The INBAR Working Paper Series

The International Network for Bamboo and Rattan (INBAR) is a network of scientists and development workers from universities, governments and, increasingly, NGOs, who are working on various aspects of bamboo and rattan. The princial objectives of the network are: to improve the well-being of small-scale producers and users of bamboo and rattan within the context of a sustainable bamboo/rattan resource base; to build skills and enhance capacity of national programmes; to expand/orient bamboo and rattan research consistent with the priorities dentified; and, to strengthen national, regional and international coordination, cooperation, and collaboration.

INBAR seeks to accomplish its goals by identifying and supporting research consonant with the priorities identified by national programmes. There is a strong emphas is on collaborative approaches to address problems which have regional and international relevance. The network's research and development activities are organised according to five themes : Socio-economics Research; Production Research; Post-Harvest Technology Research; Biodiversity and Genetic Conservation (jointly with the International Plant Genetic Resources Institute (IPGRI) and Information, Training, and Technology Transfer.

Communication is vital to any network, INBAR uses a variety of fora, including a quarterly newsletter, the INBAR Technical Reports Series, and this, the Working Paper Series.

The INBAR Working Paper Series is designed to promote the rapid exchange of information on various aspects of bamboo and rattan science, and on the applications of research for sustainable development. The papers may be generated within INBAR research projects. However, other papers relevant to INBAR's mandate and objectives are welcomed, and will be given due consideration for publication.

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DOMESTICATION AND IMPROVEMENT OF RATTAN

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FOREWORD

In the early 1990's greater attention began to be focused on cooperative networking, especially in Asia, to enhance the sustainable production of rattan.This followed a decade of support by IDRC, Canada to national programmes concerned with the production and processing of rattan.

By 1993 INBAR came into being to promote and facilitate all aspects of research on bamboo and rattan. However, at the end of 1991, UNDP had established a regional project for technology transfer and training to improve productivity of man-made forests by applying advances in technologies related to tree breeding and propagation. The project, with the acronym FORTIP, is operated through FAO. Member countries of the FORTIP network have identified the problems associated with productivity as inadequate maintenance of man-made forests, mismatching the species to sites, and sub-standard seed and planting materials. Rattan became a candidate for FORTII? consideration and a consultant report was commissioned in 1993. This working paper is a revised and edited version of that report.

From INBAR's foundation in 1993, FORTIP has collaborated closely. It was felt that this consultant report, updated following key action by INBAR, would be useful to a wider audience. We trust this is so.

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INTRODUCTION

A rattan is a spiny, climbing member of the palm family found in the tropical and monsoon areas of the Afro-Asia-Pacific regions. Its strength, malleability and versatility make it much valued in the furniture and handicraft industry. After timber, rattan is the most valuable forest product in tropical Southeast Asia.

This non-wood, renewable forest resource has, over the past two decades, diminished throughout its distributional range due to over-exploitation, opening up of land for agricultural purposes and burning of forests during drought.

Restriction of export of raw cane from traditional rattan-exporting countries since 1988 has only slightly delayed exploitation but not degradation of habitats. The restrictions have driven rattan manufacturing countries to seek new sources from Myanmar, Laos, Vietnam and New Guinea, but these countries cannot sustain the market for long.

In order to replenish rattan resources, rattan-producing countries can either.(a) manage the natural forests more intensively not only for timber but also for rattan production or (b) develop rattan plantations. Since the first approach presents constraints because of difficulty in patrolling large forest reserves against illegal harvesters, the establishment of rattan plantations is the only viable alternative.

Cultivation in plantations requires the domestication of species in order to grow different species in new or modified environments. This involves silvicultural practice and genetic management.

Although rattan has been cultivated by villagers during the past 100 years along the Kapuas and Barito Rivers in Kalimantan Borneo, it is only during the past decade that Indonesia, Malaysia and the Philippines have begun establishing rattan plantations on a large scale. Even so, domestication has hardlv started.

Most rattans are not pioneer species and the following attributes have in the past, not favoured domestication:

a) seeds are difficult to store and they are short-lived with rapid loss of viability

b) they are difficult to propagate vegetatively on a large scale

c) palms producing desirable canes are slow to mature, taking 7-10, or more, years

d) commercial rattan species are usually not gregarious

e) commercial rattan species are not normally tolerant of poor sites.

Although some of these difficulties can be overcome with rapid air transport and with new storage methods, many constraints remain. Additionally, the use of the more fertile lands required for high yields have to be justified as there is likely to be competition from agriculture. Finally, the correct choice of species/provenance and site is often critical in view of the high capital expenditure and costs of maintenance involved in plantations.

The UNDP/FAO Regional Project on Improved Productivity of Man-Made Forests through Application of Technological Advances in Tree Breeding and Propagation (FORTIP) has high-lighted rattan as a candidate for attention. The report which follows focuses on considerations essential to any such network activities which might emerge.

OBJECTIVES AND EXPECTED BENEFITS OF A NETWORK APPROACH

The mosf important objectives of any coordinated network approach would be:

(i) To identify the most practicable pathways to accelerate rattan domestication by identifying (a) network countries, (b) suitable species and provenances, (c) seed supplies and methods of seed exchange, (d) techniques of planting and (e) economic constraints.

(ii) To identify the important growth attributes for groups of economically valuable species to form the rationale for genetic enhancement.

The expected outputs would be:

(i) availability of improved stocks,

(ii) a better knowledge on site suitability for species, and

(iii) established mechanisms of seed procurement for planting.

All countries participating would benefit if the coordinating project rapidly identified not only the right species but also the right provenances for introduction to particular plantation areas. In countries where genetic resources are eroding through forest destruction this will contribute to ex situ conservation. Already it is known that many provenances and races of commercial canes are probably extinct in the Philippines and Thailand and also in Indonesia and Malaysia due to large scale destruction of natural habitats.

Of the member countries of FORTIP, Bangladesh, Bhutan, India, Indonesia, Malaysia, Nepal, the Philippines, Sri Lanka, Thailand and Vietnam would clearly be beneficiaries. The other member country, Pakistan, may not have the right climates for rattan cultivation. China, Myanmar and Papua New Guinea are not currently members but are important rattan producers. INBAR includes all the countries in its activities; here FORTIP INBAR collaboration is welcomed.

Strategies to meet the objectives

In order to implement a programme to address the objectives, the following could be considered:

Organization of a workshop among participating countries to (i) identify problems and constraints in domestication and enhancement of rattans, (ii) identify research needs and priorities that might be developed within the framework of a regional cooperative network, and (iii) bring together and share current knowledge on genetic resources, ecology and distribution of priority rattan species and the stages of plantation development.

Information research on species involved. Field identification of commercial rattans and species nomenclature pose serious problems to researchers collecting seeds for trials. Multi-access field keys complete with illustrations are urgently needed.

Inventory of standing stock of rattan in natural stands, on a national basis, is required to provide information on how long they can continue to sustain the demands of the furniture industry and what areas of plantations are required to make up for shortfalls. Only the Philippines and Malaysia have inventoried their forests for rattans. The number of hectares under cultivation is known for most countries.

Genetic conservation. There is an urgent need to survey species genetic diversity so that action can be taken to conserve endangered species/provenances/populations and link them to improvement programmes.

Identify countries willing to collaborate in exchanging germplasm.

Seed collecting for in-country short and long-term breeding and on a regional basis for species and provenance trials for longer term breeding needs to be planned.

Establishment of trials needs to be planned, their progress monitored and analysis of results standardised. This should lead to identification of proven provenances and species for base populations.

Concurrent research on meristem culture for clonal propagation is needed so that clonal plantations can be developed.

Excluding Africa, the areas where rattans occur occupy an area about twice that of Europe. It would be a herculean task for any project to coordinate, finance and collect seeds of economically important species from all these areas. Thus it would only be feasible by a step-wise approach: in-country seed collecting followed by regional seed collecting.

It is suggested that individual countries collect seeds from selected plants of economically important species within their respective countries to establish seed stands in addition to establishing species and provenance trials. Areas where commercial species of rattan occur are noted during seed collection and small blocks of at least 20 - 40 ha distributed throughout their range should be noted to plan in situ conservation.

Seed collecting for species and provenance trials on a regional scale can begin if or when funds are available and countries are willing to collaborate. It is important to know which commercial species are likely to do well in the different project countries. It is possible to roughly divide the species into their respective climatic zones.

Rattan producing countries extend from perhumid to monsoonal zones. No species can be expected to grow well throughout the whole region. There is a need to know not only which species to try but where they are most likely to succeed through development of climatic matching techniques to assist in species selection. It should be noted that:

(i) In general, rattans from perhumid areas are not expected to perform well in monsoonal areas because species adapted to areas where some rainfall occur throughout the year may probably not survive the longer dry seasons of monsoonal zones especially during the seedling stage. However, some premium rattan species from perhumid areas may be included in species trials in monsoonal countries. If they survive, albeit with slower growth rates but equal to or faster than indigenous species, they are worth planting on a larger scale because of their better cane quality.

(ii) Species from monsoonal areas, on the other hand, may probably grow quite well in countries with perhumid climate but such species trials (from monsoonal to perhumid areas) is probably not cost-effective.

(iii) Species from monsoonal areas north of the equator should grow well in similar areas south of the equator and vice versa.

(iv) Not many species are adapted to cold climates. There is merit in exchange of commercial species between S. China, N. Vietnam, Laos and N. India, Bhutan and Nepal.

(v) Most countries of the perhumid region have established rattan plantations with the major commercial species and these are performing satisfactorily. Trans-regional species trials are not vital therefore but these countries need to focus more on provenance or provenance cum progeny trials.

species for trials have to focus on promising large and small diameter canes respectively for three zones: perhumid zone, “warm” monsoonal zone and “cool” monsoonal zone.

No method has been found yet to store seeds for more than one year. Rattan fruits can, however, be kept for up to three weeks after harvesting with little loss in viability provided they are treated with Chlorox bleach or a fungicide and kept damp under shade.

The Forestry Services or Departments of different countries are in the best position to know the most valuable commercial rattan species but also where they arc located and their habitats. In the In tcrnational Teak Provenance Trials for instance,DANIDA,through the cooperation of the Indian Forest Service and the Forest Research Institute managed to collect seeds for more than half of the provenances (Keiding etal.,1986).

The best way to undertake regional species and provenance trials where the seeds of the species are of short viability is for the respective countries to collect sufficient seeds of the species and provenances and to send them as soon as possible after harvesting direct to the countries that had earlier made requests for the seeds. There should be no cleaning of the seeds at the collecting sites because cleaned seeds become desiccated and viability drops drastically after about four days.

Initially, there is no point collecting large amounts of seeds (for long-term storage and future distribution) because seeds cannot be kept for any length of time. A second collecting, after trials have indicated which species and provenances are suitable for a particular country is a better strategy.

Unlike trees that give large amounts of seeds, a rattan clump may provide only 2,000 to 5,000 seeds per season. Hence the number of plants to be sampled will depend on the number of trials to be carried out. It is possible to bag fruits from specific plants for provenance cum progeny trials.

Species trials are recommended for countries in zones where virtually no rattan trials have been carried out. Guidelines are available from an INBAR technical publication (INBAR 1994).

Many species from the Indian sub-continent and Sri Lanka have been over-exploited. Some species like Calamus brandisii, C. huegelianus and have not been seen in recent years (Renuka et al., 1987) and others like C. ovoideus and C. zeylanicus have been illegally harvested to near exhaustion (De Zoysa & Vivekanandan, 1989)

However, local patterns of exploitation in the past, in relation to species are not necessarily the guide to which species merit more intensive production in plantations. INBAR has addressed this (see below) and priorities are available.

SPECIES

Nearly all species of rattan are used for some purpose somewhere. However, a limited number have entered into cultivation and even more are selectively harvested for commercial purposes. A body of knowledge has been built up on those which appear to show the greatest silvicultural potential.

The first plantations were established in Kalimantan in ca. 1850 (van Tuil, 1929) on a village scale but trials for commercial scale cultivation really only started much later in China, India, Indonesia, Malaysia and the Philippines (largely in the period 1980to the present). In addition, small experimental plantings have also been carried out in Bangladesh, Papua New Guinea, Thailand and Sri Lanka. Whereas village scale plantings will continue to be needed (and are still the basis of cultivation in such countries as Papua New Guinea), commercial plantings need to be expanded.

In the experimental plantings which supported the slow move towards commercial plantations due attention was not always paid to the best choice of species although economically important canes e.g. C.manan C. , caesius and Ctrachycoleus have received research focus. The lack of attention to species is understandable when it is recalled that the-genus Cafamus alone contains 37040 species. The genus Daemonorops contains 115 species with probably about 15 useful species (Uhl and Dransfield, 1987).

Since this report was drafted a number of activities have occurred which relate to the priority given to species. First of all a number of descriptive accounts have appeared e.g. Renuka, 1992, for

S. India, de Zoysa covering Sri Lanka 1994, and Dransfield and Manokaran, 1994 covering South East Asia. Additionally aspects of management and utilisation were dealt with in Chand Basha and Bhat, 1993.

However, most significantly INBAR, in December 1993 organized an expert consultation to prioritise species. This exercise resulted in synthesizing known information, on uses, degree of domestication and geneticerosion as well as known potential and taxonomy. It was, due to the need for further taxonomic research or taxonomic clarification, not possible to identify a very short- small list of species; some had to be treated as species complexes (Williams and Rao, 1994).

The following are agreed priority species:

C. manan

C. caesius

C. trach ycoleus

Species of Calamus Sect. Podocephalus

C. subinermis

C. palustris

C. fetradactylus

C. deeratus

C. ho1lru ngii

Sect. Podocephalus includes species such as C. andamanicus, C. ovoideus, C. zeylanius and C. merrillii as well as 11 other species; C. subinermis includes yet to be named relatives in Sulawesi and West Java and C. inops; C. palustris includes C. inermis, C. nambariensis and some others; C. hollrungii includes relatives from the Pacific, New Guinea and Queensland. C. deeratus is the only species not indigenous to Asia; it is a variable African species.

The above priorities differed somewhat from those suggested by the author of this report in 1993 but there was a large degree of agreement. INBARstresses that other species remain of priority in a local context but are not necessarily the subject for wider commercial trials across regions. Examples, for instance, would include C. mindorensis in the Philippines, C. latifolius in N.E. India, Himalayas, Bangladesh and Thailand, or C. warburgii in Papua New Guinea, (Konabe and Sastry, 1991) although this latter species may be related to the Podocephalus priorities.

Of the INBAR priority species C. manan, C. caesius, C. trachycoleus and C. tetradactylus are domesticated; Calamus Sect. Podoccphalus, C. subinermis and C. palustris are semi-domesticated and C. decratus and C. hollrungii are still virtually wild.

It should be noted that there is a need to understand the taxonomy better; and that knowledge on phenology and ecological requirements is sparse (Rao and Rao, 1995).

There are practical difficulties in moving material across regions. For instance, lethal yellowing of coconut caused by a mycoplasma-like organism is known to occur in the northern Philippines. Countries of South East Asia and the Pacific Islands, where coconut and oil palm are major crops, have strict quarantine over imports of palm materials including rattan species from countries where lethal yellowing occurs.

One last point relating to priority species concerns the genetic base. No attention has yet been given to genetic conservation, despite the over-exploitation of many resource areas. Action is needed tosupplement the establishment of arboreta of rattans since these contain only a minute fraction of the genetic variation.

PRESENT AND FUTURE PRODUCTION AND USE OF THE SPECIES

World trade in rattan increased very slowly up to the mid-1970s. Traditional manufacturers were in Europe and the USA with raw cane imported largely from Indonesia. World trade in rattan rose sharply from about 50,000 t in 1975 to 113,000 t in 1979 owing to worldwide demand for rattan furniture (Nasendi, 1994).

This resulted in increases in price of raw canes and prompted governments of cane producing countries like the Philippines, Malaysia and Thailand to reduce export of raw canes. However, only the Philippines was initially successful. Indonesia, which produced some 80% of the world rattan supply, only banned the export of unprocessed canes in September 1986. During this period, the Philippines and Taiwan emerged as major manufacturers with active support of their governments.

By 1987, trade in rattan canes exceeded 200,000 t with Taiwan and China stockpiling canes in anticipation of the Indonesian ban on the export of raw and semi-processed canes. Since the ban, developed countries shifted from local manufacture to imports as rattan producing countries progressively hindered the export of raw canes.

Present production

Following the Indonesian ban on export of unprocessed canes production of canes from rattan producing countries were no longer reported in tonnage but in value. It is not even possible to break down exports into large and small diameter canes let alone obtaining figures for the export of the different species. C. trachycoleus, for example, fetches a lower price than C. caesius. As the quality of the two canes are similar, better quality C. trachycoleus canes are often mixed with canes of C. caesiusand sold as C. caesius.Production can only be discussed in general terms for the commercial canes.

Soon after the Indonesian ban on the export of unprocessed canes, rattan furniture manufacturing countries like Taiwan began using raw material from Myanmar, Vietnam and Papua New Guinea. These countries could not keep up with demand and exports from Myanmar and Vietnam have dropped to a trickle due to overharvesting.

With the rapid decline in production of quality canes (e.g. C. man an C. merrillii and C. caesius) manufacturers have started using poorer quality canes (e.g. C. ornatus and C. scipionum) Calamus aidae from Mindanao, not previously utilized because the canes cracked on bending, is being used once it was found that the canes can be bent after treatment with boiling oil, but less desirable canes are now being overharvested. .

In order to conserve rattan resources, most cane producing countries have stopped the export of raw canes and encouraged local rattan furniture industries. Even this course of action is not sufficient to stop the decline in rattan production and natural regeneration cannot keep pace with exploitation. C. merrillii in the Philippines, as an example, has been overcut and a substantial portion of the canes are now immature, causing some traders to stop buying this species. In order to sustain the rattan manufacturing industry, Thailand, the Philippines and Malaysia have been importing canes from Indonesia and Myanmar to supplement local supplies.

Diminishing rattan resources has prompted Malaysia, soon followed by the Philippines, to establish plantations of rattan to augment the natural supplies. Indonesia is expanding its plantations in order to maintain its lead as the main rattan producing country. Areas under rattan plantations (1993) are as follows:

Country	Agency	Area (ha)	Species
Malaysia	SAFODA, Sabah	7,000	C. caesius C. trachycoleus *C. manan* C. subinermis C. merril lii
	Innoprise, Sabah	5,000	As above
	Sejati, Sabah	2,000	As above plus C. zollingeri C. inops
	Jeroco, Sabah	2,000	C. caesius C. manan
	Kesera, Sarawka	1,000	C. caesius C. trachycoleus. C. mannan C. merrtill ii
		Total ca. 18,000	

(Contd...)

Philippines	Picops, Mindanao	4,000	C. mcrril lii
	PTFI, Mindanao	1,500	C. mcrrillii
	PDP, Ilocos Norte	1,000	C. merrill ii
		Total ca. 10,000	
Indonesia	Small-holders	12,000	C. cncsius
"	Barito-Kapuas		C. trachycoleus
		Total ca. 14,000	

A large portion of rattan goes into the furniture industry with exports at around US$ 1,000 million (CIF prices). In 1988 Indonesia exported furniture worth US$ 45.2 million and US$ 56 million of lampit (rattan floor carpets) out of a total export of US$121 million. During the same period, the Philippines exported US$ 135.2 million worth of furniture and US$ 116 million of handicrafts and baskets. The handicraft industry is usually complementary to the furniture industry because lower grade canes and rejects are used.

Shortage of quality large diameter canes is causing a shift to laminated and wicker type furniture. Escalating costs and declining supplies have led to the use of synthetic cane webbing from USA and Taiwan. Furniture based on bamboo, is now competing with rattan furniture for the mid-range market.

Future production

Future demand for rattan furniture and handicraft is there but trade growth will be constrained by supply shortage and price increase. If the price is too high, consumers will turn to other types of furniture. Laminated and wicker type furniture is expected to increase as large diameter, quality canes become scarcer or until plantations come into production. With the higher price of rattan furniture, less costly bamboo furniture will increasingly encroach into the mid-level of the trade.

Rattan regeneration cannot keep pace with the rate of exploitation and more and more immature canes will enter the trade. Almost certainly rattan production will take a hit unless more plantations are established. Even if this happens, increase in production will be slow and emphasis will have to be on quality as the furniture industry moves up market. In order for rattan plantations to be economically viable, elite germplasm needs to be developed and planted. It is heartening to note that INBAR convened an expert consultation on this latter topic in May 1995.

In the furniture industry, about 2/3 of ‘the canes used are of large diameter, mainly for structural frameworks. Larger areas of plantations should therefore be planted with large diameter canes.

An inventory of canes in the natural forest and estimates of amounts used in furniture and handicraft industries are required before clear estimates can be made on areas of plantations each country needs to plant to meet the demand. Based on imports of canes during the 1980s a crude overview is given below.

Since the ban on unprocessed canes, Indonesia has more than sufficient canes for its own industry and Malaysia's inventory and plantations show it producing enough for its own needs. The Philippine's import is about 35 million metres in 1990 and will require establishment of about 50,000 ha of plantation to overcome shortfalls. Thailand which imports about 10,000 t of canes needs to plant at least 30,000 ha of rattan and China has to plant about 80,000 ha to cover its imports. India's annual import is about 20 t; imports have always been minimal but local production and rates of depletion of canes are not well itemised, although recent IDRC-supported research on inventory is producing usefuldata. Production figures for Bangladesh are also not available but employment figures in cane and bamboo industries decreased from 73,200 to 36,500 from 1964 to 1982. Reliable plantation estimates for both these countries cannot be given without better data.

RATTAN IMPROVEMENT AT THE NATIONAL LEVEL

Prior to 1990, very little improvement research was in progress. Only during the past few years has more attention been given to rattan improvement and in this respect work in Sabah is noteworthy.

Improvement relies on knowledge of a number of topics as itemised in the table below. The table includes research attention on the topics from seven countries.

Topic	Indonesia	Malaysia	Philippines	Thailand	India	Bangladesh	Sri Lanka
Reproductive biology	-	+	+	+			
Phenology	+	+	+	+	+	+	+
Species trials		+	+		+		
Provenance trials		+					
Seed stands							
Plus cane selection			+				
Progeny tests		+					
Vegetative propagation	+	+	+	+	+		
Crossing							

Summary of activities in selected countries

MALAYSIA

Reproductive biology

Some species (e.g. Daemonorops angustifolia produce inflorescences continuously throughout the year but initiation of flowering of all planted commercial species seems to be seasonal and is thought to be due to external influences i.e. increase in temperature and water stress during dry seasons possibly causing decrease in internodal length followed by inflorescence production (Raja Barizan, 1992). Further decrease in internodal length during flowering of both C. trachycoleus and C. caesius may be due to increased flow of metabolites to the developing inflorescence and less to the elongating internodes (Shim, 1989).

C. manan, C. trachycoleus and C. filipendulus began flowering about 5.5, 4.0 and 4.5 years respectively after planting and C. caesius at 5.3 years (Manokaran, 1985). There is some seasonality in flowering. Inflorescence emergence of C. caesius is mainly between July and August (Manokaran, 1989). For C. manan flowering occurs between January to late February with a second flowering in May to late June (Raja Barizan,1992), April for C. tranchycoleus with floral initiation before that date, and July to August for C. cipionum.

The fruits of C. manan take 14-15 months to ripen (Raja Barizan, 1992), 16 months after inflorescence emergence for C. caesius (Manokaran, 1985) and 14 months for C. trachycoleus to complete the process from flowering to fruit maturation. Fruits change in colour from light brown to dark green to light green and to light yellow at maturity (Manokaran, 1985; Raja Barizan, 1992). Raja Barizan (op. cit.) also recorded that the size of one month old C. manan fruits are about 7.8 x 5.0 cm and reached 25.6 x 20.4 cm at maturity.

At SAFODA (Sabah Forestry Development Authority), C. manan produces up to five inflorescences per plant and between 1,800 to 3,800 fruits per inflorescence with an average of 2,200 fruit Manokaran (1979) recorded that C. caesius and C. scipionum produced between 2,000 to 3,000 fruits per stem, about 3,000 to 4,000 per stem for C. ornatus, and C. 'trachycoleus at SAFODA generally produces about 1,200 fruits per inflorescence. With C. subincrmis, one kg contains about 4,700 cleaned seeds.

A survey done in 1990 on 7-year old plants of C. manan in a spacing trial at SAFODA gave 70.8% males and 29.2% females from 89 flowering plants out of a total of 1,134 plants. It is possible that male plants mature earlier than female plants but observations were discontinued as the Acacia mangium support trees toppled over soon after and destroyed the trial. Research at FRIM (Forest Research Institute Malaysia) showed six plants of C. trachycoleus to be males while 10 produced female inflorescences. The proportion of male and female plants of C. subinermis in natural populations in Sabah is about the same (Lee Ying Fah, pers. comm.)

In the flowering biology of C. subinermis, Lee observed that anthesis of male flowers occurred one month from inflorescence emergence and 1.5 months. for C. manan Anthesis occurred from about 6.30 p.m. with most of the flowers opened by 8 p.m. By morning, all opened male flowers would have dropped off. It took two weeks for an inflorescence of C. subinermis and three weeks for C. caesius and C. manan to complete anthesis.

Anthesis of female flowers of C. subinermis occurred during the same period as male flowers. When the female flowers opened, the stigmas were shiny yellow and remained receptive for two days after which they turned dull yellow to orange or brown. Several species of moths visited the male and female flowers during the night and Trigona bees collected nectar and pollen from fallen male flowers before visiting female flowers.

Species trials

FRIM is conducting species trials on C. manan, C. cacsius, C. ornatus and C. scipionum, all indigenous species, as well as on C. trachycoleus from Kalimantan, C. ovoideus from Sri Lanka, C. merrillii from the Philippines and C. margaritae from southern China (Aminuddin, pers. comm.). At year 5.3 after planting, a mean growth rate of 1.9 m/year was attained for C. caesius on poorly drained substrate (Manokaran, 1982). For C. scipionum, it was about 11 cm per year up to year 7 (Manokaran, 1983). The mean stem length for C. manan at year 6 was 1.3 m and ranged from 0.1 to 18 m. Growth rate for C. trachycoleus was 1.3 m per year at 2.25 years (Aminuddin, 1985). Although other exotic species are still young, surprisingly, C. margaritae from the very northernmost limit of the distribution of rattans is growing moderately well (Dransfield, 1992).

In Sabah, C. merillii from Davao, the Philippines, C. zollingeri from Sulawesi and C. inops from East Kalimantan (although this is a species of Sulawesi) have been recently introduced and planted in a number of plantations. All are performing well. The seeds and seedlings of C. merrillii and C. zollingeri are so similar that they are probably conspecific (see section on Species : page 5). The seeds and seedlings of C. subinermis and C. inops also appear identical (see also priority species under Species : page 5). Other species, namely, C. caesius, C. manan and C. trachycoleus have been planted on a large scale by several agencies for more than 10 years.

Production of canes of both C. cacsius and C. trachycoleus from Kalimantan was reported at about 2 t dried/ha at year 8 and thereafter, 3-4 t of dried canes per ha/2 years (Tardjo, 1986). At SAFODA an area well stocked with C. trachycoleus produced only about 1 t dried canes/ha at year 9 and SEJATI harvested 0.7 t dried cane's of C. caesius/ha at year 8. The amount of canes that can be harvested per hectare varies with the stocking, silvicultural treatment and method of harvesting, all of which affect the production figures.

Provenance trials and progeny tests

Five provenances of C. manan are currently being tried out at FRIM. In Sabah, a provenance cum progeny trial of C. subinermis from throughout the coastal regions of Sabah has just been established by the Forest Research Centre at inland Kolapis and is being duplicated by SAFODA at Bongkol by the sea. A lattice incomplete block design is used because some 150 families are being tested. A separate provenance trial on C. subinermis was conducted at Luasong by ICSB (Innoprise Corporation Sdn. Bhd.) which is also conducting progeny tests on C..manan, C.manan,C.caesius and C.rrachycoleus

Vegetative propagation

Multiple-stemmed species can be vegetatively propagated by cutting off the side shoots or suckers but they are tedious to collect, risky to establish and only small numbers can be collected (Tan, 1 992).

Tissue culture of rattan has been tried out at FRIM. Substantial progress has been made using the collar region or the embryo of C.manan and C. caesius seeds as explants to successfully produce plantlets (Aziah, 1992). However, plantlets obtained this way from seed material do not always take the form of the mother plant. Teo (1990) broke new grounds when he used tissue from suckers and pencil-sized seedlings of C. caesius as starting material. There was no reported performance of the plantlets in the field.

ICSB set up a tissue culture laboratory in October 1992 and is working on a range of species.

Seed stands

No seed stands have been established although in excess of 1 million seeds of each of, C. caesius C. trachycoleus and C. manan are available each season from plantations in Sabah.

INDONESIA

Phenology

Fruit maturation of the different Indonesian commercial rattans was given by Nainggolan (1986) as in the table below.

Species	Location	Fruit maturation
C. trachycolcus	Kalimantan	Jul - Aug
	Kalimantan	Jul - Aug
		*Dee - Jan
C. caesius	Sampit	Jul - Aug
	Muara Tewe	Aug - Oct
	Muara Siduyung	Jul - Aug
	Kepulauan Mentawai	Aug
	Jambi	Aug
	Bengkulu	Aug
C.	Bengkulu	Aug
	Mentawai	Aug
	Muara Suko	Aug
	Jambi	Aug & *Dee
	North Sumatra	Aug
C. inops	Sulawesi	Aug

Occasionally

Fruit production per stem was: C. manan and C. scipionum 2,000 to 3,000, C. caesius 2,000 to 2,500 and C. trachycoleus 3,000 to 5,000 (Alrasjid & Dali, 1986).

Data on species and provenance trials and seed stand establishment are not readily available although a limited number of species were included in trials in Java started in the past decade. However, Tardjo (1986) estimated that 50 million seeds of C. trachycoleus and 20 million seeds of C. caesius can be harvested from South and West Kalimantan.

THE PHILIPPINES

Reproductive biology

Fernando (1987) observed that most rattans start bearing flowers during the dry months of February to May. It took five weeks from emergence of inflorescence to anthesis for C. merrillii.The male to female ratio ranges from 3:l in C. merrillii to 10:1 in C. elmerianus. The fragrant flowers attract beetles, bees and flies. C.merrillii and C. ornatus fruits tend to ripen from August to December. Seed characteristics are:

Species	Size of seed (1xw)cm	No. of seed/fruit	Av. no of seeds/kg
C. ornatus	2.0 x 1.0	1	305
C. merrillii	0.4 x 0.3	1	3,024
C. mirtdorensis	1.4 x 1.4	1	5,727
C. manillcnsis	2.3 x 1.6	2 or 3	2,238

Source : Baja-Lapis (1983)

Species trials

C. merrillii and C. ornatus have been planted at Pagbilao since the mid 1970s but initial growth was slow due to heavy canopy. At Mindoro, the Swedish Match-Hilleshog, Philippines, Inc. (SMHI) planted C. merrillii, C. mindorensis, C. manillensis, C. ornatus and "paklakanin" (Calamus sp.) in 1983. Performance details have not been published. Commercial plantations by the National Rattan Corporation of C. merrillii are to be found at Bislig and at Talacogon by SMHI. Availability of seeds of this species from the plantations should not be a problem'as 7-year old plants at Pagbilao were producing about 7,000 fruits per stem.

Vegetative propagation

Pollisco (1989) found that aerial suckers of C. merrillii showed higher survival rates than basal suckers. When basal suckers were used, mechanical injury to the roots and stem were caused. Layering was also successfully tried.

Umali-Garcia (1985), culturing the "cabbage" of 11 species of Calamus and two species of Daemonorops in MS and other culture media, succeeded in producing calli which remained active for 3-4 weeks. When 2-4% sucrose, 1 mg/l benzyl adenine and 1 mg/l2,4-D were supplied to the media, shoots were induced from callus tissue of C. rrrcrrillii, C.ornatus var. philippinensis and a Calamus species. When transferred to a medium with 4% sucrose and only traces of auxin and cytokinin, more roots were formed.

There has been no report of seed stand establishment or species and provenance trials.

THAILAND

Phenology

Fruits of C. longisetus and C. latifolius have been harvested in August (Sumantakul, 1989). Siripatanadilok (1983) found 124 obconical to ellipsoid fruits in an inflorescence of C. longisetus. The mature fruits measured 2.5 -3.0 x 2.0 cm. She also noted that beetles were found abundantly visiting the inflorescences and may be the pollinators.

Vegetative propagation

Chutamas et al. (1989) obtained tissue differentiation and organ formation followed by plantlet formation from immature embryos of C. manan when cultured in MS or Y3 medium.

Seed stands

Seed stand establishment has not been reported.

BANGLADESH

Phenology

The only observations have been on C. viminalis var.fasciculatus which flowered twice a year from February to April and again between July to October at Chittagong (Banik & Nabi, 1981).

Tria 1s

There are no records of trials of rattan except for D. jenkinsiana in the early 1980s. Six of the I1 indigenous species of Calamus and D. jenkinsiana were planted in the arboretum at Bangladesh Forest Research Institute, Chittagong (Alam, 1991).

Seed stands

No seed stand has been established.

INDIA

Phenology

C. longisetus was introduced from Myanmar in 1810 (Basu & Basu, 1987). Inflorescence emergence took place in October and anthesis occurred two months later. Fruits matured between July and August. Lakshmana (1987), recorded the flowering and fruiting of four Calamus species under plantation and four other Calamus species under natural forest conditions. All flowered between September to December although C. gambleii and another Calamus species (Kenjari betha) also flowered in April.

In Kerala, most species flowered between September and January and the fruits matured from January to June the following year but C. hookerianus flowered annually from February to May and the time of fruiting normally fell between January and June (Bhat et al., 1989). The anatomy of the male flower of C. arborescens and both male and female flowers of C. travancoricus were studied by Renuka and Manila1 (1986).

Species tria 1s

Nine of the 11 species of Calamus found in Karnataka were tried at the Sampaje Forest Range of Kodagu district. After 12 years, 25% of the plants were less than 1 m, 70% between 1 and 10 m and 5% of height more than 10 m. The tallest cane was of C. thwaitesii at 20 m (Lakshmana, 1987). Other species included were C. gamblei C. hookerianus, C. pseudotenuis and C. rotang.

Vegetative propagation

Two important species in S. India, C. hookerianus and C. thwaitesii have been examined for propagation using suckers (Seethalakshmi, 1993). Little work on tissue culture has been done in India although KFRI is intending to pursue this.

Seed stands

There are no records of seed stands.

SRI LANKA

Phenology

Flowering of large diameter species of C. ovoideus, C. zeylanicus and C. thwaitesii started in December and peaked in March to April. Fruits matured between August and October. Small diameter species of the forest understory appeared to flower sporadically throughout the year (De Zoysa & Vivekanandan, 1989).

Species tria Is

C. ovoideus, C. thwaitcsii and C. zeylanicus have been established in plantations in varying habitats (De Zoysa & Vivckanandan, 1989).

Seed stands

There has been no report of seed stand establishment.

CHINA

Phenology

Xu (1989) noted that inflorescences of *C. tetradactylus* appeared in March, flower buds from May-to July, flowering from mid-July to September and fruits ripened between April to May. With *C. simplicifolius* inflorescence emergence began in August, flowering from February to April and fruits matured between October and December i.e. seeds developed over 6 months. *D. margaritae* flowered and fruited throughout the year with first flowering at 5 years after planting.

The fruit of *C. tetradactylus* contained one seed and about 1,000 seeds weighed 1 kg. One or occasionally two seeds were found in the fruits of *D. margaritae* and 1 kg comprised about 600 seeds.

Species trials

Large areas have been planted with *C. tetradactylus*, *C. simplicifolius*, *D. margaritae*, *C. simplicifolius* and *C. egregius*. Several species trials have been initiated in the past 10 years.

PAPUA NEW GUINEA

Research sponsored by IDRC has been recent and relates largely to botanical survey and better processing. Village plantings are still traditional.

FIJI

No rattan improvement has been carried out although two trial plots of *C. vitiensis* were established near Colo-i-Suva in 1980 and 1983. *C. caesius* was introduced through the South Pacific Forestry Development Programme in 1991 (Tan, 1992a).

SOLOMON ISLANDS

C. caesius was introduced through the South Pacific Forestry Development Programme in 1991. There has been no rattan improvement research previously (Tan, 1992a).

VANUATU

No research has been carried out on the indigenous rattans but seeds of *C. caesius*, *C. subinermis* and *C. manan* were introduced in 1991 for trials (Tan, 1992a).

WESTERN SAMOA

As with Tonga, no rattans are found on the island, however, C. *caesius* seeds were introduced in 1991 through the South Pacific Forestry Development Programme (Tan, 1992a).

GENETIC ENHANCEMENT

Forests in general, have a low stocking of commercial rattans. Among the non-commercial rattans are species with either very short stems or very soft pith and it is doubtful whether any use can be found for these species in the near future. Some FORTIP member countries e.g. Pakistan and Nepal do not even possess commercial canes. Unless enriched with commercial species, logged over forests cannot be highly productive. To meet the increasing demand for quality canes, commercial species of rattan must come from plantations of improved strains.

As defined by Zobel and Talbert (1984), the objective of plant improvement is to "breed for improved economic characteristics while at the same time to maintain or broaden the genetic base for adaptability and pest resistance."

In order to meet such objectives, it would be necessary to:

(i) Identify the commercial rattans which can be grown in the countries involved.

(ii) Establish species trials of both indigenous and exotic commercial species to find out which species are most suitable for domestication in the countries concerned.

(iii) Establish provenance trials to identify the best provenances for plantation establishment in order to obtain improved productivity.

Iiv) Improve cane quality through selection, establishment of seed orchards and where possible, through crossing.

Characteristics related to economic characters which can be improved are:

a) faster growth rates,

b) production of more suckers (for suckering species),

c) production of longer internodes, and

d) production of desired diameter si .zes.

Such objectives of genetic enhancement need to be clearly defined by individual countries which also have to be prepared to mobilize and allocate resources such as staff, facilities and finance for a minimum period of 10+ years.

Due to the high cost of taking a regional approach e.g. to species and provenance seed collections, it is proposed that improvement of indigenous commercial species be carried out first. This could be followed by regional trials at a later date, if funding were to be available.

In rattan breeding, two strategies are proposed viz short-term and long-term.

Strategies proposed

A short-term strategy canbe applied so that immediate planting can begin with improved stock (while awaiting better quality seeds from seed orchards) or where land for large scale planting is limiting and long-term improvement is not justified.

Unlike a tree plantation where the crop is harvested and replaced by improved stock resulting from a long-term improvement programme, a rattan plantation, especially with clumping species, is almost permanent and expensive to replace. With species like C. trachycoleus, removal of the old planting stock is not possible because of the long stolons that spread all over the plantation. Therefore, not all countries will justify long-term approaches.

In the short-term, two methods of collecting improved seeds can be followed. These are:

a) collecting seeds from selected indigenous commercial plants in the wild, and

b) collecting seeds from plantations after roguing i.e. establishment of a seed stand.

Collection of seeds from selected plants in the wild rather than collecting seeds because they are readily available, is probably the fastest way of starting a plantation with hopefully better planting material. However, the resulting population will still be genetically heterogeneous. Where plantations or trial plots have already been set up, these can be converted into seed stands by removal of less desirable plants. This will provide an assured seed supply with a shift in the population means for desirable characters. Heritability in plantations, however, is low because of high environmental variation and such short-term strategies cannot make great genetic gains.

Where a longer term strategy is agreed, species and/or provenance trials need to be carried out. This strategy would aim to maximize genetic gain. This is achieved through recurrent selection of individuals with the most favourable genes from a breeding population derived from the best provenances.

Thus far, no successful method has been found for mass production of vegetative cuttings or tissue culture plantlets of selected mature plants, hence transfer of material from the breeding population to the planting site would have to be seedlings grown from seeds from seed orchards.

It is best to establish trials in forests with even, short trees (10 - 15 m tall) or among rubber trees in plantations for ease of canopy manipulation in order to obtain uninhibited growth of the seedlings. In forests, trials of both single and multiple-stemmed species would follow the general planting pattern widely used in large scale plantations. Where possible, the trials should be established on flat land. Planting lanes 4-m wide separated by 6 m for trees/forest lanes would be adequate and two rows of rattans are recommended in the planting lanes. This would provide 1,000 rattans / ha.

Implementing short-term improvement

Collecting seeds from the forest is best done by following cane harvesters during the fruit ripening season. When the fruiting canes have been pulled down, they can be immediately checked for desired internodal lengths, diameters and blemish of the skin. If the canes meet the required standard, the fruits are collected for immediate sowing. The main constraint is that canes in easily accessible areas will have been harvested; collecting therefore might well be in areas that are fairly inaccessible.

If plantations or trial plots have been established, undesirable plants are rogued and seeds collected from remaining plants. In the selection of plants for retention, more weight is given to canes with long internodes than to sucker formation or other characters. For small diameter canes, manufacturers place canes with internodal lengths of 30 cm and above in the premium class. With C. caesius in Sabah, very few clumps have internodal lengths less than 30 cm whereas most C. trachycoleus plants have internodal lengths less' than 30 cm. In this case, the standard of one has to be raised and the other lowered.

For rattan seed stands, it is suggested that 250 plants are left and this means that ca. 75% of the plants are removed. It is recommended that at least 20% of the plants left are males. A count made on the number of female flowers from the two inflorescences on the stem of C. caesius and the number of male flowers from two inflorescences on the stem of a male plant gave a female:male ratio of 1:10. Since there are 6 anthers per male flower, a male inflorescence in theory is sufficient to pollinate all the flowers of 60 female inflorescences. Most of the anthers will however, be lost to insects. The plants can only be selected for male and female plants during flowering when the inflorescences have elongated.

Assuming 5% of the female plants fruit by the 6th year, between 312,500 to 625,000 fruits will be available from a 50 ha seed stand. This will provide an assured seed supply with desirable planting stock for a 300- 600 ha annual planting if the seeds are immed treated and sown after collecting.

Proper maintenance must be given to the seed stand to avoid dense overhead shade so that phenotypes can be identified and not be atypical.

Many species have a 1 - 3 year "rosette" stage when no stem is formed. In the case of C. trachycoleus, there is no "rosette" stage but stolons are produced after the third year. By the 4th or 5th year, the plants have grown sufficiently to permit selection.

Longer term improvement

-Long-term enhancement normally follows species and provenance trials. These would ideally have resulted in:

(i) Elimination phase where a large number of species or provenances have been screened for survival and growth over a short period.

(ii) Testing phase to test a reduced number of promising species or provenances for longer periods.

(iii) Proving phase to confirm, under normal plantation conditions, the superiority of a limited number of species or provenances (Hughes & Willan, 1976).

However, the above phases are not practicable&for rattans because seeds cannot be kept sufficiently long to permit establishment of the different phases. Only the species elimination phase and the range-wide provenance phase are proposed as logical steps for national programmes.

In species and especially provenance trials 30 plants per species or provenance per plot is suggested because these may be the only material available for future enhancement. Very often, the sites where promising provenances were collected, are completely destroyed by the time of the next seed collecting.

Species tria ls

The objective of species trials is to compare the performance of a number of different species in one or more sites and to select a few for more intensive trials (Burley et al., 1976).

Arandomized complete block design is suggested with preferably 30 plants per plot depending on availability and germination of the seeds. Each plot will thus consist of 2 rows of 15 plants each. Each species or provenance is represented only once in each block and the block'is replicated 5 times. No surround is required because the plants are planted along lanes cut through the forest.

The plants should receive full overhead sunlight or at least large quantities of evenly diffused overhead light. It is thus important to inspect the rows frequently and lop off branches at least once a year in order to achieve even and sufficient lighting.

Measurement of stem is from the ground to the last knee. During the first or even second year where stems are sometimes not formed, the mortality, number of suckers produced and health of the plants are noted. After the second or third year, it is normally possible to select the best species for further provenance trials.

Provenance trials

The objective is to determine the extent and pattern of variation between provenances of promising species with wide natural variation or distribution.

If less than 15 provenances are involved, a randomized complete block design with 5 replicates is suggested. The plots of 30 plants each will be in long double rows as in species trials. A lattice incomplete block design can be used if more than 15 provenances are involved and the Alpha statisti cal program me produced by Scottish Agricultural Statistics Service, University of Edinburgh can be utilised for designing the trials.

Selection of the better provenances is possible by the 4th year for species from the perhumid zone when the stems have elongated sufficiently for evaluation of characters such as long internodes, sucker formation and pest and disease resistances in addition to survival.

Breeding

Breeding of rattan involves recurrent selection where the best progeny are chosen from selected parents over successive generations.

A base population, usually of several selected provenances has to be first established. From this, plants are selected for a breeding population. A breeding population is regenerated either through controlled pollination or open pollination.

Controlled pollination is the only method of identifying both parents but it has its own problems. Firstly, inflorescences are produced at the apices of canes high up in the canopy of trees and coupled with the thorns, are difficult to get at. Secondly, if the canes are long and intertwined with each other, there is the possibility of identifying the w-rong plant instead of the one actually producing the cane. This, however, does not mean that controlled pollination is not possible. With some plants, the cirri can be cut so that the plant falls to the ground but with others, scaffolds have to be constructed for every female plant and this is costly and time consuming.

For open pollination, breeding populations should be isolated otherwise, genetic gain will be reduced. Within the population, it does not matter much if open-pollination is used because both parents are selected.

Here, a lattice incomplete block design is proposed for the progeny tests.

a) Each block will consist of 50 families and each family plot of five seedlings. Each block contains 250 plants.

b) Blocks are replicated five times.

c) 30% of the poorest families are to be rogued.

d) The families in the first block/replicate are numbered in running order 1,2,3,4,...50, down the first row, up the second row, down the third row and so on.

e) One selected male is retained (the other four plants removed) for the first, sixth, eleventh, sixteenth, twenty-first and so on of the remaining family plots, i.e. one male in every five families or 10 males per plot. For the next block/replicate which is randomized, one male from family plots 2,7,12,17,22 and so on is retained and for the third replicate, males from plots 3, 8,13,18, etc. are retained. For the fourth replicate it is 4,9,14,19,24 and so on and for the fifth replicate, males of families 5,10,15,20,25, etc. are retained. For all remaining plots, all plants are removed leaving only one selected female. The end result is that from five replicates, each family has one male and four female plants retained.

The identity of most of the males and females may not be known until possibly the 6th-7th year. From the progeny test, seeds are collected from the best 50 plants for the establishment of the next generation breeding population. Plants are selected for (a) growth rate and sucker formation and (b) internodal 1 ength. Seeds from the best few plants are used for establishment of the seed orchard which will also be culled based on performance of the second generation progeny tests.

(b) internodal 1

Hybridization of species within the same section of the genus may produce hybrids with desirable traits. No hybrids have been found in nature but it may be possible to hybridize the closer related species to breed for drought tolerance, cold hardiness, to produce multiple clumping hybrids by crossing single-stemmed C. manan with possibly C. subinermis, and for the ability to grow well in poor soils or in peat swamps.

However, hybridization is expensive and time-consuming to perform and hybrids, if successfully produced, cannot be used for operational planting unless there is a breakthrough in tissue culture so that mass production of clones is possible. When the INBAR consultation on genetic enhancement met in May 1995 it was agreed that evaluation trials using families and selected progenies would provide genetic gains probably adequate for most needs and wide hybridization should not be proposed. Crossings, however, should follow the trials but these will be within species.

REGIONAL COOPERATION

A number of activities can be carried out in the framework of a regional cooperation network, which would support the genetic enhancement activities carried out by national programmes. These should aim to bring critical mass to solve particular problems and avoid duplication of effort. Topics which need further investigation include:

i. Floral biology and pollinators

ii. Phenology

iii. Pollen storage

iv. Isozyme analysis and patterns of genetic variation

v. Micropropagation research

vi. Propagation using suckers

vii. Genetic conservation.

Additionally the following are also required:

i. Illustrated field guides with keys for identification of commercial species. These are urgent especially where local forest officers do not have relevant expertise.

ii. Climate and soil matching for species.

iii. Strategic plans for genetic conservation of priority species. In this report it is noted that an INBAR - IPGRI Working Group on Biodiversity, Genetic Resources and Conservation started work in this area in the latter part of 1994, and IPGRI (formerly IBPGK) is concerned with developing methodologies.

Network support

Rattan domestication and enhancement is new to many countries and there will be a shortage of expertise. Almost certainly a rattan breeding consultant will be needed to visit countries which establish trials for genetic enhancement.

Short-term training is likely to be needed on the use of selected computer software for data checking and statistical validation and analysis.

If supporting research is strengthened, recommendation is also made for workshops on flowering biology and vegetative propagation to provide demonstrations and practical training, and to disseminate and exchange information on the latest findings.

Rattan enhancement is a new field and there is a need to publish technical guides.

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