are in the Southern part of Thailand with high moisture content of the soils, and with plenty of supporting trees (Bhodthipuks and Ramyarangsi, 1987).

In 1986, the International Development Research Centre (IDRC) of Canada supported Royal Forest Department projects on rattan research for 3 years. These projects included collecting and planting rattan species that native to Thailand at Trang Botanical Garden, Trang Province, the establishment of seed

production area for 4 economic rattan species namely, Wai Takha Thong (*C. caesius*), Wai Kordum (*C. manan*), Wai Kumpuan (*C. longisetus*) and Wai Nampung (*C.* spp.) and the establishment of rattan demonstration plantation to distribute the knowledge of how to plant and manage rattan plantation to local people and interested person.

In 1988, the research on rattan promoted by biotechnology technique was initiated. From 1988-1991, Thailand, under the King's project, was sponsored by the U.S.Agency for International Development (USAID) to conduct the research on "In vitro Conservation and Propagation of Three Economic Species of Rattans". At the same period, the research on "Propagation of Wai Ta khaa Thong (*Calamus siamensis*)" had been conducted by Vongvijitra (1990). These researches were aimed to solve the problem in seed and seedling deficiency and to study the possibility of propagating rattan via tissue culture technique. Proper medium, condition and technique for multiple shoot and root induction were examined and discussed.

On-going Research

Several aspects of rattan research are being carried out in Thailand. These researches are as follows;

Floral biology of *Calamus viminalis*

In this studied the phenological characteristic of flowering, floral biology, pollination mechanism, types and role of pollinators were investigated. Results showed that *C. viminalis* produces flower throughout the year. The development of both male and female inflorescence completes within 50-60 days. High proportion of the number of male and female flowers suggested that a significant increase in pollen quality might play an important role in attracting more pollinators while *Apis* and *Trigona* are the most effective pollinators (Pattanavibool and Sornsathapornkul, 2001).

Fruiting phenology and reproductive success of *Calamus viminalis*

It was found that *C. viminalis* produces fruit throughout the year. Developing of fruit shows significant progress, especially development of ovary after four weeks of pollination and development of fruit and seed completes within 4-5 months. Reproductive success (RS) value; showing development potential of flowers, ovules and seeds; was quite low which could be attributed to high degree of fruit abortion rather than seed abortion during developmental stages (Satitviboon and Sornsathapornkul, 2001).

Growth of *Calamus* spp. under rubber plantation

In this studied growth of 6 rattan species, namely *C. longisetus, C. latifolius, C. peregrinus, C. rudentum, C. palustris and C. viminalis,* planted under rubber plantation had been studied. It was found that, at three years old, *C. longisetus* produced highest average cane length when compared to the others. However, at 4 and 5 years olds, *C. palustris* turned to produce highest relative growth rate and highest mean annual increment. It was also noticed that *C. palustris* could produce multiple shoots within 3 years (Kuldilok and Boonyuen, 2002).

Planting and management of rattan for shoot production

In this studied the research was done in the edible rattan plantation with the attempt to improve shoot productivity and reduce operation cost. It was found that manure application in the rattan plantation (*C. viminalis*) at 3 years old of age can increase shoot production better than chemical fertilizer application. The application of water once a week during the dry season together with manuring once a year in the 5 years old plantation of *C. viminalis* can also increase more shoot production. Besides, watering twice a week can increase both shoot size and consumable part. It was also found that at 1x1 m spacing, *C. viminalis* and *C. siamensis* produce the same number of shoots per cluster with the same amount of

consumable part while at 1x0.5 m spacing *C. siamensis* can produce more shoot per cluster with larger amount of consumable part than *C. viminalis*. Moreover, *C. siamensis* was found to be able to tolerate long drought period as good as *C. viminalis* (Kangkarn, 2005).

Study on planting and management of *Calamus caesius* for cane production at Narathiwat province

Study on planting and management of *C. caesius* for cane production was carried out in the natural forest at Narathiwat province during 2001 to 2004. It was founded that growth of *Calamus caesius* that grown in peat swamp with occasionally flooded is better than those grown in deteriorated area. The harvesting of 1-2 canes/clump can increase the number of new shoots and encourage the shoots to grow better while harvesting of 3 canes/clump will cause some effect to the number of new shoots during 1 year but will be effective afterwards (Nuyim *et al.*, 2005).

Yield of 13-15 years old, *Calamus longisetus* and *Calamus latifolius* in *Azadirachta excelsa* plantation

Yield of 13-15 year-old *Calamus longisetus* and *Calamus latifolius* planted in *Azadirachta excelsa* plantation was studied at Nai Chong Seed Production Area station, Krabi province. It was found that *C. latifolius* at all age classes showed better growth than those of *C. longisetus* when inter-crop planted in *Azadirachta excelsa* plantation. It was also noticed that rattan planting as an inter-cropping in the tree plantation grows better than those planted under natural forest except in the degraded area. With proper management in the plantation, these two rattan species can commercially be harvested annually from the age of 10 years old with the annual production of about 100 meters per rai. These species could be recommended for commercially planting inter-crop with the tree plantation (Kuldilok, 2005).

Growth and photosynthetic performance of *Calamus viminalis*

Studied on growth and photosynthetic performance of *Calamus viminalsis* was to compare the growth of seedlings that grown under different light conditions as well as their growth and photosynthetic performance after planting under the trees in plantation. It was found that *C. viminalis* seedlings grown under 30% and 50% light intensities showed better growth performance compared to those grown under the shade of *Samanea saman*. Overall, *C. viminalis* planted from seedlings grown under 30% and 50% light intensities has well adapted after planting in *Combretum quadrangulare* plantation where the light intensity was about 30% of full sunlight. Interestingly, in the long term, *C. viminalis* from seedlings grown under *S. saman* shade trees tended to adapt well under shade environments even though it had lower growth rate before planting. *C. viminalis* grown from seedlings under *S. saman* trees was able to maintain higher leaf photosynthetic activity in the dry season where water availability became limited, while that from seedlings under 30% light intensity was able to minimize water losses through leaf transpiration under such stress condition, resulting in greater water use efficiency (Diloksumpun *et al.*, 2005).

Determination of soil characteristics under rattan experimental plots of the ITTO's project sites

The studies on soil characteristics under rattan experimental plots of the project sites were carried out at Narathiwat, Krabi and Sakon Nakhon province. Results revealed that, Reddish Brown Lateritic Soils covered the experimental plot in Narathiwat. These soils were deep, moderately well drained with reddish brown sandy loam topsoil. Distinct lateritic soils were found in the lower horizons. The evaluated soil fertility was low. Red Brown Earths covered the experimental plot in Krabi province. These soils were poorly drained with dark reddish brown clayey texture and medium fertility. At Sakon Nakhon, the experimental plot was covered by Gray Podzolic Soils. These soils were developed from old alluvium on fans.

Soil profile had diffuse smooth boundary with any distinct strong brown iron mottles and low fertility. Results of the studies described the characteristics of soils under various rattan experimental plots. Information of soil properties together with the growth rate of rattan species can be used to evaluate suitability site for each rattan species (Janmahasatien, 2005).

Rattan Protection

Wai Pong (*Calamus latifolius*) and Wai Kam Puan (*Calamus longisetus*) were harvested and used for the studying on rattan protection to find suitable and practical methods of controlling staining fungi and insect infestation. Treatments of oil curing in 105°C diesel for 10 minutes gave the best result against fungi. Pre-treatment with calcium carbonate and fungicides could not protect rattan canes from the fungal infestation. It was found that the cane treated in 10% Boron compounds showed good appearance after peeling the skins. The immersion of rattan cane in 1% Stemona solution for 24 hours could not protect it from staining fungi. All treatments of both species showed no attacked by any insect, especially powder-post beetle (Jitkaew *et al.*, 2005).

Mechanical Properties of *Calamus longisetus* and *Calamus latifolius*

Mechanical properties study of *Calamus longisetus* and *Calamus latifolius* was conducted during 2003-2004. Tensile, compression parallel to grain, hardness, density and moisture content of the cane of each species were measured. For *C. longisetus*, it was found that tensile, compression parallel to grain, hardness, density and moisture content of node part were 266 kg/cm^2/26.1 Mpa, 288 kg/cm^2/22.4 Mpa, 251 kg/2.48 kN, 303 kg/m^3 and 10.63 percent, respectively. The values of internode part were 404 kg/cm^2/39.6 Mpa, 262 kg/m^2/25.7 Mpa, 206 kg/2.04 KN, 328 kg/m^3 and 10.35 percent, respectively. For *Calamus latifolius*, tensile, compression parallel to grain, hardness, density and moisture content of node part were 429 kg/cm^2/42.1 Mpa, 431 kg/cm^2/42.3 Mpa, 462 kg/4.57 kN, 425

kg/m^3 and 10.73 percent, respectively. The values of internode part were 327 kg/cm^2/32.1 Mpa, 389 kg/cm^2/38.2 Mpa, 450 kg/4.45 KN, 352 kg/m^3 and 10.00 percent, respectively. The value for mechanical properties of both rattan species was as similar as medium hardwood. Although, they had low density and lightweight but their canes are more suitable for making furniture and other house & agriculture wares than some medium hard wood species (Thaipetch, 2005).

Study on chemical properties of rattan shoot from plantation in Thailand

Edible rattan shoot was investigated for the total polyphenol content, total antioxidant activity, and chemical composition of polyphenols. In consideration of the beneficial nutritional, physiological and health promoting effects of polyphenols, rattan shoot extract could be regarded as potent antioxidant and radical scavenging active and functional food ingredient or dietary food supplement (Prasitpan, 2005).

Rattan shoot processing techniques

Techniques on rattan shoot preservation were examined for *Calamus viminalis*'s shoots. Preservation was carried out using 2 types of preservative solution, 2% brine solution and 30% syrup (pH below 4.5), in 6 oz glass bottle. No microorganisms were found after kept for 3 and 6 months under room temperature. Nutritive value of bottled rattan shoot was also analyzed. The process of drying shoot between sun drying procedure and dehydrating procedure were compared. Result showed that product obtained from dehydrating procedure gave better taste and color (Denrungruang, 2005).

Other Researches needed

Beside the studies mentioned above, in most of the experimental sites, general information on seed germination of different rattan species was also

examined. Moreover, nursery techniques seem to be the important basic knowledge that leads to better production of planting stocks. The policy of Royal Forest Department is to work on nursery techniques to support various rattan species at experimental stations distributed throughout the country.

In Thailand, it is hard to say that there is any success in the production of rattan seed. Amount of seeds from species needed each year is based on Royal Forest Department requirement and all seeds were still collected from the wild.

Due to the research on important aspects of rattan such as ecology, population structure, and demographic studies is just started. These studies will provide the basis for sustainable harvesting. However, plenty of questions are waiting for the answers. For instance; how many stems of the given specie occurs in a given forest area, of what length, whether sexually mature, how old when sexually mature and of which sex, are crucial in planning the controlled sustainable extraction from the forest. What is the fate of seeds and seedlings? What governs the change from establishment to aerial growth in the species? Attempts to address some of these questions have been made but with only partial success. Rattan studies, both in natural forest and in trial plots, are bedevilled with the difficulties of finding areas that secure from illegal rattan harvesters.

Other researches needed have been concerned by the government. It was found to be agreeing with two aspects. One is the concerning about researches on development of rattan resource which suggested by Dhanarajan & Sastry (1989), International Development Research Centre (1989), Manokaran (1990), and the International Fund for Agricultural Research. Another is the concerning about researches to enhance rattan utilization which suggested by Williams *et al.*(1991).

The priorities of research for rattan development are as follows:

1. Survey existing rattan resources to establish the taxonomic and resource base and the rate of resource depletion. At the same time, to identify critical areas and under-utilized species that could be brought into use.

2. Collection for germplasm, storage, exchange and characterization the research includes an increasing of the collection of living specimens, exploring the genetic diversity in nature and selection of suitable cultivars for various kinds of products.

3. Develop propagation techniques in order to overcome problems of low percentage of seed germination and preparing the seedling for large scale production.

4. Investigate the technologies for plantation cultivation to identify and test cultivation and management techniques for cultivating rattan economically at village level and on a commercial scale.

5. Evaluate domestic use to quantify the value of domestic use and of employment generated.

6. Develop harvesting system, utilization and marketing to explore opportunities for developing appropriate techniques for harvesting and processing including post-harvest protection. These developments will lead to the making of value added products for domestic and international markets.

7. Examine national policies covering the harvesting, utilization, marketing and development of the resources including the quarantine laws for exchanging of the propagules and germplasm.

The priorites of research for rattan development are as follows:

1. Examine the properties of commercial and some neglected species in order to facilitate assessment of the utilization potential of currently non-commercial species.

2. Protect rattan products with environmentally acceptable preservatives, since rattan is susceptible to biological deterioration.

3. Improve processing technologies to lead to a greater diversity of products of better quality especially the development for better surface and resistance.

4. Diversify the products according to species properties.

5. Improve method of coloring and finishes in furniture making.

6. Develop panel and wall-cover products.

7. Study on waste utilization and waste reduction.

8. Develop cost effective designs in keeping with contemporary style.

9. Develop hand tools and hardware.

10. Study the needs of marketing to identify the demand and determine what the market wants.

Rattan related issues

There are four issues related to the future of rattan that should be concerned. These are: 1) increase rattan resources from the wild; 2) sustainable management of natural stands; 3) conservation of threatened rattans and their habitat; and 4) socio-economic and cultural issues related to rattan harvesting. Each of these topics should be reviewed as part of any forestry activity that includes harvesting of rattans.

***Increase rattan resources from the wild*:** Quantities of useable raw rattans can be increased in two major ways. There is the need to improve harvesting techniques to minimize waste. Rattan gatherers sometimes are unable to reach the full length of commercial canes. After cut, the portion left behind usually becomes the waste. Generally, immature rattans are cut rather than allowing them to grow to more worthwhile lengths. Gatherers may leave harvested small-diameter canes in the forest to rot because they derive more income from carrying out a large-diameter cane. The foregoing problems are inherent to the gathering of non-wood forest products everywhere in the tropics and it is a socio-economic issue.

A second means of increasing wild cane production is to harvest a wider range of different species. At present, only about 20 percents of rattan species are commercially used (Dransfield and Manokaran, 1994). Clearly seen that, there is potential to start utilizing some of the remaining species. To introduce new commercial species to the industry requires involvement at every level of the product chain from the rattan gatherer to the rattan product consumer. Critical point on finding new commercial rattan species is how to study its' property and educate collectors and end users about those new raw materials. The attempt to increase wild cane production is found in South India where research efforts are focusing on 15 native *Calamus* spp., a source of raw material for cane furniture and other products (Renuka 1992; Bhat 1992). Lesser known canes can contribute to wild rattan supplies; some also can be selected for silvicultural trials (Dransfield 1985).

***Sustainable management of natural stands*:** To ensure stability of rattan supplies in the future, management is a reasonable compromise between continuing to rely exclusively on wild rattans and outright rattan cultivation. Rattans possess difficult and unique management due to their growth habit since they may climb from tree to tree in the forest canopy. This creates problems in the inventory of standing stock as well as in monitoring of conditions of rattan populations and their natural regeneration.

Three basic types of management that are applicable to rattans:

A) Natural regeneration within the forest: This level of management requires no specific technical inputs but does require that a sustainable harvest plan be developed and adopted. Protected areas such as national parks or watersheds, any of which permit gatherings of wild resources are highly suitable to this management approach.

B) Enhanced natural regeneration and/or cultivation within natural forest: In this instance, forest cover is still largely intact and an area may be set aside for rattan and other non-wood forest products. Management inputs may include clearing of competing undergrowth vegetation in naturally occurring forest canopy gaps to promote young rattan growth. Selective felling to create artificial canopy gaps is also an option as it is known that canopy gaps are highly favorable for rattan growth (Chandrashekara, 1993).

C) Rattan cultivation as part of shifting cultivation or agro-forestry: Incorporation of rattan into shifting cultivation is noticed in an indigenous system at Kalimantan. Weinstock (1983) described how the Luangan Dayaks clear a forest plot to plant food crops for 1-2 years. However, before leaving the land fallow they planted rattan. When the rotation is repeated at 7-15 years, the farmers will first harvests rattan then clear the plot again for food crops. In Malaysia, trials to interplant rattans with rubber trees were being studied (Aminuddin *et al.*, 1985).

All of these approaches need further attention since rattan cannot be grown as a monoculture crop.

***Conservation of threatened rattans and their habitat*:** Conservation is a matter of expediency for rattans because of the shortage of raw material is being experienced by rattan industries in Southeast Asia together with the potential loss of essential gene pools for rattan domestication and plantation establishment. It is somewhat encouraging the need for rattan conservation which should be seriously recognized.

Rattan conservation cannot be separated from general forest conservation. The combination of decreasing forest cover and over-exploitation of wild canes threatens the survival of commercial rattan industries in many parts of Southeast Asia (Dransfield, 1989).

***Socio-economic and cultural issues*:** The impact on local rattan collectors of the decline in wild rattan resources is often overshadowed by the more publicised concerns for rattan product industry. Affected groups may be indigenous people who live and spend their traditional life in/or near the forest or small landholders and earning their living by shifting cultivation. There are a number of instances of local groups that are dependent on gathering wild rattan and other non-wood forest products for a cash income to purchase necessary modern industrial goods.

Two interrelated socio-economic elements play a vital role in the future of rattans as non-wood forest products. One is the land tenure. Rattan management, of whatever kind, will only be a success if those involved have clear title to the land, or have long and easily renewable lease rights, so that the future benefits of sustainable practices can be guaranteed. The second element involves the rattan collectors' stake in the rattan resources they exploit. Currently, a rattan collector rationally maximizes his or her income by harvesting the best and most accessible

canes. Larger canes bring the best price and minimizing walking time for the collector. This same situation applies to most non-wood forest product collecting. What is needed is a means to provide rattan collector with a stake in wild resource management and a method of payment, which rewards sustainable practices over excessive or wasteful exploitation.

Recommendation

Strategy for rattan conservation and management in Thailand should based on the view of private sectors and farmers in the regions who saw great potential in utilization of rattan to enhance rural incomes through the development of small-scale rattan industry. Their views were that rattan resources in Thailand should be better utilized for value-added production in term of rattan furniture and weaving for the rural communities. Appropriate technology on rattan shoot production should also be introduced to the project through a feasibility study on the establishment of rattan shoot small factory.

In Thailand, four communities' forests in the north, northeast, west and south regions have different kinds of economic rattan species and people of the regions also have utilized rattan in different styles. Therefore, it was concerned that the establishment of small-scale demonstration plot should be set up in different parts of Thailand for studying sustainable management practices of rattan.

In this report, our recommendation can be divided into two categories;

1. Recommendation for government sector and researcher

Inventories of rattan resources should be done to facilitate sustainable management and utilization. It is necessary to train rattan collector to improve harvesting techniques and to reduce waste. Finally, various economic rattan plantation trials should be initiated with a view toward supplementing the declining stocks of natural rattan.

2. Recommendation for the interested investors and private sectors

Those interested to invest in planting rattan have to consider about rattan species that can provide good quality canes and lead to the high price that are needed by the market. Planting clump rattan is better than planting solitary rattan as the clump rattan will save cost on replanting after harvesting. Moreover, clump rattan provides higher and more sustainable yield. Solitary rattan is recommended to plant in rubber plantation or fruit plantation for easier management and maintenance.

Recommended rattan species for plantation in Thailand

At present, rattans which provide good quality and high economic value that should be promoted can be classified into 3 categories namely, small size rattan, big size rattan and edible rattan.

A. Small size rattan

1. ***Calamus caesius*** Blume (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Takha Thong

Clustering moderate-sized rattan, climbing high into the canopy, with stems ultimately to 100 m or more in length. Clump very close. Stem without sheaths variable but 7-12 mm in diameter, with sheaths to 20 mm in diameter. Internode up to 50 cm long (or even more on young stems). Cane surface highly polished. Sheaths dull green armed with sparse triangular spines to 10 mm long by 5 mm wide, covered with sparse grey indumentum and sometime with scattered brown scales. Minute spinules sometimes present between the large spines. Knee prominent. Ocrea inconspicuous. Leaf to 1.5 m long, longly petiolate in juvenile stems, petiole absent in mature stems; cirrus to 75 cm. Leaflets to about 15 on each side of the rachis, arranged irregularly, usually in alternate pairs occasionally in 3's; leaflets dark green above, bluish-white indumentose below, the longest to 30 cm long by 5 cm wide, usually culculate, somewhat plicate. Inflorescences male

and female superficially similar to 2 m long with up to 7 partial inflorescences each to about 75 cm long. The inflorescences ending in a divaricate tip about 20 cm long. Partial inflorescences with upto 12 rachillae borned distichously. Rachillae to 10 cm long. All inflorescence bracts sparsely pale brown indumentose. Ripe fruit ovoid or almost oblong, greenish white, drying yellowish, to 1.5 cm long by 1 cm wide with beak to 2 mm long covered in 15-21 vertical rows of scales. Seed ovoid to oblong about 12 mm long by 7 mm wide; endosperm deeply ruminate. Seedling leaf forked, but with the two tips parallel, the two lobes normally only length of whole lamina, dark green above, pale indumentose below.

Uses: The very best cane of small diameter, supreme for all types of binding and weaving in the furniture industry. Structure of cane is fine and beautiful. Shooting productivity is high and provide big clump. It is widely used locally in the finest basket ware. Its unique glossy golden cane surface makes it highly sought after for making 'tatami' mats or rattan carpets for the lucrative Japanese market. Its commercial usage has now surpassed traditional usage.

2.*Calamus blumei* Becc. (Dransfield 1979; Dransfield et al. 1994)

Vernacular name: Wai Kaepung

Clustering rattan climbing to 15 m tall. Stem without sheaths 8 mm in diameter, with sheaths to 1.5 cm. Internodes to 25 cm. Sheaths green densely covered with yellowish grey scales, drying grey, and caducous chocolate-coloured scales, and bearing low rounded swellings, sometimes bearing short upward pointing spines. Knee conspicuous. Ocrea to 1 cm long, dark brown. Flagellum to 1.25 cm. Leaf ecirrate, or with a very short vestigial cirrus, to 60 cm long with petiole to 15 cm; leaflets 4-5 on each side of the rachis broadly diamond shaped, and shortly stalked, to 20 cm long by 7.5 cm wide with 5-7 nerves. ± unarmed or sparsely bristly near the tip, leaflets drying dull dirty grey green. Inflorescences male and female superficially similar to 1.25 m long with 3-4 partial inflorescences to 35 cm long. Male rachillae about 1.5 cm long, female to 13 cm long. Ripe fruit

rounded to obovate or elliptic, to 2.2 cm long by 1.7 cm wide. Endosperm deeply ruminate.

Uses: It is small sized but expensive rattan, which grows as clump. This is one of the rare species recently found in natural forest. Even if the cane has a good appearance it is probably too rare to be of any significance.

3. *Calamus javensis* Blume (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Lek, Wai Sai

Extremely variable slender to very slender clustering rattan, sometimes forming low thickets scarcely 2 m tall, sometimes climbing to 10 m or more. Stem without sheaths 2-6 mm in diameter, with internodes up to 30 cm, usually less. Sheaths bright green when fresh, frequently tinged reddish, slightly longitudinally striate with very variable armature, varying from sheaths inerm to sheaths densely covered with small horizontal spines. Spines sometimes very fine sometimes triangular, rarely exceeding 5 mm. Knee present. Ocrea quite conspicuous, deep-crimson-tinged when young eventually tattering. Flagellum to 75 cm. Leaf ecirrate, very variable in form, but in adult leaves, always with a terminal flagellum formed by two apical leaflets joined along at least length. Lowermost pair of leaflets frequently convex and swept back across the stem enclosing a chamber sometimes ant-infested. Number of leaflets varying from 4-10 on each of the rachis, Usually irregularly grouped the penultimate very close to the terminal flagellum and median leaflets ± opposite; rarely the leaflets arranged ± regularly. Leaflets exceptionally to 20 x 5 cm, oval in outline, except for tip, with 3 main veins and conspicuous transverse veinlets, shiny green. Young leaves reddish tinged. Inflorescences male and female superficially similar, bearing 2-5 partial inflorescences crimson rachillae borne at right angles to the axis. Ripe fruit ovate to rounded to 1.2 mm long by 8.12 mm wide, covered in pale greenish-white scales in 15-21 vertical rows. Seed somewhat angular. Endosperm homogenous. Seedling leaf with 4 broad shiny leaflets.

Uses: An excellent small cane used for twine and furniture.

4. *Daemonorops sabut* Becc. (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Pon Khonnon

Clustering moderate-size rattan climbing up to 20 m or more. Stem without sheaths to 1.5 cm in diameter, with sheaths to 3 cm. Internodes to 10 cm. Sheaths bright green densely armed with collars tipped with black and brown horse-hair like spines varying from 1-6 cm in length, the collars frequently somewhat oblique; and caduceus blackish-brown indumentums between the collars, at least some of the collars interlocking to give ant tunnels. Knee well developed. Ocrea inconspicuous. Leaf cirrate, to 2.5 m long including the petiole and the 1.2 m cirrus; petiole to 60 cm long with scattered reflexed spines to 5 mm long and small groups of black spicules on collars near the base. Leaflets to 17 on each side of the rachis, very irregulary clustered, in 5 groups of 2-5 leaflets in each, the lowermost group often very crowded; leaflets all ± the same size, rather narrow about 45 cm long by 3 cm wide, sparsely spiny along margins. Inflorescences male and female superficially similar the prophyll long persistent armed with collars and black bristles like the leaf sheaths, other bracts quickly falling at anthesis. Whole inflorescence to about 60 cm. Mature fruit rounded to ovate, very shortly beaked, about 1.6 cm long by 1.2 cm wide covered in 14-17 vertical rows of yellowish reflexed scales. Seed about 1.2 cm long by 9 mm wide, densely pitted. Endosperm deeply ruminate. Seedling leaf unknown.

Uses: This rattan is a small to medium size rattan with good price. It is used for weaving products that need strength and beauty.

Silvicultural practice of small size rattan

The establishments of plantation normally use seedlings 40-50 cm tall for planting out in the field. Rubber trees, *Lagerstroemia* sp. and fruit trees have been used to provide shade and support by smallholders. Large-scale commercial

planting has been carried out under plantation forest. There is solid information in Thailand shown that *C. caesius* can be planted successfully under rubber plantation. The commercial plantation normally adopted a spacing of 2x8 m. or 2x10 m.

Seedlings production for planting normally starts with seeds, after germination they will be transplanted and potted in black polythene bags of about 15 cm deep and 15 cm in diameter when the shoots have emerged the spear like protuberances about 1cm in length. Seedlings are nursed in these bags for at lease 9 months under partial shade of plastic net to provide about 50% of normal light. After hardening under the full sunlight for 1 month then they are ready for planting out in the field.

Plantation maintenance is by circle-weeding manually for 2-3 years since planting. The conditions for optimum growing require about 50% sunlight. The overhead canopy of the supported trees should be manipulated in order to provide light for optimum growth. Clearing the paths along the planting rows should be maintained to allow easy access and maintenance. The application of organic fertilizer should improve further growth.

B. Big size rattan

1. *Calamus manan* Miq. (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Kordum

Solitary massive high climbing rattan reaching eventually lengths of over 100 m. Stem without sheaths to 8 cm in diameter, sometimes quite slender (2.5 cm) at the very base, with sheaths to 11 cm in diameter; internodes to 40 cm long. Sheaths dull grey green densely armed with black laminate hairy edged triangular spines arranged in lateral groups or scattered, the largest to 3 cm long by 1 cm wide at the base, and with numerous much smaller spines to 5 mm long between; spines horizontal or slightly reflexed; thin white wax abundant between spines. Knee

conspicuous armed as leaf sheath. Ocrea ill-defined. Leaf cirrate very massive to 8 m long including the cirrus to 3 m long; petiole short, to 12 cm long by 5 cm wide in mature plants, much longer in juveniles armed densely as is the rachis with short triangular spines both on the upper surface and beneath, with scattered grey indumentum between. Leaflets irregular in juvenile leaves, regular in mature leaves, limply pendulose and versatile, to 45 on each side, pale grey-green, the largest to 60 cm long by 6 cm wide bristly near the tips. Inflorescences massive, the male much more finely branched than the female, to 2.5 m long with up to 9 partial inflorescences on each side to 70 cm long; all bracts rather densely armed with triangular spines to 3 mm high and red-brown indumentum. Rachillae to 15 cm long. Ripe fruit rounded to ovoid, to 2.8 cm long by 2.0 cm wide shortly beaked, and covered in 15 vertical rows of yellowish scales with blackish brown margins. Seed ovoid, to 1.8 cm long by 1.2 cm wide, with finely pitted surface; endosperm densely and deeply ruminate. Seedling leaf with 2 divergent leaflets cucullate with a waxy blue-grey bloom on a pale dull green surface.

Uses: The premier large size furniture cane of unsurpassed quality. It is the best quality among big rattan in the world and is commonly used for furniture structure. At present, this is one of the rare species in Thailand.

2. *Calamus longisetus* Griff. (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Kam Puan

Very robust clustering erect rattan with stems rarely more than about 5 m tall. Stem without sheaths to 5 cm in diameter, with sheaths to 8 cm in diameter, with short internodes about 10 cm long. Sheath densely armed with erect, spreading and reflexed laminate yellow based brown spines of varying length, the longest to 3 cm long by 4 mm wide at base armed very small spines in between, and abundant dirty grey indumentum. Ocrea fibrous. Knee only slightly developed. Leaf ecirrate, to 4 m long with petiole to 1.5 m long; rachis and petiole yellowish armed with flat black brown yellow based laminate spines; leaflets numerous

grouped in 2's-5's alternately or opposite, the longest to 75 cm long by 4 cm wide, sharply spinulose along margins and upper side of mid-vein and with long bristles (to 2 cm) on the mid-vein beneath. Inflorescences male and female superficially similar, to 4 m long, pendulose, with densely armed primary bracts, and tattering secondary bracts. Male flowers densely distichous on rachillae to 10 cm long. Female flowers laxer on rachillae to 15 cm long. Fruit to 3.5 cm long by 2 cm wide, ovoid to pointed, covered in 12 vertical rows of shiny dark brown to blackish flat scales with conspicuous pale fringed margins. Endosperm homogeneous. Seedling leaf unknown.

Uses: It is a big size rattan that frequently used in the industries. Except for Wai Kordum and Wai Nampung, Wai Kampuan is popularly used as it grows in a big clump and give high yield of shoot productivities. Fruit is said to be eaten and leaves used for thatch.

3. *Calamus peregrinus* Furtado (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Nguay, Wai Hua Daew

Solitary rattan with stout stem to 20 cm tall without sheaths about 2 cm in diameter, with sheaths to 3.5 cm. Internode about 6 cm only. Sheaths mid green with broad yellow streaks when fresh, pale brown when dry armed with scattered large pale yellow-green laminate spines with black tips and rough hairy edges; to 2.5 cm long by 8 mm wide at the base; sparse brownish scales on young sheaths. Knee well developed. Ocrea short, blackish. Cut surfaces exuding yellow sap. Flagellum to 3.5 m long. Leaves ecirrate very large, 4-5 m long. Petiole 1-1.75 m long armed with pale yellow green spines tipped black. Leaflets numerous, stiff regular, on part of leaf ± opposite 50 cm long by 2-4 cm wide, with main nerves armed with bristles above and below; and along margins near the tip. Inflorescence 3 m long including long flagellum, bearing 2-3 partial inflorescences; bracts armed with scattered pale spines with black tips, tattering in age. Female flowers relatively large, densely arranged 7.5 mm long. Fruit globose or very slightly

obovoid, borne on a stalked disc; fruit to 2 cm long by 1.6 cm wide covered in 16 vertical rows of reddish brown scales, shiny, and scarcely grooved, with darker marginal lines. Seed globose, pitted, deeply ruminate.

Uses: It is a big cane that commonly used for furniture structure.

Silvicultural practice of big size rattan

In general plantations establishment is from seedlings. The seedlings will be transplanted at the stage of spear like protuberance appearing. The transplanted seedlings are potted in the polythene bags like other rattans seedlings and raising for at least 12 months under 50% sunlight before ready to be planting out. Seedlings require plenty of moisture without waterlogged. The commercial rattan plantations can be established in the rubber plantations or other kinds of forest tree plantation with the spacing of 8 x 3 m. Rattan inter-planting in rubber plantation is the concept of agroforestry. It is aimed at increasing the yield of land and supplements the income of smallholders/rural people. The income was estimated to be more than sufficient to cover the costs of replanting rubber (Salleh & Aminuddin, 1986). In Malaysia, the survival and growth of *Calamus manan* planted under rubber trees in plantations were reported to be better than when this specie was planted under forest. It is also cost-effective than planting in forest areas. This is because the prevailing conditions in managed rubber plantation are almost ready-made for immediate establishment of rattan seedlings (Razak Mohd Ali & Barizan, 2000). In Thailand, experience shown that the latex production and growth of rubber trees reduced at the age of more than 9 years after inter-cropping *C. manan* in rubber tree plantation. It was recommended that even if inter-cropping rattan with rubber trees appears feasible, rattan should be viewed as a supplementary crop only. In the planting phase, rattan planting should be timed for harvesting when the rubber trees are reaching the stage when they need replanting, i.e. at around 25 years of age. This would minimize the difficulties encountered during harvesting of rattan, and prevent damage to the rubber tree that

could occure if the cane is harvested earlier. For the *Calamus longisetus* and *C. latifolius,* it was found that growing these species in *Azadirachta excellsa* plantation can perform better growth and provide better production than those planted in the natural forest. However, when rattan continues to grow up further, twig and stem of *A. excelsa* was not strong enough to support the weight of top part of rattan and usually cause the tree to fell down. Due to these big size rattans are very robust when mature, so the supporting trees should be strongly concerned. In general, *Lagerstroemia* is recommended to be used as supporting trees for rattan. The trees canopy manipulation to allow 50 – 60% light is necessary for vigorous growth of rattans. The maintenance is by circle-weeding 3-4 times a year up to the age of 3 years. The application of organic fertilizer can also enhance the growth of rattan.

C. Edible rattan

1. *Calamus viminalis* Willd. (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai Dong, Wai Kom, Wai Nham or Wai Nham Khao

Clustering rattan with medium stem size. Diameter of the cane about 2-2.5 cm. The compound leaves are composed of 75-90 leaflets, and the climbing organs with spiny thorns acted as flagellum originate from the upper part of stem sheath. The plants begin flowering after 2 years old. The fruits are round diameter 0.8-1 cm, and there is only one seed inside. Stem up to 35 m long and 0.5-1.5 cm diameter, occasionally even less. Sheath 0.9-3 cm diameter, pale green with white indumentum with rapidly falls off. Whole leaf 1.0-1.5 m long. Petiole of upper leaves 5-20 cm long with straight spines 1-4 cm long. Leaflets in groups of 2-4 on each side, not all held on the same plane but fanned. Above middle veins prominent. One line of yellow-based bristles above and below. Margins bristly. Inflorescences 1.5-3 m long plus flagellum. Branches quite stiff, slightly pendulous. Primary bracts entire, closely sheathing, with scattered calws. Fruit 0.8

cm long and 0.8 cm wide, whitish (yellow when dry) with fine dark margin. Perianth wholly split, no tubular part. Seed not ruminate.

Use: Shoot is edible and fruit sometimes sold for food.

2. *Calamus siamensis* Becc. (Dransfield 1979; Dransfield *et al.* 1994)

Vernacular name: Wai NumPung

Clustering rattan climbing to 5 m, forming thickets in open ground. All part drying pale. Stem without sheaths about 8 mm in diameter, with to 1.5 cm, with internodes to 10 cm long. Sheaths bright green with scattered triangular brown yellow-based reflexed spines to 2 cm long and abundant red brown indumentum. Knee prominent. Ocrea inconspicuous. Flagellum to 1.5 m. Leaves ecirrate, usually without petiole in leaves of mature stems, to 1 m long; rachis flattened above and armed with erect spines to 5 mm long; upper part of rachis armed with solitary reflexed spines. Leaflet 30-35 on each side, all in one plane, arranged in irregular groups of 4-12; largest leaflets to 25 cm long by 1.7 cm wide; all leaflets densely armed with long yellow spines along mid-vein on upper surface, and shorter spines along margins and mid-vein beneath. Inflorescence female and male superficially similar to 1.5 m long with 6 or more partial inflorescences with bracts very sparsely armed. Fruit rounded about 8 mm in diameter, covered in 15-17 vertical rows of straw-coloured scales. Seed angled with homogeneous endosperm.

Use: Shoot is edible and cane for parts of furniture.

Silvicultural practice of edible rattan

In general, *C. viminalis* and *C. siamensis* are propagateded by seed or vegetative portion. For vegetative propagation, sucker is removed from rhizome in the cluster. However, it was found that this method is not practical as it can not be done in limited time in large-scale plantation and the survival rate by using this method is also low. Except from the two methods mentioned above, tissue culture

technique can also be done but the procedures and technique are in improving stage. However, it was also concerned that the technique may be too complicate to introduce to the farmers.

Propagation by seed is the most practical way. Seed are extracted at maturity (notice from the fruit that turn from green color to white color and contained brown seed with slightly sweet soft pericarp inside). Fruits for seed propagation can be collected from February to April that will provide 8,000 – 8,500 seeds per kilogram after scales covered and pericarp were removed.

For seed propagation, if high percentage of germination is required, seeds should be treated with special technique. The processes started by completely removing seed cover and pericarp from the seeds. The most fast and easiest way for this step is by using mortar and pestle. One can of dry mature fruits mixed with ½ can of cleaned sand is pounded in mortar for 2 – 3 minutes then washed on the sieve to remove sand and debris. Next step is removing of minute seed coat portion that necessary for seed germination by using small knife. This step need skillful for making a very small wound that is not too deep on seed coat as it may cause damaged to the embryo. Generally, one skillful farmer can prepare 0.8 – 1 kilogram of seeds by this technique. Next step is sowing 0.5 k.g. of seeds in 18 inches diameter enameled basin, which contains 3 inches dept of cleaned moist coconut husks as a medium and cover with 1-inch dept of layer of moist coconut husks. It was recommended that coconut husks should be boiled for 1 min. in boiling water before use, to make it clean and increase property in holding water. Then put the basin into big transparent plastic bag and tightly tie the bag opening. Let the seeds in the basin germinate under the shadow. About 7 days, the seeds start germinating and within 1 – 1.5 months they will get strong enough to transfer into soil bag and kept in nursery before transplanting during rainy season. Approximately, 60 – 65 % of seeds are successfully germinated by this method.

In case of enormous amount of seeds are obtained and a few workers are available, the seeds can be propagated by sewing directly to seed-bed without removing any parts of seed. This method should be done as soon as possible after seed collecting due to the germination rate decrease drastically after seeds were collected and stored (the germination rate decrease from 40% to 15% within 6 months). The medium used in seedbed in this method contains soil, sand, burned rice-husk and disintegrated cow manure in 1: 1: 1: 1 ratios. Not less than 70%-80% of sun light needed for seedbed. The seeds are sewing along 1- inch dept of furrows prepared in seedbed. Each furrow is separated for 3-4 inches apart. Cover each furrow with 1-inch dept of medium and keep watering. Sewing seeds in furrow will make it easy when transfer seedlings to soil bag. The seeds will germinate within 2 months and strong enough for transferring to soil bag within 3-4 months. Germination rate by this method is about 35%-40%.

Seedlings that big enough and first leaf starts to expand are suitable for transferring to soil bag. Transferring at this stage caused almost 100% of survival rate. However, not all rattan seeds germinated at the same time. Therefore, transferring should be graded into several generations. Suitable medium for the soil bag contains loose soil and disintegrated cow manure at 3 : 1 ratios.

Transferred seedlings should be kept in not more than 50% of sun light as higher percents of sun light may caused leaf blight or burned. Watering should be done once a day or up to climatic situation when seedlings get 4-5 months. Sometime blight leaf or burned leaf is found which may cause from lacking of micro-biotic elements. This can be solved by spraying fertilizer contained micro-biotic elements (e.g. urinate) once a week. It can be noticed that this symptom seldom occurred when using medium containing manure.

Frequently examining and arranging seedlings according to the height to let all seedlings to have chance to get equal light, water, and mineral to encourage survival rate of rattan seedlings. At this stage, seedlings are ready to be planted

into the plantation in early of rainy season (May – June) in the next year. During this moment, seedlings should reach 40-60 cm. in height. Hardening process should be done to make the seedlings get stronger by keeping all seedlings under full sunlight and decreasing water.

For shoot harvesting purpose, let rattan seedlings grow under full sunlight in an open area. This will enhance seedlings to grow fast and produce big clusters, which give high productivity. Upland is better than lowland for *C. viminalis* and *C. siamensis* plantation. For flooding area, the land should be lifted as these species cannot survive under long time of flooding condition.

Before planting, an area should be well prepared by 1-2 times ploughing. First plough is for weeding and after 1-2 weeks the second plough will make soil loosed that help encourage root system of rattan.

As these species can be harvested for more than 30 years, spacing for planting should also be concerned in long term management. The most suitable spacing is 3 x 1.5 m , which means 2,187 plants per ha.

The amount of shoots that can be extracted from each clump varied according to the plant age. Harvesting begins in the second year, when only one or two shoots can be cut. More shoots can be cut in each year and more than 10 shoots are available for each clump after 6 years or so. After each cutting, humus is applied to encourage growth of the new shoots

Fresh rattan shoots are normally sold to the middlemen who come and buy directly from the owner of plantations. At present, the demand for rattan shoots is increasing. Even in Bangkok, preserved rattan shoots in bottle is also found in some markets. Perhaps more of such products are needed. Encouragement in establishing small enterprise for the quality products from rattan shoots should be done to provide job opportunity to the rural people. This will also upgrade the living standard of the farmer and create income for the rural population. Rattan

plantations both for shoot and cane production will reduce not only the pressure on naturally occurring populations, but also will increase the supply of raw rattans.

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ANNEX

Rattan species for big cane production

Calamus manan

Calamus longisetus

Calamus peregrinus

Rattan species for small cane production

Calamus ceasius

Calamus blumei

Calamus javensis

Daemonorop sabut

Rattan species for shoot production

Calamus tenuis

Calamus siamensis

Calamus viminalis

Rattan Fruit

Fruits of *C. viminalis*

Fruits of *C. longisetus*

Fruits of *C. caesius*

Seed Processing for Germination

Selection of ripe fruits

Pounding with sand for 2-3 minutes

Cleaning with water to separate seeds

Shoot Producing Plantation

Planting between the rows of vegetable plants

Shoot producing plantation of *C. viminalis*

Plantation of *C. siamensis* for shoots and cane production

Utilization

Furniture and handicrafts

Shoot for food

Edible shoots and food from *Calamus viminalis*

Preserved rattan shoots for sale

Rattan in Thailand

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