BIOLOGY, PROPAGATION AND CONSERVATION OF RATTANS OF BANGLADESH

GIFT

A Thesis Submitted for the Degree of

Doctor of philosophy

in the Department

of

Botany

University of Dhaka

403671

ঢাকা
বিশ্ববিদ্যালয়
গ্রন্থাগার

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CERTIFICATION

This is to certify that this thesis contains the results of research on **"Biology, Propagation and Conservation of Rattans of Bangladesh"** and has been carried out by Mrs. Rowshon Ara under my supervision. It is further certified that the work presented here is original and suitable for submission as a Ph. D. thesis.

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DECLARATION

I do hereby declare that this thesis entitled **"Biology, Propagation and Conservation of Rattans of Bangladesh"** has been composed by myself and all the works presented here are my own. I further declare that this work has not been submitted anywhere for any academic degree.

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ACKNOWLEDGEMENT

I strongly feel to express my heartiest gratitude to my supervisor Professor Syed Hadiuzzaman Ph.D.,Department of Botany, University of Dhaka, Bangladesh for his overall supervision, faithful criticism, valuable suggestions, proper evaluation and continuous encouragement throughout the progress of this research work.

I am highly thankful to the respected Chairman and other teachers of the Department of Botany for giving me permission to undertake this research work; to the Director, Bangladesh Forest Research Institute for providing me the facilities to go to the field and work extensively; to the Ministry of Environment and Forest for granting me a permission and study leave to persue Ph.D. degree on this programme; to Dr. Neaz Ahmed Siddiqi, Divisional Officer, Minor Forest Products Division, Bangladesh Forest Research Institute for his sincere encouragement and valuable suggestions to make progress with this programme; to Dr. M.K. Alam for his guidance as pioneer and first worker in the field of taxonomy of rattans in Bangladesh; to the Ministry of Science, Information and Communication Technology to grant me a partial financial support in the form of NSICT fellowship during the progress of this research programme.

I ought to thank to Mrs Sayeeda Rayhana Merry, Mr. Abul Bashar, Mr. Abul Hossain and other staff of Minor Forest Products Division, Bangladesh Forest Research Institute for their sincere help in the progress of this research work. Thanks are also due to Forest Department for supplying me various information from Bana Bhaban; to all officers and staffs at different range and beat offices of Forest Department, which I visited, for their nice co-operation; to Mr. M. Sala Uddin, Lecturer, Department of Botany, University of Chittagong for his assistance both in field and laboratory works for soil and plant analyses; to Mr. M. Khaled Chowdhury for his assistance in computer operation; to all my friends, colleagues and well wishers for their nice co-operation; to my family members for their continuous moral supports, encouragement and sacrifices during the progress of the programme.

Finally, all praise go to the Almighty Allah, - the Most Merciful and the Most Compassionate Who enables me to execute this research programme smoothly.

Rowshon Ara

Abbreviations

ACF	Assistant Conservator of Forest
ANOVA	Analysis of variance
BFRI	Bangladesh Forest Research Institute
BGCU	Botanical Garden Chittagong University
BNPG	Bhawal National Park Gajipur
^{0}C	Degree celsius
CHT	Chittagong Hill Tracts
cl^{-1}	per clump
cm	Centimeter
CRD	Complete randomize design
CS	Clean seed
CUC	Chittagong University Campus
DBP	Dormancy breaking period
DFO	Divisional Forest Officer
DSPCB	Dulahazara Safari Park Cox's Bazar
Dwt	Dry weight
EC	Electrical Conductivity
EPSC	Eco-park Sitakunda, Chittagong
EM	Early Monsoon
FAO	Food and Agriculture Organisation
FD	Forest Department
FF	Female flower
FP	Flushing period
Frs	Fruit setting
FW	Fresh weight
GOB	Government of Bangladesh
GP	Germination per cent
gpl^{-1}	Gram per plant
GR	Germination rate
HDSTUD	Haji Danesh Science and Technology University, Dinajpur
HSF	Homestead forest
ID	Indoor

IFESCU	Institute of Forest and Environmental Sciences, Chittagong University
INBAR	International Network for Bamboo and Rattan Research
IPGRI	International Plant Genetic Resource Institute
IUCN	International Union for Conservation of Nature
K	Potassium
KSRSC	Keochia Silviculture Research Station, Chittagong
L. let	Leaflet
LM	Late monsoon
LSD	Least significance difference
m	Meter
m	Month
M	Monsoon
MF	Male flower
MFS	Moist fine sand
mgg^{-1}	Miligram per gram
mm	Milimeter
MMmt	Mean of monthly minimum temperature
MMMT	Mean of monthly maximum temperature
MMRF	Mean of monthly rainfall
MMRH	Mean of monthly relative humidity
N	Nitrogen
NBGM	National Botanical Garden, Mirpur
NF	Natural Forest
OC	Organic Carbon
P	Phosphorus
p	Pink
PF	Protected Forest
pH	Hydrogen ion concentration
RCBD	Randomize complete block design
RF	Reserve Forest
RG	Refrigerator
RGA	Rattan growing area
RGFD	Rattan growing forest divisions
RGFDB	Rattan growing forest divisions, Bangladesh
Sd	Seedling

se^{-1}	per season
SEM	Standard error of mean
SF	Social Forest
sp^{-1}	per species
Su	Sucker
TTC	Tetrazolium tri chloride
UCS	Unclean seed
USF	Unclassed State Forest
VF	Village Forest
w	White
W	Wilding
W	Winter
WF	Whole fruit
Wks	Weeks
yr	year
$\mu g g^{-1}$	Micro gram per gram

Abstract

Studies were made on biology, propagation and conservation of rattan species in eight rattan growing forests divisions (RGFD) *viz.* Chittagong, Chittagong Hill Tracts (CHT), Cox's Bazar, Dhaka, Dinajpur, Khulna, Sylhet and Tangail of Bangladesh during 1998-2004. Literature review states that a total of fifteen rattan species (*viz. Calamus acanthospathus* Griff., *C.erectus* Roxb., *C.flagellum, C.floribundus, C.giminahs, C.gracilis* Roxb., *C.guruba* (Buch-Ham) ex Mart., *C.jenkinsianus, C.latifolius* Roxb., *C.longisetus* Griff., *C.temuis* Roxb., *C.travencoricus* Bedd., *C.quinquenervius, C.rotentum, C.rotang, C.viminalis* Willd. var. *fasciculatus* (Griff) Becc. and *Daemonorops jenkinsiana* (Griff) Mart.) have been reported to occur in Bangladesh since 1984. Present extensive survey recorded only ten rattan species (*viz. C.acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus, C.temuis, C.travencoricus, C.viminalis* var. *fasciculatus* and *D.jenkinsiana*) which were found to grow in a wide range of habitat ranging from sea level to an altitude of about 1000 m. Intensive experimental studies on biology, propagation and conservation were carried out in canetum, nursery and trial plantation of Bangladesh Forest Research Institute and Chittagong University campus. Soils collected from canetum, nursery and plantation of rattan growing forests were analysed for major physico-chemical properties and were found to be sandy loam to clay loam, acidic and moderately fertile. Climatic data on diurnal changes in monthly temperature and relative humidity, and monthly rainfall with change of seasons were recorded, where rainfall and relative humidity were found to vary remarkably compared to temperature in RGFD.

Biological studies identified the recorded ten rattan species as loose and compact clump forming, dioecious, pleonanthic, perennial, evergreen, canopy-crown forming, high climber, fast growing, economically valuable and commercially important ones except *C. erectus*, which is erect, robust and is regarded valuable as ornamental, highly aesthetic and sacred one. Clump size, shoot regeneration, canopy size, leaf size, culm formation, culm size, culm length, flowering age, ratio of male-female clump, periodicity and plasticity of flowering, fruit setting, fruit maturity, fruit production, fruiting cycle and natural regeneration potential were examined intensively both in selected and natural clump, and were found potential enough and varied with species, habitat and seasons. Four species *viz. C.erectus, C.gracilis, C.guruba* and *C.viminalis* var. *fasciculatus* are monophasic and the other six *viz. C.acanthospathus, C.latifolius, C.longisetus, C.temuis,*

C.travencoricus and *Daemonorops jenkinsiana* are diphasic. Flowering, fruiting and fruit ripening occur through out the year irrespective to species and habitat. Major reproductive features *viz.* inflorescence initiation time, number and length of inflorescence, number of partial inflorescence, inflorescence flushing period, flower size, ratio of male and female flower, placentation type, embryo type, number of fruit setting, ratio of female flower and fruit setting, fruit ripening season, seed out put, germination per cent and reproductive capacity culm^{-1} species^{-1} season^{-1} habitat^{-1} were examined. Species were ranked in term of plasticity of fruit setting culm^{-1} species^{-1} season^{-1} habitat^{-1} in the order of *C.viminalis*> *C.longisetus*> *C.acanthospathus*> *C.gracilis*>*C.tenuis*> *C.latifolius*> *C.travencoricus*> *C.guruba*> *D.jenkinsiana*> *C.erectus*. On the other hand the species were ranked in term of reproductive capacity culm^{-1} species^{-1} season^{-1} habitat^{-1} as *C.tenuis*> *C.acanthospathus*> *D.jenkinsiana*> *C.latifolius*> *C.travencoricus*> *C.viminalis*> *C.erectus*> *C.longisetus*> *C.guruba*> *C.gracilis*. Ripen fruit of early season of the year exhibited maximum reproductive potential compared to fruits of late season of the year both in monophasic and diphasic species except that of *D.jenkinsiana*. It concludes that recorded ten rattan species are still highly potential to regenerate themselves naturally both sexually and vegetatively.

Large scale propagation programme considers seed as the easiest and important compared to all sorts of possible vegetative propagation. But seedling raising has remained an unsolved livelong problem in all rattan species due to limited seed supply and lack of techniques to shorten the dormancy breaking period for maximum germination per cent. Present study took a series of initiative to innovate a practiceable technique to shorten the dormancy breaking and flushing period, with increasing germination rate concomitant germination per cent in used sowing media under shade house conditions. Fine sand was found excellent among three used sowing media (*viz.* fine sand, sandy loam and clay loam) for maximum germination per cent of seeds in ten rattan species. Depending on germination potential of clean seed in fine sand, the species can be ranked as *C.tenuis*> *C.acanthospathus*> *C.travencoricus*> *C.erectus*> *C.longisetus*> *C.gracilis*> *C.guruba*> *C.latifolius*> *D.jenkinsiana*> *C.viminalis*. Clean seeds of all rattan species stored in the pit of moist fine sand remain viable with out reducing germination per cent even by 10 per cent compared to the fresh ones after a year of preservation except those of *C.acanthospathus, C.erectus* and *C.travencoricus* where the viability of seeds were observed to get reduced almost to nil even after two months of

preservation in moist fine sand. Highest survival percentage of transferred seedlings in poly bags of sandy loam soil was observed to depend on seedling raising, pricking age, transfer technique and nursing under shade house condition. Seedling of six months old raised in fine sand of seed tray had maximum survival per cent compared to seed bed raised seedlings where seedling of 1-2 month old showed maximum survival per cent compared to 3-6 months old irrespective to seed tray and seed bed raised seedling. Survival per cent and culm formation of seedling, wilding, sucker and rhizome of 1-3 years old irrespective to species planted in sandy loam soil in same sized container for a period of five years varied significantly with species and propagules and can be ranked in the order of seedling> wilding> rhizome> sucker. This study concludes that rattan seedlings depending on culm emergence can be ranked as *C.tenuis*> *D.jenkinsiana*> *C.guruba*> *C.longisetus*> *C.acanthospathus*>*C.travencoricus*> *C.gracilis*> *C.viminalis*> *C.latifolius*> *C.erectus* both in ***ex situ*** and ***in situ***. Seedling of all recorded rattan species exhibited as the best in all aspects for large scale plantation programme and conservation.

Information based extensive and intensive survey was made on the frequency of occurrence, distribution and *in situ* conservation of rattan species in natural forest and homestead forest of eight RGFD *viz.* Chittagong, CHT, Cox's Bazar, Dhaka, Dinajpur, Khulna, Sylhet and Tangail. *In situ* conservation status of recorded ten rattan species in term of frequency of occurrence-distribution can be ranked as *C.tenuis*≥ *D.jenkinsiana*> *C.viminalis*> *C.guruba*> *C.longisetus*> *C.erectus*> *C.latifolius*> *C.travencoricus*≥ *C.acanthospathus*≥ *C.gracilis*. Whilst *in situ* conservation of recorded rattans in eight RGFD in term of number of species can be ranked as CHT> Chittagong> Sylhet> Dhaka≥Cox's Bazar> Tangail> Dinajpur> Khulna. Calculated rattan index of eight RGFD justify the ranking of forest divisions as Dhaka> Cox's Bazar> Chittagong> Tangail> CHT> Sylhet> Dinajpur> Khulna. Bangladesh has occupied sixth position in her rattan index among twelve rattan growing countries of the world. Forest Department of Bangladesh planted over 2.74 million seedlings of five rattan species (*viz. C.guruba, C.longisetus, C.tenuis, C.viminalis, D.jenkinsiana*) in 61,146 acres of land until 2002 in seven RGFD. Number of *in situ* conservation of planted seedlings ranged from 49,060 to 12,14,859 $RGFD^{-1}$ and RGFD can be categorised as Sylhet> Chittagong> Cox's Bazar> Dhaka> Tangail> Dinajpur> CHT. Whilst *in situ* conservation of planted rattan species in order of richness in number can be ranked as *C.tenuis*> *D.jenkinsiana*> *C.viminalis*>

C.guruba> *C.longisetus*. Present *in situ* conservation of recorded ten rattan species justifies that *C.tenuis*, *D.jenkinsiana* and *C.viminalis* are cultivated and *C.erectus*, *C.guruba*, *C.longisetus* and *C.latifolius* are vulnerable. While *C.acanthospathus*, *C.travencoricus* and *C.gracilis* are extremely rare where *C.acanthospathus* and *C.travencoricus* are two new records and *C.gracilis* is rediscovered one from Bangladesh. *In situ* conservation measures of recorded ten rattan species were initiated in nine reserves (*viz.* BFRI, BGCU, IFESCU, KSRSC, EPSC, NBGM, BNPG, DSPCB, HDSTU) as canetum. It is concluded that out of fifteen previously reported rattan species, only eight species (*viz. C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus C.tenuis, C.viminalis* and *D.jenkinsiana*) were recorded with an extra addition of two new records (*viz. C.travencoricus, C.acanthospathus*) in the present investigation. The remaining seven (*viz. C.flagellum, C.floribundus, C.giminalis, C.jenkinsiana, C.quinquenervius, C.rotang* and *C.rotentum*) were not found and seems to be disappeared / lost / unexplored from the nature of RGFD of Bangladesh which requires further extensive survey to reconcile or record more new species to enrich the rattan resource of Bangladesh.

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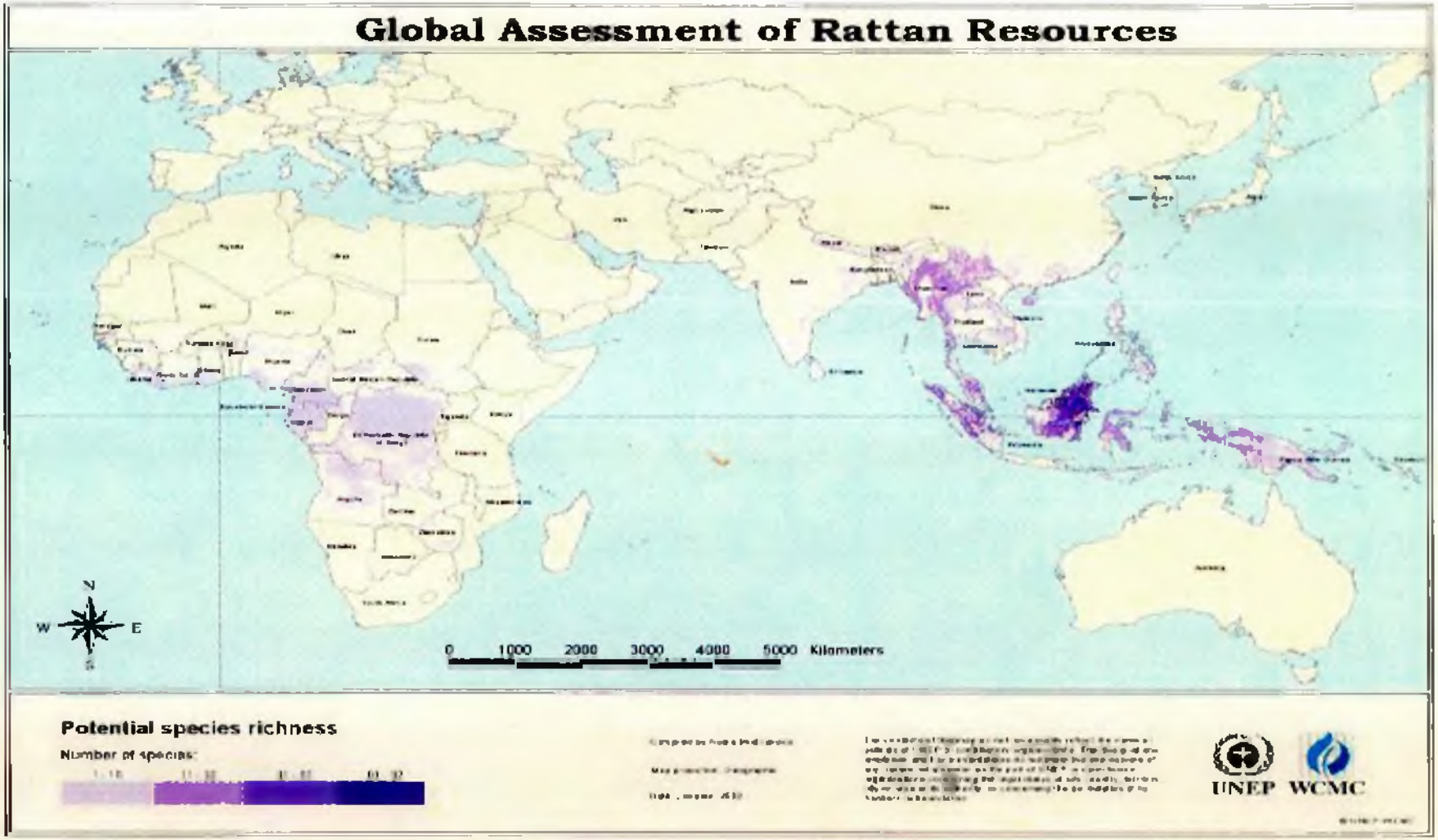
CHAPTER 1 : GENERAL INTRODUCTION

1.1 Importance of research on rattans in Bangladesh : Rattans are a unique group of climbing palms with spines under Palmae or Arecaceae family. There are about 614 different rattan species under 13 genera and they are concentrated solely in the old world tropics. Distribution of rattan genera and their corresponding species in different countries and regions of the world along with Bangladesh are given in Map-1, Table-1 and Figure-1-2. They belong to a large subfamily of palms known as the Calamoideae (Uhl and Dransfield 1987) that also includes some palms, which do not climb. Most of the rattan species grow as clumps and only a few are single-stemmed. Single-stemmed rattan gives a single harvest while the multi-stemmed species can be harvested as sustainable product. The culm is the main product called 'cane' and used for various purposes by man since the prehistoric age. Rattans are distributed over a vast area from the tropical to the cool monsoonal areas of the Afro-Pacific region (Shim 1995b). Sarawak boasts one of the richest rattan flora in the world with a total of 106 species in 8 genera (Dransfield 1992a). Rattans of the world may have a possible number of about 614 species consisting of 13 genera in tropical and sub-tropical areas or in temperate regions. Ten genera occur in the Asia-Pacific region and four in West Africa. Only genus *Calamus* is common to grow in both the widely separated regions.

Rattan products play an important role in the economic activities of many countries. It is a very important source of livelihood for the economically and socially weaker section of the community. In South East Asia, it is estimated that over five million people are involved directly or indirectly as rattan supplier in the World market (Lakshmana 1993). The rattan-based industry is highly labour-intensive and hence acts as a good employment generator. So, it has a great social significance. Over-exploitation of rattans from its natural source, in addition to deforestation and extraction-exploitation has led this resource to exhaustion in many rattan producing countries. Rattan is a unique and versatile material suitable for various products. It is relatively light but strong, durable and pliable (Bhat 1992). Rattans constitute an integrated part of the tropical-forest ecosystem. The innumerable pinnate leaves, which extend up to 1-3 meter in length with leaflets play a major role on intercepting the splash effect of rains and improve the water holding capacity of the soil. Rattans also play a vital role in enriching the soil by their leaf litter, which adds the organic content of the soil (Lakshmana 1993). Rattan is one of the most important natural resources of Bangladesh, which grow both in hill



Source : Bystriakova (2002)

Map-1: Showing the rattan species richness in rattan growing countries of the world.

forests and village groves, after timber and bamboo (Banik and Ahmed 1986; Alam 1990). It is used in this country from the time immemorial as binding materials, weaving strips for making furniture, furniture frame, walking sticks, broom handles, carpet beaters, fish traps, bird cages, hanging bridge and other novelty items (Mohiuddin *et al.* 1986; Alam 1990; Ara 1997a and 1997b). In addition to its use in furniture making, split cane

Table1: Distribution of rattan genera and species in different countries and regions of the world.

Countries/ Regions	*Calamus*	*Calospatha*	*Ceratolobus*	*Daemonorops*	*Eremospatha*	*Korthalsia*	*Laccosperma*	*Myrialepis*	*Oncocalamus*	*Plectocomia*	*Plectocomiopsis*	*Pogonotium*	*Retispatha*	No of genera	No of species
Australia	+(8)													1	8
Bangladesh	+(9)			+(1)										2	10
Borneo														8	150
Brunei Dar.														8	80
Celebes	+(1)			+(1)		+(1)								3	28
China	+(40)			+(1)						+(4)				3	45
Cambodia														5	11
India	+(46)			+(6)	+(3)	+(3)				+(4)				5	62
Indochina	+			+		+				+				4	33
Java	+		+	+		+				+				5	25
Kalimantan	+(53)		+(4)	+		+(2)				+(1)	+	+	+	8	105
Laos	+(19)			+(4)		+(2)		+(1)		+(2)	+(3)			6	32
Malaysia	+(113)	+(1)	+(4)	+(47)		+(19)		+(1)		+(4)	+(5)	+	+(1)	10	211
Maluka														3	18
Myanmar	+(23)			+		+		+		+				5	30
Nepal	+(6)			(1)										2	7
New Guinea	+(48)			+		+								3	55
Philippines	+(70)			+(14)		+(5)				+(2)				4	91
Solomon Isl.	+(3)													1	3
Sri Lanka	+(10)													1	10
Sumatra	+		+	+		+								7	90
Sulawesi														3	33
Thailand	+(51)		+(1)	+(15)		+(5)		+(1)		+(3)	+(2)			7	62
W. Africa	+(12)				+(4)		+(7)		+					4	24
W. Pacific														1	3
No. of sps per genus	+(400)	+(1)	+(6)	+(115)	+(7)	+(26)	+(7)	+(1)	+(5)	+(16	+5	+3	+1		
Total														13	614

Source: FAO (2002); Rao (1997)

furnishes material for handicraft and cottage industries to make basket, mats, bags and host of other products. Rattans are also used as cordage for tying and binding. About three decades ago, it was abundant in the forests, but due to indiscriminate cutting and

lack of proper management it is now on the verge of disappearance (Ara *et al.*1994). Today there is a great demand worldwide for rattan (cane) products. Naturally all rattan

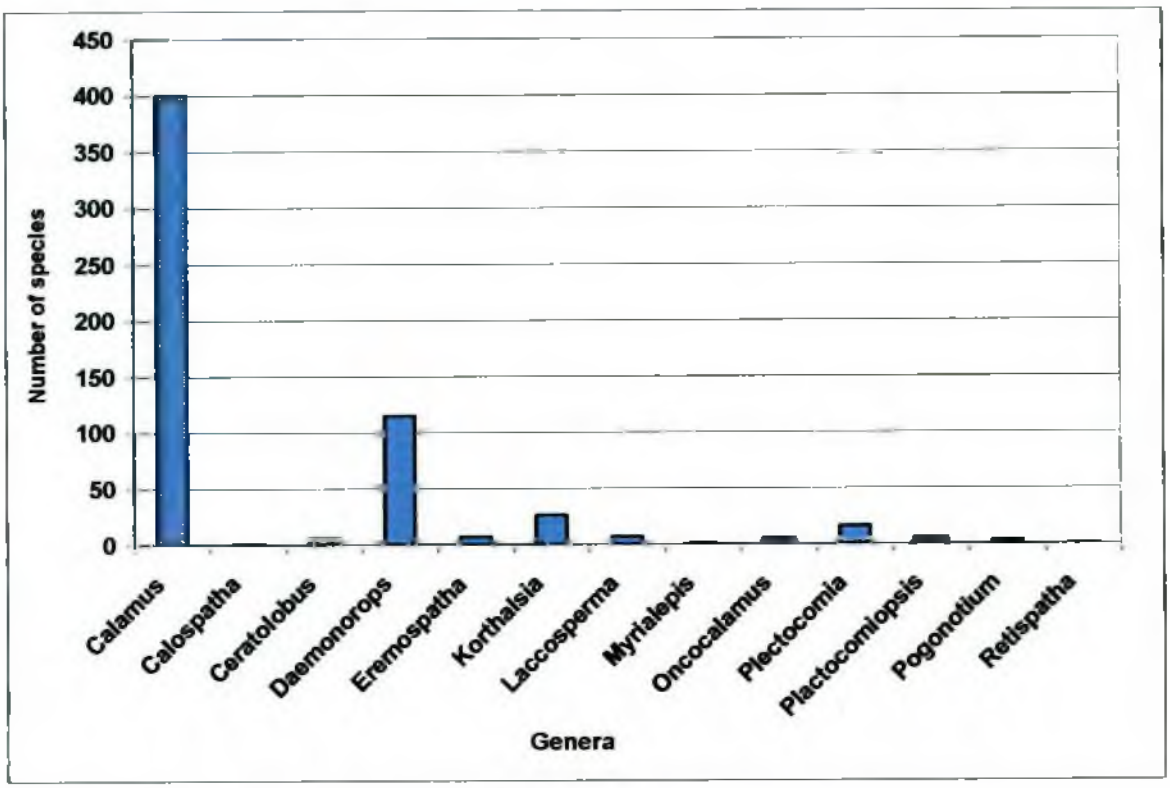


Figure 1 : Distribution of species under thirteen genera over the world.

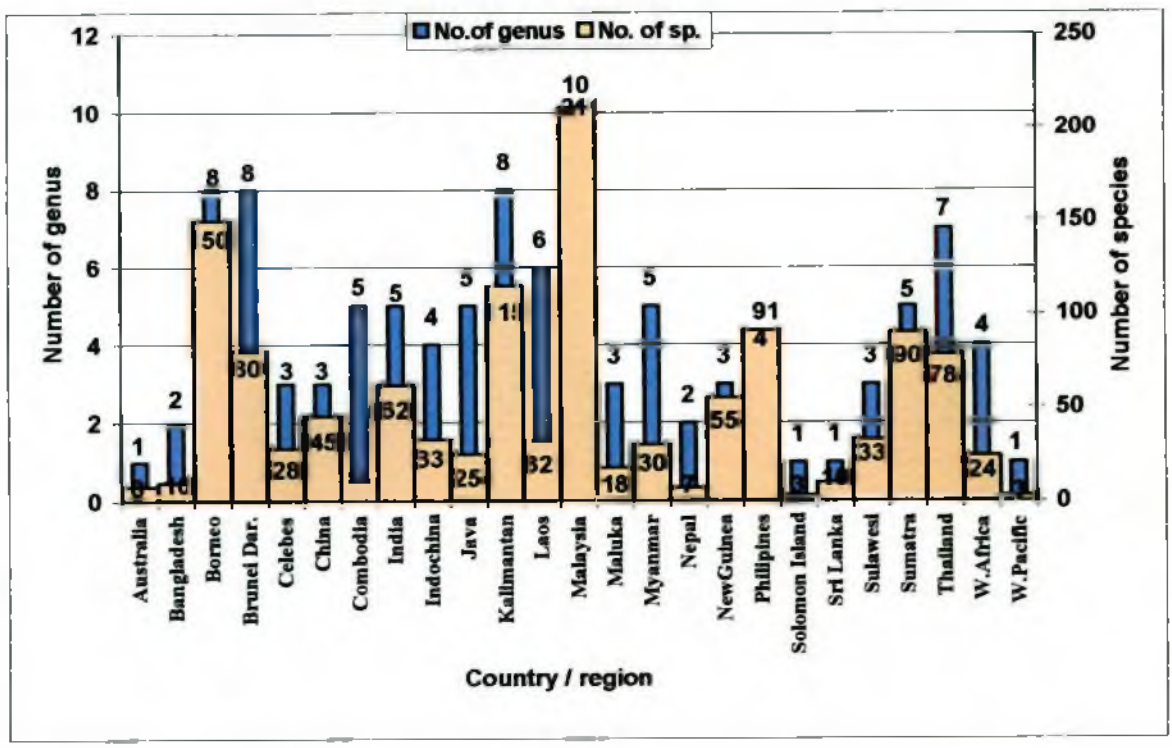


Figure 2 : Status in number of species under different genus in different rattan growing regions of the world.

canes continue to come from wild plants. As a result of heavy harvesting of the naturally occurring rattans from forest and homesteads soon it will lead to a sharp decline of the resource (Siddiqi 1995). These rattan-based industries of the country have a significant contribution towards the national economy. Rattan industry can play a major role in Third World country like Bangladesh, where there is unemployment problem. Unfortunately, shortage of raw materials makes it difficult to feed those industries resulting reduction in employment opportunity of rural people, women in particular in this sector. Consequently, large quantity of rattans is being imported annually at a very high cost to keep those industries running. Rattans are categorised as a Minor Forest Products (MFP). It stands next to timber, probably equal to those of bamboos from utility point of view. The following desirable properties characterize rattan canes as unique *viz.* long solid flexible stems that need support; excellent splitting ability in straight lines; it can be lacquered to preserve their natural light colour or can also be painted; it is renewable-sustainable resource and multiple use of land with extra cash returns.

1.2. Previous research done on rattans in Bangladesh : Among the available genera of rattans, only two, *viz. Calamus* and *Daemonorops* occur in Bangladesh (Alam 1990 and 1991). Beccari (1913) and Tewari (1994) reported that nearly 20 species of rattan occurred in Bengal-Bangladesh. Though seven rattan species (Mohiuddin *et al.* 1988) were recorded and centralized in the canetum of Bangladesh Forest Research Institute (BFRI) yet a total of 11 rattan species were claimed (Alam 1990) to occur in natural forest of Bangladesh. But Alam (1990) could not have recorded more than seven species *viz. C.erectus* Roxb. *C.tenuis* Roxb, *C.viminalis* Wild, var. *fasciculatus* (Roxb.) Becc., *C.latifolius* Roxb, *C.longisetus* Griff., *C.guruba* Buch. Ham. and *Daemonorops jenkinsiana* (Griff) Mart. where the other four species *viz. C.gracilis, C.floribundus, C.flagellum* and *C.quinquinervius* were regarded to be disappeared in the forest. Among the recorded rattan species, three valuable species namely *C.latifolius, C.erectus* and *C.longisetus* are going to be disappeared. Over exploitation has probably led to a restricted distribution for these species. The gradual decline of rattan resources due to their growing demand for rattan products has necessitated initiation of a programme for the development of nursery, plantation and management techniques of rattan. However, little attention on the studies of various aspects of rattans for increasing their sustainable yield has been paid. On these some works have already been undertaken relating to the nursery techniques of rattans (Mohiuddin *et al.* 1986 and 1988; Rashid *et al.* 1993; Ara *et*

al. 1994; Banik and Nabi 1979; Siddiqi 1996). Until now very little is known about biology and silvicultural management practices of these valuable resources.

1.3. Research necessary to be taken on rattans in Bangladesh : Rattan is important non- wood forest produce for Bangladesh. It needs a very intensive study and research due to its increased demand in the cottage industries, and also of social significance as a source of income to some of the poorest communities in the country. Within the last two decades there has been an upsurge of research activities that has led to an appreciation of the importance of rattan and a growing awareness that rattan cultivation has real potential. The increasing demand for rattan has opened up new trade channels and is providing greater employment opportunities for the rural people. Much of the rattan entering to international trade for the furniture industry is collected from the wild-primary and logged-over forests. At present the resource is seriously threatened by loss of habitat as forests are converted to agricultural and other land uses by over exploitation of the remaining stocks. To meet the increasing demand for the products there is an urgent need to propagate and cultivate rattans. Considering both ecological and economical importance, the Government of Bangladesh recently has emphasized the need of rattan plantation and management of resources in the forest and private lands. Rattan cultivation and management will play an important role in providing source of raw materials and to relieve some pressures on threatened wild populations to keep ecological balance of nature.

Rattans are gaining importance as plantation crops in many Asian countries. The demand for natural cane products is ever increasing despite substitutes being available on the market (Anon 1982; Basu 1991). The scarcity of rattan resource and the growing demand for cane items (furniture and novelty items in particular) have made research on various aspects of rattan as most essential. The greatest impediment in the maximum production and utilization of this renewable resource is the difficulty in raising large scale plantations. It is not possible to raise rattan seedlings every year because of non-availability of seeds of most species. Moreover, very little is known about the biology, propagation, planting techniques and management of these valuable resources. Alternatively, easy and mass macro propagation techniques are also not known for raising large number of propagules. Investigations on the availability of species and their distribution in different parts of the country are important to get an idea of the rattan diversity of Bangladesh. Basically, rattan research has two purposes *viz.* firstly to

increase the plant productivity and as such the income that can be generated from there and secondly is to conserve the genetic resources and biodiversity so that the known varieties can be genetically improved. Unfortunately, proper management systems could not have developed for the commonly growing rattan species of Bangladesh due to lack of information on their culm production, pattern of elongation and clump expansion behaviour as well as other related parameters.

Under these circumstances, systematic attempts need to be taken up to study biology and propagation to develop nursery and silvicultural management practices of rattans for their conservation in Bangladesh. This will help to maintain ecological balance and to bring back past lost glory of rattan population to sustainable level resulting biodiversity conservation to have supply of raw materials for rattan based industries, and to strengthen the national economy.

1.4. Aims and objectives of this research programme :

i) To assess the present status and distribution of rattan species in Bangladesh.

ii) To study biology to develop nursery, plantation and management of recorded rattan species of Bangladesh.

iii) To determine the growth performance of common rattan species in nursery and plantations of both trial plots and natural forests.

iv) To assess the propagational potential of propagules for large scale plantation.

v) To centralize and conserve all recorded rattan species on priority basis as canetum in official reserve areas for their future possible prospects.

1.5 Work schedule of the research proposal : The following steps were followed to carry out this research programme -

i) Literature review.

ii) Survey of rattan species in rattan growing forest divisions (RGFD) of Bangladesh.

iii) Collection of propagules *viz.* seeds, suckers, rhizomes, wildings etc.

iv) Testing of seed storability, viability, dormancy breaking, flushing and germination per cent for their preservation and maximum propagation.

v) Developing of standard nursery techniques *viz.* seed conditions, sowing media, sowing depth, sowing seasons, germination success, seedling raising, seedling pricking age, survival per cent of pricked seedling, transplanting age, seedling establishment etc.

vi) Developing of standard methods for *ex situ* and *in situ* mass propagation of the propagules.

vi) Assessment of growth of seedlings both in *ex situ* and *in situ.*

vii) Laboratory assessments and data analyses.

viii) Thesis write-up and submission.

CHAPTER 2 : BOTANY OF RATTANS

2.1 Introduction : Rattans are very unevenly distributed in the tropics, subtropics and mild temperate regions of the world. With habitats ranging from sea level to over 3000 m elevation, from equatorial rainforests to monsoon savannas and the foothills of the Himalayan, there is a huge range of ecological adaptation among rattans. However, rattans are predominately plants of primary rain and monsoon forest. Some species may be adapted to grow in secondary habitats, but they are exception. Rattans are a unique group of climbing palms with spines under Palmae or Arecaceae family. All species of Calamoideae are characterized by overlapping reflexed scales on the fruit and spiny- a necessary pre-adaptation to the climbing habit (Dransfield 1992b). Out of 13 genera ten occur in the Asia-Pacific region and four in West Africa. Three are endemic to Africa. Only *Calamus* is common to both the widely separated region. This (*Calamus*) is the largest rattan genus with 370-400 species. It is predominantly an Asian genus and ranges from the Indian subcontinent, south eastern China and extends through the Malaysian region to Fiji, Vanuatu and tropical and subtropical parts of eastern Australia. Most of the commercial species of rattan are members of this genus. The remaining rattan genera, *Daemonorops, Ceratolobus, Korthalsia, Plectocomia, Plectocomiopsis, Myrialepis, Calospatha, Pogonotium* and *Retispatha* are centered in South East Asia and extends further eastwards and northwards (Uhl and Dransfield 1987, Dransfield 1992a). Sarawak alone has 106 different rattan species of 8 genera and it represents the richest rattan flora in the World (Dransfield 1992a). But with in Sarawak, Kuching has an unbelievable rich diversity of rattans (Dransfield 1997). A total of 1,543,920 km^2 of forest in Asia-Pecific region and Africa potentially contains rattans. A maximum potential species richness of 92 species km^{-2} was recorded for a total area of 8,400 km^2 in Sarawak, Malaysia. In Africa the highest potential species richness of 15 species km^{-2}, was recorded for a rather small area in Cameroon (Bystriakova 2002). Status in number of species under different genera in different rattan growing countries and regions of the world is shown in Table-1, Figure1-2, Appendix-8.1.

2.2. Habitat : In general, rattans display a high degree of endemism. Thus about half the rattan species occurring in Malaysia have not yet been found elsewhere (Dransfield 1979). The restriction of rattan species to different climatic zone suggests that these species may have precise climatic requirements. In altitudinal range they occur from sea-

level up to 3000 m. The highest altitude record is held by the endemic Bornean species *Calamus gibbsianus* that occurs at 3000m on Gunung Kinabalu. The large number of rattan species and their wide geographical range is matched by great ecological diversity. These are differences usually in the flora between different altitudinal zones of South East Asia. At an elevation of 1000 m there is usually a shrinking change in the flora above this elevation several species or even genera abundant in the lowlands are replaced by other species and the rattan flora becomes less diverse (Dransfield 1979). Generally rattans grow in evergreen and semi-evergreen forest. Some species are seen in the deciduous forests too. The rainfall in these forest ranges from 1910-5080 mm. *Calamus* is the largest genus with 370 species (Moore 1973). They can be found from the sea level up to 2000 m high (Sounthone and Yang 1997). Manokaran (1985b) reported that for high climbing rattans earlier stem production from the rosette stage and greater production of stems in a clump are initiated by exposure to adequate light. He also mentioned that light enhances stem elongation. Stem elongation is continuous but variable from period to period. Rao (1994) reported that humid lowland forests are suitable for rattan growth.

In Bangladesh all species except that of *Calamus tenuis* are primarily forest dwelling rattans. *C.tenuis* grows at the edge of water and in marshy places in village groves. Among the forest dwellers most species except *C.viminalis* var. *fasciculatus* grow in semi-evergreen forests. *C.viminalis* var. *fasciculatus* grow in the dry soils of mixed deciduous or scrub forests (Alam 1990). Generally, in the forest of Bangladesh rattans occur in the north eastern hill forests of Chittagong, Cox's Bazar, Hill Tracts and Sylhet. In the sal forest there is no association of rattans. Only *C.viminalis* var. *fasciculatus* sometimes occur in the outskirts of the forest. In hill forests rattans are found to grow well in well-drained, moist, sandy loam soils on the slopes. Prain (1903a, 1903b) reported two species; *C.tenuis* and *D.jenkinsiana* from the northern parts of the mangrove forests of Sunderbans. But generally rattans do not occur in the mangroves. *C.tenuis* is found to occur along the edge of the littoral forest towards the land side along northern borderline.

2.3. Habit : Rattans are mostly trailing or climbing palms with characteristic scaly fruits, classified in tribe *Calameae* of sub-family *Calamoideae* (Uhl and Dransfield 1987) of the palmae family. Rattans range in habit from stem less plants to high climbing giant creepers (Basu 1985). Almost all members of the thirteen rattan genera are climbing plants. There are some that do not posses the climbing habit. Actually these palms

scarcely fit the general concept of a rattan but they belong to rattan genera because of their flower and fruit behaviour *e.g. C.minutus, C.arborescences* and *C.nanodendron*. The remaining species are climbers. Some climb high into the forest while others climb rather weakly or scramble in the forest undergrowth or forest floor. Rattans grow either as single stemmed individuals or may exhibit a clustering habit *i.e.* having numerous stem brought about by the production of suckers at the base of the original stem (Dransfield 1979). Suckering from aerial stems in rattan has been reported by Dransfield (1978) for the genera *Plactocomia* and *Calamus*. It is recommended that in order to promote growth of planted seedlings in the forest the relative light intensity should be maintained at 10-50 % (Manokaran and Wong 1983). Most of the rattan species grow as clumps and only a few are single-stemmed. Single-stemmed rattan gives a single harvest while sustainable harvest is possible from multi-stemmed species. The stem/culm is the main product called 'cane' and is used for various purposes by man since the prehistoric age. All rattans available in Bangladesh are multiple stemmed and climber except that of *C.erectus* which is multi stemmed but erect in nature like that of bamboo.

2.4. Vegetative features: Dransfield (1979) has given a concise and simple account of the general morphology of rattans noting important variations. A brief morphology of rattans with particular reference to Bangladeshi species by following Dransfield (1979) and Alam (1990) is summerised below.

2.4.1. Root : The root system of rattan remains a rather neglected field of study. Very little is known about the root system of rattans. Generally, rattan has fibrous root. Casual observations indicate that the root system of some species, *e.g. Calamus caesius*, may be complex, with widely radiating horizontally growing roots, and vertical root systems, some growing geotropically *i.e.* downwards and some growing apogeotropically *i.e.* upwards (Dransfield 1979). The apogeotropic roots may be concentrated in the leaf litter layer, and frequently bear patches of loose corky tissue, usually associated with gas exchange. These so called breathing roots may be of particular significance in waterlogged soils, but even on well drained areas they seem to be well developed. Noor and Mohamad (1989) reported that roots of *C.manan* could radiate from the base of the plant as far as 8 m. Clearly under dense plantations there will be some competition between the roots of the rattans themselves and with root systems of the supporting trees. Where the supporting tree is itself a tree crop, we may expect some deleterious effect.

But this interaction between individual rattans and between rattans and their support trees has scarcely been studied.

2.4.2. Stem : The stem system of rattan is variable; it affects the general appearance of the plant and is of considerable taxonomic value. Branching appears to be very complex. The usual method of branching is by the production of suckers at the base only which build up the clumps and then grow vertically. The basal branching system is of very great significance. Dransfield (1979) mentions the presence of stolen in some species like *C.trachycoleus*. In Bangladesh, stolen are sometimes developed in *C.tenuis*. Aerial branch development in rattan palms is not very common. Aerial branch development in *Plectocomia elongata* and in a few species of *Calamus* has been reported (Dransfield 1978; Renuka and Nambiar 1985; Fernando 1987). In Bangladesh *C.erectus* exhibits regular sub-aerial shoot production from the nodes towards the base at ground level or three to four nodes above the ground (Alam 1988). Very recently the author found aerial suckering in *C.travencoricus* where the tip of the stem produce numerous (2-14) shoots 2-3 meter far from the base of mother clump. Shim (1989a) reported that the aerial stems produced by aerial suckers are slender compared to the main stem. The value of the slender stems is between half to one third the price of the much larger diameter main stem. The longest cane recorded by Burkill (1935) was an individual of *C.manan* which was measured to be 175.8 m (586 ft.) long. It is very unusual to find rattans of this type of length at present. Because of the intensity of exploitation of canes. The diameter of the stem varies enormously from slender species up to 20 cm in *Plectocomia* sp. (Dransfield 1979). In Bangladesh, the average diameter also varies from slender (0.8 cm with sheath) in *C.gracilis* to robust (9 cm without sheaths) in *C.erectus*. Rattan stem does not increase in diameter with age. The seedling first grows in stem diameter and then increases in length. The early establishment growth is being responsible for the diameter of the aerial stem. However, there is some variation in diameter along the stem. The base usually is being thicker and then decreases in diameter upward. The diameter usually attains a maximum size when the rattan crown reaches the forest canopy or reproductive maturity. There may also have variation in diameter between nodes that produce inflorescences and those that do not. The former usually being thinner. All such variation in diameter may affect the quality of the harvested cane. The stem surface is smooth and generally straw yellow in colour. Surface features, such as colour, gloss and texture vary considerably among different species of rattans. The species available in Bangladesh do not have much

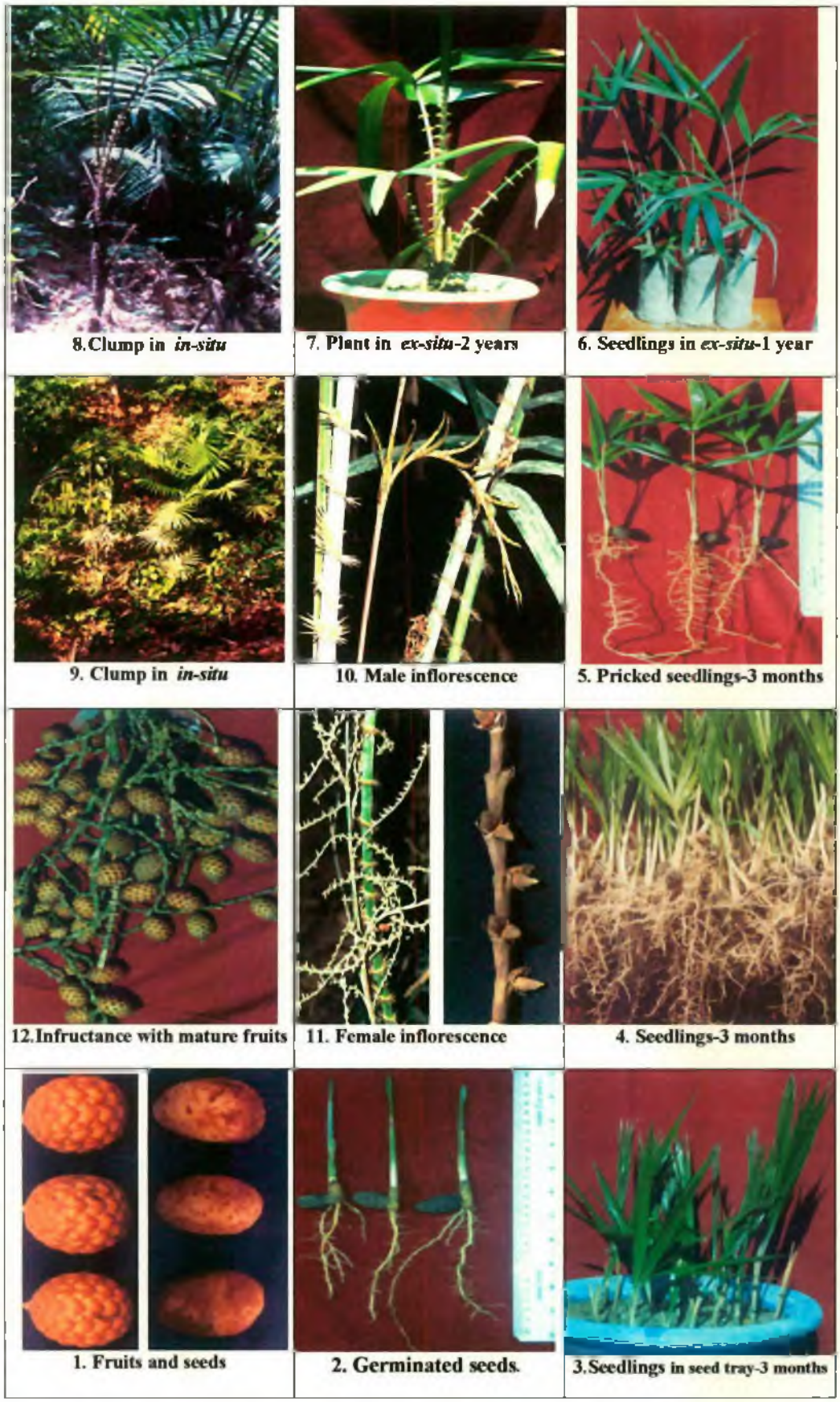


Plate 2: Photographs showing the major stages of life cycle of *Calamus erectus*.

variation in colour or texture after drying. There is significant anatomical difference among most of the rattan genera. The quality of cane also depends on anatomical character to some extent. Generally, good quality cane has an even distribution of vascular bundles throughout the stem, and the ground parenchymatous tissue is uniformly lignified. Cane with little lignification and uneven distribution of vascular bundles is usually poor in quality.

2.4.3. Leaf : The rattan leaf may be divided into three or four parts: the sheath, the petiole, the laminar area and the cirrus.

***Leaf-sheath*:** The lower portion of the rattan leaf that encircles the stem is the sheath. It develops basipetally. The leaf sheath is almost always spiny; the spines are confined to the exposed areas. In the climbing rattan species, stems are covered by densely spiny leaf-sheaths. As with the stem age the lower leaves die and drop off and the stem becomes exposed. The spiny leaf sheaths cover the actual stem. The spine arrangement on leaf-sheath bears field taxonomic importance for identification. Because the arrangement of spines on the sheath helps to identify sterile specimens of rattans represented by sheaths alone (Dransfield 1979). Rattans occurring in Bangladesh have characteristic sheaths having stiff recurved spines in sub-whorls to slender spines in an irregular fashion. The sheath may be glabrous or covered with various forms of indumentums. These are of taxonomic value. Floccose indumentums characterizes *C.viminalis* var. *fasciculatus* and rust coloured indumentums is present on the rachis of *C.erectus* and *C.guruba*.

At the mouth of the leaf-sheath and the point of origin of the petiole, there may be a prolongation of the main part of the sheath. This is termed as ocrea, and is not usually very well developed in all species and frequently disintegrating as the leaves develop. Sometimes in some species the ocrea is splited and the margins inrolled. It may be leathery in texture or papery. Sometimes ocrea is very conspicuous and often taxonomically useful. In Bangladeshi species ocreas are conspicuous in *C.erectus* and *C.guruba*. A membranous, lacerated ocrea is characteristic of *C.guruba*. Tubular, hispid ocrea extend up to 30 cm beyond the petiole margin characterize *C.erectus*. Bristle type of ocrea is present in *C.gracilis* (Ara 2005). In most climbing rattans there is a marked swelling on the leaf-sheath just below the petiole. This is termed as knee. It is only present in climbing members of the genera *Calamus, Ceratolobus, Calospatha, Daemonorops* and *Pogonotium*. In acaulescent members of these genera it is absent. The

knee is usually quite woody in texture, and in a few species such as *C.tumidus* and *C.paspalanthus* it may be grossly swollen. The presence or absence of a knee has also considerable taxonomic value for the field identification of rattan genera when flowers are not available. The function of knee is unknown. It is not a prerequisite of the climbing habit as many high climbers such as *Korthalsia* and *Plectomia* do not possess knees. In all Bangladeshi species knee is present except *C.longisetus*.

Petiole : The petiole is the region just above the sheath. The length of the petiole is variable depending on the species. It is usually much longer in juvenile stage than in mature stage. The petiole is often characteristically armed with spines.

***Leaf rachis* :** The leaf rachis is the part of the leaf axis which bears the leaflets. It is the backbone of a leaf. It has reflexed spines on the lower surface and these help to the climbing process by locking on to support.

***Leaflets* :** Rattan leaves are basically pinnate. Leaflets arrangement, shape and texture of leaflets have great diagnostic importance especially in the identification of sterile materials. The two apical leaflets may sometimes be joined partially. A major leaflets distinction is between entire margined and erose-margined leaflets but there are no erose-margined species in Bangladesh. The leaflets may be arranged either regularly or irregularly. In regularly arranged leaflets there is an uninterrupted even series of leaflets along each side of rachis. In irregularly arranged leaf-lets there may be an interrupted series of leaflets or the leaflets may be grouped. The commonest arrangement for leaflet is regular. Among the Bangladeshi species the leaflets are equidistant and regular in *C.erectus*, *C.guruba*, *C.tenuis* and *D.jenkinsiana*. Clustered leaflets are present in *C.latifolius*, *C.gracilis*, *C.viminalis* var. *fasciculatus*, *C.acanthospathus*, *C.travencoricus* and also in *C.longisetus* at young stage. The width of the leaflet often helps in differentiating the species. *C.latifolius* can be easily identified in the field having 3-5 cm wide leaflets. Shape of leaflets may be narrow, linear or lanceolate or diamond. All Bangladeshi rattan species are linear. It is wise to mention that the juvenile foliage may be completely different from adult foliage. So, for taxonomic purpose, only the mature leaf characters should be used.

2.4.4. Climbing organs: There are two whip-like organs associated with the climbing habit of rattans. They are superficially very similar, but are of completely different in morphological origin. Generally, they do not develop in a rattan until it begins to climb out of the rosette stage. One of these is cirrus--a spiny extension of the leaf rachis beyond

the leaflets and the other one is flagellum--arises from the leaf sheath near the knee and is, in fact, a modified inflorescence. A leaf having cirrus is said to be cirrate, while a leaf without such a whip is termed ecirrate. A species which bears flagella is called flagellate. Flagella are found only in *Calanus* but there are some exceptions (*i.e. C.erectus*). Climbing organs are absent in a few acaulescent species of *Calamus* and *Daemonorops*. Usually flagella and cirri are mutually exclusive, *i.e.* where the rattan has cirri, it does not have flagella and *vice-versa*. Among Bangladeshi species cirri are found in *D. jenkinsiana* and *C.latifolius*. On the other hand *C.acanthospathus, C.gracilis, C.guruba, C.longisetus, C.travencoricus, C.tenuis* and *C.viminalis* var. *fasciculatus* are flagellate. There are some rattans which has neither cirri nor flagella *e.g. C. erectus*. Cirri or flagella are flexible and have spines. They are driven to and fro by the wind and by this swinging action they easily become fixed to the nearest support. All rattans do not have cirri and flagella. A rattan species with an erect habit does not have strong claws, hooks or definite climbing organs. Members of the genera *Pogonotium*, *Retispatha* and *Calospatha* do not have climbing whips but climb weakly in the forest with the aid of the refluxed spines on the lower surface of the leaf-rachis.

2.4.5. Crown-canopy : All recorded rattans of Bangladesh are either loosely or compactly packed clump. Leaf size of all these rattan species varies with species and habitat. The slender is the culm size, the smaller the size of leaf. The higher is the shoot number, the larger is the crown canopy. The leaves usually persist enclosing the culm for 3-4 years depending on species and continues to produce leaves uniformly along the length in all recorded rattan species except that of *C.erectus* where it forms a clear canopy at the crown like non thorn palm. All climbing recorded rattans of Bangladesh usually do not form clear crown at the canopy of supporting trees. It is perhaps due to partial sciophytic nature. Crown-canopy colour varies with species and ranged from light green to bottle green. The size of canopy crown also varies with species and even with in species depending on habitat, and ranged from small to giant which is reciprocal to culm size.

2.5. Reproductive features

2.5.1. Phenology : Phenological pattern of rattan species are generally poorly known. In different species and in different localities, the time of flowering, the duration of flowering, the time of fruit set and the time taken for fruit to become mature may be different. Generally, flowering occurs annually. In most of the species flowering starts

between October-January and fruits mature between April and June (Anon 1991). Stems that had flowered once can flower again in the next season, or may skip a season or possibly two, to flower subsequently (Manokaran 1985b). In seasonal areas, *e.g.* North Celebes, there is evidence of seasonality in flowering (Dransfield 1979). Dransfield (1979) stated that in pleonantic rattans in Malaya there seemed generally to be some seasonality in flowering but such seasonality varies much from area to area. Flowering in *C.caesius* and four more species is seasonal and annual (Manokaran 1989). Seasonality in *Calamus* spp. from Kerala, South India, is also evident (Renuka *et al.* 1982). Manokaran (1989) reported the anthesis time for *C.caesius* is about 1½-2 months (from the inflorescence emergence). Some species of rattan produce inflorescences continuously throughout their adult life but the number of fruits produced per inflorescence is often very few.

In Bangladesh there is seasonality in the flowering and fruiting of rattan species. Banik and Nabi (1979) reported that *C.viminalis* var. *fasciculatus* flowers twice in a year: from February to April and August to October. In *C.erectus, C.guruba* and *C.gracilis* there are two distinct flowering seasons: February-May and August-October. One flowering season is observed in rest of the species occurring in Bangladesh. Fruits are usually produced in abundance. Fruits in one inflorescence generally seem to ripe simultaneously. In *C.viminalis* var. *fasciculatus* fruit formation and development start within one month of flowering and requires 4-5 months for ripening. As a result fruits produced in the first phase of flowering overlaps the next flowering phase (Banik and Nabi 1979).

2.5.2. Inflorescence and flowering : The inflorescence appears to emerge out from the leaf-sheath obliquely opposite to the petiole, usually lower part of axis of the inflorescence is joined to leaf-sheath of the following leaf. There are two major types of flowering among the rattans. One hapaxanthic and the other one is pleonanthic. They are distinguishable (Dransfield 1979). In hapaxanthic a long period of vegetative growth is followed by the simultaneous production of inflorescence from top most nodes of stem and stem dies after flowering or fruiting, usually replaced by sucker shoots from the base. In pleonanthic flowering, after a juvenile period of vegetative growth, stem continues to produce inflorescences, and stem has capability of unlimited growth. All species of *Korthalsia*, *Plectocomia*, *Plectocomiopsis*, *Myrialepis*, *Laccosperma* and *Oncocalamus* and a few species of *Daemonorops* are hapaxanthic; all other rattans are pleonanthic.

World known best commercial rattans are pleonanthic. All species available in Bangladesh are pleonanthic. Rattan inflorescence varies greatly in size and overall structure. Inflorescence structure offers the basis for separating the genera. The basic branching pattern of inflorescences of rattans is more or less same. Differences between rattan genera are found in elaboration or reduction of bracts and difference in degree of persistence and also in number of orders of branching. The main axis bears a basal bract or prophyll, which may be short and tubular, large and enclose entire inflorescence. Branches are borne in axils of subsequent bracts. The inflorescence may branch to two or three orders. The ultimate flower bearing branches are called 'rachillae'. The inflorescence branches to 2 or 3 orders, and ultimate branches of the rachillae bear flowers or flower groups in axils of minute bracts (Dransfield 1979). In most rattans male inflorescence is more highly branched than female one. This is of great value in deciding sex of a rattan flower. The bracts in *Calamus* are usually tubular and in *Daemonorops* they are open and boat-shaped. In *Calamus* and *Daemonorops* male flowers are born on branches of third order, whereas in the female inflorescence flowers are borne on branches of second order. In Bangladesh *C.latifolius* is an exception, where male and female both are borne in third order.

Most of the Asiatic rattans *viz. Calamus, Daemonorops, Plectomiopsis, Plectomia, Myrialepis, Ceratolobus, Calospatha, Ratispatha* and *Pogonotium* are dioecious, *i.e.* male and female flowers are borne on separate plants (Dransfield 1979). Only *Korthalsia* in this region has monoecious flowers. In *Calamus, Daemonorops, Ceratolobus* and *Pogonotium*, male rachillae bear flowers arranged singly in the axil of each rachilla bract. In female flowers are arranged in pairs (known as dyads) along each side of the rachilla in axils of rachilla bracts. The pair consists of a fertile female flower and a sterile male or 'acolyte flower'. The sterile male flower usually falls soon after anthesis and then female flower appears solitary; however, a scar is visible. The sterile male has all the appearance of a fertile male flower except that the anthers are emptied (Dransfield 1981b). This is a feature of most members of sub-tribe Calaminae (Uhl and Dransfield 1987). All available rattans of Bangladesh are commercially important and are dioecious.

2.5.3. Flower : Male inflorescence of *Calamus* has only fertile male flowers, which is also called staminate flowers. The staminate flower is symmetrical with three sepals and three petals englobing six stamens (Uhl and Dransfield 1987). In female inflorescence of *Calamus*, female flowers-pistillate flowers are borne in pairs with sterile male flowers

(acolyte flowers). The pairs are known as dyads. The acolyte flower has all appearance as a fertile male flower except that the anthers are emptied. The pistillate flower has a tubular calyx, shallowly 3-lobed (Uhl and Dransfield 1987). All rattan flowers have three sepals (variously free or fused), three petals (variously free or fused), six stamens or staminodes, and a trilocular ovary or pistillode (Renuka 1992a, 2000). The ovary at young stage is covered with vertical rows of reflexed imbricate scales. The stigmas are frequently relatively large and reflexed. Each locule of the ovary contains only one ovule. In pistillate flower of *C.manan*, gynoecium is tricarpellate, ellipsoidal, whitish with a pineapples like base covered with scales, and with a well developed and fleshy styles, six staminodes surround the gynoecium and united into a ring almost up to the top of filament.

2.5.4. Fruit and seed : All true rattan fruits are alike. The fruits of rattans generally contains only one seed, which consists of a fleshly sarcotesta enclosing a hard diaspore (Dransfield 1979). Generally, sarcotesta adheres to the seed and is difficult to separate. They are covered by vertical rows of reflexed overlapping scales and there is often a beak at the top of the fruit, tipped by the remains of the stigmas and the remaining of the petal and sepals are found at the base of the fruit. The scales are hard, shiny and frequently groved vertically along the mid line. The number of vertical lines; the colour and appearance of the scales are sometimes of taxonomic significance. Fruit maturity is usually indicated by a slight change of colour of the scales. Inside the fruit usually there is only one seed but rarely there are two or three seeds. The seed of nearly all rattans has an outer fleshy layer, called sarcotesta. This fleshy sarcotesta is acidic to sour or bitter and edible. In most of the Asiatic rattans, fruit wall is very thin and dry at maturity, and the seed is covered with a fleshy outer layer, but in *Korthalsia, Laccosperma, Eremospatha* and *Oncocalamus* there is a fleshy outer layer or mesocarp, which is usually sweet. In all other genera pericarp is thin and dry at maturity, and the seed is covered with a fleshy outer layer. Number of fruits produced by plants varies from species to species. Theoretically, single-stemmed as *C.manan* may produce fewer fruits per plant compared with clustered species in Bangladesh. The seeds may vary considerably in shape. The endosperm is deeply or shallowly ruminates. The endosperms are homogeneous in *Plectocomia* and in some species of *Calamus* and *Korthalsia* or ruminate as in *Daemonorops, Korthalsia* (most species) and *Calamus*. In Bangladeshi rattan species all are ruminate excepting *C.erectus*, *D.jenkinsiana*, *C.acanthospathus* and

C.travencoricus. The embryo lies in a shallow pit basally or laterally. If the embryo is kept to dry for sometime the embryo loses its ability to germinate.

2.5.5. Seedling and wilding : Seedling is the best source of propagation in rattan species. Seedling production depends on quality and quantity of seeds. Seed supply is a main problem in raising seedlings. Extraction of rattan culms before flowering makes seed supply more complicated. The increasing demand of canes in local market reduces seed supply for raising seedling due to destruction of mother culm even in more remote and inaccessible area. Besides this, seed supply becomes more acute due to the dioecious nature of all rattan species of Bangladesh. As a result, seedling raising has become limited in most rattan species. Rattan species of Bangladesh produce fruits throughout the year and potential enough for raising seedling. Seedling raising from seeds has been facing much problem with dormancy breaking, flushing, germination per cent and nursing. These problems have been accounted with seed maturity, seed collection time, sowing season, sowing media etc. Germination of seed varies with species and ranges from 4-12 weeks. Seedlings are transplanted to poly bags within 2-3 months and become ready for out planting at an age of 18-24 months depending on species. Wildings are seedlings growing naturally in forest as opposed to those raised seeds sown in nursery. Wildings are regular phenomenon of natural regeneration in rattans. All recorded rattans of Bangladesh are potential to produce wildings under the floor of clumps. The density of wilding varies with species, habitat and clump age. Population of wilding varies with age and very few wildings are recorded to survive to form daughter clump under the floor of mother clump. One year old wilding is preferred for pricking. Identification of wildings at young stage is a problem and it needs field experience for proper identification. Pricking of wilding is preferred in monsoon. Pricked wildings are transferred to poly bags containing suitable media and kept under shade house condition for one year before out planting.

2.5.6. Sucker and rhizome : Sucker is a means of vegetative propagation and is used as alternative of seedling. It is best for propagation of its own trait. Suckers are the young shoots of clump forming rattan species. Recorded ten rattan species of Bangladesh are potential enough to produce suckers. But number and rate of suckering vary with species, habitat and seasons. Suckers of about one year old with some intact root system are collected carefully from the clumps and are transferred to poly bags containing suitable

rooting media for acclimatization, and are kept under shade house condition for one year before out planting. Rhizome is used as a substitute of seedling, sucker and wilding under special circumstances. Rhizomes could be of different sized and aged depending on species, age and habitat. Usually suckers of more than two years old are considered as rhizome. The rhizome system supports several suckers, which ultimately develop in to clump. Rhizomes collected and transplanted to the field during rainy season are recorded to survive well.

2.5.7. Clump and culm formation : All recorded rattans are cluster forming. Depending on the pattern of cluster formation, rattan species of Bangladesh are of two category *viz.* compactly arranged (*viz. C.longisetus, C.guruba, D.jenkinsiana*) and loosely arranged (*C.acanthospathus, C.erectus, C.gracilis, C.latifolius, C.tenuis, C.travencoricus, C.viminalis*). Clump size varies with species, age, habitats and reciprocal to shoot formation. All lateral shoots-suckers of all rattan species of Bangladesh do not develop into culm. Four species *viz. C.erectus, C.longisetus, C.guruba* and *D.jenkinsiana* are found to produce more dead and rosette shoots compared to others six where culm formation are more frequent. Culm sizes vary with species and habitat where the heights of culm vary with age rather than species except that of *C.erectus*. Culm formation continues more or less in number in all recorded rattan species with the extension of clump for longer period depending on habitat. Potential life both for clump extension and culm formation of recorded rattans of Bangladesh has not yet been clearly worked out.

CHAPTER 3 : GENERAL LITERATURE REVIEW

3.1. Biology

3.1.1. Introduction: Research work on biology of rattans in the whole world is very scanty in number. A few countries have done some work on it. Rao (1989) reported that research on flower structure, role of pollination and fruit set in rattan is limited. There is no detailed study on the embryology of rattans. All these emphasis the great need for more taxonomic and morphological research to understand the biology of rattan species of Bangladesh in particular. A detailed knowledge of rattan biology is essential for the success of rattan improvement programme. A brief literature review on the biology of rattan is summarized below:

3.1.2. Flowering : Like many forest tree species, flowering in most rattan species is seasonal. Flowering of rattans may be triggered by the fluctuation of temperature and weather (Manokaran 1989; Raja and Hamzah 1992; Sulaiman 1992). Burgress and Griffin (1991) stated that in natural forest, flowering varies widely with site, provenance, from tree to tree within species and to some extend from year to year. Alloysius (1994) reported that young inflorescences of *C.caesius* emerged between June to September every year, while *C.manan* starts to produce inflorescences in October and continues until December every year. In 1995 *C.subinermis* were observed to produce inflorescences in January, May and July (Alloysius 1996). Most of rattans in India start flowering in October-November and fruits are available in April-May (Renuka and Seethalakshmi 1988; Renuka 1992a). Depending on the species, rattans need about 2 to 5 years in the field before the onset of flowering. In *C.manan* the age for first flowering of male plants is less than that of female plants. Banik and Nabi (1979) reported that *C.viminalis* flower twice a year, once in February-April and then August-October in Bangladesh and fruits become mature in about 160-170 days after flower initiation. All species in the genus *Calamus* have lateral inflorescence (Corner 1966) and the stem continues to grow after flowering and so on. Several authors reported about the age of first flowering of rattans. Manokaran (1982,1985b) observed that *C.caesius, C.manan, C.trachycoleus* and *C.filipendulus* started flowering at 5.3, 5.5, 4 and 4.5 years, respectively after planting in the field. The number of flowering and fruiting stems increased in the following years. Ahmad and Ghani (1987) confirmed the work of Manokaran (1985b) and reported that

the age of first flowering in *C.manan* is about 5 years. Manokaran (1989) reported that flowering both in *C.caesius* and *C.scipionum*, is also annual with fruit maturing in the following year *i.e.*16 months after inflorescence emergence. The planted *C.rotang* and *C.hookerianus* in India started flowering from 4th year onwards (Renuka 1994). In Sabah *C.subinermis* started flowering on 5.25 years after seed germination and about 3.42 years after planting in the field (Alloysius 1997). In *C.subinermis* average number of inflorescence was found 2.1 in 5 year old plantation. The number of inflorescence produced per stem was usually two or three. Sometimes, there was only one and rarely there were four. It has been reported that *C.manan* can exceptionally produce up to seven female inflorescence in one flowering occasion. Basu and Basu (1987) reported that in India the flowering season begins from October with the emergence of sterile inflorescence (flagella) followed by the emergence of fertile inflorescence. They also mentioned that anthesis in male and female flowers were observed in December. Alloysius (1997) reported that in the flowering of rattan four stages can be recognised. The first is the emergence stage, where inflorescence emerges from leaf sheaths and completes development. Second is the pre-anthesis stage, when the inflorescence is fully developed. Third is the anthesis stage, where the male flowers open, to release pollen and female flowers become receptive to pollen. The final stage is the post anthesis stage, where the male inflorescence starts to dry out and the fertilised ovary develops into fruit. In *C.caesius*, the period requires from the first stage to the third stage is about 2 months and in *C.manan*, it takes about 1.5-2 months to complete stage 1 to stage 3 (Alloysius 1994). Small developed fruits of *C.caesius* can be detected by the naked eye after the third months of the emergence of the inflorescence. The size of the fruits increased gradually until the 12th month when the endosperm turned darker in colour and harder. During 13th or 14th months the colour of the fruits changed from pale-green to pale-straw-green and then to pale-straw (yellowish) when fruits become mature (Alloysius 1994). The period from inflorescnce emergence to fruit maturity in *C.manan* and *C.subinermis* was reported to be 16 and 10 months respectively (Alloysius *et al.* 1994). Abdullah and Jusoh (1999) reported that flowering patterns in tropical rain forest are often unpredictable. Seed production is although more predictable because it is dependent on flowering; once flowering is observed, then fruit maturation can be predicted provided the time it takes between flowering and fruit ripening is known (Abdullah and Jusoh 1999).

3.1.3. Sex ratio : There is no conclusive study made to determine the rattan sex ratio in wild population. Rattans are dioecious species and fruit production to some extent is dependent on the distribution and ratio of sexes in any locality. A total of 10 out of 24 mature individuals were identified as female plants in *C.tumidus* in Malaysia (Manokaran 1985b). Aminuddin and Nur Supardi (1993) made observation that 12 years old *C.manan* and *C.caesius* in 12 years old plantation planted in secondary forest in FRIM, Kepong and reported that a sex ratio of female and male was obtained as 1:1.55. While Alloysius (1994) observed a sex ratio of female and male plants in a mixed plantation of *C.manan* and *C.caesius* to be as 1:2.6 and 1:1.6 respectively. Lee *et al.* (1995) estimated that the pollen: ovule ratio of *C.subinermis* in the natural population was 93000:1. According to Cruden (1977) as cited by Lee *et al.* (1995) confirmed that *C.subinermis* and *C.caesius* were usually out breeding. Fernando (1987) reported that male to female ratio ranges from 3:1 in *C.merrillii* to 10:1 in *C.elmerianus*. Fruit maturation period from emergence of inflorescence to maturation of fruits is very difficult to know because the collection of information from the crowns of high-climbing rattans was impossible.

3.1.4. Anthesis-pollination : Insects are reported as the main pollinators in rattan species. Lee and Jong (1995a) suggested that nocturnal insects play a very important part as carrier in *C.subinermis*. Insects are reported to be the main pollinators in rattans (Alloysius 1997). During daylight *Trigona* bees, *Apis cerana* and other *Hymenoptera* were the main visitors to rattan inflorescence. Bogh (1996) also suggested that bees, especially *Trigona*, were the most important pollinators of the four *Calamus* species studied in Thailand. Wind pollination seems to be not important in rattan pollination. Lee and Jong (1995b) showed that the maximum horizontal distance of *C.subinermis* pollen dispersal by wind was 4 m and about 88% of the pollen was dispersed within 3.5 m from the inflorescence. The stigma of *C.subinermis* remained receptive for 2 days under high light intensity or 3-4 days in low light intensity and high relative humidity (Lee and Jong 1995a). The receptivity of the *C.caesius* was slightly longer *i.e.* 5 days. The stigma receptivity of *C.longisetus* and *C.peregrinus* was suggested to be 48 hours and anthesis of the whole female inflorescence lasted for about a week (Bogh 1996). Anthesis lasted for 10-15 days in case of *C.subinermis* (both the sexes) and 15-20 days in *C.caesius* (Lee and Jong 1995a). In *C.subinermis* the process of bud opening of a male flower took about 20

minutes to complete and most of the male flowers opened between 6-8 p.m., following anthesis the flowers shriveled and fell off between midnight and 6 a.m. (Lee and Jong 1995b). Bogh (1996) observed four *Calamus* sp. in Thailand that anthesis of male flowers was between 10 p.m. to 6:30 a.m. of the following day and few flowers stayed open until 10 a.m. According to Bogh, by noon most anthers become emptied and the male flowers dropped off before sunset around 6:30 p.m. All the above mentioned researchers observed that during the opening of staminate flowers nectar was produced and a strong fragrance emitted. Pollen grains of *C.subinermis* and *C.caesius* are round or elliptic, and about 15-25 microns (Lee *et al.* 1995). The estimated number of pollen grains in an anther was about 74000 and 76000 for *C.subinermis* and *C.caesius* respectively. A male inflorescence in theory is sufficient to pollinate all the flowers of 60 female inflorescence (Shim 1995a). Pistillate flowers did not produce nectar while open but acolyte flowers produce nectar during anthesis. The behavior of the "acotyle" (sterile male) flowers on the female inflorescence was the same as the fertile males except that no pollen was produced. Therefore, the role of acolyte flowers in pollination was suggested as a visual attractant and providing nectar for pollinators (Lee and Jong 1995b). Fernando (1987) observed that most rattans start flowering during the dry months of February to May and it took five weeks from emergence of inflorescence to anthesis. He also mentioned that fragrance of flowers attract beetles, bees and flies.

3.1.5. Fruit production : In general the mature fruits of rattan are available from March to June (Renuka 2000). Rattan fruits are obtained once every 16-18 months from the time of first fruiting. The number of rattan fruits may vary around 2500-3500 fruits per bunch. Fruit production of *Calamus* is most important commercially because the genus containing the highest number of dioecious species. *Daemonorops, Plectocomia, Ploctocomiopsis, Myrialepis, Calospatha, Ceratolobus, Pogonotium* and *Retispatha* generally found in the South East Asian region, are also dioecious (Dransfield 1978). Only genus *Korthalsia*, in these regions, is monoecious. Being dioecious fruit production is possible from about half of the breeding population. Manokaran (1979) and Shim (1995a) reported that more than 2000-3000 fruits can be obtained from a single rattan stem. Fruit production in inflorescence is low initially but increases considerably in subsequent years. *C.manan* is known to produce up to 5000 fruits per stem (Manokaran 1979). Fruits mature from late July to August. When fruits mature squirrels eat the fruits

if the branches of fruits are not protected with wire nettings. Sometimes seeds from half eaten fruits with undamaged embryo germinate on the ground some of which develop into adult plants. Abdullah and Jusoh (I999) reported that fruit production took 12-13 months for *C.scipionum* and *C.ornatus*; and 8-9 months for *C.palustris*. They also observed differences in the timing of flowering and fruiting in different climatic zones in these three species *viz. C.palustris, C.scipionum* and *C.ornatus*. Theoretically, single stemmed species such as *C.manan* may produce less fruits per plant compared with clustering species such as *C.caesius, C.trachycoleus* and *C.scipionum* based on fruit counts from identified stems of various species. Thus, during the lifetime of each stem of these species the number of fruits produced probably runs into ten thousands. However, the rare *Pogonatium divaricatum* produces only one or two fruits and *C.gonospermus* five fruits per inflorescence (Dransfield 1981b). The solitary high quality small-diameter rattan, *C.laevigatus* may produce only about 400-500 fruits on any one occasion (Manokaran 1979). Based on fruits purchased for raising seedlings, the solitary *C.tumidus* and the clustering *C.ornatus*, (both are commercial canes) may produce about 3000-4000 per clump and up to 1,000 fruits per culm respectively (Manokaran 1985b). For fruit collectors, the usual sign of rattan fruit in the canopy is the presence of thorns and twisted inflorescence branches with fragmented pericarps on the forest floor due to feeding by animals and attracted by the taste of matured fruits (Dransfield 1978). Preferably, the rattan fruits should be collected while they are still on the tree. Fallen fruits are prone to fungal infestation. Generally, the fruits produced from the first flowering are of inferior quality and the fruits are slow to germinate with low germination percentages. All of the commercial *Calamus* spp in Malaysia generally produce abundance fruit during fruiting season. An average of 2120 fruits per stem was produced by 7 year old *C.manan* with an average height of 35 m in Malaysia (Ahmad and Ghani 1987). It was also mentioned that fruit produced from each plant of *C.manan* was separately counted and found at an average of 5123 (Alloiysius 1994). Islam *et al.* (2003) reported that artificial pollination with stored pollens, which produced fruits in the female inflorescence, emerged in late. They also mentioned that artificially pollinated female flowers produced more fruits than naturally pollinated flowers in *D.jenkinsiana* and enhance more fruit setting and seed production.

3.1.6. Soil condition : Vongkaluang (1985) reported that *C.peregrinus* grows well in soil which was sandy-clay-loam, loam-sand or sandy-loam with medium to high amount of organic matter (1.8-3.9 %), acidic with a pH of 3.6-4.9 where the amount of potassium was found to be 65-90 ppm and the soil moisture content was 35-45%. Rattans occur naturally as an undergrowth in evergreen, semi evergreen and to some extent in moist deciduous forest. Water availability, water retention capacity and depth of soil and overhead light are the important conditions for the growth of rattans. Very little is known about the ecological conditions required for the growth of rattan while data on soils are virtually absent (Balagopalan and Sarkar 1992). Mindawati and Suriamiharja (1986) suggested that growth of the rattan seedlings was not affected by fertilizer treatments. The results of the experiment suggested that among others *Pterygota alata* provided the best climbing support to growing rattan seedlings. The soil mixture of 75% forest topsoil and 25% sand used as a standard practice in the nursery was found to be adequate for rattan seedlings. Transferred seedlings to potting bags was placed side by side in seed bed in east-west direction so that direct heat from the sun is avoided during sunrise and sunset. Seedlings are kept in the nursery until they are transplanted to the field. They should not be completely exposed, as they would become unhealthy due to scorching of their leaves by the sun's rays (Manokaran 1980, 1981a). Balagopalan and Sarkar (1992) mentioned that rattans require adequate but not too much light, poorly drained and strongly acidic soil with rich humus layer. A thin layer of sawdust about 3 cm is spread on top as a covering medium to maintain a moist environment for the seeds. Ahmad (1983) found that *C.manan* seeds preferred a medium of high water retention capacity such as sawdust or a mixture of forest topsoil and sand (3:1). He also mentioned that *C.caesius* did not show any preference to any sowing media.

3.1.7. Growth : There is no published information on the growth rates of rattans growing in the wild. Such information is available for commercial species undergoing silvicultural trials. In general, management of plantation begins soon after planting. Seedlings become ready for out planting after one year and survival per cent was found 50-70%. Replacing of planted seedlings require when they are growing very poorly. This process should be completed within 3-6 months after planting. Shim (1988) reported that for field plantation the diameter of the hole should be 15 cm. Care should be taken to ensure that the seedlings are not planted too deeply as this would delay production of suckers. He also

reported that too much light causes burning of fronds and rosetting of plants and too much shade retards growth. Rattan grows well where the moisture is abundant. Light is also an important factor for enhancing growth. In seedling stage they are shade loving with very slow growth. With the onset of stem formation, plant shoots climb up and then requires more light (Renuka 1992b, 2000). Vongkaluang (1988) studied the effect of light on growth of different rattan species. Xu (1989) reported that 50 per cent shade conditions round the year was found optimum for maximum growth of rattan. Mori *et al.* (1980) also found that *C.manan* seedlings show maximum growth at about 50% shade condition. It was also generally observed that seedlings grew faster in partially open areas than in totally shaded places during rainy months than in dry months. Extreme dryness is one major cause for sucker mortality. Young seedlings with unexpanded primary or at two leaf stages are transplanted to polybags of suitable size containing rooting media of soil and sand (3:1). The potted seedlings are placed on concrete beds until they have reached plantable size of about 30-40 cm in shoot height. Seedlings are ready for out planting at about 12-15 months age with more than 7 leaves. There is no stem formation up to three years and after that plants increase in height (Haridasan 1997). Siddiqi *et al.* (1996) reported that seedling of *C. tenuis* attains a height of 109 cm with 3.34 culm per plant at eighteen month age after planting. Weeds are not a serious problem either on the sowing beds or in the pots. Weeding is carried out whenever necessary (Ahmad and Hamzah 1985). Anon (1994) reported that multiple-stemmed species built up clumps by the development of sucker shoots produced from axillary or leaf-opposed buds at the base of the stem. Such buds usually develop as short rhizomes that then grow into aerial stems. They also reported that in *C.trachycoleus*, sucker shoots develop into stolons that may reach up to 3 m or more in length before metamorphosing into aerial stems. Vongkaluang (1988) noticed that some rattan (*Plectocomia pierreana*) species grows 240 cm per year and *C.caesius* 45 cm per year. Others *viz. C.rudentum, C.oxyleyanus, Korthalsia grandis* and *C.peregrinus* grew more slowly. Seedlings were found to grow well in the temperature range of 20°C-30°C. Aida (1986) found 55% survival rate after one-year period. Guiangtian *et al.* (1992) reported that fertilizer application enhances the growth of seedling of *D.margarita*. Shim (1989b) reported that *C.trachycoleus* can grow more than 7 meters a year on good sites. These canes would be harvestable 2 years later when they would be about 28 meters long. He also reported that in *C.trachycoleus* up to 30 canes

might be produced per clump from rhizomes by the third year before the production of stolons. Some variation in diameter along the stem is found where the base usually becomes thicker and then decreases in diameter upward. Nodes that produce inflorescence were found thinner in diameter than the others. All such variation in diameter may affect the quality of the harvested cane. Stem elongation is continuous but variable from period to period in rattan. Aminuddin (1985) as well as Mohamad (1985) reported that several factors could affect the growth of the various rattan species. Among these factors optimum light and soil moisture regimes are prominent. Manokaran (1982) and Manokaran and Wong (1984) recorded that *C.caesius* can grow as much as 5-6 m/year for the first 5 years of planting at optimum conditions (with canopy thinned and poorly drained soil). This suggests that *C.caesius* requires enough light for the first few years of establishment phase. *C.manan* also requires adequate light for optimal growth (Manokaran 1977). Aminuddin (1985) stated that growth rate of *C.trachycoleus* was found as 1.3 m/year. The clump would require clearance of debris to encourage development of new shoots. Lakshmana (1987) also reported that nitrogenous fertilizer is beneficial for growth and survival. Xu *et al.* (1988) reported that primary leaf of rattan seedling took 1.5 - 2.0 months for expansion after sowing. At the 2.5 and 15 month stage, the mean height of rattan seedlings was found 6.5 and 30 cm respectively. This growth rate in the seedling stage was lower than that of seedlings of *D.margaritae* (Xu 1984). The seedlings in the polybags become ready for planting after one year. It can be maintained in polythene bags for a maximum period of two years. The only drawback is that as the age of seedling advances these seedlings develop spines and it becomes difficult to handle plant at the time of planting in the field. Two years old seedlings have good rhizome and root formation, and they are more suitable for plantation purposes (Lakshmana 1993). Soon and Momen (1985) showed that aerial stems become double in number for the first year in *C.caesius* and the first 4 years in *C.trachycoleus*. Nainggolan (1985) recorded that *C.manan* seedlings had better growth rates and lower mortalities during the first year after transplantation when grown under shade of half canopy or under full shade irrespective of wet or dry soil moisture regimes. The shade-grown seedlings were first acclimatised to gradual removal of shade (Nainggolan 1985). Feaw (1992) mentioned that rattan cultivation in rice field is most unusual practice. Basu (1985) reported that canes are not found in the bamboo-infested areas. The aggressive growth of

the bamboos antagonizes the spread of canes. *C.viminalis* var. *fasciculatus* is the only cane that grows near the bamboo brakes. Gulati and Sharma (1983) made an observation that application of fertilizers after transplanting has no significant effect either on the growth of plants, number of suckers even after 4 year of growth or the survival percentage in *C.tenuis* in India. Shim (1988) mentioned that it is debatable whether the addition of fertilizers could further increase growth or whether closer spacing could increase the yield.

Tan (1988) reported that five granules of compound fertilizer per seedling applied fortnightly were essential for growth of rattan seedlings. Aminah and Afendi (1989) reported that compound fertilizer applied at 0.5 to 2.0 gm per plant every two months significantly improved the survival and shoot root ratio of *C.manan* potted seedlings. Aminah (1990) reported that the diameter growth was significantly affected by the frequencies of fertilizer application. Sharma and Choudhary (1987) reported that *C.tenuis* (cane) seedling under favorable climatic conditions at Dehra Dun grown to a maximum height of about 4 m after 6 years. Wong (1984) mentioned that *C.viminalis* and *C.garuba* at the age of 8 and 6 year had 5-6 stem per clump with longest stems at about 8-10 m. While that of *C.latifolius* at the age of 6-7 years had the longest stem at about 8m. The best specimen of *D.jenkinsiana* at the age of 8 years had the longest stem at 3.5m in Bangladesh Forest Research Institute. Dransfield (1988) reported that *C.manan* grows to 7m per year in Malaysia. Manokaran (1985a) reported that seedlings are best planted out at rainy season so that they receive adequate water for initial growth. Guangtian *et al.* (1989) reported that light is an important factor affecting seedling growth of rattans. Most rattan seedlings are unlikely to grow well under full shade or full light conditions. Guangtian *et al.* (1989) worked on effect of different levels of light intensity on growth of rattan seedlings and based on these result rattans were classified into three types for optimum growth -1) Shade demanding species: The seedlings of this type *e.g. C.simplicifolius,* are likely to grow well under less than 40% light intensity. 2) Slight light-demanding species: The seedlings of this type like *C.tetradactyleus* require 40-75% light intensity to grow well. 3) Light-demanding species: The seedlings such as those of *D.margaritae* are unlikely to grow well under too much shade (dense canopy), and they require more than 75% light intensity for optimum growth. The stem diameter is an

important criterion in determining the end use of rattan (Bhat and Renuka 1986). It is reported that internode length varied greatly within the same cane sample.

Rattans like all other plants require sufficient water for growth. Besides water, adequate light is an important factor for enhanced growth, and this has been demonstrated for *C.caesius* (Manokaran 1981a, 1981b, 1982). *C.scipionum* (Manokaran 1980 and 1983), and observed to be so for *C.manan* (Dransfield and Manokaran 1975; Manokaran 1977). Despite the importance of light, however, seedling of *C.scipionum*, *C.caesius* and *C.manan* will not withstand full light throughout the day (Manokaran 1985b). Environmental variations would general account for most of the variations in growth. In addition to that, genetic variation could also contribute in some way, considering that present seed sources are derived from open pollination (Manokaran 1985b). Variability in growth has been noted for *C.manan*, *C.acipionum* and *C.caesius* in the trial plots. Manokaran (1980, 1981a) reported that leaves of *C.scipionum* and *C.caesius* found to be scorched and unhealthy when left exposed in the nursery. Sulaiman and Phillipps (1989) mentioned that *C.manan* grow fastest among *C.manan*, *C.subinermis*, and *D.fissa*. Growth is sometimes positively related to size at the beginning of the growth period and possibly negatively related to numbers of suckers at the beginning of the period.

3.1.8. Supporting trees : Existence of convenient supporting tree is a prerequisite for successful establishment of rattan plantations (Siddiqi *et al.* 2000).The density of supporting trees determines the horizontal and vertical expansion of rattan clumps. Slow growing long rotation trees of 5-8 years are preferable as supporting trees for sustainable and higher yield (Siddiqi *et al.* 2000). Wong (1984) reported that supporting trees are essential both to encourage upward growth as well as to avoid a thicket situation in future where the canes are tangled all over the ground and would be more difficult to harvest. He also reported that bamboo clumps are not adequate as supports for the canes and in fact may compete with the planted cane, especially since the bamboo is thickly established and would have dense mats of shallow root systems that compete aggressively with unestablished young cane plants. In general canes do not thrive in bamboo infested sites and this seems to be an indication that they may be non-compatible with one another. Once the seedlings or wildings reach plantable size (approximately 20cm tall) they are planted. Ring weeding of about 1m radius is carried out on every planting spot to

eliminate undesirable weed competition with the planted crop. Weeding and maintenance operations are carried out in established plantations for a period of about 2 years (Madulid 1985). Sengdala and Evans (1999) reported that *C.tenuis* do not need shade and support trees.

3.1.9. Clump formation : Rattan like many other palms, produce basal suckers. However, production of aerial shoots has also been recorded for a number of species of the genera *Plectomia* and *Calamus*. In three *Calamus* species (*viz. C.javensis, C.heteroideus* and *C.reinwardfii*) cited by Dransfield (1978) as well in *C.hookerianus* reported by Renuka and Nambiar (1985), aerial shoots were observed. Suckering occurs only on stems, which fall over and make contact with the forest floor. Aerial branching in the rattan palms is known only in the genus *Korthalsia* sp where it is a regular occurrence (Dransfield 1978, 1981a). Axillary shoot development (suckering) on aerial stems of rattans has also recently been reported in *C.gamblei* from south India (Renuka and Nambiar 1985). Alam (1988) reported sub-aerial shoots of *C.erectus* in Bangladesh. It has been observed that *C.erectus* exhibits regular sub-aerial shoot production from the nodes towards the base at ground level or three to four nodes above the ground level (Dransfield 1978; Alam 1988). Fernando (1987) reported the production of both basal and aerial suckers in many plants of *C.merrillii* in Philippines. Evolutionary trend of habit for palms is from sympodial to monopodial *i.e.* clustering to solitary (Moore and Uhl 1982). The multiple stem in some plants of *C. manan* is thus a throw back to its primitive habit. One stem from a clump of *C.merrillii* produce up to four aerial branches from 2 to 14 meters long. The production of aerial stems may be a survival mechanism in response to the effect of typhoons blowing down support trees (Shim 1989a). Economically the aerial suckers show great potential for vegetative propagation. However, the stems produced by aerial suckers are slender compared to the main stem (Shim 1989a). Dransfield (1977a) reported that clustering species might cause problems at the time of harvest if the spacing is too close. Soon and Momen (1985) reported that the first 3 years after planting only short orthotropic rhizomes are produced by *C.trachycoleus*. According to Dransfield (1977b) *C.caesius* produces a rather dense clump of many aerial stems (15 in number) radiating from a condensed system of shoot underground rhizomes. Baharuddin and Ali (1981) found average height of *C.trachycoleus* as 1.7 m and the longest plant measured

2.6 m. They also reported that 32 suckers were produced from 12 plants and one plant had 5 suckers. All they developed into orthotropic stems and grew faster than the parent stems. Aminuddin (1985) reported that the rate of growth for the rattan in the plantation varies every year. Weiliang *et al.* (1989) studied the effect of group-planting of *C.tetradactylus*. Seedlings planted in different groups are discussed with reference to survival, stem growth, sucker shoot formation and length of stems. They reported that the survival percentage of seedlings and stem growth did not show variations even after 24 months of planting, but the sucker shoot formation per plant varied.

3.1.10. Harvesting : The growth of all palms for the first few years is slow. However, rattans are relatively fast growing and high yielding and can be harvested on relatively short rotations (Sunderland and Dransfield 2002). Badhwar *et al.* (1957) reported that a certain amount of canes may be harvested after 5-6 years of growth depending on the species and locality, the clumps do not come into full bearing until about 15 years by which time they should have 50 or more stems averaging 24 to 33 feet. However, about 10% of the stems could be harvested every 2 or 3 years (Badhwar *et al.* 1957, Bhat *et al.* 1989). The quality of the first harvest is not the best, but the subsequent collections are of better quality. Naturally growing rattans are cut once in 3 years in Assam, Bengal and in Puri Division, Orissa. It is better to cut canes in every alternate year. In Madras, rattans are harvested on 3 year rotation. In Coorg, the period of maturity of naturally growing canes is believed to be 5 years. In Ghat forests, a cutting cycle of 6 years has been adopted (Troup 1921). The best season for harvesting canes is November to March. Harvesting must be done carefully so as to avoid damage or death to the clump. It is collected by cutting at base and dragging it down from the crowns of supporting trees. The soft terminal portions are discarded. Tewari (1994) mentioned that in North East India, Orissa, Uttar Pradesh and Tamil Nadu cutting cycle is operated once every three years. The mature rattans can be collected by cutting out ground level after they attain a length of about 15m by which time they would be about 12 years old. After harvesting leaf sheaths are removed and the entire cane is cut into 3-4m long and dried in the sun by spreading on the ground or by stacking against temporarily constructed supports (Basu 1992). Saharia and Sen (1990) reported that there is significant difference in the total number as well as the total length of cane (*C.tenuis*) obtained from per unit area at

different harvesting cycle. They mentioned that maximum number as well as length of cane could be obtained from two years harvesting cycle in *C.tenuis*. In general, *C.trachycoleus* is said to be ready for harvest in 7-10 years after planting (Godoy and Tan 1989). *C.caesius* is said to be harvestable in 9-10 years after planting (Menon 1980). Under good plantation conditions it is possible to get 250 rattan stems of about 13-15 m in length after 15 years. Thus the total yield can be around 3500 m per hectare in the 15th year. Almost the same yield can be expected on a three to four year felling cycle (Lakshmana 1993). Tewari (1994) mentioned that cane is considered ready for harvesting when their lower portion becomes exposed and the leaf sheaths start loosing or falling off. The upper most portion (30-200 cm) is discarded. It has been estimated that on average 28% of the estimated total merchantable length of a rattan cane is wasted or left unutilized in the forest through conventional harvesting. Siddiqi *et al.* (2000) reported that rattan could be harvested from ten years age and 8-10 stems of varying length from 10-12 m can be harvested depending on site conditions and locations. They also said that *C.tenuis*, *C.viminalis* and *D.jenkinsiana* could be harvested at the age from 6-8, 9-11 and 10-12 years respectively.

3.1.11. Uses : Xu *et al.* (1991) reported that the amount of total protein in the shoots of *D. margaritae* and *C.simplicifolius* is high about 1.93 and 3.01 per cent respectively in fresh sample. Total protein in the shoots of *C.simplicifiolius* is higher than the average total protein of bamboo shoots and vegetables. It has been reported that there are 17 kinds of amino acids in the rattan shoots and of these seven are essential to human beings. The contents of total sugar were very low *e.g.* 0.025 and 0.044 per cent in fresh shoots of *D.margaritae* and C.*simplicifolius*. Rattan shoots are therefore an excellent source of vegetables. The expansion of rattan plantation areas will not only increase the raw material supply for the production of handicrafts and furniture but also provide shoots as a source of valuable food (Xu *et al.* 1991). From the utilization point of view rattan is placed next to timber and almost same with bamboo (Tewari 1994). The tribal people of Andamans eat the ripe fruits and use the leaves for thatching. Basu (1985) reported that the root of *C.rotang* in combination with other herbs is useful for treating snakebites and scorpion strings. The root is also useful for its antidysenteric, antibilous tonic, febrifuge and depuration properties. Rattans have 100% moisture in them, which is used for

drinking purposes in emergency, when water is not available in forest. Wild boars also chew the green stems and quench their thirst. Canes are used largely for furniture, *C.tenuis* and *C.gracilis* are useful for spinning the seats, binding etc. *C.flagellum* and *C.latifolius* are used as stands. Walking sticks are made out of *C.tenuis*, *C.floribundus* etc. (Haridasan 1997). The leaves and fruits of several canes are eaten. The tender leaves of *C.travencoricus* are used for treating biliousness, dyspepsia as antihelmenthic. The powdered seeds of *C.rotang*, *C.rheedei* and *D.draco* are useful for abdominal ulcers (Caius 1935; Hartwell 1970). The young tender white shoot tips of *C.flagellum* and fruits of *C.longisetus* are edible (Anon 1982; Haridasan *et al.* 1990). Cane fruits are also used as fruit and medicine. The fruits of some species are very sweet and of some are very sour. The fluid of *D.draco* and *D.kurzianus* a climbing cane of East Asia is collected from scaly fruits and called Dragon's Blood (Blatter 1926; Badhwar *et al.* 1957). This was once an important commodity in the trade between South East Asia and China where some rattan species are used in preparation of varnish, dye and in chinese medicine. Rattan shoots are considered as delicacy and thought to promote good health (Belcher 1999). The stem of *C.andamanica* and that of *Plectomia himalayana* when cut provides soft drinking water (Sangal 1971; Basu 1985). Badhwar *et al.* (1961) reported that *C.rheedei* and *C.gamblei* are used for making handles of cricket bats and hockey sticks and for making javelins. Basu (1992) reported that root of rattan is used in veterinary practices as tonic and aperients. Commonly known canes are used as vegetable, dye, medicine, drinks, stick, fruit pulp, varnish, hedge, soil binder and shelter for wild lives.

Review of biology of commonly known rattans of the world has clearly revealed very important information on general habit, habitats, flowering, fruiting, anatomy and other aspects. The present study aimed at examining those aspects of rattans of Bangladesh. Unfortunately, due to limitation some important aspects such as anatomy, cytology and embryology have left undone. So, these aspects of biology must be worked out in Bangladeshi rattans by some one interested in this field in near future.

3.2. Propagation

3.2.1. Introduction : The usual method for propagation of plants is from seeds. In the event of difficulties in obtaining seeds, other vegetative methods require the use of planting material such as suckers and rhizomes, or even stem cuttings for some rattan

species, would have to be employed. The method of layering is also a possibility for some rattan species. Both for solitary and cluster forming rattan species for which there is a seed supply problem, wildings may have to be procured for propagation purposes. Many workers reviewed the various ways in which rattans are propagated. They mentioned that rattans are usually propagated by seeds (Renuka 1990). Vegetative methods through the use of offsets, suckers and rhizome transplants and tissue culture are rarely employed. Vegetative propagation of rattans for the purpose of mass multiplication is limited because of their morphological features and growth habits. Cluster forming species usually propagate through the division of rhizomes. Solitary stemmed types do not propagate by conventional vegetative propagation procedures like cutting, layering and grafting (Tewari 1994). So, propagation of rattans mainly is concerned with seed, seedling, rhizome, sucker and wilding.The literature review on the above phenomena are summarized below.

3.2.2. Seed viability : Cane seeds are known to be viable only for short periods of about 1-2 months (Badhwar *et al.* 1961; Gulati and Sharma 1983; Renuka 2000). With proper storage conditions, viability can be extended to about 6 months (Ahmad and Hamzah 1985; Biswas and Dayal 1995)). Shim reported (1995b) that no method has been found yet to store seeds for more than one year. Mori *et al.* (1980) reported that *C.manan* seeds have a very low natural storability. Storage of whole fruit in well ventilated conditions at 22-28^{0}C could be done for up to two weeks without affecting viability. Manokaran and Wong (1983) demonstrated that naked seeds kept in closed bags at 22-28^{0}C maintained a high viability (50%) for about 6 months. The factors influencing the storability were -- a) The desiccation of fruits to about 100% moisture content did not affect the viability. b) The seeds, with removed sarcotesta dried quickly and lost viability within a few days. c) The fruits stored in closed plastic bags maintained high seed viability for one month at room temperature d) Moisture content of naked seeds must be kept at a level around 55% during storage period.

3.2.3. Seed germination: All rattan contain only one seed. Seethalaksmi (1992) reported that generally rattans produce seed in bulk and about 90 per cent seed germinate if ripe seeds are collected and sown soon after collection. The outer scaly pericarp of the fruit and the fleshy sarcotesta has to be removed before the seeds are sown (Manokaran 1978;

Manokaran and Wong 1983; Vongkaluang 1985; Yusoff and Manokaran 1985). Seeds sown with the intact pericarp and sarcotesta have shown poor germination rate (76.25%) and longer germination period (48 days). On the other hand, seeds sown without pericarp and sarcotesta showed high germination rate (91.25%) with shorter germination period (35 days) (Manokaran 1978; Biswas and Dayal 1995). Bhat *et al.* (1989) found 95% germination in 95 days in *C.hookerianus*, 95% germination in 45 days in *C.pseudotenuis*, 97% germination in 50 days in *C.rotang* and 90% germination in 50 days in *C.thwaitesii*. Lakshmana (1987) reported that sowing of entire fruit causes delay germination sometimes up to one year. Rai (1979) reported that it is ideal to sow freshly collected and cleaned seeds for maximum germination per cent. It is reported that best month for collection of ripe fruit are April-May (Anon 1991). The germination process in rattans is adjacent-ligular (Tomlinson 1961; Uhl and Dransfield 1987). A short peg-like cotyledon sheath appears out side the germ pore from which roots and shoot develop. The eophyll or the first foliage leaf is not identical in all taxa of rattans. In *Calamus* the eophyll may be bifid or with 4-5 leaflets connate at the base or free as seen in *C.longisetus*, *C.viminalis* etc. In many species of *Daemonorops* the eophyll consists of 4 radiating leaflets originating from the petiole (Basu 1992). When the seeds began to germinate a white columnar peg emerged first. The emergence of this peg is a characteristic of germinating rattan seeds (Dransfield 1978). In general 5 days after emergence the plumule emerged from one side of the peg. On average, another 4 days elapsed before the radicle was seen to develop on the opposite side of the plumule. Vongkaluang (1985) reported that sometimes the plumule and the radical emerged on the same day. He also mentioned that the plumule become green in colour and showed negative geotropism. While the radicle remained white in colour and showed positive geotropism. On the plumule, the leaf sheath developed within 7-20 days from emergence of the root. Two weeks later, the first leaf appeared which made up of 6 leaflets each of them was about 14.7 cm long and 1.2 cm wide. Two to three months later the second leaf appeared (Vongkaluang 1985).

C.caesius seeds germinated 3 weeks after sowing and germination is completed after 10 weeks (Ahmad 1983). The polythene bag used for potting rattan seedlings is 8 cm diameter and 16 cm in height. Rattan seedlings may be kept in the nursery up to 8-12

months during which they may have reached a height of 30-40 cm (Manokaran 1988). Propagation by seed is easy and profitable for large scale or commercial plantation (Ara 2001). In nature seeds are dispersed by monkeys, birds and even squirrels, which relish the fleshy sarcotesta. Where ripe fruits are fallen to the ground, germination occurs with the decay of the pericarp and sarcotesta. Mature seeds is important for raising seedlings (Vongkluang 1985). Only ripe fruits are collected. *i.e.* when the skin becomes yellow white and the fruits fall easily on slightly shaking the plant. Experiments shown that a few seedlings may come up within a month of sowing of rattan seeds, more seedlings come up later on, and the seeds go on increasing germinating even when they have been in the soil for about 12 months (Renuka and Nambiar 1985). Bagaloyos (1988) reported that most of rattan seeds are available during second half of the year from August to December. He also mentioned not to dry the seeds. Freshly harvested matured seeds of rattans normally display a high rate of germination (Renuka and Nambiar 1985; Awang 1994). However, rattan seeds are very sensitive to dehydration. Effective temporary storage is maintained at low moisture content to reduce infection of microorganisms but not so low as to kill the seeds. In practice, rattan seeds are not stored for any length of time prior to sowing. Mori *et al.* (1980) found that rattan fruits stored in closed plastic bags restored high seed viability for 1 month at room temperature and for 3 month at temperature of 10-14^{0}C. Pollisco (1989) and Xu (1989) reported that moisture content below 50% results in a sharp decline in germination rate. Seed viability decline rapidly due to desiccation of the seeds. The recommendation of the FRI, Malaysia is that the moisture content of naked seeds must be kept between 45 to 55% during the storage period. Seed moisture content by more than 60% will induce seed germination during storage and less than 40% will decrease the seed viability. Seed moisture content of 40-60% appears to be very critical for seed viability as above 60% the seeds tend to germinate and below 40% they tend to become non-viable (Mori *et al.* 1980). It may be rather difficult to provide suitable storage conditions for maintaining proper moisture content. Badhwar *et al.* (1961) reported that the seeds lost viability even during air transport. Bagaloyos (1988) reported that reducing the moisture content level of seeds of four species (*viz. C.ornatus* var. *philippinensis*, *C.merrillii*, *C.filispadix* and *Daemonorops mollis*) adversely affected their viability. Initially the germination percentage was 89%, 97%, 41% and 83% when moisture content was 82%, 54%, 86%

and 72% respectively. In general therefore, viability of the seeds of the four species was greatly lowered when the seed moisture content was lowered to below 26%. Nainggolan (1985) mentioned that trials were carried out using charcoal powder or dry saw dust to maintain suitable moisture content of fruits and seeds in storage. Zoysa and Vivekananda (1989) reported that collection of seeds at maturity and proper storage until sowing are the two key factors that ensure high germination. A simple method was developed for successful seed storage by storing cleaned and washed rattan seeds with all excess moisture removed, in air tight polythene bags at around 27% (Zoysa and Vivekananda 1989).

Sumantakul (1989) mentioned that maturity of seed has a major effect on germination. It is important to use only fully matured seed in the experiments. There are some species (*C.pereginus*) which can germinate within 7-15 days if sown under suitable conditions (Vongkaluang 1985). Pollisco (1989) reported that germination rates of rattan is highly variable. Generalao (1977) mentioned that germination rates were found too low for *C.merrilli* and *C.ornatus*. Duration from sowing until germination varied from 90-365 days. *C.merrillii* seeds can be successfully germinated in 2 days with 97.5% germination by simply removing the pore cover a process, which can be easily applied to prepare 100 seeds in 10 minutes by a layman (Agmata 1985). Removal of the pore cover of *C.ornatus* var. *philippinensis* seeds gave rise to 3 important results- (a) the germination rate was greatly improved from 35-46% to 93% (b) the pregermination period was shortened to 8 days from 39 days and (c) the germination process was completed in 15 days as compared to 7 months obtained previously. Successful breaking of the dormancy was achieved with the application of Gibberellic Acid (GA_3) at 1000 ppm concentration, resulting on a 100% increase in shoot and root length of *C.ornatus* var. *philippinensis* seeds (Agmata 1985). Madulid (1985) found the highest germination percentage (30.19%) from seeds without pretreatment sown in stratified sawdust for two rattan species. Wong (1984) reported that for plantation in Forest Department of Tilagar Beat pericarp of *D.jenkinsiana* was removed from the seeds and soaked in water for 24 hours. Then seeds were sown in soil bed and germination per cent was found 75% with in 3 to 6 months. Gulati and Sharma (1983) reported that *C. tenuis* can be raised by seeds or suckers They reported about the collection of fully ripe fruits in mid July and said that one kg. contain

about 1100 to 1110 fresh ripe fruits. They also reported germination per cent of *C.tenuis* as higher (77.1%) in whole fruit, than fruits with pulp (57.3%) and clean seed (22.9%). Rai (1979) reported seeds of *C.thwaitesii* treated with hot water and sulfuric acid resulted in complete loss of germination. He also mentioned that seeds soaked in water for 18 hours and then sown gave 60% germination between 15 and 30 days. Basu (1992) reported that *C.thwaitesii*, seeds when soaked with water for 30 hours immediately after collection and sown without further treatment gave about 95% germination. When seeds stored for two months and sown with the same treatment recorded only 65% germination (Rai 1979). *C.longisetus* seeds when sown within 2-4 hours of collection after removing the sarcotesta gave 90% germination. Mohiuddin and Ara (1997) reported that intact fruits of both *C.tenuis* and *C.guruba* stored in closed polythene bag at refrigerator (10-12^{0}C) showed higher germination per cent (68% and 69%) after 120 days of storage than clean seed. Germination per cent in *C.tenuis* was found 10, 70 and 86.6 in whole fruit, seed with pulp and clean seed respectively (Siddiqi *et al.* 1996; Rashid *et al.* 1993). Information on maturation period and characters of the ripe fruits of rattan should be recorded (Xu 1973). To enhance germination seeds can be treated in hot water (50-60^{o}C) for a day or in running water for 3 day; or treating seeds with a solution of sulfuric acid for 3-5 minutes depending on species. Bhat *et al.* (1989) mentioned that propagation of rattan by seed is easy. Yusoff and Manokaran (1985) reported that seeds may be directly sown in soil at the planting site. Such direct sowing avoids the cost, time and labour of raising seedlings in a nursery. But direct sowing is unlikely as heavy losses of seeds and will result from predation by animals and birds, and damage from hot weather and disease. This method is not recommended for rattans. Ahmad and Ghani (1987) reported that to obtain a good germination percentage, the fruits must be mature, fresh and uninfected by their outer appearance or by examining the seeds. If the seed kernel is hard and dark in colour, there will be a very good chance of germination. Seed beds are shaded with attap (palm thatch) and *C.manan* seeds are sown in rows where the sowing distance within and between the rows was being 2 and 4 cm respectively. *C.caesius* seeds can be sown by broadcasting because the size is smaller compared with that of *C.manan* seeds. Seeds with out sarcotesta removed were found to germinate faster than those with intact sarcotesta as in seeds of *C.manan* (Manokaran 1978; Mori 1980). The sarcotesta can also be removed by rubbing the seeds gently on coarse wire mesh (Ahmad 1983). By this

method, the percentage of germination obtained was between 60 and 80%, depending on the maturity and freshness of the seeds. Mori *et al.* (1980) in their laboratory trial, found that complete removal of sarcotesta of *C.manan* seeds gave a germination percentage ranging from 90-100%. Germination tests in the nursery showed that the germination percentage of *C.manan* with complete removal of the sarcotesta was 80% and with partial removal 67% (Ahmad and Hamzah 1985). Manokaran (1978) reported that slow rate of germination in rattans may be due to slow development of the embryo and not due to any inherent dormancy (Mori *et al.* 1980). Mendoza and Generalao (1979) reported that provenance did not significantly affect the germination period of *C.ornatus*. Renuka and Seethalakshmi (1988) mentioned that soon after collection, ripen fruits were crushed and soaked in water for about 48 hours to induce fermentation. They also mentioned to use 1% sodium pentachlorophenoxide and kept for stratification in moist sawdust for two weeks that hasten germination. Germination takes place after 1-7 months (Renuka and Seethalakshmi 1988). Pritchard and Davies (1999) mentioned that germination rate is dependent on the quality of the seed lot and this may be highly dependent on harvesting time and post-harvest treatment. Haridasan (1997) reported that germination of rattan seed is poor due to short viability, faulty storage and faulty method of sowing. Seeds germinate in 20-25 days and continue up to 50 days or even more. Seedlings are transferred into polybags soon after germination and kept under partial shade, which is essential for survival and growth of seedlings. Seedlings will be ready for planting in 12-14 months depending upon seeding time and seed sown in the bed.

3.2.4. Seedling : Seed is the best source of propagation (Renuka and Seethalakshmi 1988; Renuka 1994). Due to the uncertainty of viable seeds and unavailability of large quantity seeds from a dependable source, production of rattan seedling is a great problem. Also extraction of canes before flowering makes the situation further complicated. Yusoff and Manokaran (1985) mentioned about the main problem facing by the cultivators is that of seed supply for sowing. As the demand for canes go on increasing and as the resource becomes depleted, fruits can only be obtained from mother plants located in more remote and inaccessible areas. For large scale planting, sufficient numbers of fruits have to be harvested for raising the required number of seedlings. It is evident that plantation of 10 years old may produce maximum number of fruits. A seed stand of

C.trachycoleus would probably supply a large number of fruits earlier than that of *C.caesius* possibly by 8-9 years after planting. Seeds derived from the same mother plant from the same occasion of flowering, germination vary over a week or months. This means that the relatively long period between initial and final germination may be a reflection of differences in the developmental state of embryos of each seed batch. Manokaran (1988) reported that seedlings of 2-3 cm height where the primary leaf is unexpanded, are transplanted to pot from the nursery bed. The polythene bag used for potting rattan seedling is 8 cm diameter and 16 cm in height, may be kept in the nursery up to 8-12 months by which time they may have reached a height of 30-40 cm (Manokaran 1988). The soil and sand mixture of 3:1 used as a standard practice in the nursery. After pricking, seedlings should be placed in an east-west direction so that direct heat from the sun is avoided during sunrise and sunset (Manokaran 1988). Seedlings are kept in the nursery until they are transplanted to the field, should not be completely exposed, as they would become unhealthy due to scorching of their leaves by the sun rays (Manokaran 1980,1981a). Bagaloyos (1988) reported that plants of 16-18 months have been observed to do much better than those planted 12 months old. One year old plants, about 15 cm high and bearing 4 to 5 leaves can be transplanted with a ball of earth during the rains (Renuka and Nambiar 1985). One year old seedlings were found suitable for successful plantation in *C.tenuis* (Siddiqi *et al.* 1996). To ensure regular seed supply in the future, seed stands will have to be established.

3.2.5. Wilding : Wildings are seedlings growing naturally in the forest as opposed to those raised from seeds sown in the nursery. This is a source of rattan seedlings for planting. For conservation purposes, wildings are materials for propagation of non-economic species. The disadvantage here is that of identification as many rattan seedlings are very similar in appearance, and no formal identification key at seedling stage has yet been devised (Yusoff and Manokaran 1985; Basu 1992). Anon (1994) reported that the use of wildings obtained from the forest floor allows more rapid establishment of a plantation by circumventing the nursery stage. However, wildings of economic species are generally found too low in density to be the source of propagating material for large-scale cultivation. Furthermore survival per cent is low in wildings. Wildings of *C.rheedii, C.gamblei, C.rotang* and *C.travencoricus,* were used in planting trials in India (Nair

1963). Except for *C.travencoricus*, the trials were failure. Madulid (1985) tried using wildings collected in the forests and transplanting them in veneer pots or placed in recovery bed, together with seedlings grown from seeds to ensure healthy and vigorous planting stocks. Yusoff and Manokaran (1985) reported about the methods of raising plants from seeds and of using wildings from the forest floor. Lakshmana (1987) mentioned that wildings proved superior to seedling. Height of one year wilding was found significantly lower in *C.viminalis* compared to seedlings (Siddiqi *et al.* 1998). Seedlings germinate spontaneously on the forest floor giving wildings. Wildings are largely used in India by the Forest Department in silvicultural practices. A survival of 98% was observed in wildings after one year by Siddiqi *et al.* (1998) in *C.viminalis*. Aida (1986) reported that wildings only with the height of 10-45 cm were collected for plantation. Leaves more than 30 cm was pruned before they were transported. She also added that 100 ppm GA_3 was applied to maintain the freshness of the uprooted materials. It has also been reported (Aida 1986) that the wildings with a height of less than 30 cm survived better than those, which were more than 30 cm tall regardless of species. The wildings attained an average height increment of 3.64 cm after 6 months, 8.94 cm after 1 year and 10.23 cm after 14 months (Aida 1986). Aida (1986) also suggested not to collect wildings and suckers more than 30 cm in height to ensure better survival rate. Michael (1990) found 46% survival per cent after establishment of plantation with wildings of *C.hollrungii* and *C.warburgii*.

3.2.6. Sucker : Vegetative propagation using sucker, rhizome and stem cutting appear to be a viable alternative to circumvent seed problem. Suckers from clustering rattans could be separated from the clump and are used as planting material. The suckers are removed from the mother clump with some roots intact, and are potted immediately in a suitable soil mixture. The sucker seedlings could be transplanted to the field after a period of stabilization in the nursery. The clustering rattans have numerous stems brought about by production of suckers at the base of the original stem. Lakshmana (1993) reported successful plantation of eight *Calamus* species by small plantlets of 40-50 cm separated from the parent material in India. Renuka and Nambiar (1985) reported suckering from aerial stems of *C.hookerianus*. They also reported that aerial suckers can be collected from the stem of *C.stoloniferous* and *C.lacciferus*, when the stems falls to the ground,

strikes roots in the soil and established suckers. Badhwar *et al.* (1961) reported that 20 seedlings of *C.caesius* were introduced in India from Indonesia and suckers were separated from the clumps and transplanted successfully after five years. Haridasan (1997) mentioned about the use of suckers and offsets for propagational purpose. Previous studies showed that suckers up to 20-25 cm in height could be planted successfully during early July *i.e.* with the onset of monsoon. Vegetative propagation by sucker is feasible only when it is difficult to obtain seeds and is applicable only to freely clustering species (Anon 1994). Planting of one year old rooted suckers bearing 4-5 leaves during the monsoon was found promising in *Calamus* species (Badhwar *et al.* 1957,1961) and *C.tenuis* (Gulati and Sharma 1983). A preliminary trial with suckers of *C.hookerianus* at Kerala Forest Research Institute showed better root formation with a treatment of Indole Butyric Acid (IBA 100 ppm). There are a few instances of layering occurring under natural conditions in *C.javensis, C.heteroideus* and *C.reinwardtii* (Dransfield 1977a). Yusoff (1988) mentioned that vegetative propagation of rattan for the purpose of mass production is limited by morphology and growth habits of rattans. In solitary stemmed rattan, which has a single growing apex, it is not possible to propagate by the conventional vegetative propagation procedures such as cuttings, grafting and layering. Recently vegetative reproduction from aerial parts of *C.ganiblei* and *C.hookerianus* has also been observed in Kerala (Renuka and Nambiar 1985). Layering may be another promising method for propagation of canes. Biswas and Dayal (1995) also mentioned that rattan can be propagated by seed, wildings, suckers, cuttings and tissue culture. Rattan species are generally propagated through seeds or by sucker planting. The sub-aerial axillary shoot development in *C.erectus* seems to show a great potential for vegetative propagation. The treatment of growth regulating substances induced better rooting of the suckers of rattan in India (Bhat *et al.* 1989). Basal branching is an extremely common feature in palms; axillary shoot development in the aerial stem is a rare phenomenon. Vegetative reproduction by means of axillary buds is seen in *C.gramblei* (Fisher and Dransfield 1977). The vegetative propagation by suckers and subsequent survival in the nurseries depend on the following factors (Fernando 1984): (1) ease of extraction form the mother plant (2) size of suckers (3) number of roots present (4) potting medium used and (5) time and season of collection. But Tan (1992) reported that multi-stemmed species can be vegetatively propagated by cutting of the side shoots

or suckers but they are tedious to collect, risky to establish and only small numbers can be collected. Suckers of *C.ornatus* var. *philippinensis* and *D.mollis* were difficult to extract because the suckers are generally large and are very close to the main stem. *C.merrillii* produces both aerial and basal suckers. Potting mixture of soil and saw dust (1:1) was found most suitable for growing aerial suckers of *C.merrillii*. Pollisco (1985,1989) mentioned that rattan can be propagated vegetatively by suckers. Aerial suckers showed higher survival rates than basal suckers. Use of basal sucker is not recommended because it causes mechanical injury to roots and stems.

Rattan can be propagated by asexual reproduction through offsets and rhizomes as reviewed by Yusoff and Manokaran (1985). Seed propagation is a common method since there is difficulty in gathering enough suckers and rhizome systems for extensive propagation; even if it is possible but the materials are bulky, difficult to separate, handle and transport, expensive and also show low survival per cent after transplanting in the field. However, vegetative propagation by suckers or rhizome systems is of great value in the conservation of genetic diversity and the establishment of seed orchards of economically valuable species.

3.2.7. Rhizome : By the nature of their growth habit, clustering rattans develop a system of rhizomes, the specialized stem structures that are the proximal parts of individual stems growing at or just below the ground surface. The rhizome system supports the numerous suckers that develop into stems. For propagation purposes, stems of a clump could be cut off to base level leaving young suckers intact, and the whole plant carefully dug up without damaging the rhizome system and transplanted to the desired sites. Possibly the rhizome system could be divided and the sections planted out (Manokaran 1981b). An advantage of planting rhizomes is that the suckers on the well-developed root stock could quickly give rise to stems. The clump here would develop much faster than that from a seedling. Wong (1984) reported that 15 acres area was planted by Forest Department with 9000 individuals of *D.jenkinsiana* as a trial in Bangladesh. It was observed that rhizomes require some shade and less hot conditions for effective establishment. This seemed to be a reasonable inference when the rhizomes raised plants of *D.jenkinsiana* planted under Garjan (*Dipterocarpus turbinatus*) trees at Tilagar Beat. Maximum percentage of establishment after three years for both seedlings/wildings and

rhizomes/offsets indicated that rhizomes/offsets were better for most of the species (Wong 1984).

3.2.8. Micropropagation : Plant tissue culture is the *in vitro* cultivation of plant segments, tissues or cells under aseptic conditions in a nutritionally and physically controlled environment. Several reports have indicated that there are differences in the internal anatomy and ultrastructure of *in vitro* propagated shoots to those raised in the greenhouse or in the field (Wetzstein and Sommer 1981; Dunstan and Sutter 1982). It is considered that vegetative propagation of rattan by tissue culture (Umali 1985) may be potentially useful method for large scale plantation, when available seeds will be limited in supply in near future. Review of propagation of commonly known rattans of the world has considerably revealed very important information on seed viability, seed germination, seedling and seedling transfer, wildings, suckers, rhizomes and tissue culture. The present study aimed at examining those aspects of rattans of Bangladesh. Due to limitation, some important aspects such as tissue culture has left undone. Some one interested in this field in near future may work out tissue culture and further progress on desired rattans of Bangladesh.

3.3. Conservation

3.3.1. Introduction: Rattan is the third most important forest product of Bangladesh after timber and bamboo. It is one of the least protected group of flowering plants with many species being severely threatened and becoming rare (Renuka 1992a). With the rapid destruction of the tropical forests, genetic diversity of rattan populations is being eroded at a tremendous pace. Many tropical plant species have their center of diversity in South East Asia, for example, the major tree species in the families of Depterocarpaceae, Leguminosae, Palmae, Bambusaceae etc. Rapid depletion of forests during the past ten years in the tropical zone, especially in South East Asia, has caused great loss of species diversity of plant resources. The deforestation crisis certainly causes the reduction of abundance of rattans that belongs to the family Palmae. The number of rattan species and their growing habitat has also been severely reduced due to decrease of the forest area. From the past record, it has been learned that many of the rattan species available from different areas of Bangladesh are not found now. If the forest continues to be cleared/ felled or logged there is a danger that some of the species may become extinct. The

alarming rate at which tropical rainforest destruction is continuing means measures have to be taken to reduce the equally alarming rate of genetic erosion and loss of species that follows. Rattans, like many other plant species, are faced with the same dilemma of becoming extremely scarce, and will have to be cultivated both on a large scale (for elite species) as well as on a smaller scale for the purpose of sustaining the trade and for conserving them respectively. Rattan received low priority in national forest conservation policies. Rattan is an important commodity in international trade. At the local level, it was of critical relevance for rural livelihood strategies as primary, supplementary and emergency source of income. Rattan collection complemented agriculture in terms of seasonal labour and as a source of capital for agricultural inputs. A number causes are seen to affect the conservation of rattans in rattan growing countries of the world.

3.3.2. Causes for loss of rattans : There are many forest plants in evergreen tropical forest which require special habit. Due to destruction of forest some species are becoming vulnerable and some are extinct. Rattan resources are depleting at a very fast rate due to increasing demand for rattan products as well as over exploitation of the commercially important species and destruction of natural forests. At present many of the important species have become scarce and a few even to the verge of extinction. The forest area is decreasing gradually every year and the rattan species is also disappearing from the tropical rain forest. We do not know the exact rate of extinction, but it is claimed that about 137 species are disappearing worldwide per day (Stork 1996). The consequences of rapid depletion of tropical forest resources are quite enormous; global warming, soil erosion, endangered biodiversity and shortage of timber trees. The major reasons for the depletion of rattan resources is imbalance between demand and supply, large scale destruction of forests and past unscientific exploitation (Renuka *et al.* 1982). In a survey in India, it was observed (Basu 1984) that some endemic species of India become vulnerable due to commercial exploitation. With the fast depletion of the tropical forests, it is imperative to obtain this knowledge for the sustainable management of the remaining rattan resources. In recent years the ever-increasing demand for rattan canes has put severe pressure on wild stocks in forests often resulting in uncontrolled and excessive harvesting. The destruction and alteration of natural habits has greatly threatened rattan species with extinction.

3.3.2.1 Deforestation: The term "deforestation" as used by forestry statisticians and refers to the transformation of forested land to permanently cleared land or to a shifting cultivation cycle (Whitemore 1990). The annual per cent of change of forest with total forest area and per cent of threatened plants are presented in Table-2 and indicates both current forest area, rate of deforestation and chance for loss of plants. From this table it is clear that annual per cent of changes in rain forest is highest in Jamaica (5.3%) followed by Haiti at 3.8%. Bangladesh is in the third position in annual forest change due to deforestation Although India and Myanmar the two neighboring countries of Bangladesh have controlled their deforestation rate. Per cent of threatened plants are highest in Jamaica (22.5%). Deforestation rate in India is 0.6 but % of the threatened plants is

Table 2 : Per cent of threatened plants in the countries with the highest rate of recent forest loss in the world (Jamaica, Haiti, Bangladesh) and compared with the neighboring countries of Bangladesh.

Countries	Rain forest x1000ha	Annual percent change 1981-90	% of threatened vascular plants
Jamaica	122	5.3	22.5
Haiti	5	3.8	1.9
Bangladesh	572	3.6	0.5
Thailand	3082	3.3	3.3
Philippines	3728	3.1	4
Myanmar	12094	1.2	0.5
India	8246	0.6	7.7

Source: WRI (1999).

07.7% while deforestation rate in Bangladesh is 3.6 and per cent of threatened plant is 0.5. However, the low rate could mean the most threatened species have already become extinct.

3.3.2.2. Habitat destruction : Habitat destruction is the most effective form of removal of any particular form of life from the face of earth. In Bangladesh, destruction of natural forest is the greatest threat to rattan existence. The people who are living by selling the natural products of the forest like honey, cane, bamboo etc. are the main agents of destruction in that area. The fuel wood and leaf collectors also destroy the forest floor. Ghosh (1961) pointed out that by the introduction of selected species in the natural forests, the prevailing forest ecosystem is being upset. This practice is responsible for the

loss of rattan populations in the forests of West Bengal. It is presumed that over exploitation and imposed change in the ecosystem are both responsible not only for loss of elite species but also for reducing the wealth of rattan flora of the country. Jain (1983) reported that about 10% of the Indian vascular flora are under different categories of threat of extinction, where the most vulnerable are being the endemic ones. About 90% of the world's supply of rattan comes from the wild. Rapid depletion of the natural resource result cultivated rattan, which seems to dominate the rattan trade in near future (Sulaiman and Choon 1992).

3.3.2.3. Forest fire: Sometimes in winter, people set fires in the forest to make forest trails clear and keeps away reptile. As a result, the rattans clump and wildings become destroyed. Occasionally rattan can give new sucker from a burn clump but sometimes they become failure.

3.3.2.4. "Jhum" cultivation : From this study it was revealed that Hill Tracts is the richest area of Bangladesh with rattan diversified flora. But the Hill Tracts people put fire in the forest for their special "Jhum" cultivation. As a result the rattan flora has been disappearing from this area.

3.3.2.5. Agricultural extension : Rattans are one of the least protected groups of flowering plants (Dransfield 1981b). It is an established fact that natural forests are converted into revenue-earning timber forests, causing loss of valuable plant species. For conservation of rattans, either *in situ* or *ex situ*, knowledge of rattan biology is essential (Basu 1985). Agricultural expansion and road construction has resulted in destruction of rattan habitats. Forest areas are brought under different agricultural projects to grow crops and other plantation than maintaining the forest.

3.3.2.6. Indiscriminate harvesting : Rattan harvesting is often a secondary activity for many farmers who rely on the cash sale of rattan canes to invest in developing their agricultural base or during times when immediate cash is needed for household support. It is a easy way to earn money by selling natural resources without any investment. Basu (1985) reported that overexploitation of rattans for trade is causing depletion of rattan population in their natural habitats. So, immediate measuring steps should be implemented to save these valuable natural resources. Otherwise, we may lose some

species forever very soon. Once this valuable resource was abundant in the nature. But due to increasing demand in the world and local market people are exploiting this resource every day in unscientific way (Salleh 2002). They believed on present but they do not think about future. As a result an imbalance between demand and supply has been made. Rattan propagation more female plants to produce enough seeds for future plantation programmes. While some conservation activities are begun, a large number of plants should be raised to avoid the probability of all plants developing into a single sex, either male or female. Conservation measures have been initiated in countries like India to control the indiscriminant cutting of rattans following the harvesting regulations as follows-only mature canes should be extracted from the clumps; immature or tender ones should not be collected or damaged; digging of rhizomes or roots will not be permitted; no canes shall be extracted from out side the specified blocks; all the one-year-old canes plus six stems of the second year shall be retained in the clump; clumps consisting of less than six stems shall not be worked; felling should be done not less than 15 cm and no more than 30 cm from the ground level (Anon 1994).

3.3.3. Recovery of rattan diversity : Rattans are a threatened group of tropical plants (Dransfield 1981b). World's demand for rattan and rattan products is increasing and there is tremendous pressure on the wild population of this species in rattan rich areas of the globe. The factors behind depletion of the species are such as, destruction of their habitats, industrialization, shifting cultivation, irrigation and power projects, extension of agriculture, afforestation with introduced plants and over-exploitation of the species. The population of various rattans particularly those little or less-known, rare and endemic are depleting at an alarming rate. Of the approximately 614 species of rattan, 117 are recorded as being threatened to some degree (Walter and Gillett 1998). Of these, 21 are "Endangered", 38 are regarded as 'Vulnerable", 28 as being "Rare" and 30 as "Indeterminate" (IUCN Red List Categories). While this listing may give some indication of the global threats to rattan species. Very few of the listed species are known in detail. Rattan can be used in shifting cultivation. The tribals of Borneo follow this practice. They have a tradition of planting rattans before leaving the area to another place (Weinstock 1985).

3.3.4. Measures of scientific extraction : Rattan size in diameter and length vary with species and habitat. Usually rattans grow naturally as wild in rattan growing countries of the world. Rattans extraction-harvesting is also referred to as "rattan collection". It has been traditionally carried out by villagers residing close to the forest, either on a full time or part time basis. These professional collectors walk in the forest in search of mature and usable canes to be harvested. Usually they harvest rattans through selection-improvement by traditional cut-pull method, which damages young shoots and deshape the growing clumps. Besides, the local rattan collectors usually do not think about the future of the rattan resource rather they think about the easiest way to collect more cane with minimum labour and cost. This rattan harvesting and cane wastage during the operation has never been evaluated under any standard methods. Though rattan harvesting in Asian countries have been practiced under the commission of forestry through license or permit issued to individuals, companies or cooperatives for granting them the right to collect rattans in addition to other forest products with minimum royalty. Rattan collections sometimes become dangerous with the possibility of any mishappening in addition to coming into contact with the spines of various nature. A series of factors *viz.* distance, forest structure, selection of mature stem, age of stem at harvesting, cutting cycle, pre harvesting assessment, wastage, harvesting equipments, time of harvesting and method of harvesting are involved in a harvesting operation. Rattan collectors in most rattan growing countries usually practice either manual for most small diameter rattans or mechanical for most large diameter rattans. In the methods, cutting the stem at the base, pulling down the cut stem and freeing the rattan from the tree canopy is a regular phenomenon. Recently, rattan supply has shifted from wild to plantation to either secondary forest or monocultured plantation like rubber. In any case rattan harvesting has remained as a great problem due to the lack of scientific method of harvesting to the planters over the years in rattan growing countries of the world. A number of mechanical methods *viz.* four wheel drive vehicle, tri fore, lier and prototype of different models have been used for specific species in different rattan growing countries. No such mechanical method has yet been evolved to handle effectively the extraction of rattans from their habitats. So, research is needed to adapt modern technology to make scientific rattan extraction inexpensive.

3.3.5. Prospects of conservation : Restoration of forest is helpful for conserving rattans in nature. If the forest is restored *in situ* then it has good impact on rattans as undergrowth. There are some protected and reserve forests in Bangladesh. These should be protected for proper conservation of rattans. All the National Parks, Eco-park, Botanical Gardens can take necessary steps to protect and conserve rattans as many other plant species. Most of parks are more concerned with the flora other than rattans. So, rattans are neglected. Now, days have come to take necessary measures for protecting this valuable natural resource. Rattan is entering in world trade and is overwhelmingly collected from the wild with only a very small portion coming from cultivated sources (Bystriakova 2002). The reasons for the poor regeneration and destruction of the canes is taking place resulting in exploitation of all utilizable lengths. This will reduce the number of mature plants in the forests. Another draw back is that rattans are dioecious *i.e.* the male and female plants are separate. Hence, half of the population tends to be female plants that bear fruits after attaining maturity age of about 10-14 years. The forest fires and over exploitation of the evergreen forests are also inhibitory to natural regeneration. Rattans have a tendency to throw out new rhizomes by the side of the original culm resulting in the formation of clump.

Rattans are an exhaustible raw material of the evergreen forests in rattan growing countries of the world. It is reported that in Malaysia wild populations of elite canes in the forests are being depleted. Restrictions have, therefore, been imposed for the protection of commercially important rattan species. Possible cultivation strategies have also been suggested for sustaining the industry (Manokaran and Wong 1983). In recent years the ever-increasing demand for rattan canes has put severe pressure on wild stocks in Philippine forests resulting in uncontrolled and excessive harvesting. It has thus become an urgent priority to develop and increase rattan plantations on the main islands, set up living collections and strict rattan reserves in order to protect and preserve the genetic diversity of this very important and valuable plant resource (Fernando 1990). It is reported that *C.longisetus* is degenerating at an alarming rate (Alam and Basu 1988) and are occurring sporadically at present. Some clumps are sometimes found in homesteads or fellow lands. Due to over-exploitation most of the species probably led to a restricted distribution. According to traders of Bangladesh, most of the rattans now used in the cane industry are smuggled from Assam and Myanmar (Alam and Basu 1988). Over exploitation could be one factor, which is responsible for depletion of the resources.

Other factors, which have been adversely affecting cane population, are deforestation, shifting cultivation, habitat destruction, landslides, flood etc. (Haridasan 1997). Pritchard and Davies (1999) reported that it has recently been suggested based on changes in the IUCN Red lists, that half the palm species of world wide could be condemened to extinction within the next 50-100 years (Smith *et al.* 1993; May *et al.* 1995). Of the 194 indigenous palm species of Peninsular Malaysia only 10 are not threatened, and 115 Calamoid species in this area are rare to endangered (Kiew 1989). Only 10 of the 82 rattan species at present are considered to be not threatened (Johnson *et al.*1996). The high social and economic importance of rattans in the world rattan industry due to shortage of supply of cane is a great crisis. The reasons for this shortage range from loss of forest habitat due to logging and to over harvesting as a result of increased demand for rattans in the international market. Rattan cultivation is to promote, develop and sustainable manage to over come the shortage of supply. Wild populations remain the major sources of rattan and are likely to continue to play an important role (Dransfield 1981b, 1989). We have to find ways and means to solve such problems so that rattan improvement and propagation are made possible. Government action alone is inadequate to overcome all the problems. It is also suggested that private enterprise should carry out all aspects of research, plantation establishment, management and utilization. Forest areas should be based to private enterprise to grow rattan. The main aim is economic gains coupled with protection of the environment (Bhodthipuks and Ramyarangsi 1989). Thus, the urgent need for habitat preservation for the purpose of *in situ* conservation of populations of rattan species is unquestionable. The raw material shortage started to become acute after 1980. Over exploitation of local resources to meet the growing demand of the industries as well as rapid deforestation have caused the depletion of the raw material base. The country is increasingly becoming dependent on the import of raw material from other country. The raw material supply from both local and imported success cannot meet more than 50% of the total requirement of the industries (Bhat *et al.* 1989). The extraction of immature rattan resource of the country should be banned. Hence, there is an urgent need for habitat conservation in the form of National Parks, nature reserves or managed nature reserves for *in situ* conservation together with large scale cultivation.

CHAPTER 4 : MATERIALS AND METHODS

Introduction : The present investigation was made on three major aspects *viz.* biology, propagation and conservation of rattans of Bangladesh. Efforts were made to study the occurrence, distribution, habitat, clump habit, appearance, species diversity; natality, mortality, rosette, culm formation, growth, clump expansion, culm exploitation; phenology of inflorescence, flowering, periodicity, plasticity, fruiting cycle; reproductive features, reproductive potential and natural regeneration; growth, total biomass, photosynthetic pigments and NPK status of non-senescence leaves of plantable seedlings; seed condition, rooting media, sowing seasons, sowing depths, storage conditions, storage periods, viability, pretreatments, temperatures, constant temperatures effect on dormancy breaking, flushing and germination per cent of seeds; propagational potential of propagules *viz.* seedlings, wildings, suckers and rhizomes of rattans for mass scale plantation as well as conservation in canetum like reserves for future use as reference.

Various standard methods were used to assess the above mentioned variables. The detail of the methods of above mentioned items have been described in respective chapters. Most of the biological, propagational and conservational studies were conducted in the nursery, canetum and trial plots of Bangladesh Forest Research Institute (BFRI) campus, Solashahar, Chittagong during 1998-2004.

4.1 Materials

4.1.1. Geographical information about Bangladesh and selected study sites.

4.1.1.1. Geographical position : Bangladesh lies in the north eastern part of South Asia between 20^0 24′ and 26^0 38′ north latitude and 88^0 01′ and 92^0 41′ east longitude. The country is bounded by India on the west the north and north east, Myanmar on the south east and the Bay of Bengal on the south. The area of the country is 1,47,570 km^2.

4.1.1.2. Physiography and topography : The country consists of high hills, hillocks, high lands, medium high land, medium low land, low land, very low land and flat land with fertile soil. The topography of all compartment of the country ranges between sea level to thousand meter. Most hilly regions are in the north east and in the south east. Some areas of high lands are in the north and north western part of the country. A net work of rivers *viz.* the Padma, the Jamuna, the Tista, the Brhamaputra, the Surma, the

Meghna and the Karnaphuli are the important, and their tributaries numbering about 230 with a total length of about 24,140 km covering the country flow down to the Bay of Bengal. The alluvial soil thus continuously being enriched with heavy silts deposited by rivers during the rainy season. Some data on physiography and topography of eight rattan growing areas are mentioned in Table-5.

4.1.1.3. Geology and soils : Bangladesh occupies the major part of the Bengal basin composed of Holocene and Neocene sediments. The Neocene sediments occur in the northern, north eastern and south eastern parts where they are also folded (Ismail and Mia 1972). Bangladesh is one of the biggest plain land in the world. The plain land is made up of alluvium of flood plain sediments. The soil of Bangladesh mainly consists of flood plain soils (*viz.* non calcareous alluvium, calcareous alluvium, acid sulphate, pit, non calcareous grey flood plain, calcareous grey flood plain, grey piedmont, acid basin clay, non calcareous dark grey flood plain, calcareous dark grey flood plain, calcareous brown flood plain, non calcareous brown flood plain, brown piedmont, black terai); hill soils: grey-brown and terrace soils (*viz.* shallow red brown, deep red brown, mottled, shallow grey and deep grey). Some data on geology and soil of eight rattan growing forest divisions are mentioned in Table-5.

4.1.1.4. Climate : Bangladesh enjoys generally a sub tropical monsoon climate. There are six seasons in a year. Three seasons namely winter, summer and monsoon are prominent. Winter, which is quite pleasant, begins in November and ends in February. During winter temperature fluctuates, which ranges from minimum of 7-13 ^{0}C to maximum of 24-31^{0}C. The maximum temperature recorded in Summer months is 37 ^{0}C although in some places the temperature occasionally rises up to 41 ^{0}C or even more. Monsoon starts in July and continues up to October. This period accounts for about 80% of the total rainfall. The average annual rainfall ranges from 1429-4338 mm with areas. The maximum rainfall is recorded in the coastal areas of Chittagong and Cox's Bazar and also in northern parts of Sylhet district, while the minimum rainfall is recorded in the western and north western part of the country. Monthly average relative humidity (%) remains fairly high throughout the country and ranges from minimum of 58-91 % during February and to maximum of 78-85% during August. The maximum relative humidity is recorded in the coastal areas and the minimum is recorded in the south central, western and northern part of the country. The climatic data on monthly average minimum and

maximum temperature, rainfall and relative humidity of eight rattan growing forest divisions during 1999-2004 as recorded from the reports of Statistical Yearbook of Bangladesh are mentioned in Table-5 and in Figure-3.

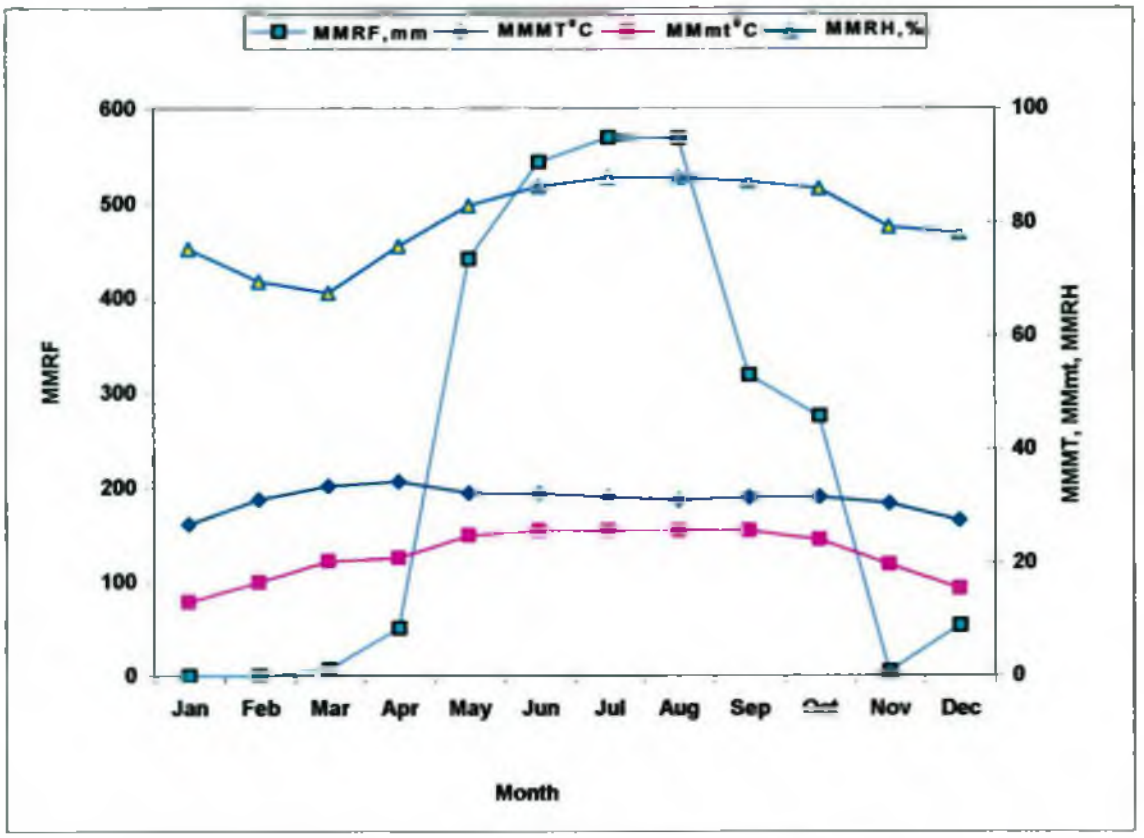


Figure 3 : Mean of monthly maximum-minimum temperature, relative humidity and rainfall in eight rattan growing forest divisions of Bangladesh.
(**Legend:** MMMT= Mean of monthly maximum temperature; MMRF= Mean of monthly rainfall; MMmt=Mean of monthly minimum temperature; MMRH=Mean of monthly relative humidity).

4.1.1.5. Forest types : Forests are distributed all over Bangladesh. Major natural forest *viz.* hill forest, sal forest and mangrove forest are found to be distributed in three different distinct zones of the country. Mangroves occupy the south and south eastern part along the coast, sal forests are located at high lands in the south central and north western part and hill forests are distributed in the hilly areas on the north eastern and the south eastern part of the country. These three distinct types of forest are dissimilar in their species composition. Although these three forests have been thoroughly disturbed over the last several decades through clear felling, illegal cutting and afforestation with introduced species, yet the original nature of these forests are identifiable with their existing species

Bangladesh. Previous reports on the occurrence of rattans also reveals that available rattans of Bangladesh have been found to grow naturally as under growth in the hilly areas of Bangladesh. Habit and habitats of rattan have remained an unresolved problem in this country. Though some of the rattan species are found to grow sporadically in the village groves of some areas of Bangladesh yet rattan species are not found to prevail in greater part of the natural forests of Bangladesh. Besides natural forests, homesteads forests occupy a substantial area of the country. So, it is worth of investigating the occurrence of rattans and their species composition in the prevailing forests type of Bangladesh. But it was a difficult job. Still some areas of the forests irrespective to forests types were selected as sites. A brief review of statistics of forests area and different types of forest are given in Table-3 and 4.

Table 3 : Statistics of forest types and area (km^2) of Bangladesh.

Year	Reserved forest	Protected forests	Vested forests	Acquired forests	Unclassed state forests (USF)	WAPDA /Khas	Private forests	Garden area	Total	% of total land
1977	13219	575	106	945	9070	123.7	-	0.9	24040	16.70
1987	12644	534	91.0	935	4087	119.5	-	0.9	18410	13.40
1992	14615.37	385.91	85.34	963.48	4765.6	705.91	-	-	21521.61	14.58
1999	13191.02	349.9	226.2	422	7213	1015.20	-	0.86	22418.24	15.19

Source : Reza *et al.* (1992); Statistical Yearbook of Bangladesh (2002); Ali (2003a).

Table 4 : Area (km^2) under different types of forests of Bangladesh.

Types	State forests	Unclassed state forest	Total	% of forest land
Evergreen	7820.45	5346.77	13167.22	8.9
Moist deciduous	1209.14	23.52	1232.66	0.83
Mangrove	7412.40	100.49	7512.89	5.09
Total	16441.99	5470.78	21912.77	14.82

Source: Ali (2003b).

4.1.1.6. Descriptions of sites of rattan growing forest divisions of Bangladesh : Eight selected rattan growing forests *viz.* Chittagong, CHT, Cox's Bazar, Dhaka, Dinajpur, Khulna, Sylhet and Tangail as located in Map-2 were selected and thoroughly studied in respect to local climate, physiography, edaphic conditions and species composition. The information of the above mentioned parameters are presented in Table-5 and 6.

Table 5 : Description of climate, physiography and edaphic conditions of study sites in rattan growing forest divisions of Bangladesh.

Forests divisions	Total area, km^2	Total forest area, km^2	% of forest cover	Climatic factors				Physio-graphic conditions	Edaphic conditions
				Temp (^0C) $month^{-1}$	Rainfall (mm) $month^{-1}$	RH (%) $month^{-1}$	Sub-climatic zone		
Chittagong	5283	2730.0	51.67	15-34	0-879	71-88	South eastern-heavy rainfall, mild summer	Hilly, undulated	Brown hill soil, sandy loam-clay loam, acidic, infertile
Chittagong Hill Tracts	13275	9608.4	72 38	13-35	0-1117	66-89	South eastern-heavy rainfall, mild summer	High, hills,high valley, undulated	Brown hill soil, sandy loam-clay loam, acidic, infertile
Cox's Bazar	2492	1163.8	46.70	16-35	0-1134	69-91	South eastern-heavy rainfall, mild summer	High, hills,high valley, undulated	Brown hill soil, sandy loam-clay loam, acidic, infertile
Dhaka	1464	358.8	24.51	13-36	0-553	58-86	South central-fairly heavy rainfall , mild summer	Undulated	Brown-red brown terrace soil, clay loam-clay, strongly acidic, infertile
Dinajpur	3438	103.4	3.01	11-34	0-589	61-89	North western-moderate rainfall, hot summer	Elevated, undulated	Dark grey-black teri soil, sandy loam-clay loam, strongly acidic, barind tract, infertile
Khulna	7395	5770.5	78.03	13-36	0-420	68-89	South eastern-heavy rainfall, mild summer	Flood plain, undulated	Calcareous alluvium, dark grey, silty clay loam-heavy clay loam, flood plain, fertile
Sylhet	8926	748.8	8.39	14-33	0-775	65-88	North eastern-heavy rainfall, mild summer, cloudy cool winter	Hilly, high valley, undulated	Brown hill soil, sandy loam-clay loam, acidic, infertile
Tangail	3414	501.4	14.69	12-33	0-415	69-88	South central-fairly heavy rainfall, mild summer	Elevated, undulated	Deep brown-red terrace soil, clay loam-clay, strongly acidic, barind tract, infertile
Total	45687	20985.1	4593	11-36	415-1117	58-91	-	-	-

Source: Statistical Yearbook of Bangladesh (2002).

Map 2 : Showing study sites (as mentioned in Table-8 &12) of rattans in eight rattan growing forest divisions of Bangladesh (Source: Bangladesh Forest Department 1999).

Legend: 1a (BFRI); 1b (BGCU); 2a (Panchari); 2b (Sitapahar); 2c (Ampupara); 3a (Dulahazara); 3b (Ramu); 3c (Teknaf); 4 (BNPG); 5 (Nilphamari); 6 (Bagerhat); 7a (Tilagar); 7b (Lawachara); 8 (Madhupur).

Table 6 : Description and composition of rattan supporting tree species in selected study sites of rattan growing forest divisions of Bangladesh.

Forest divisions	Forest type	Nature of forest	Rattan supporting tree species	
Sylhet	Ever green-Hill forest	Reserved Acquired Khas land USF Private	*Artocarpus lacucha, Dipterocarpus turbinatus, Michelia champaca, Mangifera indica, Psidium guava, Lagerostroemia speciosa.*	*Cassia fistula, Tectona grandis, Artocarpus chaplasha, Erythrina indica, Terminalia arjuna.*
Chittagong Hill Tracts	Ever green-Hill forest	Reserved USF	*Acacia auriculiformis, Bambusa molluccana, Dipterocarpus turbinatus, Bambusa vulgaris, Lannea coromandalica, Mangifera indica.*	*Cassia fistula, Ficus glomerata, Salmalia malabarica, Tectona grandis, Xylia dolibriformis, Hevea brasiliensis.*
Khulna	Mangrove	Reserved	*Lannea cormandalica, Mangifera indica, Samanea saman.*	*Erythrina indica, Acacia auriculiformis.*
Chittagong	Ever green-Hill forest	Reserved Protected Acquired	*Casuarina equsitifolia, Erythrina indica, Lannea coromandelica, Mangifera indica, Terminalia arjuna.*	*Albizia procera, Artocarpus chaplasha, Artocarpus lacucha, Streblus asper.*
Dinajpur	Sal-moist deciduous forest	Reserved Protected Acquired Vested	*Mangifera indica, Acacia auriculiformis, Albizia procera, Dalbergia sissoo.*	*Shorea robusta, Lannea coromandalica, Artocarpus lacucha.*
Cox's Bazar	Ever green-Hill forest	Reserved Protected Acquired	*Michelia champaca, Swietenia mahagoni, Chickrassia tabularis, Alstonia scholaris, Casuarina equsitifolia, Dipterocarpus turbinatus.*	*Erythrina indica, Streblus asper, Tectona grandis, Lennea coromandelica, Mangifera indica, Syzygium grandis.*
Dhaka	Sal-moist deciduous forest	Reserved Acquired	*Shorea robusta, Terminalia arjuna, Streblus asper.*	*Cassia fistula, Mangifera indica, Erythrina indica.*
Tangail	Sal-moist deciduous forest	Acquired Vested	*Streblus asper, Erythrina indica, Acacia auriculiformis, Lagerstroemia speciosa, Lennea coromandelica, Albizia lebbeck.*	*Shorea robusta, Tectona grandis, Mangifera indica, Cassia fistula, Havea brasiliensis.*

4.1.2. Plant material : All together ten naturally occurred/grown/cultivated/domesticated recorded rattan species consisting of two genera *viz. Calamus* and *Daemonorops* were used in this investigation.

4.1.2.1. Rattan species : A total of ten rattan species as mentioned in Table-7, were recorded from the survey made in eight rattan growing forest divisions during 1998-2001. These ten rattan species were used to study the biology, propagation and conservation in the subsequent years.

Table 7 : List of recorded rattan species in Bangladesh (2005).

Naturally occurred
Calamus acanthospathus Griff.,
Calamus erectus Roxb.,
Calamus gracilis Roxb.,
Calamus guruba (Buch-Ham) ex Mart.,
Calamus latifolius Roxb.,
Calamus longisetus Griff.,
Calamus tenuis Roxb.,
Calamus travencoricus Bedd.,
Calamus viminalis Willd. var. *fasciculatus* (Griff) Becc.,
Daemonorops jenkinsiana (Griff) Mart.

Grown / cultivated / Domesticated
Calamus tenuis Roxb.,
Calamus guruba (Buch-Ham) ex Mart.,
Calamus viminalis Willd var. *fasciculatus* (Griff) Becc.
Daemonorops jenkinsiana (Griff) Mart.

4.1.2.2. Propagules :

Seeds : Clean and unclean seeds of both matured and ripen fruits of ten rattan species were used. Some times whole ripen fruits were also used in some experiments. Both monophasic (*i.e.* flower once in a year) and diphasic (*i.e.* flower twice in a year) seeds were used in the same experiment for comparison.

Seedlings : Seedlings of 1-24 months of ten recorded rattan species were used for transplanting to both poly bags and out planting.

Wildings : Generally, wildings of various ages (1-24 months) were noticed to grow under some particular clumps of all rattan species at different frequency depending on species and habitat. Wildings of three different ages *viz.* 3-6, 9-12 and 15-18 months old were used. Nine to twelve months old wildings were extensively used.

Suckers : All rattan species were noticed to produce suckers at different rate, number and size. Suckers of 6-24 months were practiced. But suckers of 9-12 months were used in most of the experiments.

Rhizome : Usually suckers of 2-3 years old with one or two young suckers were used as rhizome. The shape and size of rhizomes varied with species and habitat. For the convenience of handling, uniform but minimum sized rhizomes of the same species were used for respective experiment.

Other propagules : Aerial shoots (*C.erectus*) and multiple tip shoots (*C.acanthospathus*) were available. But these were not used for propagational purposes.

Clumps : Clumps of different known ages (10-12 years old) were used in different experiments.

4.1.3. Propagating-rooting media : Three different rooting media *viz.* fine sand, sandy loam and clay loam were used for sowing of seeds and raising-growing of seedlings.

4.1.4. Propagator : Both natural propagator *viz.* shade house, seed bed, seed tray, plastic pots, polybags and artificial propagator like growth incubator were used.

Shade house : Two types of shade house *viz.* open (bamboo ceiled) and closed (transparent polythene ceiled and surrounded it with sheet having proper ventilation) having an area of 2m widths x 5m length x 2m height were used. Shade houses were constructed in the nursery of Minor Forest Products Division, BFRI.

Seed bed : Seed beds of 0.3m depth x 0.5m widths x 2m length were prepared independently with fine sand, sandy loam and clay loam. These seed beds were used successively with proper maintenance during the progress of investigation.

Seed tray : Seed trays (measurement- 0.3m depth x 0.3m widths x 0.5m length) made of plastic with drainage system were prepared separately with fine sand, sandy loam and clay loam soil.

Pots : Plastic pots of three different sizes (measurement- 0.3m height x 0.25m diameter; 0.25m height x 0.20m diameter; 0.20m height x 0.15m diameter) having proper drainage system were used by filling with respective rooting media for sowing of propagules (*viz.* seeds, seedling, wilding, sucker, rhizome and others).

Poly bags : Translucent poly bags of three different sizes (measurement- 6cm x 10cm, 10cm x 18cm and 15cm x 25cm) having perforation system were used by filling with

respective rooting media for sowing of propagules (*viz.* seeds, seedling, wilding, sucker, rhizome and others).

Incubator : Incubators were used for some specific experiments and maintained at four different temperature *viz.* 15^0C, 20^0C, 25^0C and 30^0C.

4.1.5. Experimental sites :

Nursery: Nursery of Minor Forest Products Division of BFRI was used to carry out all nursery based experiments. The nursery covers an area of about 0.2ha and consisted of five sections *viz.* seed beds, seedling beds, net house, seedling hardening shed and shade house.

Canetum: A canetum was established in 1982 at the middle of BFRI campus adjacent to the Silviculture Research Division that occupies an area of about 0.5 ha. A total of ten rattan species have been planted over the area as undergrowth on randomized block design. A good number of clumps of different species were earmarked and were used to collect most of the physical appearance of clump habit and reproductive features of each species. Similar type of canetum have been established at BFRI, BGCU, IFESCU, EPSC, KSRSC, NBGM, BNPG, DSPCB and HDSTUD.

Trial plots : Five trial plots *viz.* BFRI, BGCU, Keochia, Hinguli and Dulahazara (Malum ghat) were raised with almost all recorded rattan species since 1999 to verify the growth attributes of each rattan for further extension work. Some clumps of each species at each trial plot were selected and were studied.

Plantation : Plantations have been established by both BFRI and Forest Department in most rattan growing areas of Bangladesh. A total of 6,146.4 acre of rattan plantation have been raised with 27,41,338 seedlings in eight rattan growing forest areas since 1981-2002. It was identified that only five rattan species were used to raise commercial plantation. The present study was carried out in 155 sub-sites of 47 sites in eight rattan growing forest areas of Bangladesh as mentioned in Map-2.

4.1.6. Climatic and edaphic status of selected sites : Study of rattan species was carried out at 155 sub sites (stand) consisting of 47 sites in eight rattan growing forests and village grooves of Bangladesh as described in Table-8. Most close door observations both on short and long term experiments were conducted in the nursery, canetum, trial plots and plantations. All studied sites were under the influence of tropical monsoon climate having a range of annual rainfall 2500-3000 mm, annual air temperature 10-36 ^{0}C,

relative humidity having 70-98% (Figure-3), light intensity 2200-4300 Lux; soil texture ranged from sandy loam-clay loam; soil organic matter 0.80-3.2%, pH 4.3-6.9, nutrients level infertile (Appendix-8.3). Rainfall was high during May-Aug and very low during Nov-March. Seedlings of ten rattan species were successfully raised in the nursery of Minor Forest Products Division and grown them in the canetum for further study as future reference.

4.1.7. Rattan reserves (canetum) : Seedlings of ten rattans were planted in eight official reserve areas *viz.*

BFRI- Bangladesh Forest Research Institute, Sholasahar, Chittagong.

IFESCU- Institute of Forestry and Environmental Sciences, Chittagong University.

BGCU- Botanical Garden, Chittagong University.

EPSC- Eco-park, Sitakunda, Chittagong.

DSPCB- Dulahazara Safari-park, Cox's Bazar.

NBGM- National Botanical Garden, Mirpur.

BNPG- Bhawal National Park, Gajipur.

KSRSC- Keochia Silviculture Research Station, Chittagong.

HDSTUD- Haji Danesh Science and Technology University, Dinajpur.

4.1.8. Rattan plantation statistics : Forest Department has been raising rattan plantation mostly in the forest areas of all over the country since 1981. An up-to-date information on the records of rattan plantation till 2002, in respect to location, area, number of species, number of seedlings and year of plantation, were collected through personal communication from Divisional Forest Office of eight forest divisions *viz.* Chittagong, Chittagong Hill Tracts, Cox's Bazar, Dhaka, Dinajpur, Khulna, Sylhet and Tangail Forest Divisions. Seedling plantations of ten rattan species were also raised during 2000-2005 in five *viz.* BFRI, BGCU, Keochia, Hinguli and Dulahazara (Malum ghat) trial plots in addition to nine canetum as mentioned above.

4.2. Methods:

4.2.1. Survey of rattans in rattan growing areas : Rattans of Bangladesh were surveyed based on previous literature and current information collected through personal communication from range offices of Forest Department. Repeated personal visits were made in 155 sub sites of 47 sites in eight selected rattan growing areas of Bangladesh

Table 8: Date of visit and study in sites and sub-sites of rattan growing forests and village groves of Bangladesh.

Division	Regions	Sites	Sub-sites	Dates of visits and records of data
Chittagong Division	Chittagong North (1)	Fatikchari	7	6.11.02
		Hazarikhill	3	6.11.02,9.10.03
		Hinguli	3	18.9.97, 07.02.01, 22.01.01, 24.10.03, 5.04.05, 25.10.03
		Sitakunda	3	7.4.01, 13.03.03, 06.07.02, 07.07.03, 26.10.03, 1.04.04, 05.04.05
		Korerhat	2	31.01.01, 7.2.02, 25.10.03, 5.04.05
		Hathazari	7	20.2.02, 09.10.03
		BFRI (1a)	1	1996-2005
		BGCU (1b)	1	1996-2005
	Chittagong South	Dhopachari	3	15.11.03
		Poitya	4	30.10.02
		Boalkhali	3	06.12.02
		Keochia	3	30.10., 02.03.03, 20.04.05, 17.05.05
Cox's Bazar	Cox's Bazar (3)	Fasiakhali	4	05.05.00,14.2.00,02.11.00,07.06.00,21.04.01,05.05.01, 09.04 02. 21.04.01. 22.03 04. 16.05.05
		Ramu (3b)	3	10.4.02, 16.05.05
		Teknaf (3c)	4	10.4.02
		Dulahazara (3a)	3	07.06.00, 15.05.01, 09.04.02, 16.05.05
		Ukhia	7	10.04.02
Chittagong Hill Tracts	Bandarban (2)	Sadar	6	30.01.02
		Lama	5	24.03.03
		Alikadam	3	9.04.02, 30.10.02
		Ampupara (2c)	3	30.10.02, 2.3.03, 22.4.03, 25.04.04, 16.03.05,20.4.05
		Bolipara	3	2.3.03
		Thanchi	3	3.3.03
	Khagrachari	Sadar	3	22.04.02
		Panchari (2a)	3	22.04.02
		Dighinala	2	23.04.02
		Baghaihat	3	23.04.02
		Matiranga	2	23.4.02
	Rangamati	Sadar	3	05.10.03
		Boritali	3	06.10.03
		Kaptai	2	01.05.02, 10.03.05
		Sitapahar (2b)	3	25.03.03, 215.03.05, 11.04.04
Dhaka	Dhaka (4)	NBG.M	1	24.09.02
		BNPG	4	24.09.02
		Salna (4)	3	24.09.02
Dinajpur	Dinajpur (5)	Nilphamari (5)	2	P. commu.
Khulna	Khulna (6)	Bagerhat (6)	2	P. commu.
Sylhet Division	Sylhet sadar (7)	Tilagar (7a)	3	13.01.01,07.02.01,12.02.02,14.09.02,07.02.04,04.04.04, 06.03.04
		Khadimnagar	4	17.10.02,14.02.02,13.01.01, 08.02.04, 6.03.04, 4.04.04,
	Hobigong	Kelanga	5	12.02.02
		R.Kelanga	4	18.09.02
	Moulovi Bazar (7)	Kalachara	4	16.09.00, 14.02.02
		Lawachara (7b)	3	13.01.01, 08.02.01. 07.02.02. 12.02.02
		Jankichara	4	13.01.01, 07.02.01. 12.02.02. 16.09.02
Tangail	Tangail (8)	Sadar	3	14.03.02, 06.08.05
		Madhupur (8)	3	14.03.02, 06.08.05
		Serpur	2	06.08.05

Legend: BFRI-Bangladesh Forest Research Institute; BGCU- Botanical Garden Chittagong University; BNPG-Bhawal National Park Gazipur; NBGM-National Botanical Garden Mirpur; P. commu.-Personal communication.

during 1999-2004. Dates of visits to sub sites and sites of different rattan growing regions are being mentioned in Table-8.

4.2.2. Identification of recorded rattans : Rattan materials collected from survey made during investigation were preserved as herbarium and museum specimens. The following characters as mentioned in Table-9 relating to habitat and habits consisting of both vegetative and reproductive structures were considered on the basis of description, drawings and photographs as illustrated by Alam (1990) and Basu (1992) to identify the recorded rattan flora for further treatment.

Table 9 : List of used identifying characters of recorded rattan species in Bangladesh.

- Clumps habitats
- Culm size
- Climbing organs
- Arrangement of thorns on leaf sheath
- Nature of ocrea
- Arrangement of leaflets
- Fruit size and colour
- Clump shoots arrangement
- Climbing habit
- Colour of leaf sheath
- Nature of knee
- Size of leaf
- Nature and mode of inflorescence
- Seed size, shape and ornamentation

4.2.3. Selection and marking of clumps : Clumps of (10-12 years old) ten recorded rattan species *viz. Calamus tenuis, C.viminalis* var. *fasciculatus, C.guruba, C.erectus, C.latifolius, C.longisetus, C.acanthospathus, C.travencoricus, C.gracilis,* and *Daemonorops jenkinsiana* were selected and earmarked in different selected areas as mentioned below for regular observation during investigation period-1999-2004. Measures were taken to protect the selected clumps from physical disturbances during this investigation. Clumps were selected randomly and the age of the clumps were recorded from official records of Bangladesh Forest Research Institute, Forest Department and owner of the forest villagers. According to the availability of number of species, number of clumps were earmarked.

4.2.4. Collection of propagules : Propagules of rattans *viz.* fruits, wildings, rhizomes and suckers were collected from selected clumps of investigated areas.

Fruits: Fructance of each rattan was collected from selected clumps as mentioned in Table-5. Rattan fruit collection was found very difficult because it is a high climbing plant. In most cases fruits were collected by climbing up the adjacent tree or by making hook or cutter in a long bamboo. Properly matured fruit was the prerequisite for good

germination. So, fruits and seed colour were examined before collection. The colour of fruits varied with species. In that case, the fruit scales and sarcotesta were removed to see the seed colour. Dark coloured seeds were the proper matured one. For this purpose, only

Table 10 : List of selected clumps of ten rattan species with locations for close door investigation.

Sl.no.	Name of species	Location	No.of selected clumps
1	*C.acanthospathus*	BFRI; Ampupara-Bandarban	5
2	*C.erectus*	BFRI; Sitapahar;Chandranathpahar	10
3	*C.gracilis*	BFRI; Tilagar-Sylhet	10
4	*C.guruba*	BFRI; Tilagar-Sylhet	10
5	*C.latifolius*	BFRI; Salna-Gazipur	10
6	*C.longisetus*	BFRI; Ukhia and Teknaf	8
7	*C.tenuis*	BFRI; Tilagar-Sylhet	10
8	*C.travencoricus*	BFRI; Ampupara-Bandarban	5
9	*C.viminalis* var. *fasciculatus*	BFRI; Keochia-Chittagong	10
10	*Daemonorops jenkinsiana*	BFRI; Tilagar-Sylhet	10

ripen fruits were collected which was ensured with the fruits falling easily on slightly shaking the plant. So, the fruits with this type of seeds were collected. After collection, fruits were brought to the Minor Forest Products Division, BFRI, Chittagong with fructance. Observations were made on the seeds of all the above mentioned species. At first fruits per fructance were counted and were qualitatively described and recorded. In each species, the measurements were made on size including length, breadth and diameter (cm) from 3-5 samples randomly drawn from the collected fructance. Weights (gm) of per 100 fruits of 3 replicates were also recorded. All the measurements were taken within 1-3 days after collection of fructance.

Wildings: During the investigation of selected culms as well as the other culms, wildings were noticed under some clumps. The wildlings of latest generation (usually of 6-12 months) were pricked out carefully from the clump floor with whole root system rounded as a soil ball for easy handling and brought them to the nursery of Minor Forest Products

Division of BFRI and kept in the moist place. These wildings were transplanted with in 24 hours in the polythene bags (23×15 cm) containing sandy loam soil.

Suckers: Sucker of three different ages *viz.* 9, 12 and 15 months were selected for study. Suckers of these three different ages were collected from selected clumps of BFRI campus except those of *C.acanthospathus, C.erectus, C.gracilis, C.travencoricus*

Table 11 : Periods of collection of fructance and fruit of ten rattan species in Bangladesh.

Species	Seed source	Study year	Fruit collection period, month	
			Monophasic	Diphasic
C.acanthospathus	Ampupara-Bandarban	2002,2003,2004	April-May	-
C.erectus	Chandranathpahar-Chittagong; Sitapahar-CHT	2001,2002,2003	-	April-June & October-December
C.gracilis	Tilagar-Sylhet	2001,2002,2003	-	February-April & July-September
C.guruba	Lawachara-Sreemangal, Lama-Bandarban, Tilagar-Sylhet	2000,2001,2002	-	December-February & June-August
C.latifolius	BFRI-Chittagong,Salna-Gajipur, Sitapahar-Kaptai, Ampupara-Bandarban	2001,2002,2003	June-July	-
C.longisetus	Ramu-Cox's Bazar; Ukhia-Cox's Bazar, Takenaf-Cox's Bazar	2001,2002,2003	June-July	-
C.tenuis	Dulahazara-Cox's Bazar; Hathazari-Chittagong.; Lawachara-Sreemangal	1998,2000,2002	May-June	-
C.travencoricus	Ampupara-Bandarban	2002,2003,2004	March-April	-
C.viminalis	BFRI and Keochia-Chittagong,	1999,2001,2003	-	January-March & July-September
D.jenkinsiana	Kelanga-Sreemangal; Tilagar-Sylhet, Lawachara-Sreemangal,	1999,2000,2002	September	-

C.latifolius and *C.longisetus* where the suckers were collected from their respective habitats as mentioned in Table-10. The above ground portion of the selected suckers of each species was of 4-5 leaves with healthy shoot. The healthy suckers were separated from the mother clumps by a sharp cut off at the base and dug out with roots, which was rounded as soil ball with mud, and brought them to the nursery of Minor Forest Products Division of BFRI and kept them in moist place. The collected suckers were transplanted in polythene bags (23×15cm) containing sandy loam soil.

Rhizomes: Rhizomes of each species of suitable sizes of 2-3 years old were selected from their respective habitats. Uniform rhizomes were separated carefully by sharp cut off from the mother clumps and dug out from the soil so that no young shoot on the underground part got injured. The collected rhizomes were brought to the nursery of Minor Forest Products Division of BFRI and kept in the moist place, and were transplanted them in the polythene bags (23×15cm) containing sandy loam soil.

4.2.5. Sampling and processing of soils: Soils were sampled from the floor of clumps of selected sites *viz.* Nursery-BFRI, Botanical Garden-Chittagong University, Malumghat-Dulahazara, Hinguli-Mirashari, Lawachara-Sreemangal and Tilagar-Sylhet during September, 2002. Soils were sampled randomly from each plot in triplicate with augur. Each sample was collected from two different depths *viz.* top soil (1-25 cm) and sub soil (26-50 cm) and put into separate polybags. Three soil samples (both top soil and sub soil) were collected from each plots and were mixed together to make a composite sample for each plot. The soil samples were tagged separately and preserved for soil analyses in the laboratory. Collected soil samples were carried into the laboratory and processed for the determination of major plysico-chemical properties *viz.* soil moisture content-SMC, Soil texture-ST, pH, electrical conductivity-EC, organic carbon-OC, organic matter-OM, cation exchange capacity-CEC and major nutrients-nitrogen (N), phosphorus (P) and potassium (K). These soil samples were dried in air under laboratory condition and sieved through a 2 mm sieve, dried at 105^{0}C, pulverized and put in to the plastic pot and then stored in a cool-dry place in the laboratory for further analyses.

4.2.6. Sampling and processing of leaves: Leaf pinna of top 15cm of 1st fully exposed leaf (non-senescence) of three uniform culms of selected clumps of respective habitats *viz.* Nursery-BFRI, Botanical Garden-Chittagong University, Malumghat-Dulahazara, Hinguli-Mirasharai, Lawachara-Sreemangal and Tilagar-Sylhet were plucked by sciccatier during September, 2002. The plucked pinna were put into separately labeled polytnene bags and carried to the laboratory for further processing.

Collected leaves were used both as fresh (*viz.* MC and photosynthetic pigments-PP), and dry (*viz.* NPK analyses). Leaf samples were air dried at laboratory desk and then dried them in oven at 65^{0}C for 48 hours and ground to pass through 0.1 mm sieve and preserved in airtight plastic film vial for analyses of NPK.

4.2.7. Assessment of clump habitat and species diversity : Habitats of each rattan were assessed through frequent visits mainly made to rattan growing areas *viz.* evergreen, semi-evergreen, deciduous forests and village groves during investigation. Number of species and their association with supporting trees in respective habitats were assessed and mentioned in Tables-12-14 and 16.

4.2.8. Assessment of clump habit and physical appearance : Observations and required measurements on the characters (*viz.* clump size, clump-crown colour and size, clump shoot arrangement, culm nature and size, climbing habit, nature and length of climbing organs, leaf sheath nature, thorn style and length on leaf sheath, nature of knee, nature of ocrea, size of leaf, arrangement of leaflets, colour and shape of leaflets, diameter and length of internode, annual height increment, flowering age, nature of flowering, mode of flowering, number and nature of inflorescence, size of inflorescence, tenure of male and female inflorescence, number of male and female flower, ratio of male and female flower, fruit set and maturity period, fruit harvesting period, colour of young and ripen fruits, shape and size of ripen fruits, regeneration potential (*viz.* seed out put, presence of wildings and sucker production) of selected clumps of each of the rattan species from respective habitats were made at regular interval as mentioned in Table-15.

4.2.9. Assessment of shoot emergence, culm formation, growth and clump expansion : Total number of shoot emergence and their gradual development in respect to shoot deformation, culm formation, culm increment and clump expansion in selected clumps of respective habitat at one month intervals for a period of five years were evaluated as detailed in Table-19-20 and Appendix-8.4.

4.2.10. Assessment of clump growth of three common rattans in seedling raised plantations of Forest Department (FD) and trial plots : FD started to raise plantation of three common rattans *viz. C.tenuis, C.viminalis* and *D.jenkinsiana* with greater emphasis from 1990. Most of the successful plantations were found in Sylhet, Chittagong, Dhaka and Tangail Forest Divisions. Information were taken from Divisional Forest Offices about the plantation records (Appendix-8.5). Besides this, Minor Forest Products Division, BFRI also raised trial plantations at Dulahazara, Hinguli and Chittagong University Campus. About 10 % of the clumps were measured in each

locality. Data on circumference (cm), shoot number, height (m) and diameter (mm) of main shoot for each clump were recorded from FD plantations of ten different ages and trial plots for the consecutive five years during 1999-2003 as presented in Table-17 and 18 respectively. The diameter of main shoot was measured by slide caliper; height with bamboo gauze and the area occupying the clump by measuring tape. Flowering phenomenon relating to phenology of inflorescence, flowering (*viz.* flowering initiation period, flushing period of male and female inflorescence), periodicity and plasticity of flowering and fruiting cycles (*viz.* fruiting, fruit maturity and ripen) of all rattan species both in selected and natural clumps were recorded throughout the investigation period as illustrated in Table-25 and Appendix-8.7.

4.2.11. Assessment of clump for exploitable culm : Selected and natural clumps of all rattan species in their respective habitat were evaluated for flowering age, number of culm formed, annual height increment of culm (m), internode number, diameter (cm) and length (cm), length of exploitable culm (m) and average number of wildings per square meter as mentioned in Table-15.

4.2.12. Assessment of reproductive features and reproductive potentials : Reproductive features (*viz.* clump age, flowering time, length of flowering culm, number of inflorescence per culm, number of partial inflorescence per inflorescence, inflorescence flushing period, number of male and female flower per culm, ratio of male and female flower, number of female flower and fruit set per culm, fruiting season and seed out put per culm, seed out put per cent and ratio of fruit set and seed out put) and reproductive potential (*viz.* seed dormancy breaking period, flushing period, germination per cent and reproductive capacity) were assessed both from the selected and natural clumps of all rattans during 1998-2004 and mentioned in Table-25 and Appendix-8.7.

Seed out put per culm = No. of seed per infructance x No. of infructance per culm

Seed out put % = Total no. of fruit set / Total no. of seed out put x 100

Reproductive capacity per culm = Avr.seed output per culm x Percentage of germinated seeds / 100.

(Salisbary 1942)

4.2.13. Assessment of natural regeneration potential of clumps :

Wildings: Wildings of different ages *viz.* 1-3 years old were noticed to grow under the floor of both selected and natural clumps. Wildings were found to grow abundantly under some clump compared to others depending on species as well as habitats. Frequent observations were made on the natality, mortality, clump formation, habit and rate of different species irrespective to habitats. Wildings on the floor of (both selected and natural clumps) of each rattan species were recorded for three consecutive years for assessments.

Sucker: Selected and natural clumps of all rattan species of respective habitats were observed to produce suckers as propagules for natural regeneration. Numbers of suckers varied with clumps, species and habitats. Sucker production of clump of each species was assessed month wise for a period of five years.

Rhizome: Selected and natural clumps of all rattan species were found to produce several rhizomes and the number of rhizomes varied with clumps, species and habitats. Number of rhizome formation of clump of each species in respective habitats was assessed.

4.2.14. Collection and preservation of fruits : Fruits of both monophasic and diphasic rattans were collected and the collection procedure was the same as described in 4.2.4. The collected fruits of all rattan species were allowed to ripe uniformly and preserved them in gunny bag for easy processing of fruits for seeds.

4.2.15. Processing of fruits for seeds : Fruits of recorded rattan species were of different nature and sizes. Seed extraction was a difficult job. Fermenting process was found suitable and practiced for all rattans through out the investigation period. Ripen fruits of all rattans were kept in suitable sized air tight polybags for 2-5 days (depending on species) for fermentation. Fermentation period was enhanced in some cases by moistening the fruits with water. Seed extraction from scales and sarcotesta were done manually and cleaning of seeds was done by repeated washing in running water.

4.2.16. Sorting and storing of seeds : Seeds of all rattans were sorted out after cleaning. Defective and floating seeds were discarded. Only dark coloured seeds were selected for storing. Sorted seeds were air dried on news paper under room temperature (20-26^{0}C) for a period of 24 hours. Seeds were then preserved in heavy duty brown paper bags at low temperature 4^{0}C for further treatments.

4.2.17. Preparation of seed tray and seed bed :

Seed tray: Seed trays (measurement- 0.3m depth x 0.3m widths x 0.5m length) made of plastic with drainage system were prepared separately with sieved (2 mm) fine sand, sandy loam and clay loam soil.

Seedbeds: Seed beds of depth 0.3m x 0.5m widths x 2m length were prepared independently with sieved (2 mm) fine sand, sandy loam and clay loam soil. Edges of bed were made of brick or bamboo split to protect the media from wash out. These seed beds were used successively with proper maintenance during the progress of investigation.

4.2.18. Preparation of pots and polybags :

Pots: Plastic pots of three different sizes (measurement- 0.3m height x 0.25m diameter; 0.25m height x 0.2m diameter; 0.2m height x 0.15m diameter) having proper drainage system were used by filling with sieved (2 mm) sandy loam for sowing of propagules (*viz.* seeds, seedling, wilding, sucker, rhizome and others).

Poly bags: Translucent poly bags of three different sizes (measurement- 0.1m x 0.15m, 0.23m x 0.15m, and 0.23m x 0.3m) having perforation for drainage system, were used by filling with sieved (2 mm) sandy loam for sowing of propagules (*viz.* seeds, seedling, wilding, sucker, rhizome and others).

4.2.19. Sowing of whole fruit, unclean and clean seeds for germination assessment : Fresh whole fruits (WF), unclean seeds (UCS) and clean seeds (CS) of ten rattan species were sown individually in sandy loam soil of seed tray and seed bed under shade house condition for assessment of germination. Twenty five fruits-seeds (clean and unclean) in triplicates were used for each treatment both in seed bed and seed tray in each species. All these three types of fruits-seeds were sown at 3cm depth and watered at regular intervals to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Fruit-seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-26.

4.2.19.1. Assessment of germination in sowing media : Clean seeds of ten rattan species were sown at 3 cm depth in clay loam, sandy loam and fine sand contained in

seed tray to assess the suitable sowing media for germination. Twenty five fresh seeds were sown in triplicates in seed tray for each medium and watered at regular intervals to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), germination rate (GR), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-27 and Appendix-8.9.

4.2.19.2. Assessment of germination with depth : Seeds of ten rattan species were sorted out into three sizes on the basis of volume as small, medium and large. Fresh seeds of ten rattan species were sown individually in fine sand of seed tray and seed bed under shade house condition for assessment of germination. Twenty five seeds in triplicates were used for each treatment both in seed bed and seed tray in each species. Seeds were sown at 2,3 and 4cm depth according to their sizes and watered at regular intervals to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-28.

.4.2.19.3. Assessment of germination on sowing seasons : Clean seeds of both monophasic (produce fruits once a year) and diphasic (produce fruits twice a year) rattan species, which were collected on the basis of maturity in early and late monsoon, were sown in fine sand of seed tray and seed bed under shade house condition for assessment of germination. Twenty five seeds in triplicates were used for each treatment both in seed bed and seed tray in each species. Seeds were sown at uniform depth of 3 cm and watered at regular intervals carefully to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-29 and Appendix-8.7 and 8.8.

4.2.19.4. Assessment of germination with pretreatments : It is well known that most of the rattan seeds are recalcitrant (Pritchard and Davies 1999). Seeds of two rattan species *viz. C.viminalis* and *D.jenkinsiana* were found to take long time to break dormancy and to

complete flushing of seedling compared to others. Seeds of these two species were pretreated with hot water, water soaking period, different conc. of sulphuric acid, potassium nitrate and gibberellic acid for shortening the dormancy breaking period and flushing period with the increase of germination per cent and compared with *C.tenuis* under same treatment. Procedure adopted for assessment of germination of seeds pretreated with water, sulfuric acids, potassium nitrate and gibberellic acid were as follows.

a. Water soaking treatment: Twenty five seeds of three rattan species *viz. C.tenuis, C.viminalis* and *D.jenkinsiana* in triplicates were used for each treatment. Seeds were pretreated with normal water and soaked for 24, 48, 72 and 96 hours. Seeds soaked for 24 hours were treated as control. Water soaked seeds were sown in fine sand of seed tray at uniform depth of 3cm and watered at regular intervals carefully to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were also recorded as mentioned in Table-30a.

b. Acid treatment: Twenty five seeds of three rattan species *viz. C.tenuis, C.viminalis* and *D.jenkinsiana* in triplicates were used for each treatment. Seeds were pretreated with different conc. *viz.* 5, 10 and 20 N of H_2SO_4 and distilled water as control and kept for 24 hours. Seeds were washed thoroughly under running water and sown in fine sand of seed tray. Seeds were sown at uniform depth of 3cm and watered at regular intervals carefully to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were also recorded as mentioned in Table-30b.

c. KNO_3 treatment: Twenty five seeds of three rattan species *viz. C.tenuis, C.viminalis* and *D.jenkinsiana* in triplicates were used for each treatment. Seeds were pretreated with different conc. *viz.* 250, 500 and 1000 ppm of KNO_3 and distilled water as control, and kept for 24 hours. Seeds were washed thoroughly under running water and sown in fine sand of seed tray. Seeds were sown at uniform depth of 3cm and watered at regular

intervals carefully to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were also recorded as mentioned in Table-30c

d. GA_3 treatment: Twenty five seeds of three rattan species *viz. C.tenuis, C.viminalis* and *D.jenkinsiana* in triplicates were used for each treatment. Seeds were pretreated with different conc. *viz.* 250, 500 and 1000 ppm of GA_3 and distilled water as control and kept for 24 hours. Seeds were washed thoroughly under running water and sown in fine sand of seed bed and seed tray. Seeds were sown at uniform depth of 3 cm and watered at regular intervals carefully to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were also recorded as mentioned in Table-30d.

4.2.19.5. Assessment of germination with storage conditions : Fresh clean seeds, of ten rattan species collected on different season of the year, were stored under three different conditions (*viz.* moist fine sand-MFS at 12 ± 4^0C, refrigerator-RG at 3 ± 1^0C sealed with aluminum foil and indoor-ID at 20 ± 4^0C covered with aluminum foil) for 6-12 months depending on collection time and species to adopt the suitable storage condition to keep the seeds viable and to avoid unfavorable condition for maximum germination. Clean seeds were used to assess the viability of seeds sown under favourable condition during early spring (22 ± 6^0C). Twenty five stored seeds were sown in triplicates at 3cm depth in fine sand of seed tray for each storage condition and watered at regular intervals to keep the medium almost uniformly moist through out the progress of germination. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-31.

4.2.19.6. Assessment of germination with storage period : Moist fine sand was found suitable to store hard seeded rattan for 6-12 months. Fresh clean seeds of ten rattan species collected on different season of the year were stored in moist fine sand under

shade house condition for 6-12 months depending on collection time and species to verify the viability and corresponding germination per cent of seeds at one month interval up to 12 months for each species from collection. Twenty five stored seeds were sown in triplicates at 3 cm depth in fine sand of seed tray and seed bed for each species and watered at regular intervals to keep the medium almost uniformly moist through out the progress of germination under shade house condition. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP), germination rate (GR) and germination per cent (GP) were recorded as mentioned in Appendix-8.10.

4.2.19.7. Assessment of seed viability on storage period with TTC (Tetrazolium tri chloride) : Seeds of ten rattan species stored in fine sand were treated with three different concentrations of tetrazolium salt at every two months interval to demonstrate the viability of embryo and living tissues of endosperm for a storage period of twelve months. Freshly prepared solution of tetrazolium salt was used for each treatment. One per cent tetrazolium tri chloride solution in distilled water with the help of few drops of absolute alcohol, and was diluted to 0.1, 0.2 and 0.3 % in distilled water. Three clean seeds were selected for each treatment and splited them into equal halves with sharp scicattiar and put them in twenty ml deep petridishes containing ten ml of 0.1, 0.2 and 0.4 % tetrazolium salt solutions separately. A control was maintained with distilled water. All the petridishes were wrapped with black wrapping paper and kept them under darkness for 24 hours. Seeds of different species with different storage period showed a variation of colour intensity indicating the degree of viability of embryo and endosperm compared to the control as mentioned in Table-32. Freshly prepared tetrazolium trichloride solution of 0.1 % was found suitable to be used for viability test in stored seeds of ten recorded rattan species of Bangladesh.

4.2.19.8. Assessment of germination condition-temperature effect on germination : Though the fresh clean seeds of ten rattan species stored in moist fine sand was found suitable for maximum germination per cent under most favourable condition, yet the germination per cent of rattan seeds of any species collected on any season of the year could not have attained a maximum of 90%. Even the seeds of some rattan species *viz. C.viminalis* and *D.jenkinsiana* could not have shown germination per cent beyond 62%

and 72% respectively. So, fresh clean seeds of ten rattan species collected on different season of the year were sown in moist fine sand under three germination condition *viz.* incubator (30 ± 1^0C), indoor (20 ± 5^0C) and out door (25 ± 10^0C) to verify the impact of temperature on germination per cent. Twenty five seeds were sown in triplicates at 3cm depth in fine sand of small seed tray (10cm L x 10cm B x 15cm H) for each species and watered at regular intervals to keep the medium almost uniformly moist throughout the progress of germination under imposed temperature to given conditions. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-33.

4.2.19.9. Assessment of germination under constant temperature : The fresh cleaned seeds of two common rattan *viz. C.viminalis* and *D.jenkinsiana* were found to have attained germination per cent of about 92 and 94% respectively in incubator at a constant temperature of 30 ± 1^0C which was found to be comparable with the germination per cent of *C.tenuis*. But still the dormancy breaking period in *D.jenkinsiana* was found to be almost double compared to *C.tenuis* and *C.viminalis*. An specific temperature was thought to have profound effect on dormancy breaking period and germination related phenomenon for each species. So, twenty five stored seeds of each species were sown in triplicates at 3cm depth in fine sand of small seed tray (10cm L x 10cm B x 15cm H) and kept them in incubator under three different temperature *viz.* 30 ± 1^0C, 25 ± 1^0C and 20 ± 1^0C maintained in three individual incubator and treated them as T_1, T_2 and T_3 respectively. A similar set was maintained under shade house at temperature of 25 ± 7^0C as control for each species. Seeds of all sets of both treatments and controls of three species were watered at regular intervals to keep the medium almost uniformly moist through out the progress of germination under imposed conditions. The time and rate of emergence of shoots in sown seeds were recorded weekly and the records were continued until the flushing of seedlings completed. Seed dormancy breaking period (DBP), flushing period (FP) and germination per cent (GP) were recorded as mentioned in Table-34.

4.2.20. Assessment of pricking, nursing and survival per cent of transferred seedlings : A large number of seedlings of all rattan species were raised in fine sand of seed tray and seed bed. Twenty uniform replicates of seedlings at six different ages (*viz.*1,

2, 3, 4, 5 and 6 months) were pricked and transplanted to poly bags (0.23m x 0.15m) filled with sandy loam soil to evaluate the suitable pricking time of each species grown in both seed tray and seed bed under shade house condition. Both seed bed and seed tray were flooded with water to ease pricking. Pricking was done manually by straight spatula. Shoot height, leaf and leaflet number of each seedling were recorded at six different ages at the time of transplantation. Seedlings transplanted to poly bags were put in rows under shade house condition and were watered them uniformly and regularly to allow them to grow for one year with proper nursing and weeding. Survival per cent of both seed bed and seed tray grown transplanted seedlings were recorded for each species after a year for each age group as mentioned in Table-21-22.

4.2.21. Assessment of propagational potential of transplanted propagules : Four different types of propagules *viz.* seedlings, rhizomes, suckers and wildings of different ages were selected to assess their *ex situ* propagational potential such as survival per cent and growth- shoot number and culm formation after transplantation to poly bags (0.23m x 0.3m) filled with sandy loam soil under shade house condition. Seedlings, wildings, and suckers of 9-12 months old, and rhizomes of 2-3 years old were selected from experience to be used as propagules. Fifteen replicates of uniform size and age of each propagules for each species were used for assessment. Survival per cent, number of shoot emerged and number of culm formed for each propagules were recorded at regular intervals up to five years and the results are mentioned in Table-35.

4.2.22. Assessment of growth, biomass, photosynthetic pigments and leaf nutrient status of transferred seedlings : Survived seedlings of optimum pricking age (2 months) as mentioned in chapter 4.2.20 were used to assess their comparative growth at four different ages (*viz.* 3, 6, 9 and 12 months) along with biomass, photosynthetic pigments and leaf nutrient status (*viz.* NPK) in seedlings of 12 months only grown under shade house condition. The measured values of root-shoot length and number of leaf in randomly selected five replicates of pricked seedlings of each species were used as record of growth of seedling during transfer. Fifty uniform seedlings of about three months old were selected in each species and grouped into four and tagged them as group 1, 2, 3 and 4. Five replicates of randomly selected seedlings of each species were used to measure root-shoot length and number of leaf after every three months corresponding to seedling

age of 3, 6, 9 and 12 months as mentioned in Table-22. Seedlings of 12 months were continued to grow under shade house condition up to two years of age and replicates of five were used for assessing total biomass (fresh and dry weight of root and shoot), photosynthetic pigments (Chlorophyll a, b and Carotine) and leaf nutrient (N, P and K) status as mentioned in Table-23-24.

4.2.23. Selection and preparation of site for out planting : All ten rattan species of Bangladesh are climbers, which need supporting trees to grow well. Rattan species are always planted as under growth. The supporting trees provide shade and support to the growing rattan plants. Such aerial support can be provided by branches of near by trees where the rattans can climb up using their climbing organs *i.e.* cirrus or flagellum, depending on the species. Generally 40-50% shade appears optimum for vigorous growth. Light and support must be considered in the selection of the planting sites. Forest Department has been planting thousands of acres of land with rattan species as under growth of plantations of different species. Choice of the right tree species is very important. The maximum plant height, branching habit, growth rate, texture of the bark and strength of branches are the factors to be considered. Density of plantation, rotation age and optimum age of the tree plantation suitable for establishing rattan species were taken into account.

Field preparation: The selected area was cleaned by cutting and clearing the jungles and uprooting the unwanted plants. This debris was thrown out from the plantation area. The sites were prepared for planting during the dry season. The size of the planting holes was twice the diameter of the polybags and the depth of the hole was a few centimeters deeper than the height of the polybags. Most tree plantation usually raised by Forest Department is at a spacing of 3-3.5 m. So, the planting holes were made in between two plants.

4.2.24. Plantation in trial plots and fields : It was experienced that rattan seedlings to be hardened off before they are planted in the field. This was done in the planting site. The seedlings were moved from the nursery bed and were put under direct sunlight near the planting sites. Rainy season was found as the best time for out planting. The seedlings were planted in the pits after removing the polythene containers without disturbing the soil ball around the roots. Care was taken to ensure that the seedlings were not planted too deeply as this would delay the production of suckers. Seedling was planted in east-

west direction of the plantation to receive maximum sunlight throughout the day. Staking was made by bamboo stake for identification and better establishment.

4.2.25. Management of rattans at nursery and plantation : Weak and dead seedlings in the nursery were replaced. Regular watering and weeding were made to keep the poly bag soil moderately moist. Sometimes in the dry season brown spots appeared on some leaflets and was found to disappear with first shower of monsoon. In most of the cases some part of root system in the seedlings come out of the polythene bags due to its vigorous growth and intermingled with root system of other seedlings and ground soil. As a result during uplifting of transplanted seedlings from the beds they suffered from root damages. To minimize such problems seedlings were shifted time to time from one bed to another and polythene sheets were used to cover the ground to protect the root system of the seedling from going deep into the soil. It was done up to out planting in the present investigation.

Several operations were carried out to ensure successful establishment and better growth of the young plants after plantation. Rattan seedlings are generally quite hardy and was found to withstand unavoidable circumstances or natural disaster. Though sometimes some mortality occurred. Replacement of seedlings or gap filling was done within three months from planting. Weeding was made twice in a year up to three years after planting. After three years, weeding was made once in a year. The planted seedlings were tide up with the supporting tree when it was about to climb up forming stem (culm). Other wise it was found difficult to anchor the supporting tree (when the tree is high or unbranched) as a result the stem was found to crawl on forest floor which was seemed to reduce the quality of rattan. After three years most rattan species require less care and management.

4.2.26. Conservation of ten rattans in official reserves : Seedlings of ten rattans raised during this investigation were planted for conservation in official reserves *viz.* BFRI, IFESCU, BGCU, EPSC, DSPCB, BNPG, KSRSC, NBGM, and HDSTUD of Bangladesh. Seedlings were distributed to these organizations through personal communication as mentioned in Table-43. The distributed seedlings were planted according to the method of plantation and management as mentioned in chapter 4.2.24 and 4.2.25 respectively. Data on survival per cent were recorded after one year of plantation as mentioned in Table-43.

4.2.27. Laboratory analyses of soils : The physical properties of soils *viz.* moisture content (MC) and textural status were determined from the soil samples. The chemical properties of soils such as pH, electrical conductivity (EC), organic carbon (OC), and organic matter content (OM), cation exchange capacity (CEC), available nitrogen, phosphorus and potassium were also determined from the samples. The soil samples of two different seasons (*viz.* early monsoon and late monsoon) were used as composite to determine the physico-chemical status of the above mentioned properties by following the methods as mentioned below:

4.2.27.1 Determination of moisture content :

Procedure: Fresh field soil samples were taken separately in previously weighed aluminum pot. Soil samples within aluminum pot were then kept in an oven at 105 ± 2^0C for 48 hours and weighed again. The difference of these two weights was recorded for determining the moisture content (Misra 1968).

Calculation: Wt.of fresh soil =(Wt.of fresh soil+aluminium pot)-(Wt.of aluminium pot) = X_1

Wt.of dry soil =(Wt of dry soil+aluminium pot)- (Wt of aluminium pot) =X_2

$$MC,\ \% = \frac{X_1 - X_2}{X_2} \times 100$$

4.2.27.2. Determination of soil texture (International system) :

Reagent:

1. H_2O_2 (30%)LAR, Merck.

2.1N NaOH: 40 gm NaOH crystal were taken in a 1000 ml volumetric flask. It was dissolved in distilled water. Then the volume was made up to the mark with distilled water.

Procedure: 25 gm oven dried soil was taken in a 500 ml beaker. Few ml of distilled water was added to wet the soil. Then 5 ml H_2O_2 (30%) was added. The content was stirred thoroughly with a glass rod and made into a paste. Few ml of distilled water and 5ml of NaOH were added. The content kept over night. Then the content was transferred to a 1000 ml measuring cylinder with repeated washing. The volume was made up to the mark with distilled water. The mixture was shaken thoroughly to prepare a uniform suspension. The suspension was allowed to settle and reading was taken by Bouyocous soil hydrometer (PSI 152H, Gallenkamp, England) after 4 minutes and 2 hours successively. A similar blank (without soil) was also done.

Calculation: $$\% \text{ of clay} = \frac{X_2 - X_b}{W} \times 100$$

$$\%(\text{silt + clay}) = \frac{X_1 - X_a}{W} \times 100$$

$$\% \text{ of silt} = \% \text{ of (silt + clay)} - \% \text{ of clay}$$

$$\% \text{ of sand} = 100 - \{\% \text{ of (silt + clay)}\}$$

Where, X_1= Hydrometer reading after 4 minutes, X_2 = Hydrometer reading after 2 hours.

X_a= Blank Hydrometer reading after 4 minutes,

X_b = Blank Hydrometer reading after 2 hours

The name of texture classes were also calculated and compared on the basis of relation of proportion of sand, silt and clay (Foth and Turk 1958).

4.2.27.3. Determination of pH : 25 g air dried soil was taken in a clean dry 150 ml beaker and then 50ml distilled water was added. The content (1:2 suspensions) was stirred thoroughly with glass rod for 15 minutes and allowed to stand for another 15 minutes. Then, the pH of the suspension was determined with an electronic digital pH meter (Model TOA, Japan). The pH meter was calibrated with two buffer solutions (pH 4.01 and 6.86). The electrode was washed well with distilled water and dried by tissue paper. Then, the electrodes was inserted into soil suspension up to a depth of 2 cm and kept for 2 minutes and read the digital display. For further use, the electrode was washed well with distilled water and dried by tissue paper.

4.2.27.4. Determination of electrical conductivity (EC) : After pH determination, the soil suspension was filtered through Whatman-1 filter paper. Electrical conductivity of the solution thus obtained was measured by a conductivity meter (Jenway conductivity meter, Model- 4010) previously standardized with standard solution.

4.2.27.5. Determination of organic carbon and organic matter :

Reagents:

1. Potassium dichromate, $K_2Cr_2O_7$ (1N); 49. 06 g of solid K_2Cr2O_7 was taken in a 1000 ml volumetric flask and then distilled water was added to it. Then, the solution was made up to the mark and mixed well.
2. Concentrated sulfuric acid, (Conc.) H_2SO_4: LAR, 12N Merck.

3. Concentrated phosphoric acid, (conc.) H_3PO_4: LAR, Merck.
4. Diphenyl amine indicator,(1%): 1.0 g crystals of diphenyl amine were taken in a cleaned and dried 100 ml volumetric flask and then 10 ml conc. H_2SO_4 were added. The crystals of diphenylamine were dissolved by shaking and then the volume was made up to mark by adding conc. H_2SO_4.
5. Ferrous sulfate solution (1N): 278.5 g of ferrous sulfate ($FeSO_4.7H_2O$) was taken in a 1000 ml volumetric flask and then 750 ml of distilled water and 50 ml conc. H_2SO_4 were added drop wise and stirred well. Crystals of ferrous sulfate were then dissolved by shaking and then the volume of the solution was made up to the mark with distilled water.

Standardization of ferrous sulfate solution: 10 ml of $K_2Cr_2O_7$ solution was taken in a cleaned and dried conical flask and then 10 ml of conc. H_2SO_4 was added then shaken well and cooled. After that 150 ml distilled water and 5 ml conc. H_3PO_4 were added. After further cooling, drop wise diphenylamine indicator was added till the colour turned deep violet. The solution was titrated against freshly prepared ferrous sulfate solution until colour become bottle green. Thus the strength of standard ferrous sulfate solution was determined as follows: $S_1V_1 = S_2V_2$

Where, S_1 = Strength of $K_2Cr_2O_7$; S_2 = Strength of ferrous sulfate solution

V_1 = Volume of $K_2Cr_2O_7$ taken in the flask;

V_2 = Volume of ferrous sulfate solution required for titration

Procedure: 2 gm of oven dried soil sample was taken in a 250 ml conical flask. 10 ml of $K_2Cr_2O_7$ solution and 10 ml of conc. H_2SO_4 were added successively and it was made cooled with occasional shaking. Then, 150 ml distilled water and 5 ml conc. H_3PO_4 were added. After further cooling, diphenylamine indicator was added drop wise till the colour of the solution became deep violet. The contents of the flask were then titrated against standardized $Fe_2SO_4.7H_2O$ solution. A blank was also done and the calculation for organic carbon of soil was made following "Wet oxidation method" (Walkley and Black 1934).

Calculation: Percentage of organic carbon = $$\frac{(B - T) \times f \times 0.003 \times 1.3 * \times 100}{W}$$

Where, B = Reading of blank titration; T = Reading of sample titration

f = strength of ferrous sulfate solution; W = Weight of soil in gram

* = Since this procedure oxidizes only 77% organic carbon.

Determination of organic matter (OM) :

Percentage of organic matter content = % of organic carbon × 1.72**

**= Since soil organic matter contains about 58% organic carbon.

4.2.27.6. Determination of total nitrogen :

Reagents:

1. Concentrated sulfuric acid (conc. H_2SO_4)
2. Mixed salt catalyst: 100 parts K_2SO_4, 10 parts $CuSO_4$ $5H_2O$ and 1 part selenium were mixed and ground in a mortar, and then stored in plastic pots.
3. 2% Boric acid solution (H_3BO_3). 20 g of solid H_3BO_3 was dissolved in distilled water to make volume up to 1000 ml.
4. 40% sodium hydroxide solution (NaOH): 400g of NaOH crystals were dissolved in distilled water to make volume up to 1000 ml.
5. Mixed indicator: 0.5 g Bromocresol green and 0.1g methyl red were dissolved in ethanol to make volume up to 100ml. The solution was adjusted to a bluish purple mid colour with diluted HCl.
6. Hydrochloric acid solution, HCl (0.01N): Approximtely 0.1N solution was prepared by diluting 8.6 ml HCl (Sp.gr.1.19) into 1000 ml. This was titrated against standard 0.1N Na_2CO_3 solution. The required amount of the standard acid was diluted to make 0.01N.
7. Methyl orange indicator: 0.1g methyl orange powder was dissolved in 100ml ethanol.
8. Sodium carbonate solution, Na_2CO_3 (0.1N): 10.6 g of dried (at 105^0C for 24 hours) Na_2CO_3 was taken in 1000 ml volumetric flask and was dissolved in distilled water. The volume was made up to the mark.

Standardization of 0.01N HCl: 10 ml 0.1N Na_2CO_3 solution was taken in a clean 50ml conical flask and then 2 drops of methyl indicator were added. The content was titrated against freshly prepared 0.1N HCl solution until the colour became pink. The strength of HCl was calculated by using the formula, $S_1V_1 = S_2V_2$

Where, S_1 = Strength of Na_2CO_3 solution (0.1N); V_1 = Volume of Na_2CO_3
S_2 = Strength of HCl; V_2 = Volume of HCl consumed.

Digestion and extraction: 1gm of dried soil sample (105 ^{0}C) was taken in a 100 ml Kjeldahl digestion flask and 0.5 g of salt catalyst mixture was added. Then, 3ml of conc. H_2SO_4 was added. The flask was then heated gently on a Kjeldahl heater controlling the

frothing by the adjustment of heating. The contents of the flask was swirled from time to time and allowed to digest until the dark colour turned to whitish. Another 2 ml of conc. H_2SO_4 was added and digestion was continued. When whitish residue was left and a clear colourless solution was obtained and when the digestion was completed. Then, the contents were cooled and transferred to a 50 ml volumetric flask with repeated washing. The volume was made up to the mark with distilled water (Jackson 1973).

Distillation procedure: 5 ml of 2% boric acid solution was taken in a 50ml conical flask and then 2-3 drops of mixed indicator were added. The conical flask was then placed under the condenser of the distillation apparatus with the tip of the delivery tube just touching the liquid. 10 ml extract was then taken in a micro-Kjeldahl distillation apparatus and 5 ml of NaOH solution was added. During the distillation, liberated ammonia was received in boric acid in the conical flask placed below and the pink colour of the indicator turned to bluish green. After the initiation of green colour the distillation was continued for further 2 minutes. Then, the liberated ammonia in the conical flask was titrated against. 0.01 N HCl solution until colour became pink. A blank was also done.

Calculation: Total N, $\mu g\,g^{-1} = \frac{(T - B) \times N \times 14 \times V_1}{V_2 \times W} \times 100$

Where, N = Normality of HCl used (0.01N); T = Sample titration reading
B = Blank titration reading; V_1 =Total volume of extract (50 ml)
V_2 = Volume of extract taken for distillation (10 ml);
W = Weight of soil taken for digestion (1 gm)

4.2.27.7. Extraction of available cation exchange capacity, phosphorus and potassium :

Reagent:

1. Ammonium acetate, NH_4OAC (1N): 300 ml of glacial acetic was diluted to 1000 ml and 375 ml of liquid ammonium (NH_3 solution) was also diluted to 1000 ml. These two solutions were then mixed in a glass container and the volume was made up to 5000 ml. The pH of solution was adjusted at 7.0±0.1 with either diluted NH_3 or acetic acid.
2. Formalin, HCHO. H_2O (4%)
3. Ethyl alcohol, Absolute (C_2H_5OH)
4. Potassium chloride, 1N KCl: 372.5g KCl was dissolved in a glass jar with distilled water and the volume was finally made up to 5 liters.

Procedure: 20 g oven dried soil was taken in a 250 ml conical flask and 100 ml NH_4OAC solution (pH 7±0.1) was added. Then, contents were shaken thoroughly and kept over night. It was filtered through Whatman-42. The filtrate was preserved with two drops of formalin for the determination of available phosphorus and potassium. The residual soil was used to determine cation exchange capacity (CEC).

4.2.27.7.1. Determination of available cation exchange capacity : The residual soils were washed several times (3-5 times) with distilled water and then ethyl alcohol and finally with distilled water to remove excess ammonia. The NH_4 ions adsorbed by the soil exchange complexes were then replaced by leaching with 100 ml 1N KCL solution. It was filtered through Whatman-42 and the filtrate was used for nitrogen determination. Calculation of CEC was made by following formula (Jackson 1958).

Calculation: Cation exchange capacity, $meqg^{-1} = \frac{N \times (T - b) \times V_1}{V_2 \times W}$

Where, N =Normality of HCl used (0. 01N); T =Titration reading for the sample;
B =Titration reading for the blank;W = Weight of soil taken for extraction (20gm);
V_1 =Total volume of extract (100ml); V_2 = Volume taken for distillation (10 ml)

4.2.27.7.2. Determination of available phosphorus :
Reagents:

1. 2.5%Ammonium molybdate. $(NH_4)_6Mo_7O_{24}.4H_2O$ solution: 25 g ammonium molybdate was dissolved 200 ml distilled water and warmed up at 60 ^{0}C. The solution was filtered through Whatman-42 to remove the sediment. Then, 275 ml conc. H_2SO_4 was diluted to 750 ml with distilled water and both the solutions were cooled. Then, the ammonium molybdate solution was added slowly to the diluted H_2SO_4 solution. The combined solution was cooled and made the volume 1000 ml. This gave ammonium sulphomolybdate solution.
2. 2.5% stannous chloride, ($SnCl_2$) solution: 1.0 g pure stannous chloride was dissolved in 10 ml conc. HCL with gentle heating until the solution became transparent and then cooled. The volume was made up to 100 ml by adding distilled water. Only freshly prepared stannous chloride solution was used for phosphorus determination.
3. 1000 ppm phosphorus solution: Potassium dihydrogen phosphate (KH_2PO_4) was dried at 105 ^{0}C and cooled in a desiccators. 4.393 gm of dried KH_2PO_4 was taken in a 1000ml volumetric flask and dissolved in 100ml of distilled water. Then, 5 ml conc. H_2SO_4 was added, shaken well for thorough mixing and the volume was made up to the

mark with distilled water. The solution was kept as stock solution. Solution of suitable concentration was made with this stock solution by dilution method.

4. 2 ppm phosphorus solution: 2 ml 1000 ppm solution was taken in a 1000 ml volumetric flask and made up to the mark by adding distilled water.

Preparation of standard curve: 0, 2, 4, 6, 8 and 10 ml of 2 ppm standard phosphorus solution were taken in six cleaned 50 ml volumetric flask. 5 ml of ammonium sulphomolybdate solution was added to each volumetric flask. The distilled water was added up to the neck of the flask and 2 drops of freshly prepared $SnCl_2$ solution were also added and shaken well for thorough mixing. The volume was made up to the mark. A blue colour was developed and colour intensity was measured within 5-15 minutes at 660 nm in a spectrophotometer (Sperctronic-70). The readings were plotted on a graph paper along "Y" axis and thus the standard curve was made.

Procedure: 5 ml of soil extract was taken in a 50 ml volumetric flask. 5ml of ammonium sulphophomolybdate reagent and about 20 ml distilled water was then added. After shaking the volume was made up to the mark. A blue colour was developed and the intensity was measured in spectrophotometer within 5-15 minutes at 660 nm wavelengths. The readings were compared with the standard curve to obtain concentrations of available phosphorus of soil (Jackson 1958).

Calculation: Available phosphorus $\mu g g^{-1} = \frac{A \times R \times V \times V_1}{V_2 \times W}$

Where, A = µg Phosphorus / unit of absorbance from standard curve;
R = Spectrophotometer reading (absorbance);V=Total volume of extract (100 ml)
V_1=Volume made for colour development (50 ml);
V_2= Volume of extract taken for colour development (5 ml)
W = Weight of soil taken for extraction (20 gm)

4.2.27.7.3. Determination of available potassium :
Reagents:

1. 1000 ppm potassium solution: 1.907g (dried in an oven at 110^0C for an hour) KCL was taken in a 1000 ml volumetric flask and was dissolved with small amount of distilled water and shaken well. Then the volume was made up to the mark with distilled water. This solution was kept as stock solution. Solution of suitable concentrations was made from the stock solution by dilution.

2. 0.5, 1.0, 1.5, 2.0, 2.5 and 3 ppm potassium solution: 0.5, 1.0, 2.0, 2.5 and 3 ppm KCL solution were made by diluting the 1000 ppm stock KCL solution with 1N NH_4OAC solution using the following formula. $S_1V_1=S_2V_2$

Preparation of standard curve: Standard curve was prepared by using a Corning flame photometer. The instrument was used according to the maker instruction and adjusted with 3 ppm potassium solution and distilled water alternatively, and operated the sensitivity control until the standard reading set at "100" and distilled water at "0" points of the photometer scale. Finally, readings for 2.5, 2.0, 1.5, 1.0 and 0.5 ppm standard KCL solution were recorded. The values both for scale reading and concentrations were plotted on a graph paper with "Y" and "X" axis respectively. This gave the standard curve.

Procedure: The soil extracts were diluted for10-20 times and used for Flame photometer reading. The reading was compared with the standard curve. A potassium content of soil was calculated by using the following formula. (Jackson 1973)

Calculation: Available potassium, $\mu gg^{-1} = \frac{A \times R \times d \times v}{W}$

Where, A = µg Potassium /unit of absorbance (0.03); R = Flame photometer reading;
V = Total volume of the extract (100ml); D = Dilution factor;
W = Weight of soil taken for extraction (20gm)

4.2.28. Biomass and moisture content of plantable seedlings of ten recorded rattan species : Biomass and moisture content of plantable seedlings of ten recorded rattan were estimated gravimetrically (Misra 1968). Amount of dry matter in a seedling is called biomass and is expressed in the form of organic matter as g $pl^{-1}P^{-1}$.While the amount of moisture present within plant body is called moisture content and is expressed as per cent per seedling.

Procedure: Seedlings of ten recorded rattan species were harvested individually from the polybags of sandy loam soil and washed carefully. Replicates of 3-5 seedlings were used for each treatment. Each seedling was separated into root and shoot, each component was air dried under laboratory condition for 2 hours and weighed separately and recorded. Then, the components were oven dried at 80^0C for 48 hours. The oven dried components were weighed separately. The recorded values of both air dried (fresh weight) and oven dried (dry weight) were expressed as g $pl^{-1}P^{-1}$. While dry weight was subtracted from fresh weight and the moisture content was calculated.

4.2.29. Laboratory analyses of foliar nutrients N, P and K :

4.2.29.1. Extraction of foliar N, P and K :

Reagents:

1. Digestion mixture: In a beaker, 0.21 gm of Se and 7.0g of Li_2SO_4. H_2O were added to 175 ml 30% H_2O_2. After thoroughly mixing 210 ml conc. H_2SO_4 was slowly added and then cooled.

Procedure: Exactly 0.2 g oven dry ground foliar sample was taken in a 30 ml digestion flask and 3 ml of sulfuric acid-hydrogen peroxide digestion mixture was added. This was heated gently on a digestion heater for about half an hour. Then, the contents were cooled and further 2ml digestion mixture was added with sweeping the adhering residues to the neck of the digestion flask. A clear colourless solution was obtained when digestion was found to be completed. The contents were cooled and transferred to a 50 ml volumetric flask and made volume with distilled water, (Allen *et al.* 1986) and used as stock solution for foliar nitrogen, phosphorus and potassium determination.

4.2.29.2. Determination of foliar N, P and K :

4.2.29.2.1. Determination of foliar nitrogen :

Reagents:

1. 40%NaOH solution: 200 gm NaOH crystals were poured in a 500 ml volumetric flask. It was dissolved in distilled water, cooled and made up to the mark with distilled water.
2. 4%H_3BO_3 solution: 40g H_3BO_3 (Boric acid) was dissolve in a 1000 ml volumetric flask in distilled water. Finally the volume was made up to 1000 ml with distilled water.
3. Mixed indicator: 0.1 g bromocresol green and 0.1 g methyl red were dissolved in 100 ml rectified spirit. The solution was adjusted at bluish purple mid colour with either dilute NaOH or HCl.
4. Standard 0.0IN HCl solution: Approximately 0.IN HCl solution was prepared by diluting 8.6 ml conc. HCl (sp.gr. 1.19) into IL. This was titrated against standard 0.IN Na_2CO_3 solution. The required amount of the standard acid was diluted to make 0.0IN. The volume was made up to the mark.

Standardization of acid solution with 0.IN standard Na_2CO_3 solution: A clean burette was filled with 0.IN HCl solution. 10 ml 0.IN Na_2CO_3 solution was taken in a clean dry 50ml conical flask and then 2 drops of methyl orange indicator were added. Then the acid

solution was run into the Na_2CO_3 solution with constantly rotating the flask. At the end point the colour became faint pink. The strength of the acid was calculated from the following formula, $S_1V_1 = S_2V_2$.

Where, V_1 =0.IN Na_2CO_3 solution taken (ml); S_1= strength of Na_2CO_3 solution (0.IN)
V_2 = prepared HCI solution required (ml) for titration and
S_2 =strength of prepared HCI solution (N)

Micro-Kjeldahl distillation procedure: 5ml of 4% boric acid solution was taken in a 50 ml conical flask and then 2 drops of mixed indicator were added. The conical flask was then placed under the condenser of the distillation apparatus with the tip of the delivery tube just touching the liquid. 2ml of extract was poured into the Kjeldahl distillation apparatus and then 5ml 40% NaOH solution was added. During distillation liberated ammonia was received in boric acid in the conical flask below and pink colour of the indicator turned to bluish green. After the initiation of green colour the distillation was continued for further 2 minutes. Then, the collected ammonia solution in the conical flask was titrated against 0.0IN HCI solution until the colour became pink. A blank was also done (Jackson 1973).

Calculation: Twig Nitrogen, $\mu g g^{-1} = \frac{(T-B)\times N\times 14\times V_1}{V_2\times W}\times 1000$

Where, N = Normality of standard HCI (0.0IN); T = Sample titration reading;
B = Blank titration reading; V_1= Total volume of the extract (50 ml);
V_2 = Extract taken for distillation (2ml) and W =Weight of foliar sample (0.2gm)

4.2.29.2.2. Determination of foliar phosphorus :

Reagents:

1. 1000 ppm standard P solution: A few gram of potassium dihydrogen phosphate (KH_2PO_4) was dried at 105 ^{0}C and cooled in desiccator. 4.393 gm of dried potassium dihydrogen phosphate was taken in a 1000 ml volumetric flask and dissolved in about 100 ml distilled water. Then 5ml conc. H_2SO_4 was added, shaken well for thorough mixing and the volume was made up to the mark with distilled water. 50 ppm P standard solution was made from the stock solution by twenty times dilution. This solution was kept as stock solution.
2. Ammonium metavanadomolybdate: 25 g ammonium molybdate was dissolved in 400 ml warm water (50 ^{0}C) in a beaker and cooled. 1.25g-ammonium meta-vanadate was dissolved in 500 ml boiling water in separate beaker and cooled. After cooling, 110 ml conc. H_2SO_4 was added and cooled again. The ammonium molybdate solution was

slowly added to the ammonium metavanadate solution. The solution was mixed well, cooled and the volume was made up to 1000 ml.

Procedure: 10 ml leaf extract was taken in a 50 ml volumetric flask. 10 ml metavanadomolybdate reagent was added and mixed well and made the volume up to mark with distilled water. The contents were allowed to stand for 10 minutes. The intensity of the colour was read at "470"nm wave length in a spectrophotometer (Spectronic-70). For standard curve, 0, 2, 4, 6, 8 and 10 ml 50 ppm standard P solution were taken separately in six 50 ml volumetric flasks. The colour was developed and intensities corresponded to the volume of metavanadomolybdate reagent taken in flasks (Black 1965).

Calculation: Foliar Phosphorus, $\mu g g^{-1} = \frac{A \times R \times V \times V_1}{V_2 \times W}$

Where, A = µg Phosphorus/unit of absorbance from standard curve
V = Total volume of the extract (50 ml);R= Spectrophotometer reading (absorbance)
V_1 = Volume made for colour development (50 ml);
V_2 =Volume of extract taken for colour development (10 ml)
W = Weight of foliar sample (0.2 g) taken for digestion.

4.2.29.2.3. Determination of foliar potassium :

Reagents:

1000 ppm K solution: 1.907g KCl (dried in an oven at 110^0C for 1 hour) was dissolved in distilled water and was made to a volume 1000 ml to make 1000 ppm K solution. Standard solution of 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 were prepared by dilution with distilled water. A standard curve was made by running the standard solution in Corning flame photometer.

Procedure: Potassium was determined by Corning flame photometer. Values for the twig extracts were compared with the values of standard curve to calculate the twig potassium (Jackson 1958).

Calculation: Foliar potassium, $\mu g g^{-1} = \frac{A \times R \times d \times v}{W}$

Where, A = µg Potassium / unit of absorbance. (0.03); R = Flame photometer reading;
d = Dilution factor ;v = vol. of extract (50 ml);W= Wt .of foliar sample (0.2 gm)

4.2.30. Extraction of photosynthetic pigments : Chlorophyll a, b and carotenoids contents of fresh leaves of rattans were determined spectrophotometically (Spectronic–

70) following Wettstein (1957). Fresh leaves collected from the field were used to determine the photosynthetic pigments. Then five discs were cut from interveinal portion of each leaf by cork borer (diameter inside 1 cm) and weighed immediately in an electronic balance and dipped in 5 ml pure acetone in test tube with stopper and added small quantity of calcium carbonate and left for 24 hours in dark. After 24 hours, the coloured solution from top was decanted in 50 ml volumetric flask. The blocks were then crushed by blunt glass rod gently and fresh acetone was added to the test tube and left for 15 minutes and then again coloured solution was decanted from top carefully to the volumetric flask. The process was repeated equally for all the cases till the fragments of the leaves become colourless. The volume was made up to 50ml by pure acetone and kept as stock solution. The stock solution was diluted five to ten times by adding pure acetone and then used to measure the chlorophyll a, b and carotenoids at 662, 664 and 440.5 nm respectively. The concentrations of chlorophyll a, b and carotenoids in the extract were calculated with the following formulae.

Chlorophyll a = 9.784 ×E662-09.990×E644= mg/L

Chlorophyll b = 21.426 ×E644 - 4.650 ×E662 = mg/ L

Carotenoids = 41.695×E440.5-0.268×(Chlorophyll a + Chlorophyll b)= mg/L

$$\text{Chlorophyll a} = \frac{9.784 \times E662 - 0.99 \times E644 \times V \times d}{1000 \times FW} \text{ mg /g FW}$$

$$\text{Chlorophyll b} = \frac{21.426 \times E644 - 4.650 \times E662 \times V \times d}{1000 \times FW} \text{ mg /g FW}$$

$$\text{Carotenoids} = \frac{41.695 \times E440.5 - 0.268 \times (\text{chl} - a + \text{chl} - b) \times V \times d}{1000 \times FW} \text{ mg /g FW}$$

Where, V = Total volume (50 ml); d = Dilution factor (5 times)

FW = Fresh weight of leaf disc (ten discs = 0.5-0.6 g)

4.2.31. Experimental designing and statistical analyses : Both CRD and RCBD were used depending on the set of experiments. Analysis of variance (ANOVA) was done with the help of statistical package programme by computer. Least significant differences (LSD) were calculated at 1 and 5% level by using scientific calculator. t-test was applied in some experiments for interpretation of results. Standard deviation and standard error of means of both sample and population were also calculated by scientific calculator.

CHAPTER 5 : RESULTS AND DISCUSSION

Introduction: Present investigation was aimed at examining the major aspects of recorded rattan species mainly the biology more precisely the propagation potential for mass scale plantation sustainable conservation and also to be used as future reference for further studies relating to the improvement program to maximize the production of this natural resource. Some basic parameters *viz.* occurrence, distribution, habitat, species diversity, clump habit, identifying characters, taxonomic description, taxonomic key, present status, frequency of occurrence, size of population; existing supporting trees, exploitable culm size, *in situ* growth pattern, rate of shoot and culm formation, rate of culm and height increment; seedling raising techniques, pricking age, transfer technique, survival per cent of transferred seedlings, *ex situ* growth, total biomass, photosynthetic pigments level, NPK status; phenology and periodicity of flowering, fruit maturity, fruiting cycle, reproductive features, wilding pattern, reproductive potentials with seed conditions, sowing media, sowing seasons, sowing depth, pretreatments, storage conditions, storage periods, temperature; propagation potential of seedlings, rhizomes, suckers and wildings; distribution, occurrence and *in situ* conservation status, rattan index, numerical rattan index, canetum establishment etc. were considered to be studied exclusively for recorded ten rattan species. The data of all these parameters were recorded in accordance with the methods described in respective chapters. The results of which have been summarized and are given under the following headings.

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5.1. Occurrence, distribution, habitat, species diversity, clump habit and identifying characters of presently recorded ten rattan species in RGA of Bangladesh : Occurrence and distribution of rattans in eight studied rattan growing forest divisions of Bangladesh are presented in Table-12 which indicate that a total of ten rattan species were found in 47 sites and 155 sub-sites of rattan growing forest areas. The data as shown in Table-12 also indicate that Bandarban region was the species richest zone for species diversity compared to other rattan growing areas where 9 rattan species were recorded alone. In Bandarban, Ampupara site was found to have six rattan species alone. The species *C.longisetus* was reported earlier only from some areas of Cox's Bazar forests. But during this study it was also found from Alikadam-Bandarban; and Khadimnagar Sylhet. Similarly, *C.erectus* was previously reported (Alam and Basu 1988) to occur only

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in Sitakunda of Chittagong. In the present study it was also found in Sitapahar-Kaptai and Ampupara-Bandarban. It was found in large number occurring in several areas of Sitapahar but it was found fair in number and restricted to a very few localities of Ampupara. *C.latifolius* was previously reported (Alam 1990) to occur in evergreen forest of Chittagong, Chittagong Hill Tracts, Cox's Bazar and Sylhet. During this study the species was found in Ampupara-Bandarban, Salna (planted)-Gajipur and in BFRI (planted). *C.gracilis* was previously reported (Griffith 1850; Blatter 1926) from some where of the then greater Chittagong. Alam (1990) presented a checklist of ten rattan species where *C.gracilis* was included. But taxonomic description, status and distribution were not mentioned anywhere in his report. *C.gracilis* was recorded during this investigation from Tilagar-Sylhet but could not have recorded from any other rattan growing forest areas of Bangladesh. So, it is considered as rediscovered one from Bangladesh and new report from Sylhet. Both *C.acanthospathus* and *C.travencoricus* were recorded from Ampupara-Bandarban and was not recorded from any other areas of Bangladesh and these two rattan species are considered as new report from the territory of Bangladesh. But *C.acanthospathus* was reported (Wong 1984) to occur in adjacent areas of Bangladesh and possibly occur in Bangladesh. But the exact location was not mentioned anywhere before. *C.guruba* was generally found to occur in most of the rattan growing areas along with *C.tenuis* a very common rattan of Bangladesh. Two other common rattan species *viz. C.viminalis* and *D.jenkinsiana* were found to occur in abundance both under natural and planted forms.

Rattans were recorded from a wide range of habitats under monsoon climate of Bangladesh. Habitat conditions varied from sea level to the highest peak of mountain (~1000 m). The result as shown in Figure-32 indicate the occurrence and distribution of recorded ten rattan species based on altitude and rainfall in Bangladesh. It was observed in the present investigation that all these ten recorded rattan species were not found to occur in any one site or sub-sites. Rather the diversity of recorded rattan species as shown in Table-12 ranged from 2-7 depending on the studied sites. It was observed that the recorded ten rattan species of Bangladesh are multi-stemmed and clump forming in nature. On the basis of clump habit, two types of clumps (*viz.* loosely and compactly arranged) were identified. The overall appearance and habit of clumps of the studied rattans were very similar and troublesome to distinguish them at the time of study. It is difficult to identify the rattan species only by local name. Because same name was used

Table 12 : Distribution, occurrence and estimated status of recorded ten rattan species in 155 sub-sites and 47 sites of eight rattan growing forest divisions of Bangladesh.

Division	Regions	Sites	Sub-sites	*C.acanthospathus*	*C.erectus*	*C.gacilis*	*C.guruba*	*C.latifolius*	*C.longisetus*	*C.tenuis*	*C.travencricus*	*C.viminalis*	*D.jenkiinsiana*	Total genus	Total species
Chittagong	Chittagong North (1)	Fatikchari	7	0	0	0	3	0	0	3	0	2	2	2	4
		Hazarikhill	3	0	0	0	2	0	0	3	0	2	1	2	4
		Hinguli	3	0	0	0	0	0	0	3	0	1	1	2	3
		Sitakunda	3	0	2	0	0	0	0	1	0	1	1	2	4
		Korerhat	2	0	0	0	0	0	0	3	0	1	1	2	3
		Hathazari	7	0	0	0	2	0	0	3	0	1	2	2	4
		BFRI (1a)	1	0	1	0	1	1	1	2	0	3	2	2	7
		BGCU (1a)	1	0	0	0	0	0	0	2	0	3	2	2	7
	Chittagong South	Dhopachari	3	0	0	0	1	0	0	2	0	0	0	1	2
		Potiya	4	0	0	0	1	0	0	2	0	1	1	2	4
		Boalkhali	3	0	0	0	1	0	0	3	0	1	0	1	3
		Keochia	3	0	0	0	1	0	0	2	0	3	2	2	4
Cox'sBazar	Cox's Bazar (3)	Fasiakhali	4	0	0	0	0	0	1	3	0	3	1	2	4
		Ramu (3b)	3	0	0	0	0	0	3	1	0	2	1	2	4
		Teknaf (3c)	4	0	0	0	0	0	3	1	0	2	1	2	4
		Dulahazara (3a)	3	0	0	0	0	0	1	3	0	3	3	2	4
		Ukhia	7	0	0	0	1	0	2	2	0	3	2	2	5
Chittagong Hill Tracts	Bandarban (2)	Sadar	6	0	0	0	2	0	0	2	0	1	1	2	4
		Lama	5	0	0	0	2	0	0	2	0	2	1	2	4
		Alikadam	3	0	0	0	0	0	2	2	0	0	1	2	3
		Ampupara (2c)	3	2	1	0	1	1	0	1	1	0	0	1	6
		Bolipara	3	0	0	0	1	0	0	1	0	0	0	2	2
		Thanchi	3	0	0	0	0	0	2	0	0	2	1	2	3
	Khagrachari (2)	Sadar	3	0	0	0	2	0	0	2	0	1	2	2	4
		Panchari (2a)	3	0	0	0	2	0	0	2	0	1	2	2	4
		Dighinala	2	0	0	0	2	0	0	2	0	1	2	2	4
		Baghaihat	3	0	0	0	2	0	0	2	0	1	2	2	4
		Matiranga	2	0	0	0	2	0	0	2	0	1	2	2	4
	Rangamati (2)	Sadar	3	0	0	0	0	0	0	3	0	1	1	2	3
		Boritali	3	0	0	0	1	0	0	2	0	1	1	2	4
		Kaptai	2	0	0	0	0	0	0	2	0	1	1	2	3
		Sitapahar (2b)	3	0	2	0	1	1	0	1	0	0	0	2	4
Dhaka	Dhaka (4)	NBGM	1	0	0	0	3	0	0	3	0	3	3	2	4
		BNPG (4)	4	0	0	0	1	1	0	3	0	3	1	2	4
		Salna	3	0	0	0	3	2	0	3	0	3	1	2	5
Dinajpur	Dinajpur (5)	Nilphamari (5)	2	0	0	0	0	0	0	2	0	1	0	1	2
Khulna	Khulna (6)	Bagerhat (6)	2	0	0	0	0	0	0	3	0	0	1	2	2
Sylhet	Sylhet sadar (7)	Tilagar (7a)	3	0	0	3	3	0	0	2	0	0	3	2	4
		Khadimnagar	4	0	0	0	3	0	1	2	0	1	3	2	5
	Hobigong	Kelanga	5	0	0	0	2	0	0	3	0	0	3	2	3
		R.Kelanga	4	0	0	0	2	0	0	3	0	2	3	2	4
	Moulavi Bazar (7)	Kalachara	4	0	0	0	3	0	0	0	0	2	3	2	3
		Lawachara (7b)	3	0	0	0	3	0	0	3	0	1	3	2	4
		Jankichara	4	0	0	0	3	0	0	3	0	1	3	2	4
Tangail	Tangail (8)	Sadar	3	0	0	0	3	0	0	3	0	3	1	2	4
		Madhupur (8)	3	0	0	0	2	0	0	2	0	2	1	2	4
		Sempure	2	0	0	0	2	0	0	2	0	2	2	2	2

Legend: Status of rattans:- 0=Absent; 1=Restricted to a very few localities but found in fair numbers; 2=Found in small numbers but occurring in several areas and 3=Occurring gregariously in pure form.

for different species and different name was used for same species depending on localities. In field, it was difficult to identify rattan species because the essential flowering and fruit materials were not always available. Sometime the diameter, which is also a taxonomic character, unbelievably varied with locality. Most of the rattans were identified on the basis of taxonomic descriptions. Rattan identification in the present investigation was done based on clumps habitats, clump shoot arrangements, culm size, climbing habit, climbing organs, colour of leaf sheaths, arrangements of thorns on leaf sheath, nature of knee, nature of ocrea, size of leaf, arrangement of leaflets, nature of mode of influences; fruit shape, size and colour; seed shape, size and ornamentation.

Identifying characters of rattan species of Bangladesh.

1. Loosely arranged clump:

1.1 Clump's canopy deep green; culm flagellate, slender and diameter with sheath 1.5 to 2.0 cm and with out sheath 0.8-1.0 cm; leaf sheath sparsely covered with small-short-blunt, tuberculate, broad based solitary or jointed spines; knee present; ocrea not prominent; young leaf rachis covered with rusty indumentums; leaflets grouped into 2-4 and broadly lanceolate, terminal leaflets connate at the base; multiple shoot found at the tip of the stem; inflorescence flagellate; infructance pendulous with large fruits, ellipsoid, oval, stalked, suddenly beaked, green at young and dull orange to yellow at maturity; seed elliptic, relatively smooth walled, soft and pitted.----------***C.acanthospathus***

1.2 Clump's canopy light green; culm non-flagellate; erect, robust and diameter with sheath about 11-15 cm and with out sheath 6-9 cm, looks like bamboo, only presence of spines distinguishes it from bamboo; ocrea very large and conspicuous; knee absent; presence of assorted yellow spines on the petiole in whorl and long spines present on the back of rachis; leaf size large about 3-4 m long with broadly lanceolate regular leaflets; inflorescence compact, flagellate, large and pendulous male inflorescence larger than female; infructance pendulous with largest fruits, stalked, ellipsoid, apiculate with black stripes at maturity; seed smooth walled, relatively soft and elliptic in shape.----------
----------***C.erectus***

1.3 Clump's canopy deep green; culm flagellate, slender and diameter with sheath 1.0-1.5 cm and with out sheath 0.4 to 0.8 cm; leaf sheath covered with large and small black

straight spines, but rachis spine small and recurved; knee conspicuous; ocrea with hairy projection; leaflet grouped in 2-3, irregular, broadly lanceolate but terminal leaflets opposite and paired or digitated 4 in number and one third connate at the base; inflorescence very small, flagellate, pendulous with minute flowers; infructance pendulous with small green fruits at young and pale yellow at maturity; seed ruminate hard and sub globose.----------***C.gracilis***

1.4 Clump's canopy bottle green; culm medium sized; stem diameter with sheath 5-6cm and with out sheath 3-4 cm; leaf sheath bright green with recurved spines; conspicuous knee; ocrea papery; leaf with small cirrus, leaflets boat shaped grouped into 4-6, irregular; inflorescence pendulous with small flowers; infructance pendulous with gray coloured, sub-globose, fruit sessile, green at young stage and straw coloured at maturity; seed half convex, hard and wrinkled.----------***C.latifolius***

1.5 Clump's canopy deep green; culm flagellate; slender stoloniferous; new shoots arise from periphery; leaf sheath deep green, stem diameter with sheath about 2-3 cm and with out sheath 1.3-2.0 cm; knee conspicuous; ocrea inconspicuous; leaf sheath covered with some broad based solitary or joined recurved spines; leaflets regular and glossy; inflorescence pendulous with minute male and female flowers; infructance pendulous with greenish scaled fruits at young and whitish at maturity, fruit stalked, oblong-ellipsoid with beak; seed sub-globose hard and wrinkled. ----------***C.tenuis***

1.6 Clump's canopy yellowish green; stem slender; culm diameter with sheath about 1.0-1.2 cm and with out sheath 0.4-0.8 cm; leaf sheath dull green with floccose at young part and covered with single row of broad based blunt recurved spines on the lower surface of petiole and rachis; knee and ocrea inconspicuous; leaflets grouped into 2-3, terminal leaflets not connate at base. Multiple shoot at the tip of the stem; inflorescence short and pendulous with minute male and female flowers; infructance pendulous with deep green, medium sized stalked fruits at young; bright yellowish-red coloured oblong fruit at mature stage; seed relatively soft, smooth walled and pitted. ----------
----------***C.travencoricus***

1.7 Clump's canopy pale green; culm medium sized with white floccose at young part, stem diameter with sheath 3-4.5 cm and with out sheath 2-2.5 cm; leaf sheath covered with long broad, sharp recurved spines on the back of rachis; knee conspicuous; ocrea inconspicuous; leaflets grouped into 4-10 and irregular; inflorescence pendulous with numerous small greenish flower; infructance with small pea like sessile greenish fruits at young and whitish scaled fruits at maturity; seed sub-globose hard and ornamented.

----------***C.viminalis* var. *fasciculatus***

B. Compactly arranged clump:

2.1 Clump's canopy deep green; culm slender, moderately compact; new shoot arises from the centre; stem diameter with sheath about 1.7-2.5 cm and with out sheath 1-1.5 cm; sheath and rachis spines broad based solitary or grouped associated with small spines; knee conspicuous; ocrea papery and lacerated; leaflets regular and almost opposite; inflorescence pendulous and flagellate with small male and female flowers; infructance pendulous with very small pea like light green fruits at young and whitish with maroon channeled fruits at maturity; seed sub globose hard and ruminate with irregular channel.----------***C.guruba***

2.2 Clump's canopy deep green, robust; culm is medium sized, stem diameter with leaf sheath 8-10 cm; leaf sheath covered with numerous black flat spines arranged in rows and recurved spines on the back of rachis; knee inconspicuous; ocrea inconspicuous and fibrous; leaf-lets broad, long, lanceolate and grouped into 3 or 5 at the base at young and regular at fully grown leaf; inflorescence pendulous with small male and female flowers; infructance pendulous; fruits stalked, ellipsoid-ovoid, large sized with black stripes and whitish black at maturity; fruit scales fabricated at margins, tiger stripped; seed oblong-ovoid longitudinally channeled, hard and covered with dense silky hairs.----------

----------***C.longisetus***

2.3 Clump's canopy light green; culm robust, stem diameter with leaf sheath about 6-8 cm and with out sheath 2.5-4.0 cm; leaf sheath with numerous black flat and long spines, recurved spines on petiole and back of rachis; knee conspicuous; ocrea inconspicuous; leaves large sized and cirrated, leaflets broad, lanceolate, regular, young leaves orange red in colour; inflorescence non-pendulous covered with boat shaped spath with small

male and female inflorescence; infructance short, young fruits reddish-green and medium sized, globose and deep yellow at maturity; seed smooth walled, relatively harder and sub globose.----------***D.jenkinsiana***

5.2. Description and taxonomy key of ten recorded rattan species of Bangladesh:

Taxonomic description of all recorded rattan species is summarized as below.

Calamus acanthospathus Griff. *Calc .Journ. Nat. Hist.*5: 39. (1845); *Palms Brit. Ind.* 50, t. 190 B; & Becc. in *Ann. Roy. Bot. Gard.* Calcutta 11: 283. 1908, & Appendix Pl.105. (1913).

Local name: Gouri bet (Plate-1).

This species is confined to Ampupara, Bandarban. The species occurs in semi-evergreen forest. Numerous spines are present on the sheath of plant. Spines are broad based; white floccose and maroon powdery substances are present on sheath. This species is a new record for Bangladesh. It is very similar to the *C.travancoricus*. The only difference is fruit size and the leaflets are broader than *C.travancoricus* and the terminal pair of leaflets is attached at the base. Shoot tip suckering occurs in this species. A moderately clump forming rattan deep green in colour; stem 18-28 m long, with leaf sheath 1.5-2.0 cm in diameter, without leaf sheath 0.8-1.0 cm in diameter, smooth, green. Leaves ecirrate, about 1.5m long; petiole inconspicuous 7-10 cm, rachis with robust digitate claws on one side; leaf sheath mostly covered with small tuberculate spines and broad-based, solitary, confluent spines; flagellum about 1.5m long; leaflets 15-25 x 1.5-2.0 cm, broadly lanceolate, many-nerved, inequidistant on rachis, not in groups or in pairs; terminal leaflets slightly connate at base. Young leaf rachis is covered by rusty indumentum. Inflorescence flagelliform; primary bract leathery, closely sheathing, smooth or more or less armed with short conic prickles. Male inflorescence 1m long, 10 cm long 8-10 partial inflorescence, rachilla very small with 4-5 flowers; female rachillae arching, sub-scorpioid, 5-6 cm long with 10-14 flowers in each rachillae, arranged in unilateral series. Fruit ellipsoid oval stalked, suddenly beaked, 2.6-3.1 x 1.9-2.2 cm, dull orange in colour; fruit scales in 15 series, shining, superficially channeled at middle; seed, elliptic, 2.1-2.4 x 1.4-1.6 cm smooth walled, deeply pitted on dorsal side; endosperm sub-ruminate; embryo basal. Flowering: September-January, Fruit setting: October-January and Fruit ripening: February-April.

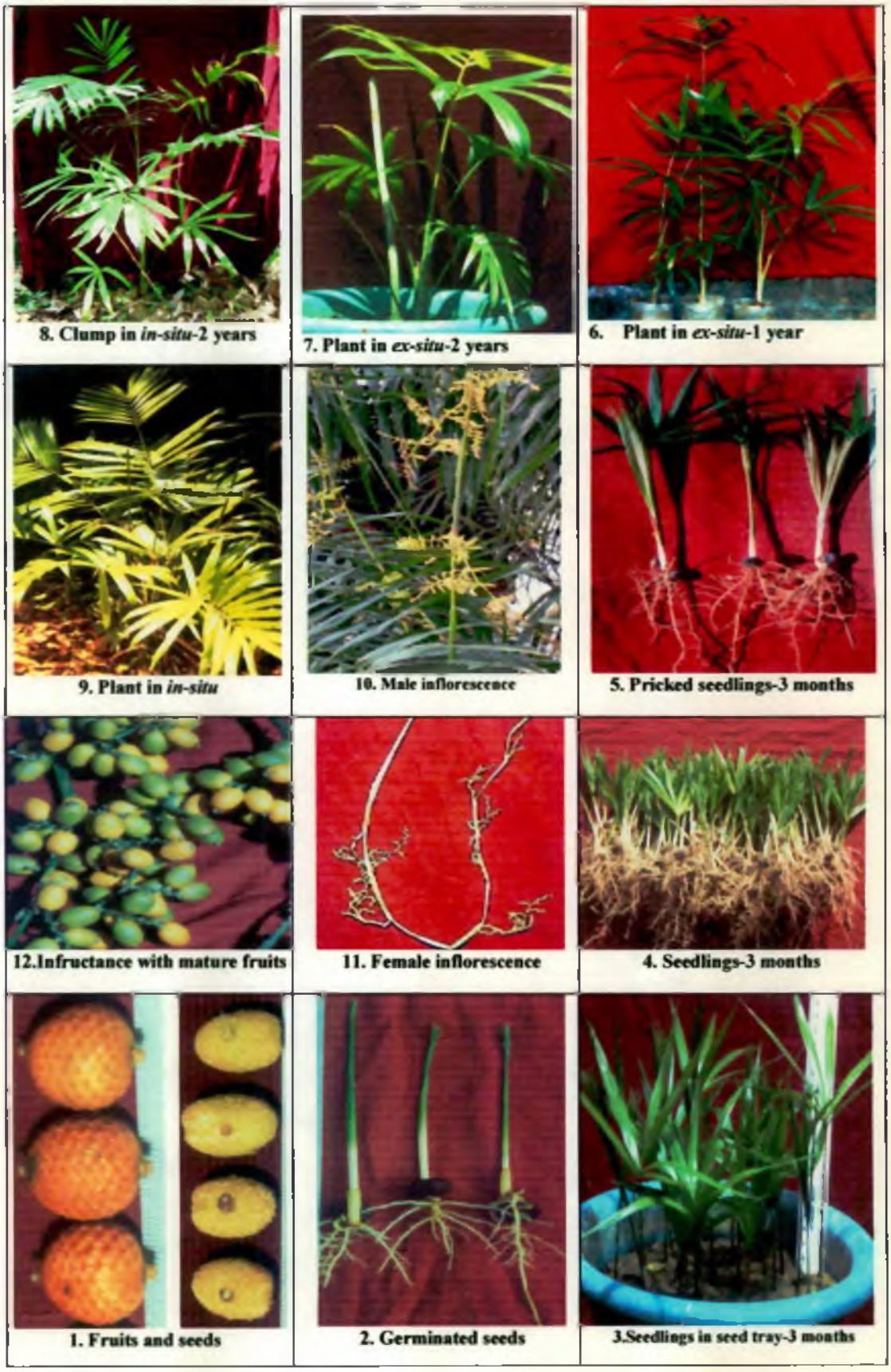


Plate 1: Photographs showing the major stages of life cycle of *Calamus acanthospathus*.

Calamus erectus Roxb. *Fl. Ind.* 3, 774,(1832); Mart. *Hist. Nat. Palm.* iii.332; Griff. in *Calc. Journ.Nat. Hist.*v, 35; *Palms of Brit. Ind.* 43; *For. Fl. of British Burma* ii. 516 (1877); Becc. in Hook. f. *Fl. Brit. Ind.*6: 438,(1892); Prain, *Beng. Plants* 2: 1099 (1903); Brandies, *Ind. Trees*: 651 (1906); Blatter, *The Palms of Brit. India and Ceylon*: 291, fig. 39 (1926); in *Ann. Roy. Bot. Gard.* Calcutta 11:126 (1908) &Appendix Pl. 2.(1913).

Local name: Kadam bet or Sita bet (Plate-2).

It is one of the vulnerable species found only in Chandranath pahar of Sitakunda, Ampupara of Bandarban and Sitapahar of Kaptai. Apparently it is seemed that number of plants in Sitakunda is abundant and the huge amount of fruits found in a special "mela" of Hindus called "Sheeb mela" held in March every year proves the presence of abundant number of plants in and around that locality. Number of plants in other mentioned area is few and scattered. It occurs in hill slopes and pockets of slopes where organic matter and moisture of soil are rich. This can easily be identified by its wide diameter. It is the widest diameter rattan found in Bangladesh. Presence of spines in leaf petiole and rachis easily differentiates it from bamboo. Its stem is green and looks like bamboo.

Multi stemmed clump, stem erect, robust, with a crown of large leaves, 3-5 m tall, new shoot develop from the nodes of the erect stem or slightly above the base as aerial shoot. Diameter of stem with sheath is 11-15 cm, with out sheath 6-9 cm. Internodes 8-11 cm long. Leaf sheath deep brown, armed with flat sharp spines up to 2.5 cm long in semicircular lines. Knee is absent in this species. Conspicuous very large ocrea. Leaves 3-6 m long with out flagella or cirrus; petiole about 90-95 cm with yellow flat spines in circle at equal distance, rachis convex trigonal. Leaf let 36-72 on either side, equidistant, opposite to alternate, comparatively smaller towards the base and tip, elongate-ensiform, green on both surface, midrib sparingly bristly. Leaf rachis armed beneath with long and straight spines. Spadix not very shortly flagelliferous at its apex.

Male and female inflorescence are superficially similar, 1-2 m long, tubular, terminating a whipe like recurve armed flagellum up to 1-2 m long, generally with 8-10 alternate partial inflorescences upto 60 cm long enclosed by the tubular bracts. Male flowers distichous in recurved rachillae up to 30 cm long, flowers about 11mm long. Female flowers distichous in recurved rachillae upto 20 cm long. Fruits brownish, shortly stalked, 4-5 x 2-2.5 cm, ellipsoid shortly stalked, oblong, slightly compressed, apiculate, covered by 12 vertical rows of shiny scales, scales cordate-trapezoid, brown towards the base and dark at the apex on the dorsal side. Seeds one in each fruit, 2.5-2.8 x 1.5-1.8 cm, elliptic-

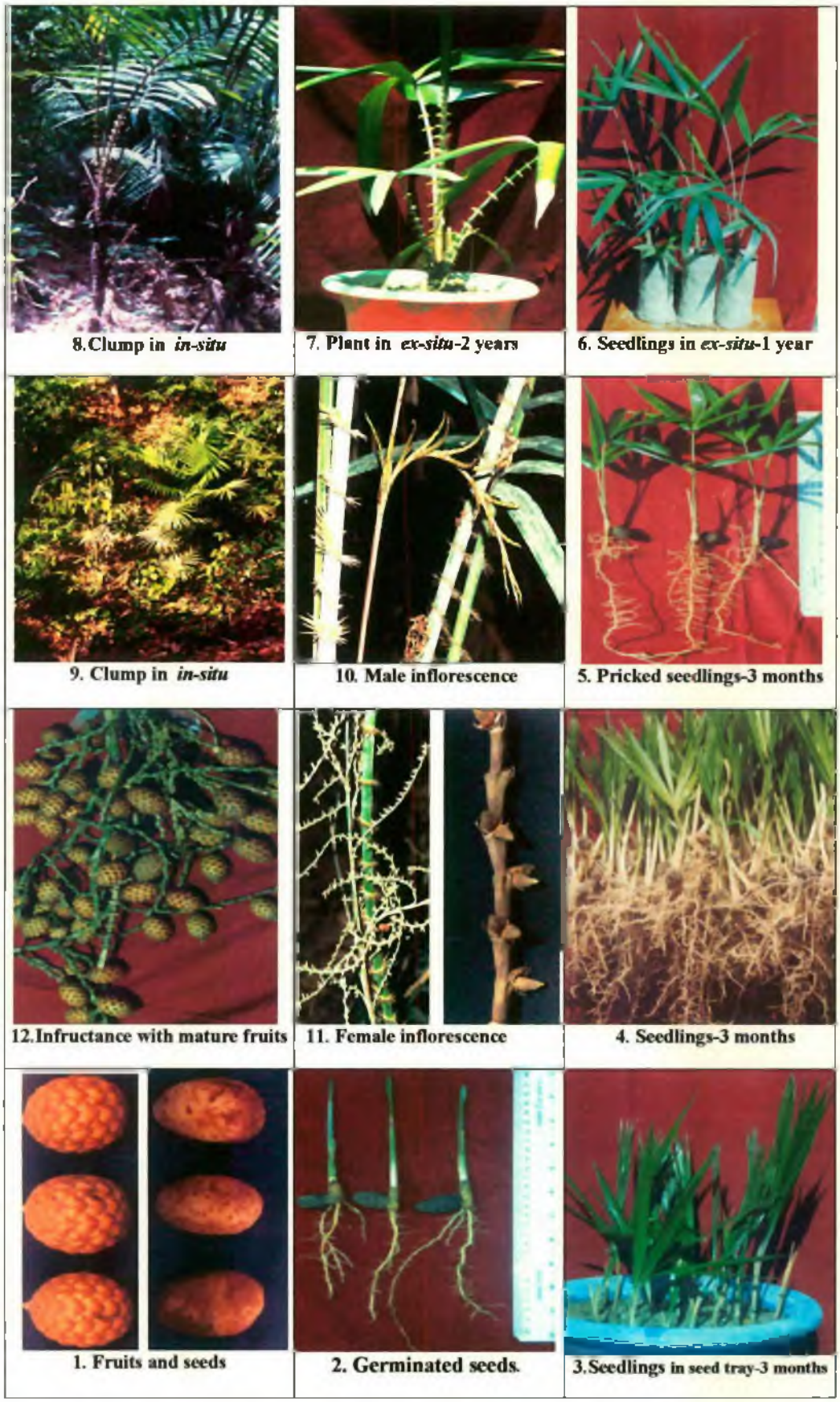


Plate 2: Photographs showing the major stages of life cycle of *Calamus erectus*.

ovoid, smooth walled, endosperm cartilaginous, embryo epibasal. Flowering twice in a year: May-July and Nov-January. Fruiting: June-September and January-March. Fruit ripen in October- December and April-June.

Calamus gracilis Roxb. *Fl. Ind.* 3, 781 (1832); Griff. in Calc. *Journ. Nat. Hist.* 5, 54: *Palms Brit. Ind.* 64, t. 196; Becc.in Hook. f. *Fl. Brit. Ind.*6, 453 (1893), & in *Ann. Roy. Bot. Gard.* Calcutta 11, 96, 318.(1908). & Appendix Pl. 124. 1913.

Local name: Mapuri bet (Plate-3).

It is one of the species, which is rediscovered during this study from Tilagar, Sylhet. It is a slender cluster forming deep green species. Leaves are grouped. This species occurs in semi-evergreen forest. It is a rare species. Presence of bristle and hairy ocrea can easily identify the clump. It can not climb up to high tree. Generally, it increase in length along the slopes of the hill on soil.

A very slender, deep green plant, crawl over the ground, densely clump forming. Stem length ranges from 16-20 m, with sheath 1.8-2.5 cm and without sheath 1-1.5 cm in diameter, internode 15-20 cm in length. Leaf sheath deep green, flagellate with short and long black spines up to 1 cm long; knees conspicuous, ocrea with hairy projection. Flagella 0.8-1m with recurved spines. Leaf ecirrate, 33-45 cm long, petiole very short 8-12 cm, rachis and petiole green with spines at the back. Leaflets 9-12 in number, in groups of 3-5, irregularly arranged on the rachis. Leaflets elliptic-lanceolate, 23-26 x 3-3.5 cm, deep green on both sides, terminal leaflet is connate and joined at the base. Inflorescence male and female inflorescence are superficially similar, arise from the lateral side of the sheath mouth, 2-3 inflorescence per culm, Length of male and female inflorescence is 100-125 cm and 65-85 cm respectively, number of partial inflorescence number ranges from 8-10 and 6-8 in male and female respectively. Male flowers are distichous, yellow in colour, male flower per clump ranges from 13928-15648. Female flowers horizontally projected on rachila, number of female flower per culm ranges 4749-6421. Fruit sessile, ovoid or broadly-elliptic, size 1.5-1.9 x 2.3-2.6 cm in scale straw colour, arranged in 12 series deeply channeled, weight of 100 fruit is 52-65 gm. Seed oblong-ovoid ornamented wall, size is 0.5-0.7 x 0.9-1.1 cm, weight of 100 seed is 24-30 gm. Plancentation lateral, embryo anatropus, endosperm ruminate. Flowering twice in a year. March-May and October–December.Fruit setting: April-June and October-December. Fruit ripen January-March and July-September. Observed to be restricted only

Plate 3: Photographs showing the major stages of life cycle of *Calamus gracilis*.

to Tilagar Forest Beat area of Sylhet. Though it was reported to be available in Chittagong (Griffith 1850) but is not found in Chittagong and its surrounding areas during this investigation.

Calamus guruba Ham. in Mart. *Hist. Nat. Palm.* 3: 206 and 330, t. 175, f.I.(1823-1853). Becc. in Hook. f. *Fl. Brit. Ind.*6: 449. (1892). *Palms of Brit. East India*: 54 (1850); Kurz, *For. Fl. Brit. Burma*,2: 522 (1877): Prain, *Beng. Plants*, 2:1099 (19030; Brandis, *Ind. Trees*: 652 (1906); Blatter, *The palms of British India and Celon*: 317 (1926).Becc. in *Ann. Roy. Bot. Gard.* Calcutta 11:299. (1908) & Appendix Pl. 114. (1913).

Local name: Sundi bet (Plate-4).

It is high climbing rattan grows both in village and forest. It is mostly available in Sylhet, Chittagong and Chittagong Hill Tracts. Sundi prefers moist habitats at the lower hill slopes of mixed evergreen forest.

Clustering to form dense clumps, high climbing 13-26 m. Stem with sheath about 1.7-2.5 cm and without sheath about 1-1.5 cm in diameter, internodes 10-30 cm long. Leaf sheath dull green, covered with rusty-brown indumentum and thin irregular flattened conical spines 1.0-1.5 cm long, associated with smaller spines. Spines are broad at the base and gradually pointed. Colour of spines is greenish yellow and 90^0 angle with the sheath. Knee conspicuous; ocrea membranous, and lacerated. Flagella about 1-2 m long lateral, slender, whip like, armed with recurved spines sheath mouth oblique. Leaf ecirrate, 90-120 cm long with petiole, petiole 15-25 cm long, rachis covered with rusty indumentum, stout recurved spines arranged irregularly on the back. Leaflets 60-80 on either side of the rachis, alternate, equidistant, glossy green, arranged on the rachis in more then 50^0 angle, 20-40 x 1.5-2.5 cm, narrowly linear, successively shorter towards the apex, secondary veins two on either side of the mid-rib, one more prominent than the other. Inflorescence male and female superficially similar, peduncle enclosed on the lateral side of the sheath. Flagelliform with terminal flagellum, 1.0-1.5 m long without the flagellum, normally with 5-8 alternate partial inflorescence, upto 35 cm long. The inflorescence is enclosed in 20-25 cm long tubular bracts at first, later longitudinally split and become laminar, terminal flagella with clawed spines. Male flowers on rachillae upto 8 cm long, with distichous flowers. Female flowers on rachillae of 2-3 cm long, rachillae slightly zig-zag with distichous flowers. Fruits greenish brown, sessile or very shortly stalked, about the size of a pea, about 5 mm in diameter, supported by the remains of sepals and

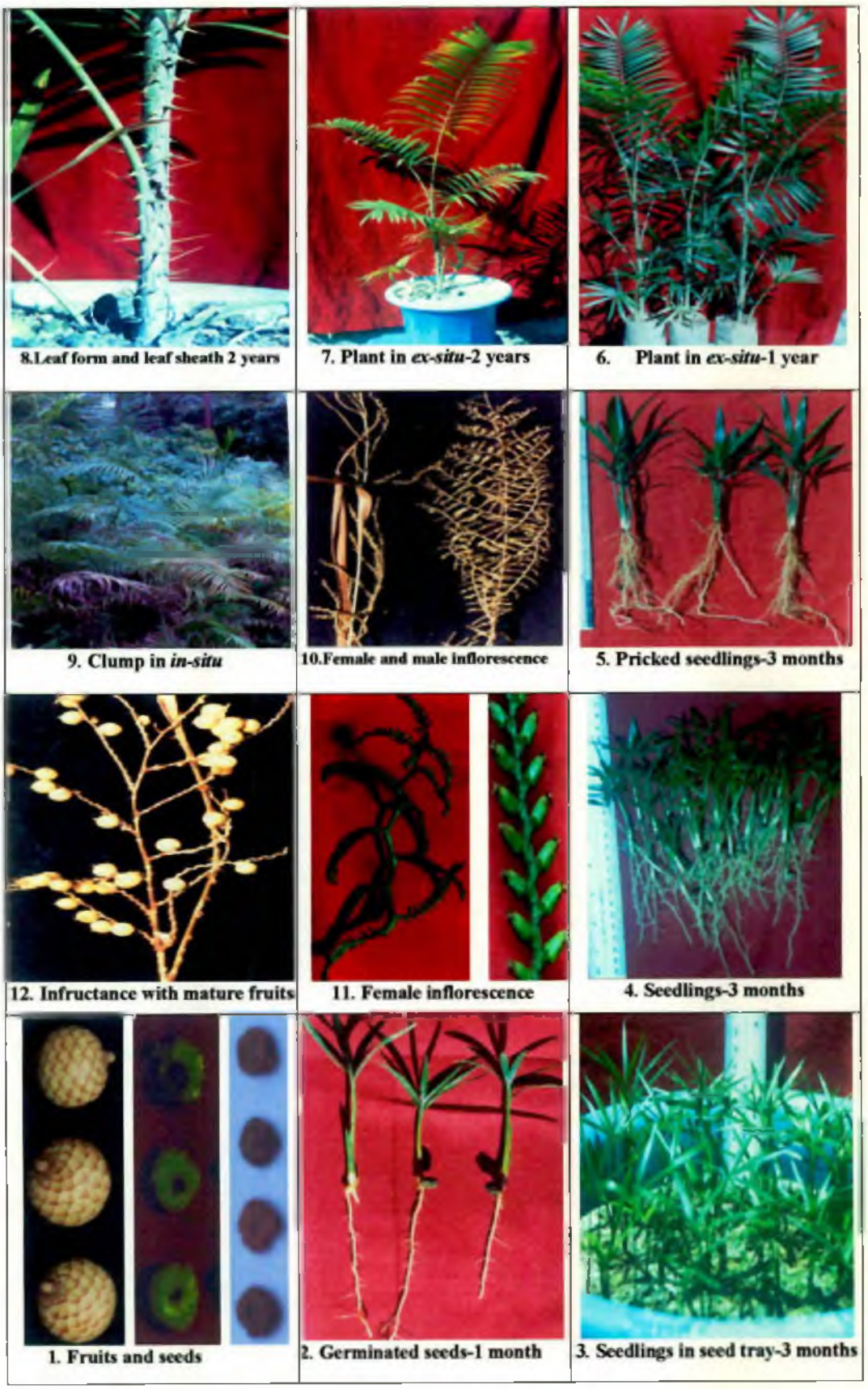


Plate 4: Photographs showing the major stages of life cycle of *Calamus guruba*.

petals, tip apiculate, 17-18 vertical rows of greenish-brown scales with blackish tip, shallowly channeled, margin brown. Seeds covered by thin greenish-grey, tannic sarcotesta, about 5 mm in diameter, subglobose, flattened on one side and convex on the other, surface ruminate with irregular channels, an elongated depression in the flattened side. Embryo basal. Flowering: January-March and August-October. Fruit setting February-April and September-November, fruit ripening May-July and December-February.

Calamus latifolius Roxb.*Fl. Ind.*3, 775 (1832); Becc. in Hook. f. *Fl. Brit. Ind.*6:455,1892 & in *Ann. Roy. Bot. Gar.* Calcutta 11: 406. 1908 7 Appendix Pl.(1913). Griff. in *Calc. Journ. Nat. Hist.* 5, 60; *Plams Brit. Ind.* 68, t. 198 (1850);

Local name: Korak bet or Horna bet (Plate-5).

It is one of the rare rattan found in the evergreen forests of Chittagong, Chittagong Hill Tracts. This species is confined to Ampupara Bandarban and Sitapahar, Kaptai. Some planted budum bets are also present in Salna Seed Orchard Research Station of Bangladesh Forest Research Institute. It is a high climbing rattan. But number of culms arise from the mother plant is very few. This species can easily be identified by it's boat shaped leaves and presence of cirrus-which is an exceptional character for *Calamus* genus. Stem stout, high climber, attaining more than 50 m in length. Stems with sheath 5-6 cm, without sheath 3-4 cm in diameter; internode 28-43 cm long. Leaf-sheath yellowish green to green, sparsely pubescent with brown hairs, tip blackish and base yellowish. sheath densely covered with very short, broad, whorled spines and a few very large, straight flat, solitary or whorled ones. Knee conspicuous. Ocrea papery, brown fragile when dry up. Leaves cirrate, 3-5 m long including petiole and cirrus; petiole short upto 30-35 cm long, cirrus 1-2 m long (cirrus not well developed in young leaves at seedling and wilding stage). Petiole armed with flat saccate spines (up to 1.5 cm long) on the back and margin, rachis sparsely covered with shorter spines but armed with clawed spines on the back, cirrus armed with clawed spines. Leaflets 24-30 on either side, clustered with one or two leaflets solitary towards the base, apical leaflets connate up to 12 cm; leaflets 46-60 x 5-12 cm. Leaves elliptic or elliptic-lanceolate, boat shaped, green glabrous on both surfaces, main veins 3-9 with many intermediaries, tip ciliate. Male and female inflorescence are superficially similar, 60-120 cm long with 6-10 alternate decompound, partial inflorescences; male much longer, upto 100 cm long; female up to 60 cm long;

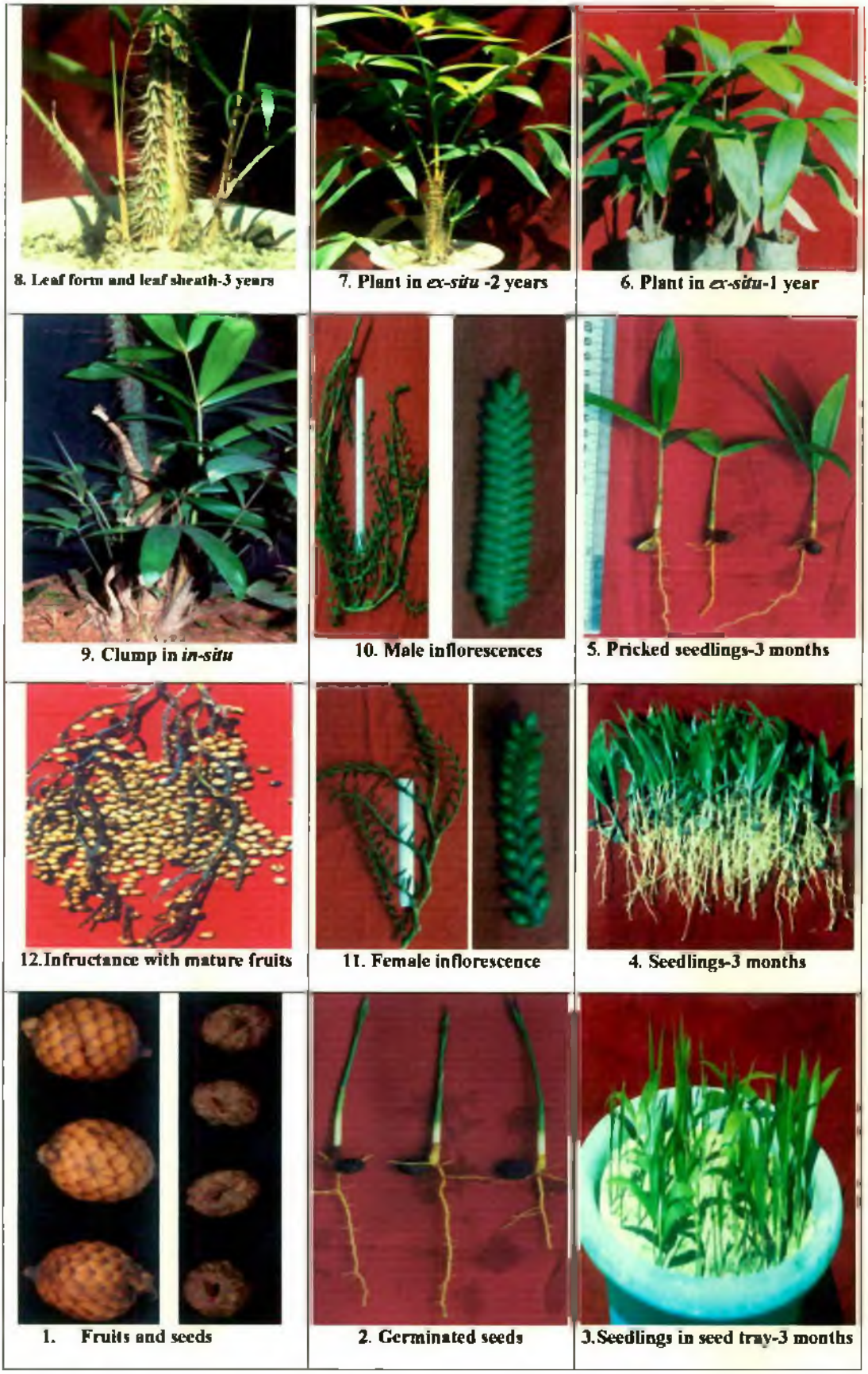


Plate 5: Photographs showing the major stages of life cycle of *Calamus latifolius*.

base of the partial inflorescence within the bract tube, primary bracts tubular with oblique mouth, armed with stout recurved spines; secondary bracts also tubular, less armed, mouth less oblique. Male flowers distichous on 5 cm long rachillae. Female flowers on rachillae upto 10 cm long. Fruit sessile, sub-globose, 1.5-1.9 x 1-1.8 cm apiculate, covered by vertical rows of scales; scales white with, faint longitudinal furrow, ripening uniformly, pulp acidic. Seed almost half convex, 1-1.5 x 0.9-1.0 cm, basal placentation, grooved and regularly wrinkled. Flowering: September-December. Fruit setting: October-March. Fruit ripening: April-July.

Calamus longisetus Griff. in *Calc. Journ. Nat. Hist.* 5, 36(1845), and *Palms of Brit. Ind.* 44,189 A. B (1850); *C. tigrinus* Kurz, *For. Fl. Brit. Burma*, 2: 519 (1877). Becc. in Hook. F. *Fl. Brit. Ind.* 6: 440. (1892) & in *Ann Roy. Bot. Gard.* Calcutta 11:134. 1908 & Appendix Pl. 9. 1913; Dransfield *A Manual of Rattans of Malay Penin. Malayan Forest Records 29*: 154. (1979). Basu and Basu, *RIC Bull.* 6 (3&4):7(1987); Alam and Basu, *Bono Biggyan Patrika* 17: 102-105 (1988).

Local name: Udom bet (Plate-6).

It is a very robust clustering to form dense clump in the dry hill slops of Teknaf, Cox's Bazar and Khadimnagar of Sylhet. It is a vulnerable species but confined to particular areas. Black long recurved semi-circular lined spines can easily identify this species. The clump is very compact. Many new culms arise from the mother plant but all of them cannot form stem. Eighty per cent of them remain as rosette.

Very robust clustering to form dense clumps; Stem with sheath 8-10 cm and without sheath 4-6 cm in diameter, internodes 12-37 cm long, leaf-sheath greenish-yellow, densely armed with 2.8-4.5 cm long, flat, blackish-brown reflexed spines with slender bristles in between in oblique semi-circular lines. Knee inconspicuous, sheath mouths oblique; ocrea fibrous; generally non-flagellate. Leaf ecirrate, 1.0-1.4 m long petiole; rachis and petiole yellowish, armed with flat black-brown yellow-based spines. Leaflets 40-50 on either side, grouped in 2-3 up to upper mid of the rachis, alternate or opposite towards the top, the two apical leaflets connate up to 1/3 of their length, 30-75x2-4.5 cm, green on both sides. Male and female inflorescence superficially similar, from the lateral side of the sheath mouth, flagelliform, up to 5 m long, partial inflorescence 5, alternate, branched up to 1m long, base of the partial inflorescence enclosed with in the bract tube. Male flowers densely disticous on rachillae up to 10 cm long. Female flowers on

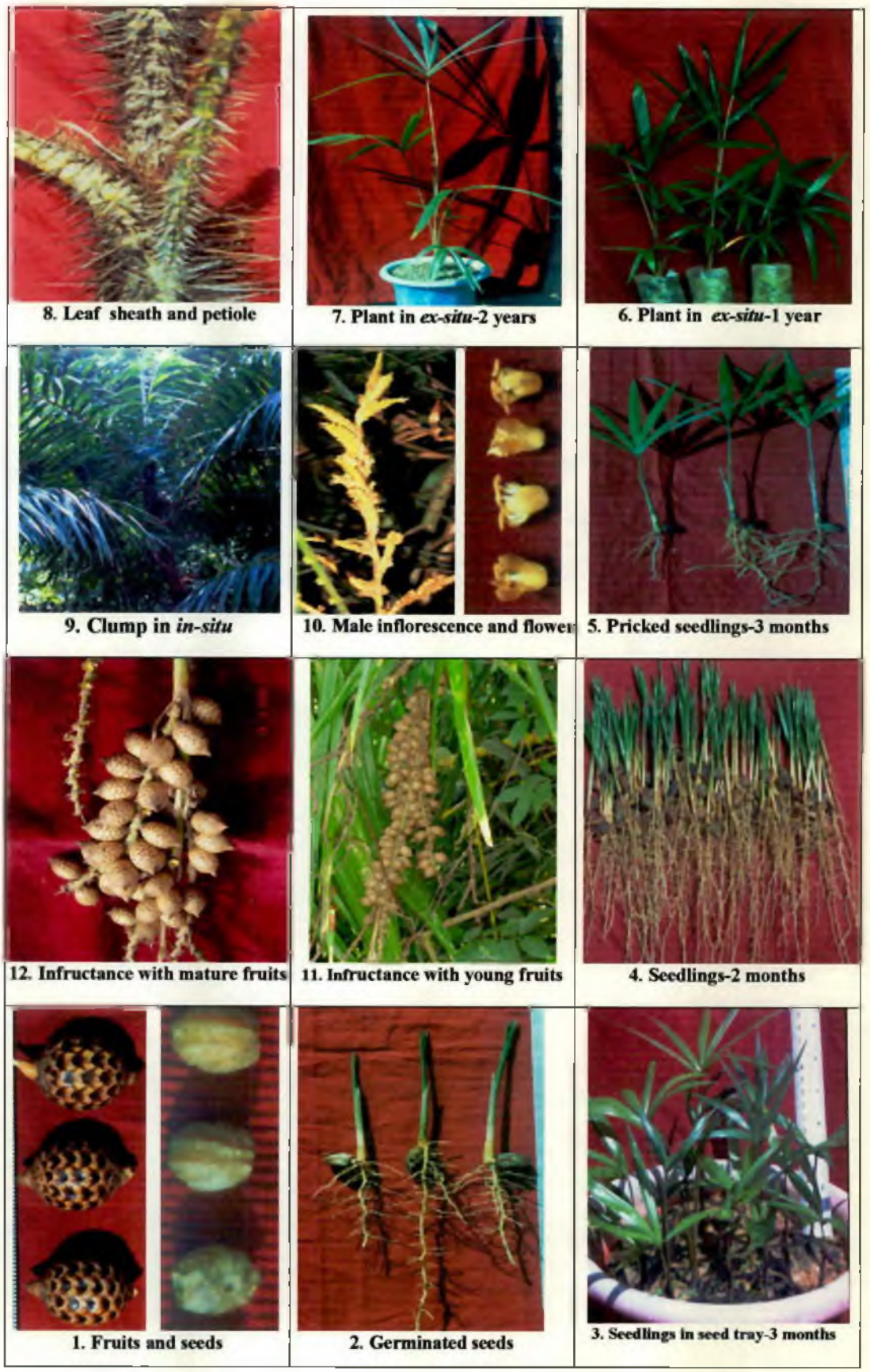


Plate 6: Photographs showing the major stages of life cycle of *Calamus longisetus*.

rachillae up to 15 cm long. Fruit sessile, 3-3.5 x 2-2.5 cm, ellipsoid-ovoid, covered by 12 vertical rows of spiny dark brown to blackish mottled flat scales, scales trapezoid, about 10x5 mm, transverse blackish band in the middle with conspicuous pale fringed margins, lacerated at the apex. Seeds about 1.8-2.6 x 101.5-1.8 mm, oblong-ovoid, light brown, longitudinally chanelled 5-7 costate; endosperm homogenous, embryo basal, seeds covered with dense silky fibers. Flowering: September-December. Fruit setting: October-April. Fruit ripening: May-August.

Calamus tenuis Roxb. *Fl. Ind.* 3, 780(1832); Hooker f. *Fl. Brit. Ind.* 6. 447 (1892) & *Ann. Roy. Bot.Gard.* Calcutta 11: 262. 1908 & Appendix Pl. 94. (1913).Kurz, *For. Fl. Brit Burma*,2:1099(1903); Brandis, *Ind. Trees*:652(1906); Blatter, *The Palms of Brit. India and Ceylon*:309,fig.41 (1928).

Local name: Jali bet (Plate-7).

It is the most common rattan species grows both in forest and village groves. It also grows by the sides of road, and edge of water. Generally, it grows well in marshy places. The clump of jali is loosely arranged. It is widely available in every district of the country either in forest or village. Leaves of this species are glossy deep green. New culms are stoloniferous and come out from ground far from the mother clump. Normally it grows in plain land and can live in water. Occasional forest fire kills the tree seedlings and other non-rhizomous plants while the underground rhizomes remain alive. During favorable conditions many new culms emerge from the living under ground rhizomes and form clump.

Clustering to form dense clumps, climbing, scandent, sometimes developing stolons from the base of the culm. Stem with sheath 1-2 cm and with out sheath 0.5-0.8 cm in diameter; internodes 12-15 cm long. Leaf-sheath glossy green with patches of deep brown or white brown pubescence, armed with irregular, flattened, horizontal, solitary spines up to 1.0 cm long with flattened base; knee conspicuous; sheath-mouth oblique; ocrea inconspicuous; flagella whipe like, slender, up to 120 cm long, armed with clawed recurved black spines. Leaves ecirrate, 40-100 cm long with petiole, petiole 5-10 cm long; rachis convex-trigonal, young rachis covered with rusty-brown floccose pubescence, armed with recurved black spines on the back, spines up to 5 mm long; leaflets 20-30 on either side, equidistant, alternate to opposite, 10-25 x 0.5-1.5 cm, linear, glossy green, polished, successively shorter towards the apex. Male and female

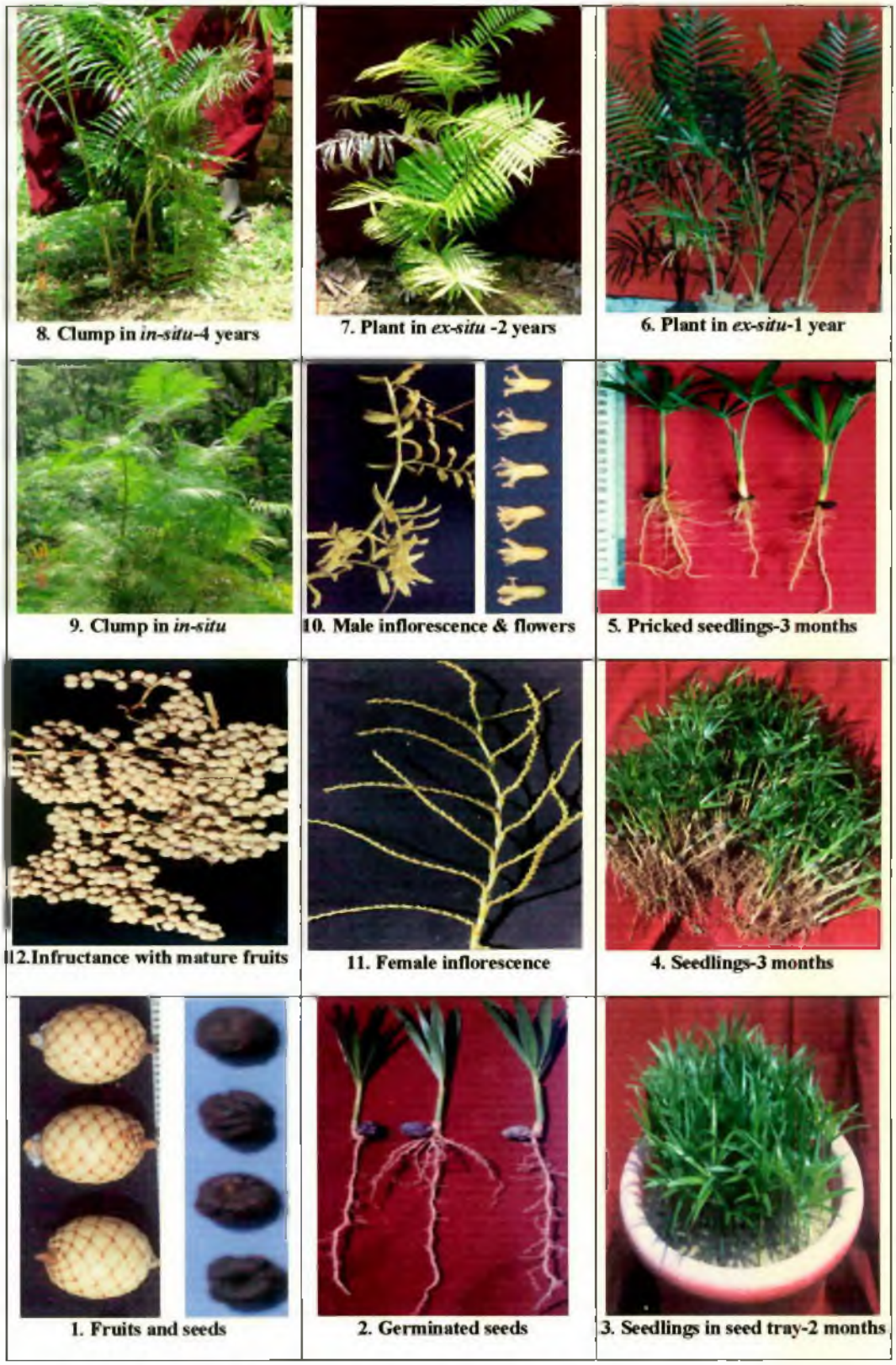


Plate 7: Photographs showing the major stages of life cycle of *Calamus tenuis*.

inflorescence superficially similar, peduncle enclosed with in the lateral side of the sheath, 1-2 m long, flagelliform with terminal flagellum, normally with 5-10 alternate recurved partial inflorescence, up to 40 cm long, enclosed at base by the tubular bracts, 15-25 cm long. Male flowers in rachillae up to 8 cm long, with distichous flowers; flowers about 3mm long. Female flowers on rachillae up to 5 cm long with distichous flowers, about 3 mm long, corolla tube split more than half way. Fruit straw, coloured stalked, 13-15 x 10-12 mm, oblong-ellipsoid with solid beak, 15-17 vertical rows of scales with shallow median channels. Seeds 7-8 x 5 mm, covered with greenish, acidic sarcotesta, subglobose, flattened on one side and convex on the other, surface ruminates with irregular channels, a deep germpore at the middle of the flattened side. Flowering: July-November; Fruit setting: August-March, Fruit ripening: April-July.

Calamus travencoricus Bedd. Hook. f. *Fl. Brit. Ind.*6: 452 (1893); Becc. in *Ann. Roy. Bot. Gard.* Calcutta 11: 95, 310.(1908), & Appendix Pl. 121. (1913). Brandis, *Ind. Trees* 653.(1906).

Local name: Noli bet (Plate-8).

It is a species confined to Ampupara, Bandarban. It is a new record for Bangladesh, which is discovered during this study. It can easily be identified by its loosely arranged culms. In the lower part of matured culms there is no spines or very little spines are present. At the top portion of stem there is broad-based spines on sheath. Leaves are grouped and irregular on rachis.

Stem very slender, clustered and climbing in nature. Stem 15 m or more in length; diameter with sheath 1.0-1.2 cm and without sheath 0.8 cm; internode 22-45 cm long; sheath dull green with floccose at young part, armed with spines of 0.5 cm long, mouth of the sheath with longer spines of 1 cm long; knee small; ocrea inconspicuous. Leaf about 45 cm long, ecirrate, petiole 11-15 cm, armed with small spines; rachis armed with recurved spines; flagella 0.8-1.0 m; leaflets grouped into 31-40 in number, opposite to alternate, linear in shape: inflorescence, tubular, about 1 m long, partial inflorescence 4-10 in number and 10-12 cm long; fruit stalked, orange in colour, 3.0-3.7 x 2.0-2.1 cm, oblong, 15-17 vertical rows of scales. Seed 2.0-2.5 x 1.2-1.6 cm, acidic sarcotesta, elliptic in shape, flattened on one side and convex on the other, a deep germpore at the middle of the flattened side. Flowering: July-September; Fruit setting: August-February and Fruit ripening: March-May.

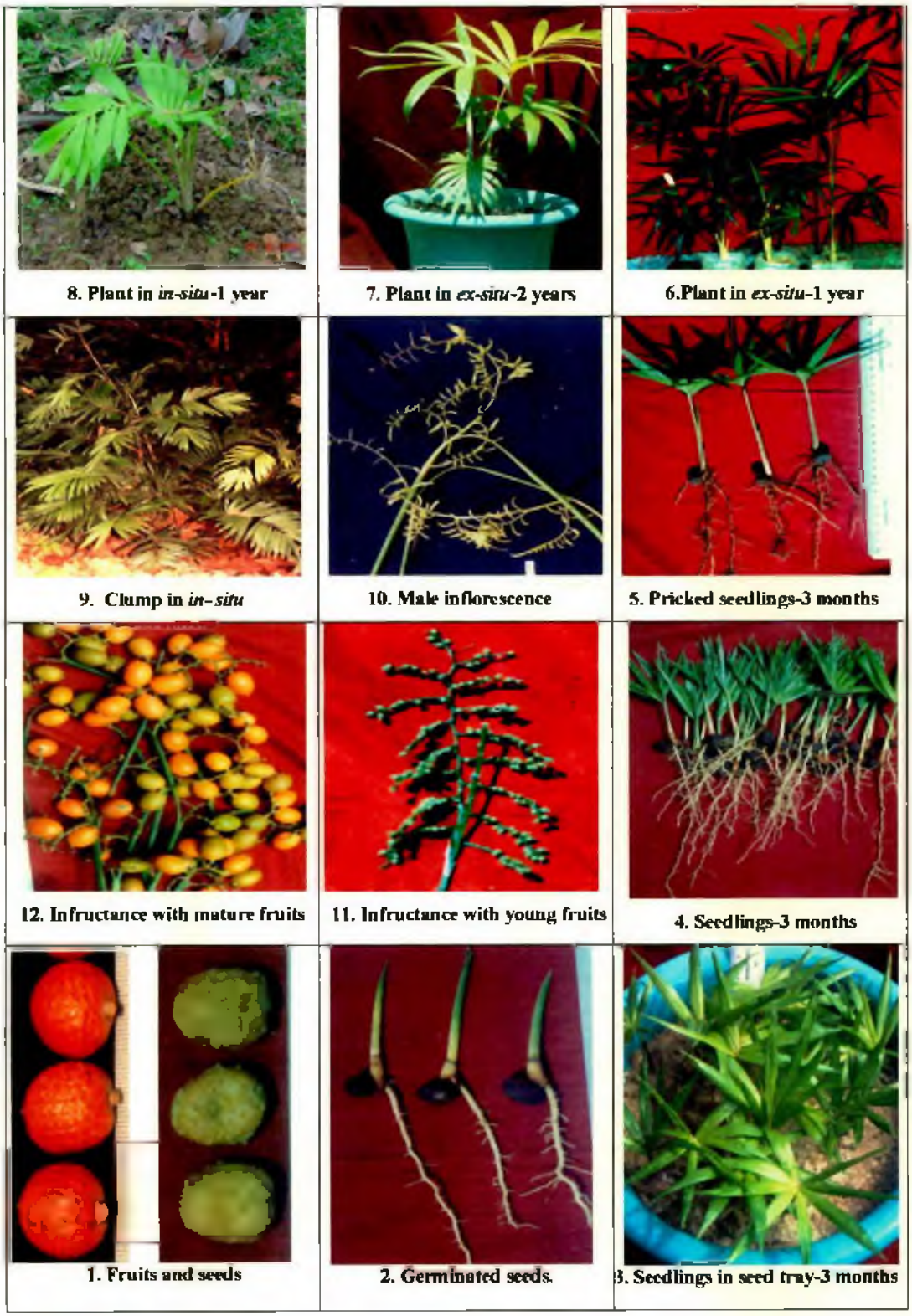


Plate 8 :Photographs showing the major stages of life cycle of *Calamus travencoricus*.

Calamus viminalis Willd. Sp. Pl.2 (1): 203, var. *fasciculatus*(Rox). Becc. ex. Hook. f. *Fl. Brit. Ind.*6. 444(1892).Prain, *Beng. Plants* 2:1099 (1903); Brandies, *Ind. Trees*: 652 (1906); Blatter, *The Palms of Brit. India and Celon*: 302 (1926).Becc. in *Ann. Roy. Bot. Gard.* Calcutta 11:310. (1908), & Appendix Pl. 121. (1918).

Local name: Boro bet, Kerak bet (Plate-9).

It is clustering to form dense clumps, scrambling forming thickets in open ground and can climb with support. This species is available both in semi-deciduous and semi-evergreen forest in dry hill slopes of Chittagong, Cox's Bazar, Sylhet, Hill Tracts and village thickets in Dhaka, Gazipur, Tangail, Mymensingh and northern districts. In hill tracts all most all tribal people plant some (5-10 no.) rattans for their house holed use. In tribal area not a single family was found without rattan plant. This species is cultivated by Forest Department in different districts (Sylhet, Tangail, Mymensingh, Chittagong, Dhaka and Chittagong Hill tracts of the country.

Clustering to form dense clumps, scrambling forming thickets in open ground, climbing with support. Stem with sheath 3-4 cm and without sheath about 1.5 cm in diameter, internodes 9-15 cm long. Leaf-sheath white-floccose, dull green, armed with irregular, flattened horizontal spines up to 2.5 cm long, spines solitary or in small series; knee conspicuous, sheath-mouth oblique; ocrea inconspicuous; flagella 3-5 m long, whipe like, slender, base enclosed in the leaf-sheath, armed with light yellowish-green, recovered spines up to 2 cm long. Leaves 90-120 cm long; petiole short to up to 15 cm long; rachis densely floccose when young, thinly or sparsely floccose when mature. Leaflets many, not in one plane of regular intervals, from solitary to grouped in 2-4; 20-25 x 1.5-2.0 cm, linear, dull-green, densely floccose when young, upper surface glabrous in old leaves and lower surface thinly floccose. Male and female inflorescence superficially similar, flagelliform, 1.0-1.5 m long with terminal flagellum, peduncle enclosed within the lateral side of the leaf-sheath, with 4-10 alternate partial inflorescence, male partial inflorescence up to 20 cm and female ones up to 25 cm long, enclosed at base by tubular bracts. Male flowers on rachillae up to 12 cm long, lower ones generally longer, flowers distichous. Female flowers on rachillae up to 15 cm long; flowers distichous. Fruit light green, 1 x 1cm, supported by the remains of sepals and petals, roundish, apiculate at the tip, with trifid stigma, covered by 15 vertical rows of light yellow scales shallowly channeled. Seed one in each fruit, erect, subglobose, somewhat flattened on one side and convex on the other. Flowering: twice in a year: March-May and September-November.

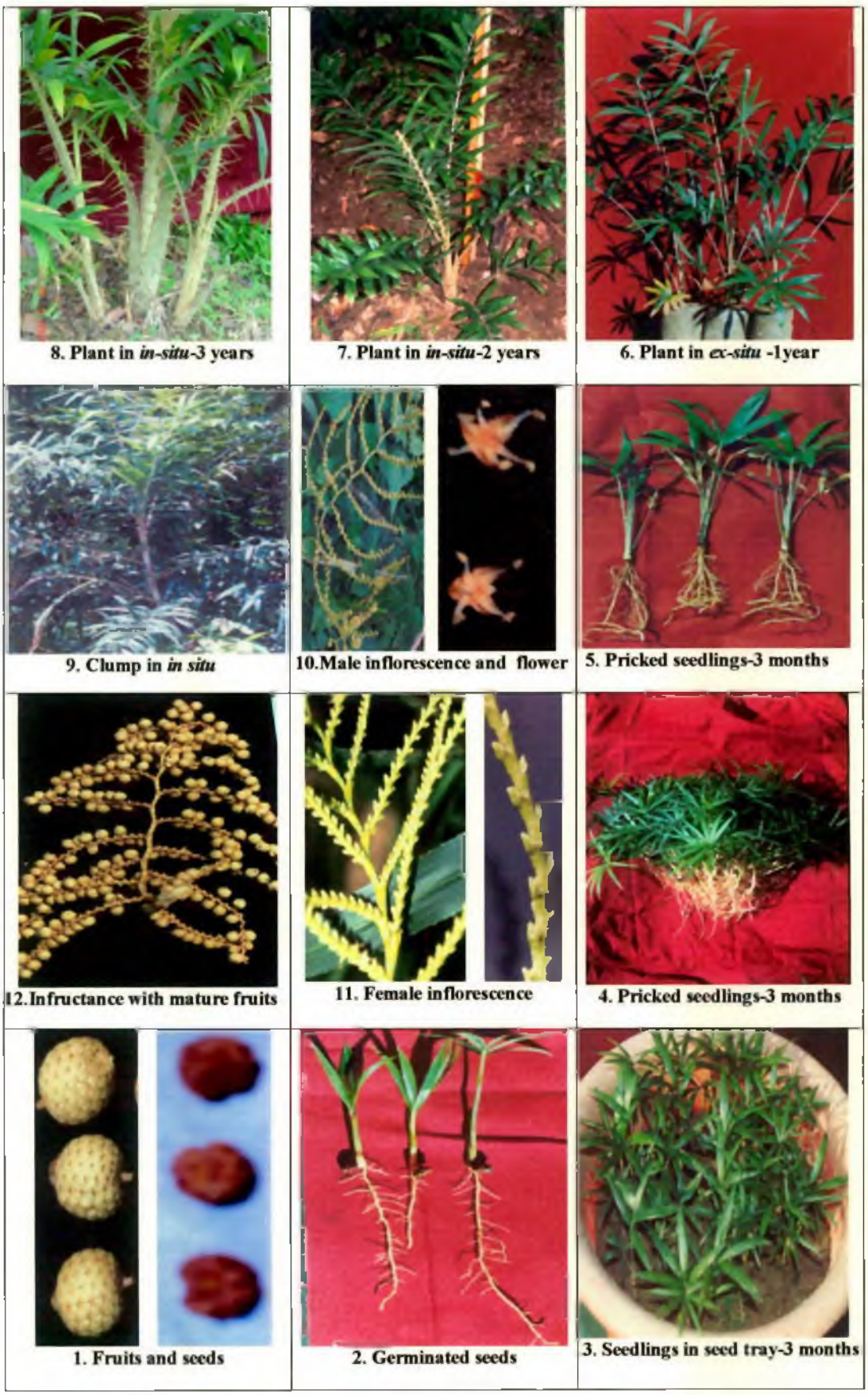


Plate 9: Photographs showing the major stages of life cycle of *Calamus viminalis*.

Fruiting Apri-July and October-December.Fruit ripening: August-October and February April.

Daemonorops jenkinsiana (Griff.) Mart. *Hist. Nat. Palm.* 3:327.(1853); Becc. in Hook. *F. Fl. Brit. Ind.* 6:462. (1893) & in *Ann. Roy. Bot. Gard.* Calcutta 12:41. (1911) Pl. 1. part II. (1911). Griff. in *Calc. Journ. Nat. Hist.* 5, 81. (1845).Prain, *Beng. Plants*,2: 1100 (1903); Brandies, *Ind. Trees*: 650 (1906). *Palms of British East India* :89(1850).Blater, *The Palms of British India and Ceylon*:333(1926).

Local name: Golla bet (Plate-10).

It is one of the common rattan present in the forest of Chittagong, Chittagong Hill Tracts and Sylhet. It grows in moist hill slopes and base of the hill and plains of evergreen forests. It is a high climber clustering dense clump. It is the only species under this genus available in Bangladesh. The culm of this species is very compact. Many new culms arise from the mother plant. But 20-25 per cent of these culms become successful to form stem and climb up and rest of the culm remain rosette.

Clustering to from dense clumps, high climbing 30-45 cm long; stem with sheaths 4-6cm in diameter and without sheath 2.5-4.0 cm in diameter; internodes 16-43 cm long. Leaf-sheath dull green to brown, covered with flattened, slender, conical, deflexed spines upto 3 cm long, either in oblique semi-circular lines or irregular, dense, young parts grey pubescent; knee conspicuous, sheath mouth oblique; ocrea inconspicuous. Leaves cirrate; 3-5 m long including the cirrus; petiole 30-40 cm, armed with deflexed stout spines; rachis planoconvex-anglar, convex on the back, armed on the back and along the margin with recurved stout spines, spines solitary up to middle. Leaflet numerous, about 100 (sometimes more) on the either side, alternate, equidistant, 50-60 x 1.2-1.5 cm, leaner-oblong with long, slender, acuminate tips, successively shorter towards the apex. Male and female inflorescence superficially similar, more or less erect, up to 50-60 cm long, 15 cm wide; bracts in boat shaped, all bracts enclosed within the outermost bract, opening along their length to expose the flowers, no flowering branch within the outer bract; bract are gradually smaller from outer to inner. Male flowers about 5mm long, dense on zig-zig rachillae. Female flowers about 5 mm long on a spreading zig-zig rachillae. Fruit yellowish brown, supported by the remains of sepals and petals, 1.8-2 x 1.5-1.8 cm, rounded, crowned at the tip by the trifid stigma, covered by 18 vertical rows of yellowish-brown scales; scales deeply channeled. Seeds covered by thin sweetish-sourer

Plate 10: Photographs showing the major stages of life cycle of *Daemonorops jenkinsiana*.

sarcotesta, about 1.2-1.5 x 1-1.3 cm, wider than long, sub-globose, embryo basal. Flowering: July-November; Fruit setting: August-May; Fruit ripening: June-September.

Taxonomy key of rattans of Bangladesh

Key to genera

Bracts tubular, persistent, partial inflorescence not within the bracts — *Calamus*

Bracts open, boat shaped, all secondary bracts with the partial inflorescence enclosed by the primary bract ..... — *Daemonorops*

Key to species

1a. Leaf-sheath flagellate or leaf rachis cirrate 2

1b. Leaf-sheath not flagellate or leaf rachis not cirrate 9

2a. Leaf-sheath flagellate 3

2b. Leaf rachis cirrate 8

3.a.Stem 3-4 cm with sheath, pale green in colour; leaf-sheath thickly covered with long broad based sharp recurved spines; rachis and young leaflets floccose; leaflets irregular, grouped into 3-9..... *C.viminalis* var. *fasciculatus*

3.b. Stem diameter 1.0-2.5 cm with sheath, rachis and young leaflets not floccose..... 4

4.a. Stem diameter with sheath 1.0-1.2 cm; leaf-sheath dull green, covered with short broad based spines in one vertical row; leaflets deflected from rachis in one plane, leaflet 24-30 cm long and 10-15mm broad; grouped in to 3-7..... *C.travencoricus*

4.b. Leaf-sheath deep green covered with horizontal spines crowded with smaller spines..... 5

5.a. Stem diameter with sheath 1.0-1.5 cm; leaf-sheath thickly covered with long thin black straight spines; ocrea hairy; short petiole, leaflets oblanceolate, inequidistant, uppermost leaflets digitate about 4 in number, each 42-55 cm long and 1.0-1.5 mm broad, terminal leaflets connate at base; one third of the leaflet is attached at base; grouped into 3-5..... *C.gracilis*

5.b. Slender broad based horizontal spines are associated with smaller spines on the leaf-sheath; no hairy projection on ocrea; leaflets

regular..... 6

6.a. Stem diameter with sheath 1.7-2.5 cm, ocrea distinct and lacerated. *C.guruba*

6.b. Stem diameter with sheath 2-3 cm, slender horizontal spines not crowded with smaller spines on the leaf-sheath; ocrea indistinct, not membranous not lacerated..... 7

7.a. Diameter with sheath 2-2.5 cm; leaf sheath armed with small, broad based spines in rows, joined at base, leaflets glossy and regular, knee conspicuous..... *C.tenuis*

7.b. Stem diameter with sheath 1.5-2.0 cm, young leaf rachis covered by rusty indumentums; leaf sheath covered with small tuberculate spines, leaflets broadly lanceolate, inequidistant on rachis, terminal leaflets slightly attached at base, grouped into 6-10..... *C.acanthospathus*

8.a. Diameter with sheath 5-6 cm, leaf-sheath with strongly recurved spines; leaflets interrupted, alternately clustered in (one or two leaflets solitary towards base), 4-5 cm wide, glabrous on both surfaces, ocrea papery; leaflets boat shaped..... *C.latifolius*

8.b. Diameter with sheath 6-8 cm, leaf-sheath with numerous black flat and recurved spine; leaflets not interrupted, regularly arranged, alternate, equidistant, upto 2 cm wide, inflorescence non-pendulous covered with boat shaped spath; ocrea inconspicuous, young leaf red in colour..... *D.jenkinsiana*

9.a. Stem erect, diameter with sheath 11-15cm; ocrea very large extending more than 30 cm along the petiole margin, split and bifurcate at the top hispid; leaflets equidistant, assorted yellow spines on petiole in whorl..... *C.erectus*

9.b. Stem diameter with sheath 8-10 cm; leaf sheath covered with numerous black flat spines in row, ocrea fibrous; leaflets grouped in 3-5 up to the upper mid of the rachis, fruit tiger striped..... *C.longisetus*

Legend: Modified after Alam(1990) and Basu (1992).

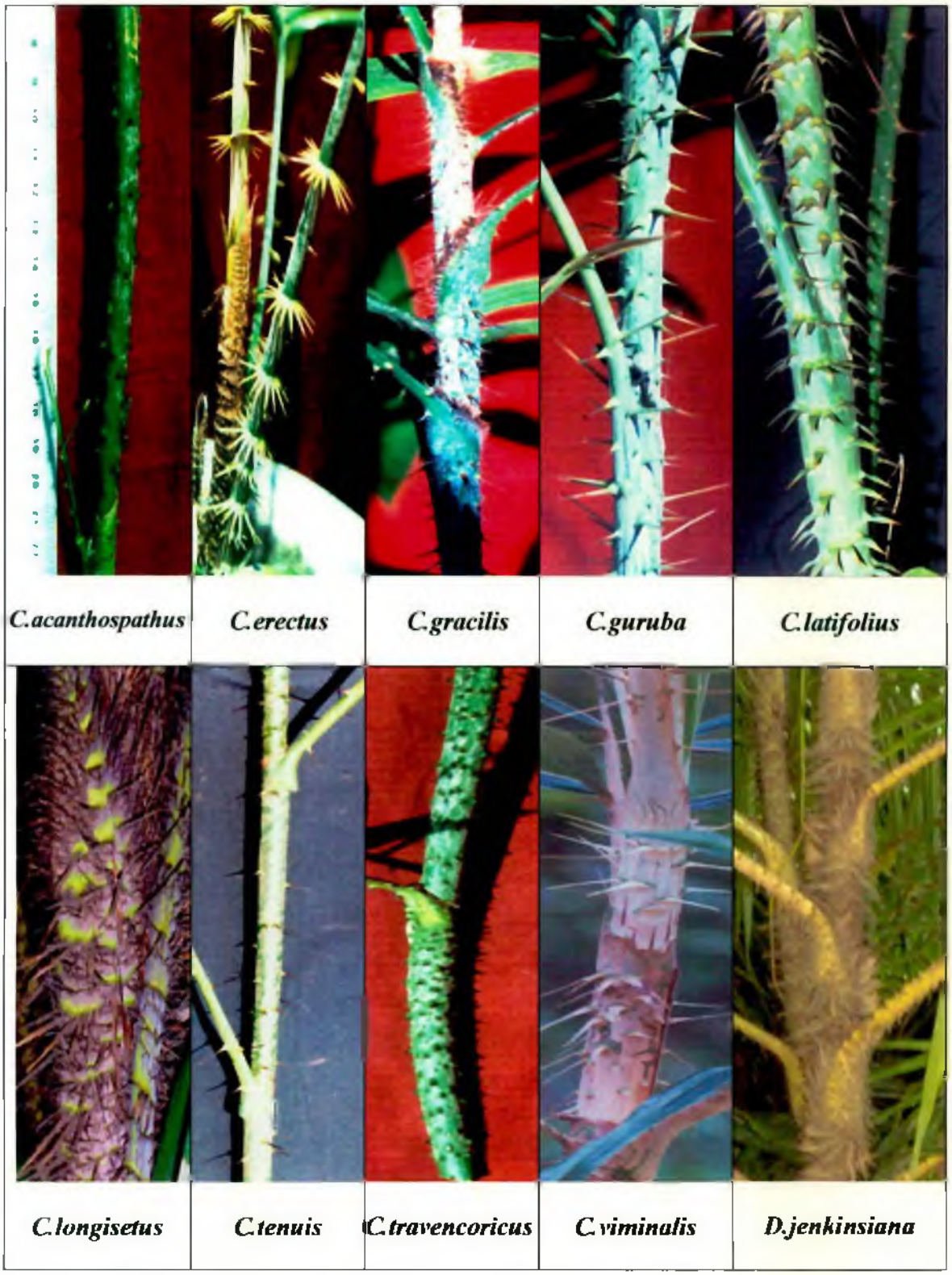


Plate 11 : Photograph showing arrangement of spines on leaf sheath-culm in ten rattan species of Bangladesh.

1.Seedlings of *C.travencoricus*

2. Suckers of *C.latifolius*

3. Rhizome of *C.tenuis*

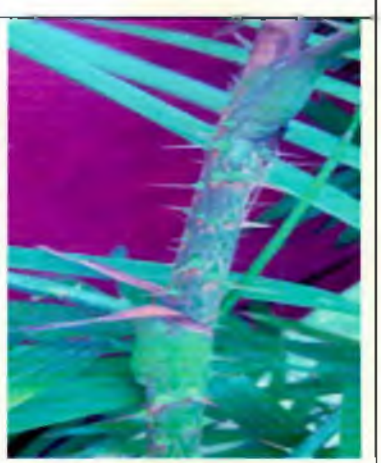
4. Wildings of *C.viminalis*

5. Aerial vegetative shoots of *C.erectus*

6. Multiple tip shoots in *C.acanthospathus*

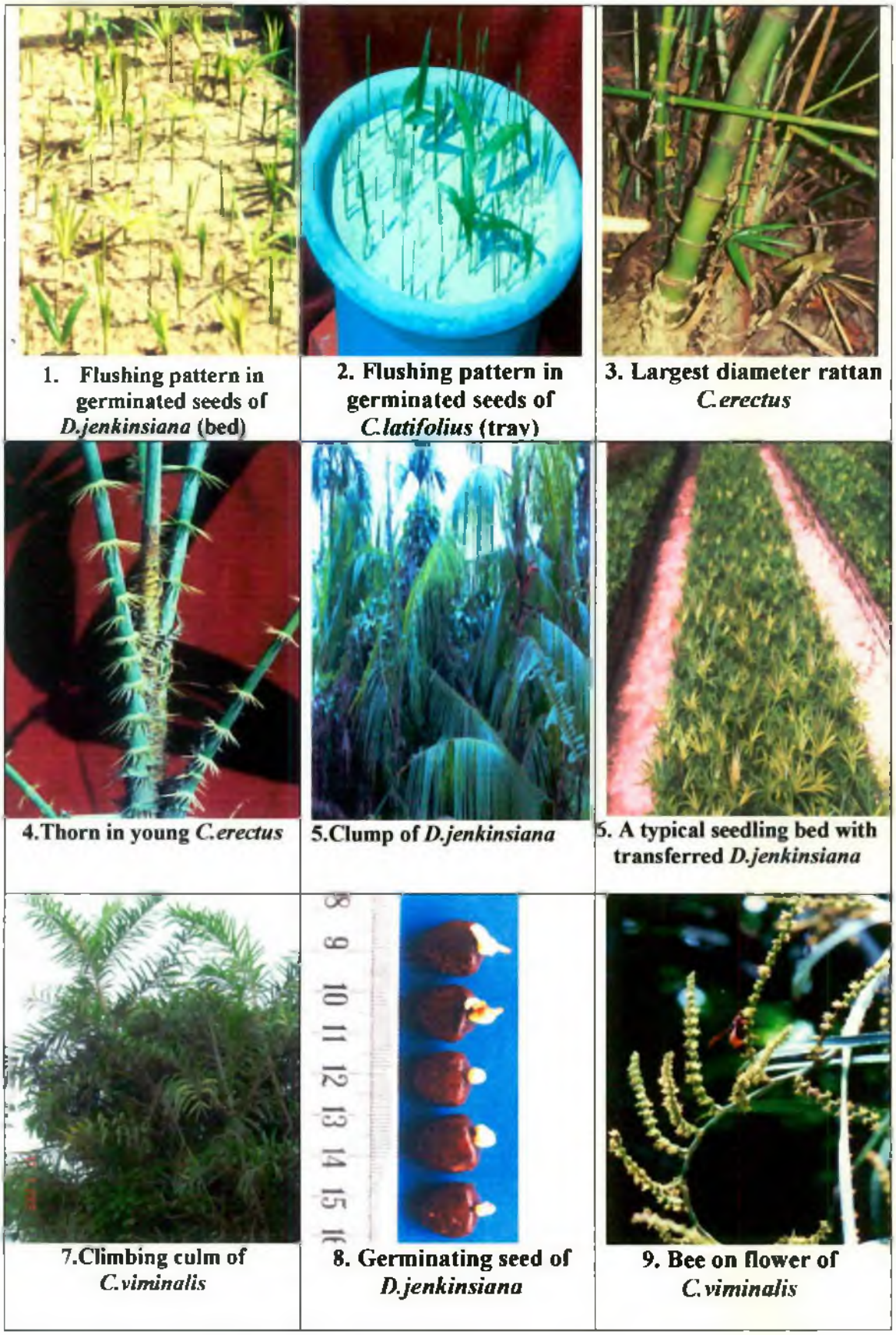
7. Flagella of *C.viminalis*

8. Hairy ocrea of *C.gracilis*



9. Prominent knee of *C.guruba*

Plate12a: Photographs showing all sorts of propagules (sucker, rhizome, seedling and wilding) flagellum, ocrea and knee of rattans.



1. Flushing pattern in germinated seeds of *D.jenkinsiana* (bed)

2. Flushing pattern in germinated seeds of *C.latifolius* (tray)

3. Largest diameter rattan *C.erectus*

4.Thorn in young *C.erectus*

5.Clump of *D.jenkinsiana*

6. A typical seedling bed with transferred *D.jenkinsiana*

7.Climbing culm of *C.viminalis*

8. Germinating seed of *D.jenkinsiana*

9. Bee on flower of *C.viminalis*

Plate 12b: Photographs showing some features of rattans of Bangladesh.

Fruits of *C.acanthospathus*

Fruits of *C.erectus*

Fruits of *C.gracilis*

Fruits of *C.guruba*

Fruits of *C.latifolius*

Fruits of *C.longisetus*

Fruits of *C.tenuis*

Fruits of *C.travencoricus*

Fruits of *C.viminalis*

Fruits of *D.jenkinsiana*

Plate 13 : Photographs showing the morphological variation of mature fructance and fruits of ten recorded rattan species of Bangladesh.

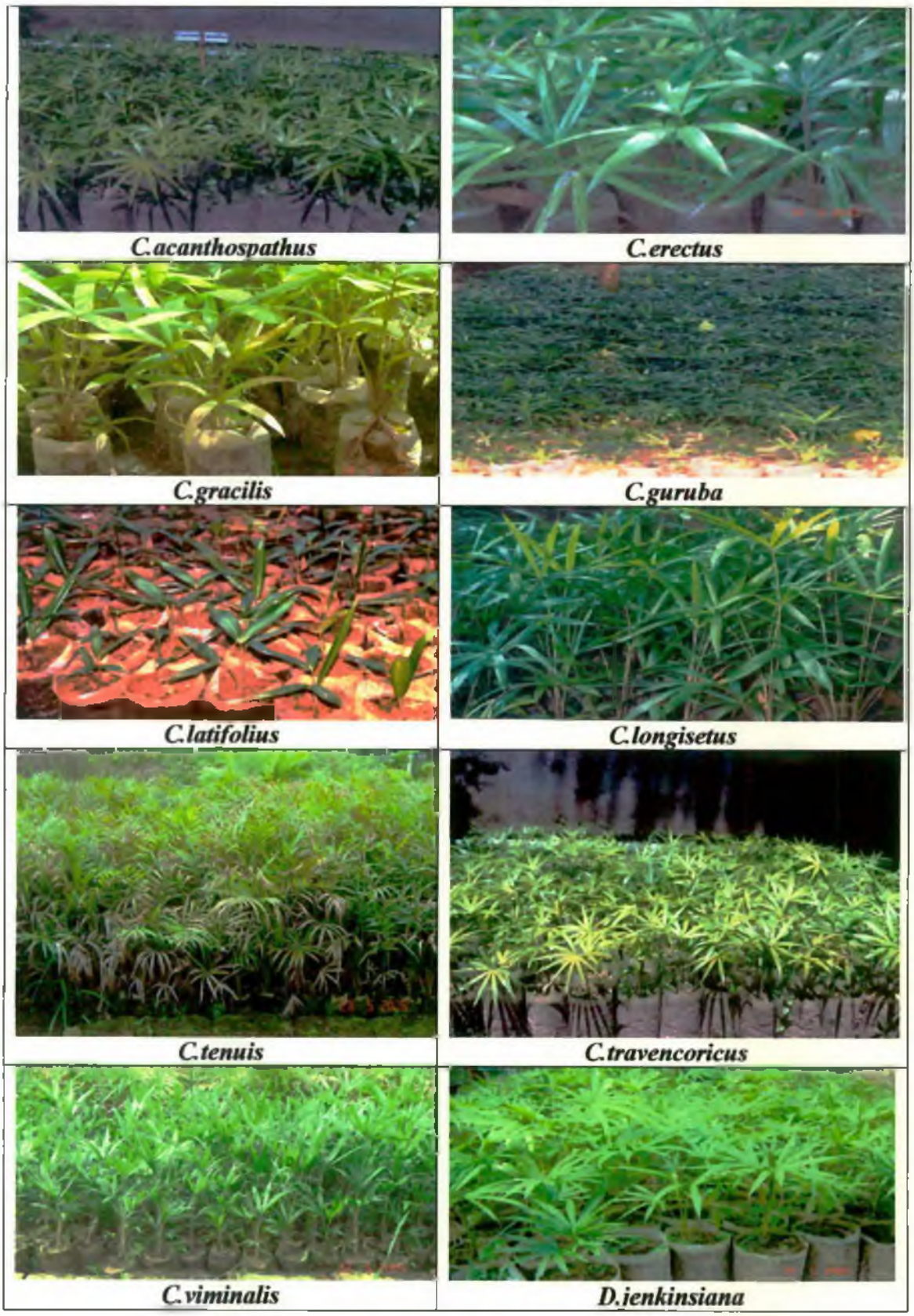


Plate 14 : Photographs showing the morphological variations in seedlings of (six-ten months old) ten recorded rattan species of Bangladesh.

5.3. Past and present records of rattan species and their reconciliation on the occurrence and distribution status in Bangladesh : Literature review reveal that Beccari (1913) was the first man who worked on the rattans of Bengal (Table-13 and 14). A major part of which is now under Bangladesh. Beccari (1913) mentioned that nearly 20 rattan species used to be available in the then Bengal. Later on Blatter (1926) made a report of 11 rattan species from the then Bengal. No report on rattan species of this geographical zone is available in literature until 1984. After liberation Wong (1984) worked on rattans of Bangladesh and reported 9 rattan species to record from Bangladesh. Alam (1990) reported 11 rattan species to be occurred in Bangladesh. But he prepared a checklist of 10 species and compiled taxonomic description of only 7 species with facts and figure. He could not have recorded four rattan species *viz. C.flagellum, C.floribundus, C.gracilis* and *C.quinquenervius* from anywhere of Bangladesh. Alam and Khan (2003) reported again11 rattan species to be available in Bangladesh. While Dransfield (2002) remarked that there must be more than 7 rattan species in Bangladesh. Nuruzzaman (2003) and Ali (2004) made two separate country reports on rattan species and mentioned the name of 13 and 11 rattan species as mentioned in Table-13 and 14. Lastly, Ara (2005) investigated the occurrence and distribution of present rattan species of Bangladesh and recorded 10 rattan species. Where one species belongs to genus *Daemonorops* and rest 9 species are under the genus *Calamus*. It is revealed that 7 rattan species *e.g. C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* and *D.jenkinsiana* are found common in all the above mentioned reports of the rattans of Bangladesh except Hooker (1894) and Wong (1984). Where Hooker reported about five (without *C.latifolius* and *C.longisetus*) and Wong reported about six (without *C.longisetus*) of those seven common species. Rest of the species *viz. C.flagellum, C. floribundus, C.quinquenervius, C.jenkinsianus, C.gracilis, C.rotentum, C.giminalis* and *C.rotang* were not common in the reports of all workers. One of the authority of world rattans like Dransfield (2002) remarked that there must be more than 7 common species in inaccessible areas of Chittagong Hill Tracts (CHT) where the workers could not have explored due to the Government restriction for political unrest. Military support and assistance was needed to explore that area which was not possible. The information as shown in Table-13 and 14 indicate that a total of fifteen rattan species consisting of 2 genera *viz. Calamus* and *Daemonorops* have been reported to occur in Bangladesh since 1984. A comparative statement, to reconcile the conflict on the occurrence of rattan

Table 13 : Reconciliation on the occurrences and present status of rattan species in rattan growing forest divisions of Bangladesh.

Name of worker	Year of publication	No. of reported species	Political boundary	Name of species recorded and reported	
				Common species recorded and exist in Bangladesh	Species reported to occur
Hooker, J.D.	1894	9	Bengal	*C.erectus, C guruba, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.flagellum, C.quinquenervius, C.floribundus, C.gracilis*
Beccari, O.*	1913	20	Bengal	*C.erectus, C.guruba, C latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.acanthospathus, C.flagellum, C.floribundus, C.giminalis, C.gracilis, C.jenkinsiana, C.khasianus, C.leptospadix, C.littoralis,C.quinquenervius, C.rotentum, C.rotang, C.travencoricus*
Blatter, E.	1926	11	Bengal	*C erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.floribundus, C.flagellum, C.gracilis, C.quinquinervius*
Wong, K.M.*	1984	9	Bangladesh	*C.erectus, C guruba, C.latifolius, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C floribundus, C.flagellum, C.gracilis*
Chowdhury,M.R.	1984	14	Bangladesh	*C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.gracilis, C.giminalis, C.jenkinsiana, C.rotentum, C.rotang, C.quinquenervius*
Alam,M.K.*	1990	11	Bangladesh	*C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.flagellum, C.floribundus, C.gracilis, C.quinquenervius*
Basu,S.K.*.	1991	7	Bangladesh	*C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C viminalis* var. *fasciculatus, D.jenkinsiana*	-
Dransfield,J.*	2002	7	Bangladesh	*C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	Several more
Alam, M.K. and Khan, S.U.	2003	11	Bangladesh	*C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.flagellum, C.floribundus, C.gracilis, C.quinquenervius*
Zaman, M.N.*	2003	13	Bangladesh	*C.erectus, C.guruba, C latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D jenkinsiana*	*C.gracilis, C.giminalis, C.jenkinsiana, C.rotentum, C.rotang, C.quinquenervius*
Ali,S.S.*	2004	11	Bangladesh	*C.erectus, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis* var. *fasciculatus, D.jenkinsiana*	*C.flagellum, C floribundus, C.gracilis, C.quinquenervius*
Ara,R.	2005	10	Bangladesh	*C.acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.travencoricus, C.viminalis* var. *fasciculatus, D.jenkinsiana*	-

Legend : * Marked workers made report on the basis of their record and reports of the previous workers published in different Journals particularly referring to "Palms of British India".

Table 14 : Past and present records / reports of rattan species in Bangladesh.

Name of worker	Year of publn.	Number of species reported	Observed areas	Name of species	
				Past records	Present record
Hooker, J.D.	1894	9	Bengal	-	-
Beccari, O.	1913	20(nearly)	Bengal	-	-
Blatter, E.	1926	11	Bengal	-	-
Wong, K.M.	1984	9	Bangladesh	*C.erectus*	*C.erectus*
Chowdhury, M.R.	1984	14	Bangladesh	*C.guruba*	*C.guruba*
Alam, M.K.	1990	11	Bangladesh	*C.latifolius*	*C.latifolius*
Basu, S.K.	1991	7	Bangladesh	*C.longisetus*	*C.longisetus*
Dransfield, J.	2002	7 + more	Bangladesh	*C.tenuis*	*C.tenuis*
Alam, M.K and Khan, S. U.	2002	11	Bangladesh	*C.viminalis*	*C.viminalis*
				D.jenkinsiana	*D.jenkinsiana*
Zaman, M. N.	2003	13	Bangladesh	*C.gracilis*	*C.gracilis*
Ali, S. S.	2004	11	Bangladesh	-	*C.acanthospathus*
Ara, R.	2005	10	Bangladesh	-	*C.travencoricus*
				C.flagellum	-
				C.floribundus	-
				C.quinquenervius	-
				C.jenkinsianus	-
				C.rotentum	-
				C.gimnalis	-
				C.rotang	-

species in eight previous reports of rattans of Bangladesh, reveal that 7 species are common where the other eight species were different with workers. It seems that most of the workers could not have recorded all the species mentioned in their reports. Perhaps they reported on the basis of their records and information served in different journals particularly referring to "Palms of British India". The present investigation continued for long five years and has recorded ten rattan species from rattan growing areas of Bangladesh where two species *viz. C.acanthospathus* and *C.travencoricus* are new records from Bangladesh and one more species *C.gracilis* is rediscovered one. Though *C.gracilis* was reported to occur somewhere in the then greater Chittagong. So, further investigation is needed to explore the lost rattan flora of Bangladesh.

5.4. Evaluation of exploitable clumps (~10-12 years) in selected sites and natural habitats of ten recorded rattan species of Bangladesh : The flowering age and season in recorded ten rattan species were found to vary with species. The data as shown in Table-15 exhibit that flowering age varied from 3-10 years. Earliest flowering age

Table 15 : Evaluation of exploitable clumps (~ 10-12 years) in selected sites and natural habitats of ten recorded rattan species of Bangladesh.

Species	Locations	Flowering age (yrs)	Exploitable culm. clump^{-1}						Average number of wildings m^{-2}
			Number	Diameter cm (with sheath)	Annual height increment,m	Internode no.	Internode length,cm	Total length ,m	
C.acanthospathus	Ampupara-Bandarban*	5±1	5±1	1.7±0.3	1.6±0.6	105±10.0	20.5±4.5	19.5±5.5	9.0±2.0
C.erectus	Ampupara-Bandarba, BFRI-Chittagong* Chandranath Pahar-Sitakunda Sitapahar-Kaptai	8±2	2±0.3	13±1.5	0.3±0.05	29.5±5.0	9.5±1.5	4.0±1.0	5.5±2.5
C.gracilis	Tilagar-Sylhet*	5±1	4±1	1.3±0.3	1.3±0.5	72.5±12.5	16.0±2.1	15.0±5.0	2.5±0.5
C.guruba	BFRI-Chittagong* Kalachara-Sreemangal Sader-Bandarban Lama-Bandarban Tilagar-Sylhet	5±1	9±2	2.1±0.4	1.6±0.5	51.0±9.0	20.0±4.1	19.5±6.5	10±1.0
C.latifolius	BFRI-Chittagong Ampupara-Bandarban, Salna-Gajipur*	7±1	3±0.9	5.5±0.5	2.7±0.6	200±20.0	21.0±3.5	35.5±7.5	2.5±0.5
C.longisetus	BFRI-Chittagong.* Khadimnagar-Sylhet Razarkul-Ramu Dulahazara-Cox's Bazar Ukhia-Cox's Bazar Teknaf-Cox's Bazar	7±1	3±0.9	9.0±1.0	1.4±0.5	41.0±9.0	24.5±5.5	16.5±3.5	2.5±0.5
C.tenuis	BFRI-Chittagong* Hathazari-Chittagong Keochia-Chittagong Kalachara-Sreemangal Tilagar-Sylhet	4±1	13±2	2.5±0.5	2.1±0.5	44.0±6.0	27.5±4.5	25.5±4.5	18.5±3.5
C.travencoricus	Ampupara-Bandarban*	4±1	4±1	1.1±0.1	1.9±0.3	116±6.0	20.5±3.5	23.0±5.0	8.0±2.0
C.viminalis	BFRI-Chittagong* Keochia-Chittagong Tilagar-Sylhet, Kalachara-Sreemangal Lawachara-Sreemangal, Salna-Gjipur	5±1	3±0.9	3.7±0.7	1.9±0.6	675±7.5	16.0±2.1	23.0±3.0	24.0±4.9
D.jenkinsiana	BFRI-Chittagong* Keochia-Chittagong Kelanga-Hobigonj Lawachara-Sreemangal Tilagar-Sylhet Rema-kelanga Hobigonj	5±1	7±2	5±1.2	3.1±0.5	121±11	19.5±3.2	37.5±7.5	21.0±9.0

Legend: Wildings were of 1-2 year o'd. Major data were collected from the clumps of * marked sites.

(4±1yr) was found to occur in *C.tenuis* and *C.travencoricus*. Longest flowering age (8±2yr) was found in *C.erectus*. Five species *viz. C.acanthospathus, C.gracilis, C.guruba, C.viminalis* and *D.jenkinsiana* were found to flower within 5±1 years; whilst two species *viz. C.latifolius* and *C.longisetus* were found to flower within 7±1 years. Manokaran (1982 and 1985b) also found that flowering age of *C.caesius, C.manan, C.trachycoleus* and *C.filipendulus* varied as 5.3, 5.0, 5.4 and 4.5 years respectively. It was observed that the male flower of every species occurred at least one year earlier than the female flower. Ahmad and Ghani (1987) observed that *C.manan* flowered five years after establishment and male flower occurred one year earlier than those of female flower. Renuka (1994) found that *C.rotang* and *C.hookerianus* in India started flowering from fourth year onwards. However, Alloysius (1997) reported that same species started flowering 5.25 years after seed germination and 3.42 years after planting in the field in Malaysia. From this it is revealed that flowering age of rattans may vary in the same species even in the same habitat due to genetical reasons. Exploitable age for different rattan varies from species to species. Sometimes, it also varies with sites. The result as shown in Table-15 and Figure-4 indicate that exploitable culm number varied with species, habitat and age of clump. A significant difference was found among the species ($F_{9,20}$=4.9; P<0.002). Highest number of exploitable culm was recorded in *C.tenuis* (13±2) and the lowest value was recorded in *C.erectus* (2±0.3). Badhwar *et al.* (1957) reported that a certain number of canes may be harvested after 5-6 years of growth depending on the species. He also mentioned that rattan comes in full bearing in 15 years time, during which they should have produced about 50 or more stem of average height of 24-33 m. Since, all the studied species of Bangladesh are cluster forming and produced stems of 1.7-15 in number depending on species at the age of 10-15 years and it was experienced that culm could be harvested at every 2-3 years interval. Stem diameter (with sheath) of ten recorded rattans also varied with species and habitats and the value ranged from 1.0-14.5 cm. Culm size was found to be very important in terms of their uses. Anatomical study of the culm was felt very necessary to evaluate the product value for their best utilization. But due to some limitations, the anatomical study of all species could not have continued and the findings of this study has not been presented here.

Annual height increments of recorded rattans were accounted significantly different amongst the species. Highest increment was found in *D.jenkinsiana* (3.1±0.5 m) and lowest in *C.erectus* (0.3±0.05 m). Similar result was found in case of total length of the

exploitable stem of each species. Adequate information was not yet available on appropriate harvesting age and cycle of all rattan species. Forest Department follows a cutting cycle of 5-7 years (ACF, per. comm.1999). The exploitable age for *C.tenuis, C.viminalis* and *D.jenkinsiana* was recommended by Siddiqi *et al.* (2000) as 6-8, 9-11 and 10-12 years respectively. Rest of the species are suggested to follow a cutting cycle of 6-7, 10-15, 6-8, 6-7, 10-12, 10-12 and 6-7 years for *C.acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus* and *C.travencoricus* respectively. Sharia and Sen (1990) mentioned that maximum number and length of stems of *C.tenuis* could be obtained from two years harvesting cycle in Assam. Siddiqi *et al.* (2000) reported that growth of rattan is related to species and locality. It is reported from India that one tenth of the standing stems could be harvested at every 2 or 3 years interval (Badhwar *et al.*1957; Bhat *et al.* 1989). The maturity period of naturally growing cane was believed to be five-year and a cutting cycle of six year was adopted (Troup 1921). Annual height increment was found significantly different ($F_{9,20}$=2.6; P<0.03) in recorded ten rattan species. Total number of internode culm^{-1} ranged from 24-220 and maximum number was counted in *C.latifolius* and minimum in *C.erectus*. While internode length ranged from 9.0-27.5 cm. Maximum value (27.5±4.5 cm) was recorded in *C.tenuis* and minimum value (9.5±1.5 cm) was recorded in *C.erectus*. Both internode number and internode length were recorded to vary with species, seasons, habitat and age (Figure-5). Total length of harvestable culm in studied clumps ranged from 3-45 m and average maximum length of culm was measured in *D.jenkinsiana* (37.7±7.5 m) and minimum in *C.erectus* (4±1 m). Price of rattan depends on length, maturity, colour and diameter. Where the diameter is mostly genetical. Wildings are important for natural propagation and increase of rattan resource (Basu 1992; Lakshmana 1993). Once the plantation is established, wildings of rattan species are found to grow under the clumps with different density. However, wildings were not always available under all the rattan clumps. The density of wildings varied depending on the species, location, age and size of the clumps. Average number of wildings m^{-2} was found maximum in *C.viminalis* (24±6.9 m^{-2}) and minimum in *C.gracilis, C.latifolius* and *C.longisetus* (2.5±0.6 m^{-2}). Rest of the studied species were found with average number of wildings m^{-2} and ranged from 21.0-5.5 m^{-2} (Figure-4). Siddiqi *et al.* (2000) recorded 100-300, 200-400 and 150-300 wildings clump^{1} under *C.tenuis, C.viminalis* and *D.jenkinsiana* respectively. They also reported that number of wildings varied depending on location, age and size of the clump.

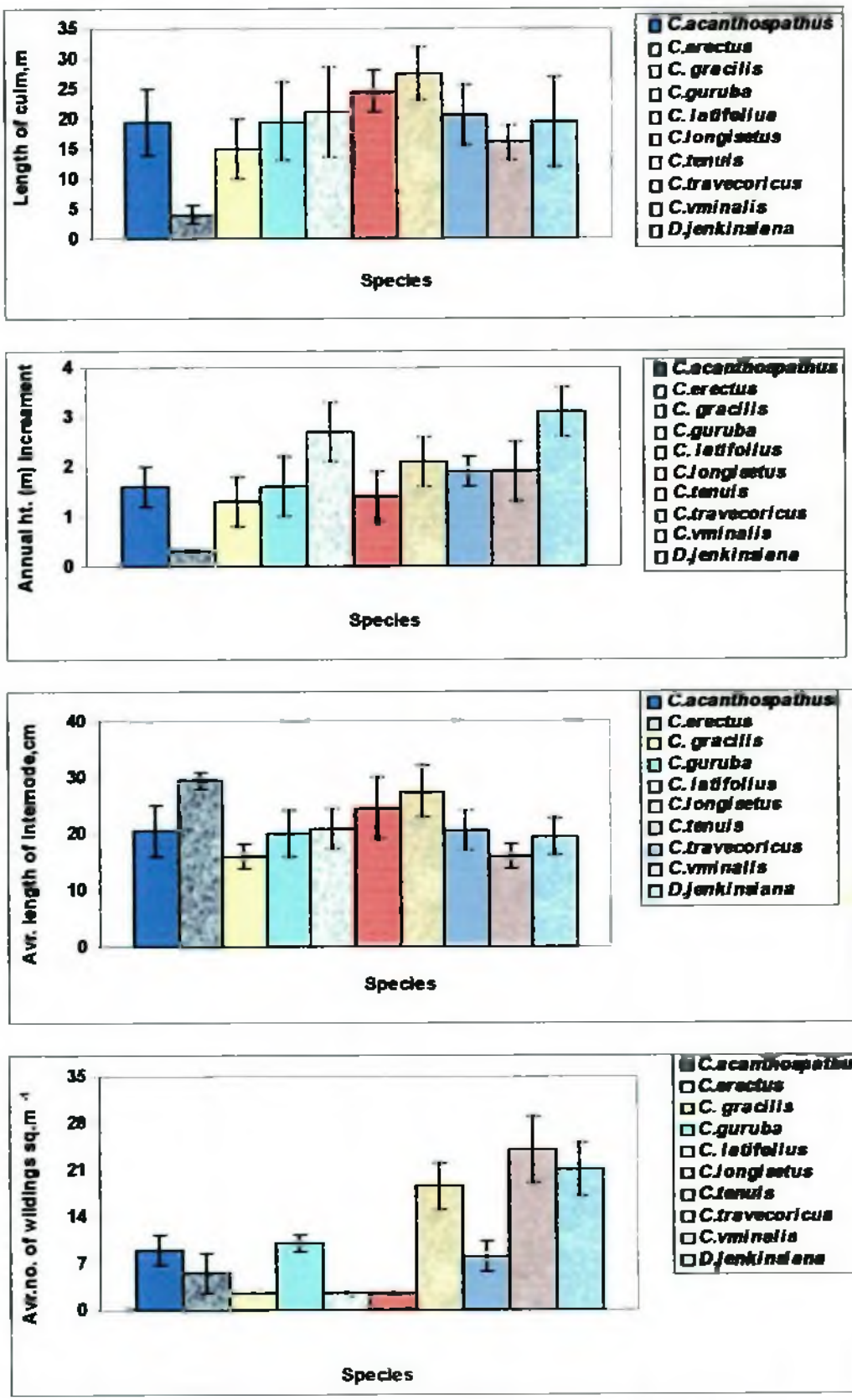
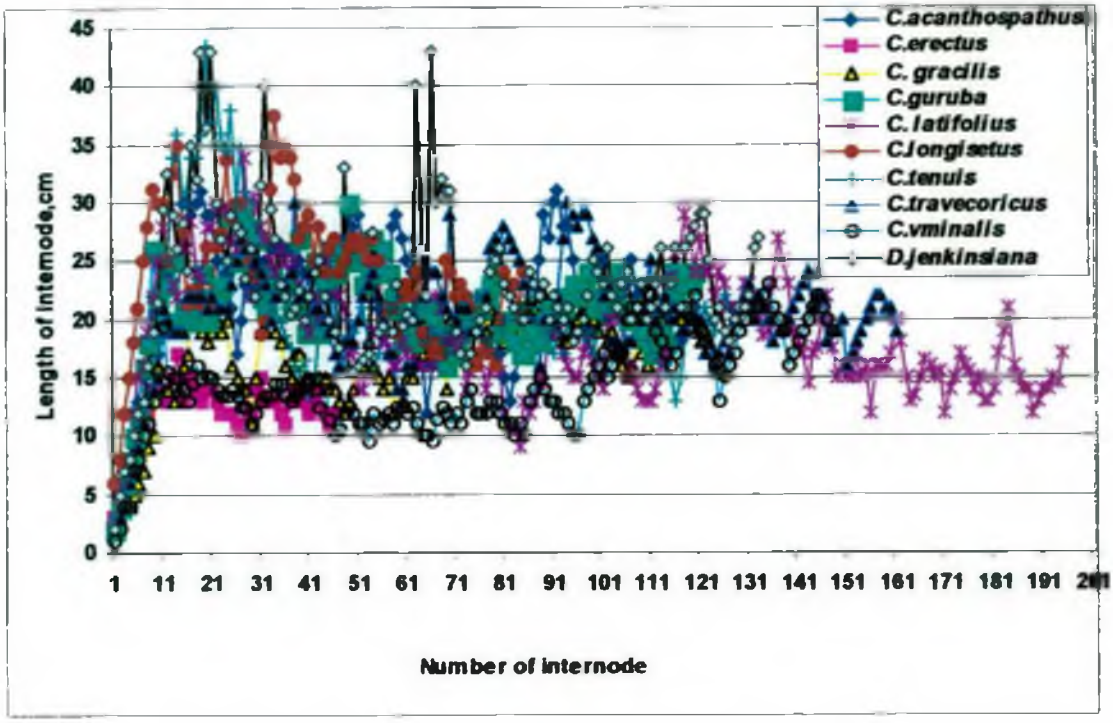


Figure 4 : Variation in average length of culm, annual height increment, length of internode and population of wilding in ten (~10-12 years old) rattan species of Bangladesh.



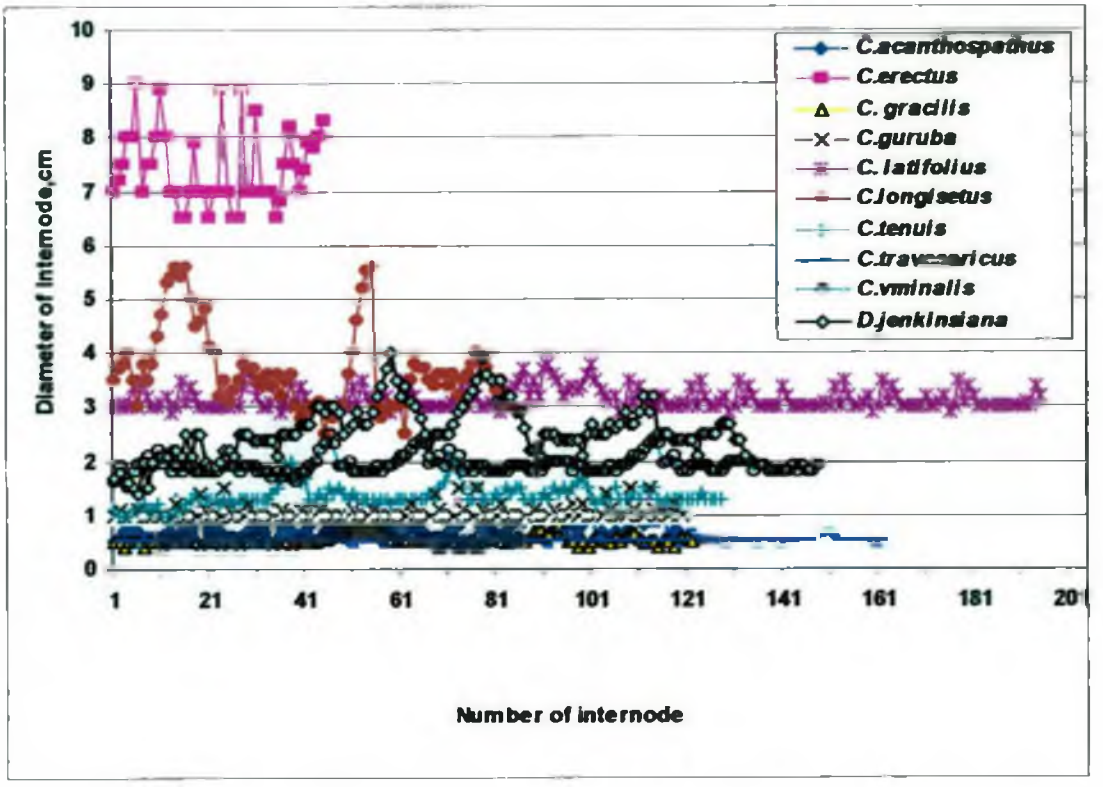


Figure 5 : Seasonal variation in length and diameter of internodes in ten (~ 10-12 years old) rattan species of Bangladesh.

It was noticed that number of first season wildings were more compared to two and three years old wildings. Very few wildings were found to get established in the form of clump.

5.5. Frequency of occurrence and population size of ten rattan species and existing supporting trees recorded in forty seven sites of RGFD of Bangladesh : The data as presented in Table-16 exhibit that the frequency of occurrence and population size of ten

Table 16: Frequency of occurrence and population size of ten recorded rattan species and existing supporting trees recorded in forty seven sites of RGFD of Bangladesh.

Name of rattan species	No.of sites in which sp occured	No. of sub-sites in which sp occured	Number of clump/site (range)	Number of culm/clump (range)	Name of major supporting trees observed in nature
C.acanthospathus	1	3	1-11	1-5	*Lannea coromandelica, Albizia lebbeck, Mangifera indica, Bursera serrata, Artocarpus locucha.*
C.erectus	4	8	1-18	1-5	No supporting tree
C.gracilis	1	4	1-32	2-9	*Michelia champaca, Tectona grandis, Dipterocarpus turbinatus, Shorea robusta.*
C.guruba	33	82	1-151	3-8	*S. robusta, Xylia dolibriformis, T. grandis, Casuarina equsitifolia, M. indica, L. coromandelica, Erythrina indica, C.fistula.*
C.latifolius	5	5	1-13	1-2	*Shorea robusta, Lennea cormandalica*
C.longisetus	9	27	1-17	1-4	*Lagerostromia speciosa, Albizia lebbeck.*
C.tenuis	45	129	1-270	5-11	*M. indica, C. fistula, Streblus asper, S. robusta, Erythrina indica, T.grandis, Acacia auriculiformis, Terminalia arjuna, F.bengalensis, Bambusa vulgaris.*
C.travencoricus	1	2	1-14	1-4	*Bursera serrata, Streblus asper, M. indica, L. coromandelica, Artocarpus chaplasha.*
C.viminalis	39	62	1-122	1-3	*T. grandis, Bambusa molluccana, L. coromandelica, Dipterocarpus turbinatus, A. auriculiformis, Bambusa longispaculata C. fistula, S. asper, Bambusa arundinacea,*
D.jenkinsiana	41	122	1-196	1-8	*Tectona grandis, Mangifera indica, Shorea robusta, Erythrina indica, Havea brasiliensis, L.coromandelica.*

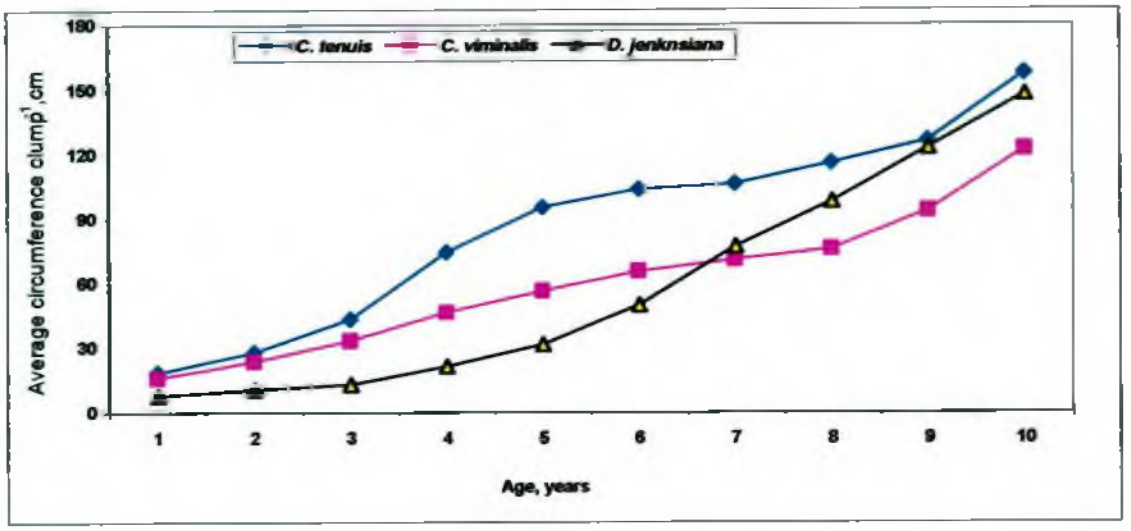
recorded rattan species varied with sites and sub-sites and ranged from 1- 45 sites and 2-129 sub-sites respectively amongst 47 sites and 155 sub-sites. *C.tenuis* was found to occur in maximum sites and sub-sites. *C.acanthospathus, C.gracilis* and *C.travencoricus* were found to occur only in 3, 4 and 2 sub-site respectively. While *C.erectus* and *C.latifolius* were found in 8 and 5 sub-sites under 4 and 5 sites respectively. Number of clumps per site was found highest (270) in *C.tenuis* and lowest (11) in *C.acnathospathus*. Rest of the species showed a variation in number of clumps from 13-196. Number of culm clump^{-1} ranged from 1-11. The maximum value (11 clump^{-1}) was found to occur in *C.tenuis* and minimum value (2 clump^{-1}) was counted in *C.latifolius*. It was noticed that a number of tree species were found to support rattan to climb up. Table-16 also exhibits that a total of 22 tree species were found to be favorite of rattan species irrespective to habitats in the study sub-sites. However, tree with rough bark, much branched with short clear bole are found to be preferable for support.

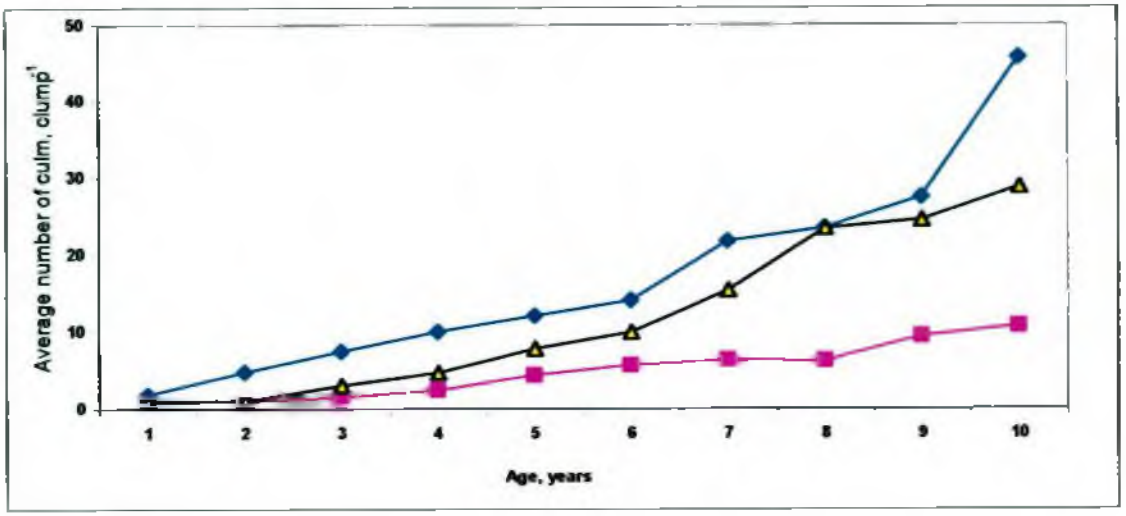
5.6. *In situ* growth performance of three common rattan species of ten different ages in seedling raised plantation grown as under growth in five studied RGFD of Bangladesh : The result as shown in Table-17 and Figure-6 reveal that clump expansion rate varied with species and age of the clump where *C.tenuis* was found to occupy more space compared to others (*C.viminalis* and *D.jenkinsiana*). After 6 years clumps expansion of *D.jenkinsiana* crossed those of *C.viminalis*. *C.tenuis* showed a sharp increase after three years (43.3±3.5 cm to74.3±10.3 cm) and it continued to expand up to six years (103.6±20.4 cm). A gradual expansion of the clump continued until the age of 10 years irrespective to species and habitat. Average number of shoots clump^{-1} was maximum in *C.tenuis* (45.6±6.7) and minimum in *C.viminalis* (5.2±0.8). Average number of shoot clump^{-1} in *C.tenuis* was recorded as 14 and 45 at six and ten years age respectively. Several scientists (Sharma and Choudhary 1987, Gulati and Sharma 1983) reported 30 shoots clump^{-1} in *C.tenuis* at six and 42 shoots at ten years of age, which is somewhat similar to the findings of present study (Figure-6). Number of shoot production in *C.viminalis* was minimum (5.2±0.8) compared to *C.tenuis* (45.6±6.7) and *D.jenkinsiana* (28.7±1.8). Wong (1984) stated that 5-4 stems clump^{-1} were found in *C.viminalis* at 6 and 8 years age in Bangladesh. An analysis of production of stem clump^{-1} in *C.viminalis* reveals that present finding is not comparable with Wong (1984) rather the lowered one.

Table 17: *In situ* growth performance of three common rattan species of ten different ages in seedling raised plantation of Forest Department grown as under growth in five studied forest divisions of Bangladesh.

Species	Locations	Supporting trees	Age of plantation (yr)	Mean circumference of clump, cm	Mean number of shoot, clump^{-1}	Mean height of main culm, m	Mean. diameter of main culm, cm
C. tenuis	Cox's Bazar Chittagong Tangail Dhaka Sylhet	*Acacia auricouliformis* *Anthocephalus chinensis* *Bombax ceiba* *Cassia siamea* *Lannea coromandelica* *Shorea robusta* *Tectona grandis,* *Terminalia arjuna* *Xylia doelabriformis*	1	18.5+1	1.85+0.23	0.8+0.3	-
			2	28+1	4.73+0.86	1.58+0.6	1.4+0.1
			3	43.3+3.5	7.48+1.75	2.48+0.6	1.4+0
			4	74.3+10.3	10.03+2.1	3.8+1.0	1.4+0.3
			5	95.3+17.2	12.08+2.25	4.6+1.3	1.4+0.1
			6	103.6+20.4	14.05+3.86	5.5+1.2	1.5+0.4
			7	106.2+15.6	21.75+2.36	6.5+1.4	1.6+0.1
			8	115.7+20.5	23.48+2.92	7.8+1.4	1.9+0.1
			9	126.1+20.6	27.48+5.24	10.28+1.1	2.1+0.1
			10	157.4+21.0	45.62+6.7	11.08+1.1	2.6+0.1
C. viminalis	Cox's Bazar Chittagong Tangail Dhaka Sylhet	*A. auricouliformis* *A. chinensis* *B. ceiba* *C. siamea* *L. coromandelica* *S. robusta* *T. arjuna*	1	16+4.5	1+0	0.57+0.1	-
			2	23.7+6.0	1+0	1.33+0.3	-
			3	33.3+7.8	1.0+0.2	2.60+0.3	2.2+0.2
			4	46.3+6.1	1.5+0.3	3.73+0.3	2.3+0.1
			5	56.3+8.5	2.1+0.7	4.73+0.3	2.5+0.3
			6	65.4+4.9	2.9+0.9	5.17+0.5	2.8+0.3
			7	70.8+13.6	3.4+0.9	6.60+0.4	3.2+0.3
			8	75.9+12.6	4.1+0.7	7.20+0.8	3.7+0.2
			9	93.7+13.8	4.8+0.7	9.80+1.3	3.9+0.2
			10	122.0+17.6	5.2+0.8	14.50+2.1	4.1+0.1
D. jenkinsiana	Cox's Bazar Chittagong Dhaka Tangail Sylhet	*A. auricouliformis* *A. chinensis* *B. ceiba* *L. coromandelica* *S. robusta* *T. grandis* *X. dolabriformis*	1	7.9+4.5	1+0	0.87+0.3	-
			2	16.7+6.5	1.03+0.1	2.13+0.3	-
			3	23.1+4.6	3.03+0.1	3.40+0.2	2.7+0.2
			4	31+5.7	47+0.4	4.90+0.1	2.8+0.2
			5	43.0+5.7	7.8+0.9	5.30+0.1	3.0+0.2
			6	56.3+12.4	9.93+1.2	6.70+0.3	3.5+0.2
			7	77.7+11.0	15.40+3.1	8.47+0.6	4.1+0.2
			8	98.07+7.9	23.40+2.5	13.43+2.8	4.7+0.3
			9	122.9+12.4	24.50+3.1	14.90+3.4	5.1+0.2
			10	147.7+15.1	28.73+1.8	16.13+3.8	5.7+0.1

Baharuddin and Ali (1981) noticed five suckers (shoot) per plant in *C.trachycoleus* in Malaysia. They mentioned that numbers of stems become double in every year for the first three years in *C.caesius* and for the first four years in *C.trachycoleus*. Soon and Momen (1985) also supported this. Shim (1989b) reported that *C.trachycoleus* might produce up to 30 canes clump^{-1} from rhizome grown clumps by the third year. Mean height of main culm uniformly increased with age in all species irrespective to habitat. Height increment of main culm was maximum in *D.jenkinsiana* (16.1±3.9 m) followed by *C.viminalis* (14.5±2.0 m) and *C.tenuis* (11.1±1.1 m). Mean annual height increment of *C.tenuis, C.viminalis* and *D.jenkinsiana* were calculated as 1.1±0.1 m, 1.4±0.2 m and





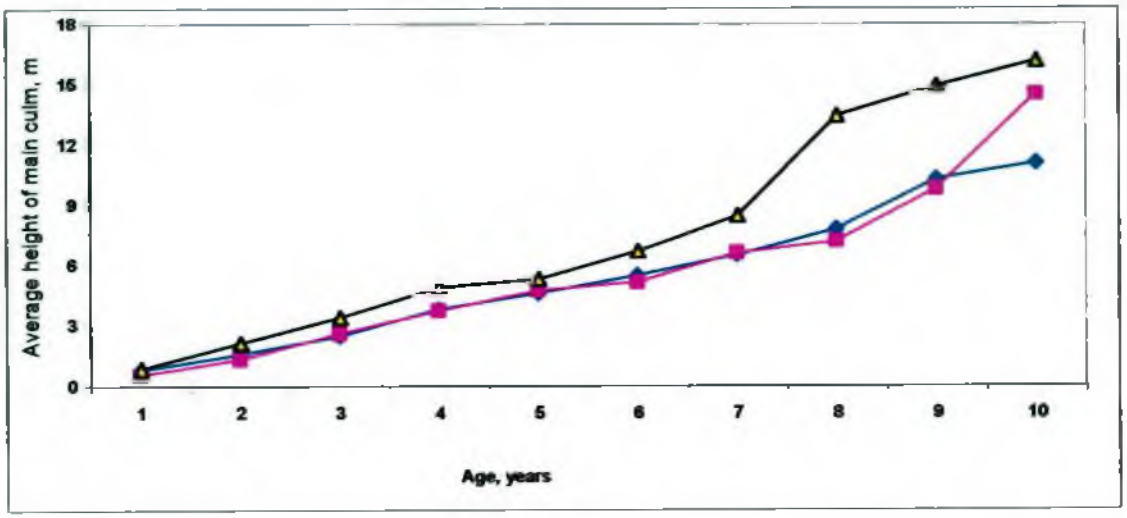


Figure 6: ***In situ*** **growth performance of three common rattan species of ten different ages in seedling raised plantation of Forest Department in five rattan growing forest divisions of Bangladesh.**

1.6±0.4 m year^{-1} respectively (Table-17, Figure-6). Average diameter of main culm in *C.tenuis, C.viminalis* and *D.jenkinsiana* were measured as 2.6±0.1, 4.7±0.1 and 5.7±0.1 cm respectively (Table-17). Biswas and Dayal (1995) reported maximum height of 14.5 m for *C.tenuis* at 10 years age which is a higher value compared to the present findings. Manokaran (1980) reported that *C.caesius* can grow as much as 5-6 m year^{-1} for the first 5 years. However, Dransfield (1988) reported that *C.manan* increased in height up to 7 m year^{-1} in Malaysia. Aminuddin (1985) and Manokaran (1982) observed culm height increment of 5-6 m year^{-1} in *C.caesius*, 1.3 m year^{-1} for *C.trachycoleus* and 11 cm year^{-1} for *C.scipionum*. Manokaran (1985b) and Xu (1985,1989) reported that mean height of culm year^{-1} in *C.caesius* and *C.scipionum* was found as 1.9 m year^{-1} and 0.1 m year^{-1} respectively. Vongkaluang (1988) found that *Plectomia pierreana* and *C.caesius* grow 2.4 m and 0.45 m year^{-1} respectively. Manokaran (1985a) remarked that stem elongation is continuous but variable with periods. However, Manokaran (1977) reported that *C.manan* was grown about 30 m at 9 years age after planting. Sunderland and Dransfield (2002) noticed that *C.caesius, C.egregius, C.hainanesis, C.manan, C.scipionum, C.tetradactylus, C.trachycoleus* and *D.jenkinsiana* could attain a height increment of 2.9-5.6, 0.8, 3.5, 1.2, 1.0, 2.3, 5.0, 2.0-2.5 m year^{-1} respectively. Manokaran (1985a) again reported that height increment of culm in *C.manan, C.caesius, C.trachycoleus* and *C.scipionus* were measured as 1.2 m year^{-1}, 5.6 m year^{-1}, 3 m year^{-1} and 1 m year^{-1} respectively in Malaysia. It is evident that the height increment of culm depends on habitat conditions in addition to genetical make up of species.

5.7. *In situ* growth performance of three common rattan species (up to five years of age) in seedling raised trial plantations of three different habitats in south east of Bangladesh : The result as shown in Table-18 and Figure-7 exhibit that growth parameters *viz.* circumference of clump, number of culm, height of culm, number of node and number of flagella clump^{-1} increased with the increase of age irrespective to species and habitat. The difference in mean height (cm) after 5 years among the species was found highly significant ($F_{2,6}$=11.54; P<0.009). Maximum height was recorded in *D.jenkinsiana* (536±17.1 cm) and minimum in *C.viminalis* (40±17.5 cm). The difference in the number of shoots with species was found significant ($F_{2,6}$=6.12; P<0.035). LSD value indicate that height of culms and number of shoots clump^{-1} in *C.tenuis, C.viminalis* and *D.jenkinsiana*

were different and can be ranked as *D.jenkinsiana*<*C.tenuis*< *C.viminalis* for height increment and *C.tenuis*< *C.viminalis*< *D.jenkinsiana* for number of shoots clump^{-1}.

Table 18 : *In situ* growth performance of three common rattan species (up to five years of age) in seedling raised trial plantations of three different habitats in south east of Bangladesh.

Species	Location	Age (yrs)	Mean circumference clump^{-1},cm	Mean number of culm clump^{-1}	Mean height of culms clump^{-1},cm	Mean number of node clump^{-1}	Mean number of flagella/ cirrus clump^{-1}
C.tenuis	Chittagong University Dulahazara Hinguli	1	20±9	2.0±0	35±4	7±0.8	-
		2	42±8	2.3±0.2	134±9.5	12±1.2	1.3±0.2
		3	51±10	3.0±0.1	249±11.6	22±2.5	4.7±0.7
		4	96±14	3.0±0.1	365±18.1	31±2.7	9.0±1.2
		5	128±20	3.7±0.2	520±21.1	42±4	13.7±1.2
C.viminalis		1	15±5	0.0±0.0	49±4.8	4±0.4	-
		2	24±7	0.3±0.2	118±7.7	7±0.4	-
		3	29±8	1.3±0.2	212±13.1	11±1.1	3.8±0.4
		4	49±10	1.7±0.2	312±20.5	16±1.2	5.1±0.7
		5	61±30	3.0±0.1	402±17.5	19±1.3	9.7±1.1
D.jenkinsiana		1	12±3	1.7±0.1	72±2.4	3±0.4	-
		2	19±8	2.0±0.1	160±10.1	8±0.5	-
		3	29±9	2.0±0.1	287±12.6	12±0.8	2.8±0.7
		4	42±14	2.3±0.2	440±14.4	15±1	4.0±0.8
		5	53±40	3.0±0.1	536±17.1	19±1.3	5.0±0.6

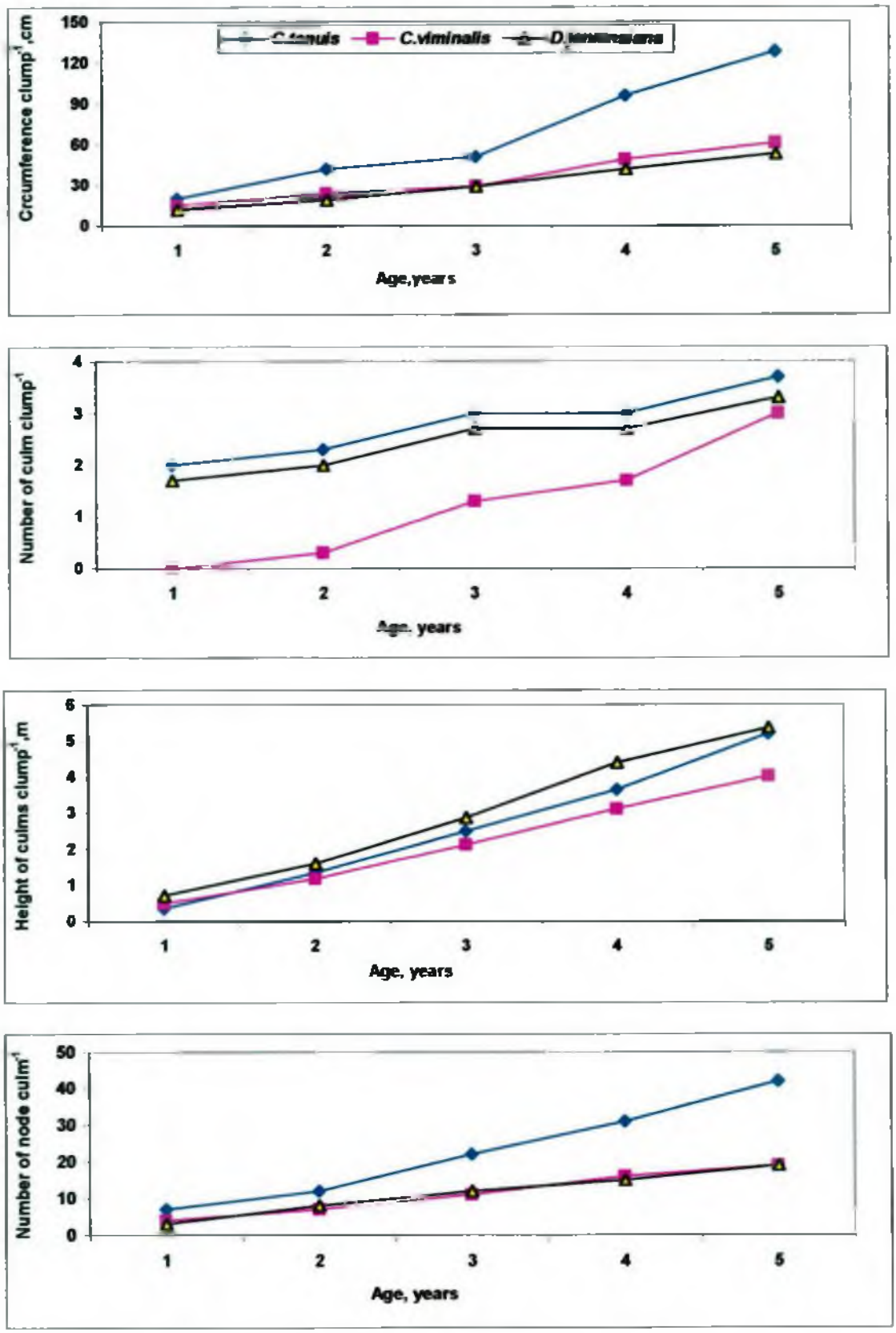


Figure 7 : ***In situ*** **growth performance of three common rattan species (up to five years of age) in seedling raised trial plantations of three different habitats in south east of Bangladesh.**

5.8. Natality, mortality, rosette, culm formation of emerged shoots and increase of height of main culm in ten rattan species (up to five years of age) of selected sites and natural habitats of Bangladesh : The result as shown in Appendix-8.4 and Figure-8 exhibit that all rattan produced new shoots every year. Rate of shoot emergence varied with species, seasons and habitat. Usually shoot emergence started in early monsoon and ceased in late monsoon in all species at all habitats. Number of emerged shoot varied from 0.8-2.8 clump^{-1} species^{-1} year^{-1}. On the basis of shoot emergence rattan species can be ranked as *C.tenuis*> *D.jenkinsiana*> *C.guruba*> *C.latifolius*> *C.longisetus*> *C.travencoricus*> *C.viminalis*> *C.acanthospathus*> *C.gracilis*> *C.erectus*.

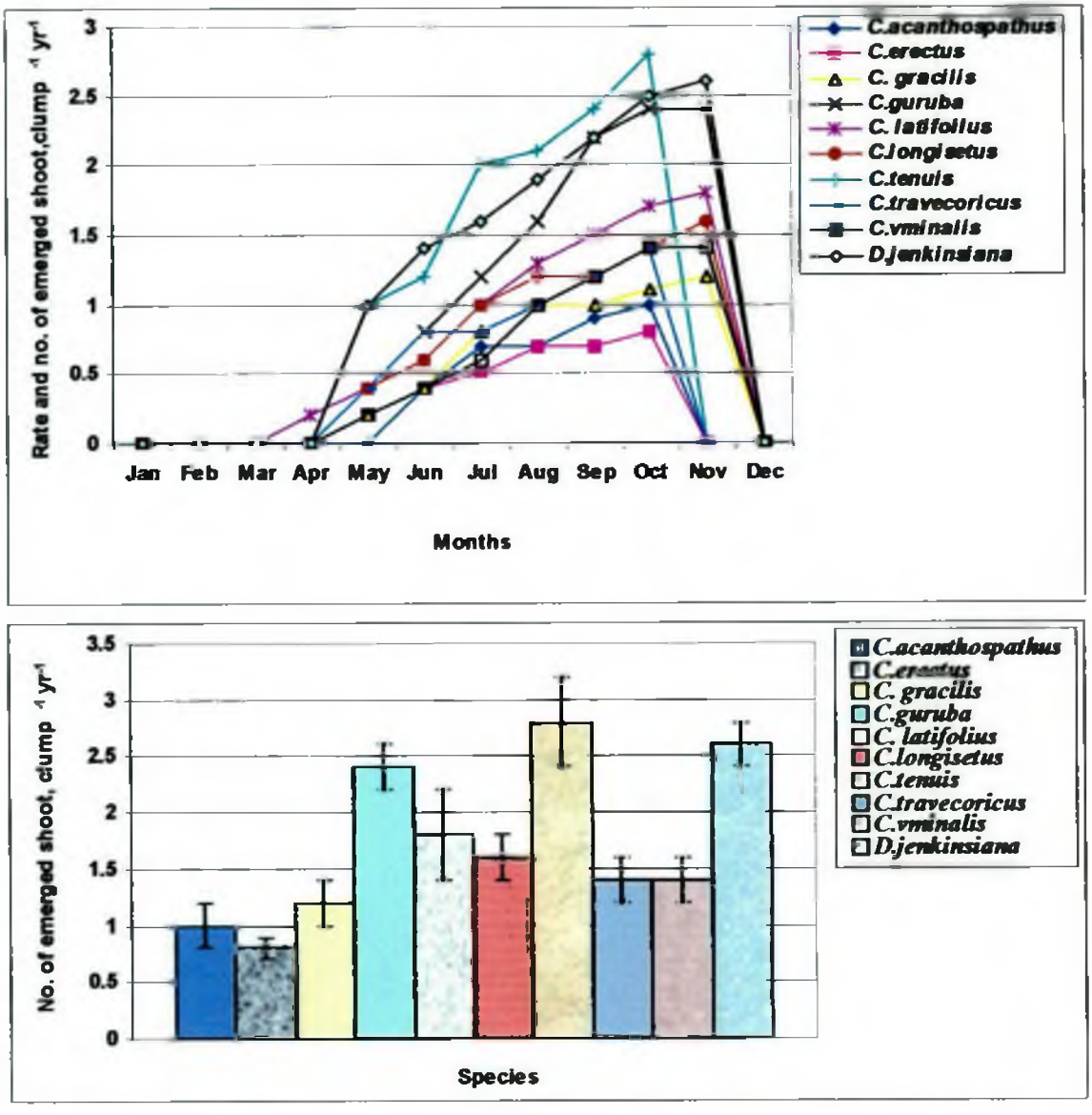
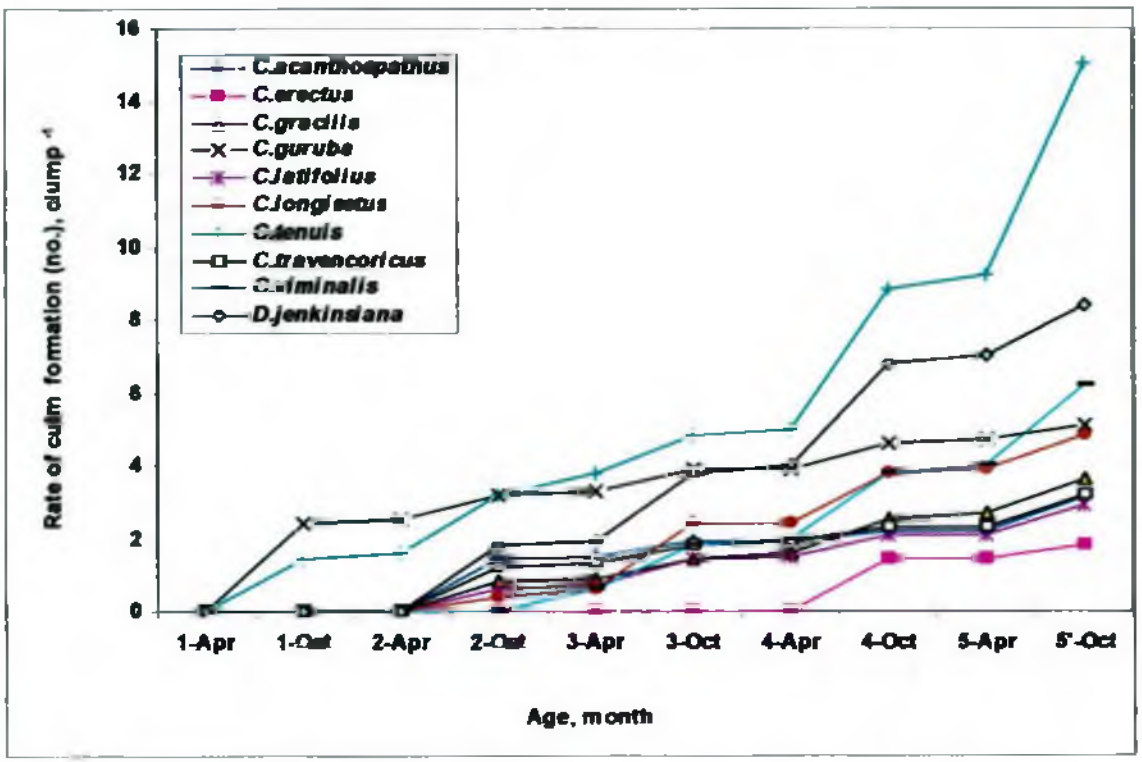


Figure 8 : Evaluation of rate and number of shoot emergence (month wise- on fifth year) in seedling raised clumps of ten rattan species in canetum of Bangladesh.

Table 19: Seasonal and annual variation in number of culm emerged, increase of height of main culm in selected clump of ten rattan species of Bangladesh.

Species	Parameter	1 yr-1999		2 yr-2000		3 yr-2001		4 yr-2002		5 yr-2003	
		April	Oct	April	Oct	April	Oct	April	Oct	April	Oct
C.acanthospathus	Height, cm	16±6	39± 5	56± 9	86± 9	103± 5	140± 14	176± 21	224± 14	254± 16	367±35
	No. of culm	0	0	0	1.4±0.2	1.5±0.2	1.9±0.2	1.9±0.2	2.2±0.2	2.2±0.2	3.1±0.4
C.erectus	Height, cm	28±3	46±4	59± 9	84± 8	105± 10	126± 13	133±13	149±16	174±19	198±28
	No. of culm	0	0	0	0	0	0	0	1.4±0 2	1.4±0.2	1.8±0.4
C.gracilis	Height, cm	14±4	30± 2	45± 6	69±7	81± 9	107± 12	130±16	211±17	252±16	346±32
	No. of culm	0	0	0	0.8±0.2	0.9±0.2	1.4±0.2	1.6±0.2	2.5±0.4	2.7±0.4	3.6±0.4
C.guruba	Height, cm	14±3	37± 6	57± 9	80± 9	91± 9	119± 7	146±16	216±10	228±18	342±20
	No. of culm	0	2.4±0.2	2.5±0 2	3.2±0.4	3.3±0 4	3.9±0.4	3.9±0.4	4.6±0.4	4.7±0.4	5.1±0.8
C.latifolius	Height, cm	17± 4	36±5	56± 8	89± 9	114±13	180± 11	234±18	327±11	378±34	490±37
	No. of culm	0	0	0	0.6±0.2	0.7±0.2	1.4±0.2	1.5±0.2	2.1±0.4	2.1±0.4	2.9±0.2
C.longisetus	Height, cm	18± 3	39± 7	52±6	70±5	83±17	110±18	129±18	171±18	192±17	226±18
	No. of culm	0	0	0	0 4±0.2	0.6±0.2	2.4±0.2	2.4±0.2	3.8±0.6	3.9±0.6	4.8±0.6
C.tenuis	Height, cm	38±19	94± 8	121± 7	170± 8	201±18	315±19	364±21	416±19	448±16	528±45
	No. of culm	0	1.4±0.2	1.6±0.2	3.2±0.2	3.8±0.2	4.8±0.4	5.0±0.4	8.8±0.4	9.2±0.6	12±1.0
C.travencoricus	Height, cm	20±13	37± 4	56±12	76± 4	90±16	113±21	129±19	219±17	269±12	372±37
	No. of culm	0	0	0	1.2±0.2	1.3±0.2	1.8±0.2	1.9±0.2	2.3±0.7	2.3±0.7	3.2±0.5
C.viminalis	Height, cm	14± 3	31± 7	82± 11	136±13	178±16	241±18	290±17	346±21	399±16	447±19
	No. of culm	0	0	0	0	0.6±0	1.2±0.4	1.8±0.3	2.2±0.2	2.4±0.2	2.6±0.4
D.jenkinsiana	Height, cm	85±11	110± 16	125± 12	193± 29	215± 33	298±26	322±15	401±27	431±27	540±27
	No. of culm	0	0	0	1.8±0.2	1.9±0.4	3.8±0.2	4.0±0.2	6.0±0.4	7.0±0.2	8.4±0.2

Legend: Measurements were made at early (Apr) and late monsoon (Oct)



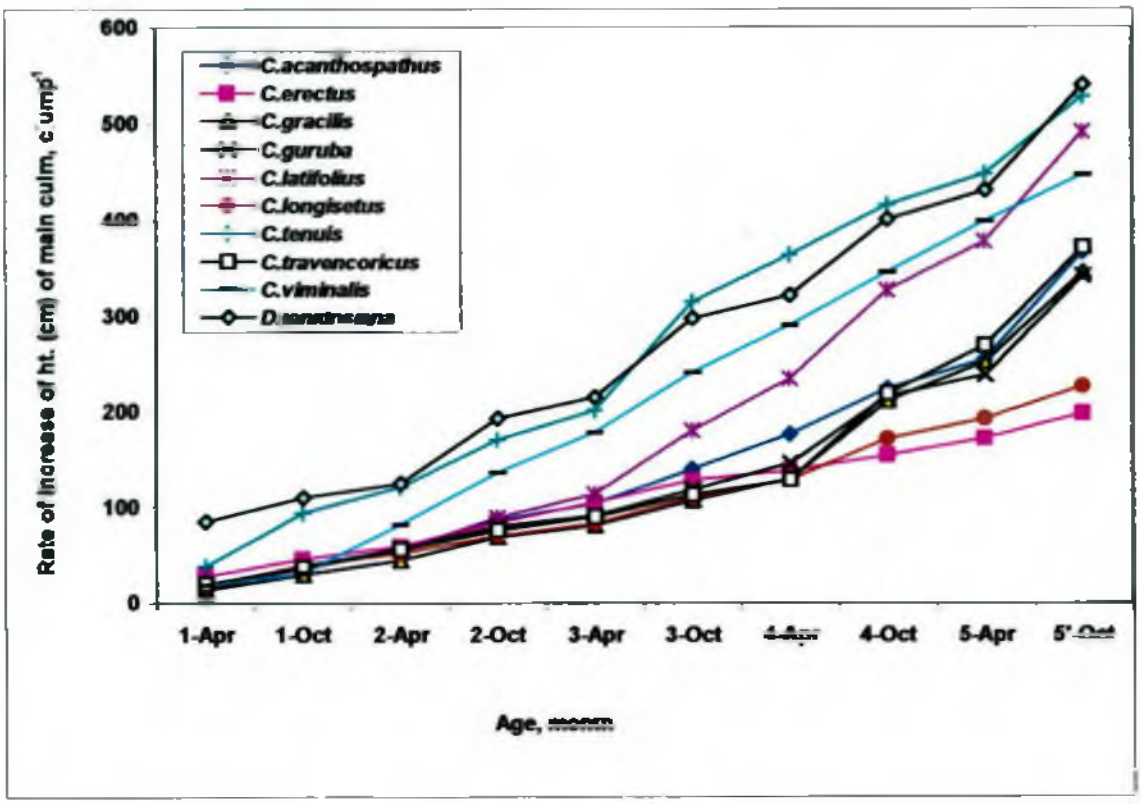


Figure 9: Assessment of rate of number of culm formation and increase of height of main culm (season wise) in seedling raised clumps of ten rattan species in canetum of Bangladesh.

Table 20 : Natality, mortality, rosette and culm formation pattern of shoot (sucker) for five years in seedling raised selected clumps of ten rattan species in canetum of Bangladesh.

Species	Year	No. of emerged shoot clump^{-1}	No. of dead shoot clump^{-1}	Shoot formed in to culm clump^{-1}	Rosette formed clump^{-1}	Total no. of emerged shoot, clump^{-1}	Total shoot formed in to culm clump^{-1}	% of culm formation
C.acanthuspathus	1998	1.3±0.3	0.6±0.2	0.7±0.4	0	6.7±1.8	4.1±1.9	50.55
	1999	1.5±0.5	0.7±0.2	0.8±0.4	0			
	2000	1.3±0.2	0.5±0.2	0.3±0.2	0			
	2001	1.5±0.4	0.5±0.2	1.0±0.6	0			
	2002	1.2±0.4	0.4±0.2	0.8±0.3	0			
C.erectus	1998	1.3±0.4	0.4±0.2	0.7±0.2	0.2±0.2	6.5±2.0	3.8±1.7	47.68
	1999	1.4±0.2	0.3±0.2	0.8±0.2	0.3±0.2			
	2000	1.3±0.3	0.2±0.2	0.7±0.4	0.4±0.0			
	2001	1.6±0.6	0.4±0.2	0.9±0.4	0.3±0.0			
	2002	1.9±0.5	0.7±0.2	0.7±0.5	0.5±0.0			
C.gracilis	1998	2.0±0.3	0.4±0.2	1.6±0.4	0	12.0±2.0	9.9±1.4	83.54
	1999	2.4±0.5	0.3±0.2	1.7±0.4	0.4±0.1			
	2000	2.2±0.4	0.4±0.2	1.8±0.2	0			
	2001	2.8±0.4	0.4±0.2	2.4±0.2	0			
	2002	2.6±0.4	0.2±0.2	2.4±0.2	0			
C.guruba	1998	2.6±0.4	0.6±0.2	1.4±0.2	0.6±0.1	12.3±1.4	5.1±1.1	40.11
	1999	2.3±0.2	0.4±0.2	0.8±0.2	1.1±0.4			
	2000	2.4±0.2	0.3±0.2	1.0±0.2	1.1±0.5			
	2001	2.5±0.4	0.4±0.2	0.9±0.3	1.2±0.6			
	2002	2.5±0.2	0.2±0.2	1.0±0.2	1.3±0.4			
C.latifolius	1998	2.0±0.3	0.2±0.2	0.9±0.2	0	10.5±1.6	4.6±1.2	41.68
	1999	2.0±0.4	0.3±0.2	0.8±0.2	0			
	2000	2.1±0.2	0.1	1.0±0.2	0			
	2001	2.0±0.3	0	0.9±0.3	0			
	2002	2.4±0.4	0.4±0.2	1.0±0.3	0			
C.longisetus	1998	3.6±0.4	0.4±0.2	1.0±0.3	2.2±0.4	17.8±2.6	5.3±1.6	27.8
	1999	3.5±0.6	0.4±0.2	1.2±0.4	2.5±0.2			
	2000	3.5±0.7	0.6±0.2	0.9±0.2	2.0±0.5			
	2001	3.7 ±0.4	0.6±0.2	1.2±0.4	1.9±0.4			
	2002	3.5±0.5	0.8±0.4	1.0±0.3	2.3±0.3			
C.tenuis	1998	3.0±0.3	0.2	2.8±0.3	0	14.9±2.0	14.5±2.0	97.17
	1999	3.0±0.3	0.1	2.9±0.3	0			
	2000	3.0±0.2	0	3.0±0.2	0			
	2001	2.9±0.4	0	2.9±0.4	0			
	2002	3.0±0.8	0	3.0±0.8	0			
C.travencoricus	1998	2.0±0.3	0	2.0±0.3	0	10±1.4	9.6±1.2	96.58
	1999	1.9±0.2	0	1.9±0.2	0			
	2000	2.1±0.2	0.1	2.0±0.2	0			
	2001	2.0±0.4	0.1	1.9±0.2	0			
	2002	2.0±0.3	0.2	1.8±0.3	0			
C.viminalis	1998	1.8±0.2	0.2	1.6±0.2	0	8.6±1.1	7.3±1.2	84.88
	1999	2.1±0.3	0.3±0.2	1.7±0.4	0			
	2000	1.4±0.2	0.2	1.2±0.2	0			
	2001	1.8±0.2	0.4	1.4±0.2	0			
	2002	1.6±0.2	0.2	1.4±0.2	0			
D.jenkinsiana	1998	3.2±0.4	0.8±0.2	0.5±0.2	1.9±0.2	17.6±2.8	3.4±1.5	16.75
	1999	3.5±0.3	0.5±0.4	0.6±0.4	2.4±0.5			
	2000	3.5±0.7	0.4±0.4	0.5±0.3	2.6±0.2			
	2001	3.7±0.7	0.6±0.3	0.8±0.4	1.9±0.5			
	2002	3.8±0.7	0.5±0.2	0.7±0.2	2.2±0.1			

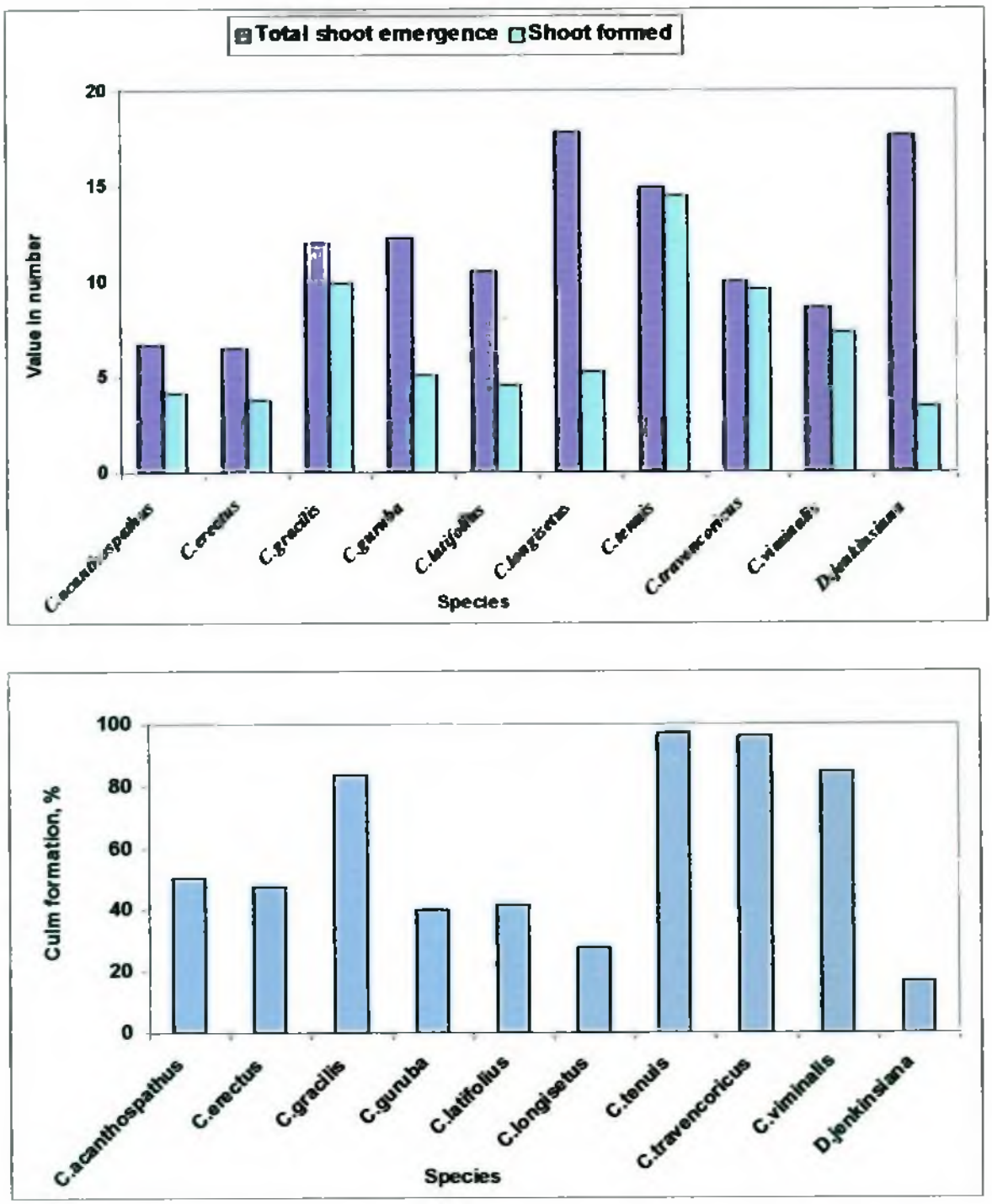


Figure 10 : Evaluation of annual variation in number of shoot natality, mortality, rosette and culm formation in seedling raised selected clumps of ten rattan species in canetum of Bangladesh.

The information as given in Table-19 and Figure-9 show a great variation both in number of culm emerged and increase of height of main culm. All species started to produce culm from fourth season excepting those of *C.viminalis* and *C.erectus* where *C.viminalis*

started culm formation from fifth season and *C.erectus* started culm formation from eighth season. All rattan species continued to increase in height of main culm with subsequent formation of daughter culm. Height of shoot was found significantly different among ten rattan species ($F_{9,20}$=10.78; P<6.43E-06). Maximum height was found in *D. jenkinsiana* (540±54 cm) and minimum was in *C.erectus* (198±56 cm). On the basis of increase of height of main culm ten rattan species can be ranked as *D.jenkinsiana*> *C.tenuis* >*C.latifolius*> *C.viminalis*> *C.travencoricus*> *C.acanthuspathus*> *C.gracilis*> *C.guruba*> *C.longisetus*> *C.erectus*. Marked increase in height of main culm of all species was found in late monsoon every year (Figure-9). Number of emerged culm was found highly significant in different rattan species ($F_{9,20}$=25.03; P<5.4328E-09). Highest number of culm was emerged in *C.tenuis* (12±2) and lowest was in *C.erectus* (1.8±0.4). On the basis of number of culm formation clump^{-1} species^{-1} year^{-5} the recorded rattans can be ranked as *D.jenkinsiana*> *C.tenuis*> *C.guruba*> *C.longisetus*> *C.gracilis*> *C.travencoricus*> *C.acanthuspathus*> *C.latifolius*> *C.viminalis* > *C.erectus*.

The result as shown in Table-20 and Figure-10 exhibit that all emerged shoots did not form culm. Some of them remained as rosette, some become dead and some formed culm to climb up. Mortality percentage of emerging shoot varied with species and habitat. Occurrence of the rosette and dead shoots were found as regular phenomenon in compactly arranged clumps rather than loosely arranged clump. Table-20 also exhibits that highest number of shoot emerged in *C.longisetus* (17.8±2.6) and lowest was in *C.erectus* (6.5±2.0). Maximum number of culm formed in *C.tenuis* (14.5±2.0) and minimum was in *D.jenkinsiana* (3.4±1.5). Culm formation in number was found significantly different in ten rattan species. Mortality of emerged shoots was found maximum in *C.longisetus* (2.8±0.3) and minimum was in *C.tenuis* (0.3±0.05). It is evident that there was a negative relation in culm formation and mortality *i.e.* the higher was the culm formation, the lower was the mortality and the *vise versa*. Rosette form of shoot was found more in compactly arranged clump *viz. C.longisetus* (10.9±0.3) and *D.jenkinsiana* (8.8±0.3). Clump of five species *viz. C.acanthospathus*, *C.latifolius*, *C.tenuis*, *C.travencoricus* and *C.viminalis* were observed not to produce any rosette form. The emerged shoots in these species either become dead or produce culm straight way.

5.9. Pricking age effect on survival per cent of seedlings (of seed tray and seed bed transferred to poly bags of sandy loam soil grown under shade house condition) in

ten rattan species of Bangladesh : The result as shown in Table-21 and Figure-11 indicate that seedling raising techniques and pricking age were observed to have profound effect on survival per cent of seedlings in all rattan species. Seedlings raised in seed tray were found to have higher survival per cent compared to those of seed bed

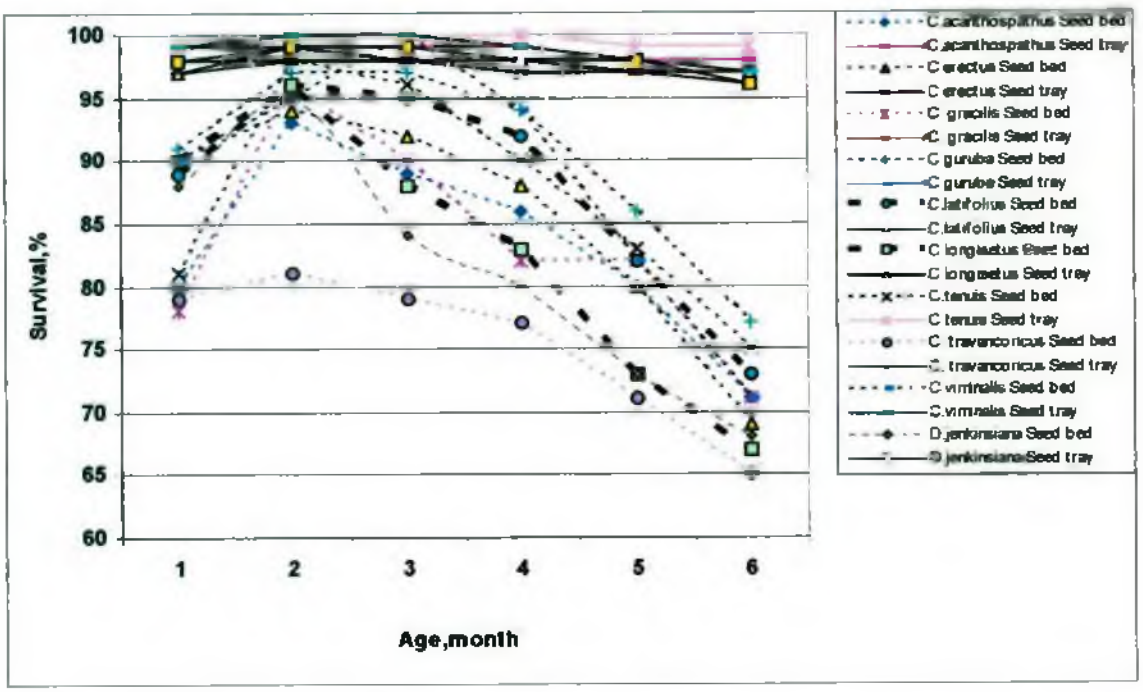


Figure 11 : Pricking age effect on survival per cent of seedlings (of seed tray and seed bed transferred to poly bags of sandy loam soil grown under shade house condition) in ten rattan species of Bangladesh.

almost in all rattan species under almost the same growing conditions. Pricking age was found to affect the survival per cent of pricked seedlings and the degree of affect was found to be related with the age in seedbed raised seedlings compared to seed tray. With all limitations (*viz.* species diversity, seedling raising technique, date of seedlings pricking, age of pricked seedling, seedling transferring technique) seedling of 2-3 months age were found to have maximum survival per cent in both seed tray and seed bed raised seedlings. Though the survival per cent of seedlings of seed tray raised seedling did not get changed with the increase of pricking age until 6 months yet the survival per cent of seed bed raised seedling started to decline even after 3 months pricking age and continued to decline with the increase of pricking age up to 35% at 6 months age. So seedling raising technique could be a major factor for the production of mass scale *ex situ* seedlings.

Table21: Pricking age effect on survival per cent of seedlings (of seed tray and seed bed transferred to poly bags of sandy loam soil grown under shade house conditions) in ten rattan species of Bangladesh.

Species	Seedling raising	Date of seedling pricking and transfer	Pricking age after germination, month																							
			1				2				3				4				5				6			
			Height cm	Leaf number	Number of L.let/Leaf	Survival %	Height cm	Leaf number	Number of L.let/Leaf	Survival %	Height cm	Leaf number	Number of L.let/Leaf	Survival %	Height cm	Leaf number	Number of L.let/Leaf	Survival %	Height cm	Leaf number	Number of L.let/Leaf	Survival %	Height cm	Leaf number	Number of L.let/Leaf	Survival %
C.acanthospathus	Seed tray	Jul,7th	6	1s	-	98±2	7	1s	-	99±1	14	1	9-10	99±1	15	2	9-10	99±1	16	3	6	98±2	18	4	6	98±2
	Seed bed		6.5	1s		80+3		1s		93+2	15	1	9-10	89+1	17	2	9-10	86+3	19	3	6	80+4	20	4	6	71+4
C.erectus	Seed tray	Jul,10th	9	1s	-	99±1	12	1s	-	99±1	14	1	4-6	98±2	17	2	4-6	98±2	20	3	4	98±2	23	4	4	97±3
	Seed bed			1s		90+2		1s		94+2	16		4-6	92+3	19	2	4-6	88+3	21.5	3	4	80+4	24	4	4	69+4
C.gracilis	Seed tray	May,15th	7	1s	-	98±2	9	1s	-	98±2	13	1	6	98±2	8	2	14	98±3	15	3	6	97±3	16	4	6	97±3
	Seed bed			1s		78+3		1s		96+2	13.3		6	90+1	10	2	14	84+4	16	3	6	82+3	17	4	6	71+4
C guruba	Seed tray	Apr,4th	8	1s	-	98±2	9	1	6	99±1	10	1	5-6	98±2	12	2	6	97±2	13	3	6	87±3	15	4	6	97±3
	Seed bed			1s		91+2		1	6	97+2	11		5-6	97+1	12.5	2	6	94+2	14	3	6	86+4	15	4	6	77+4
C latifolius	Seed tray	Oct,16th	7	1s	-	97±3	9	1s	-	98±2	12	1	2	98±2	13	2	2	98±2	14	3	2	98±2	15	4	2	96±4
	Seed bed			1s		91+2		1s		97+1	12		2	97+2	13	2	2	94+3	15	3	2	83+4	15	4	2	77+3
C.longisetus	Seed tray	Oct,4th	9	1s	-	97±3	13	1s	-	99±1	16	1	9-10	98±2	18	2	9-10	97±2	20	3	6	97±3	23	4	6	97±3
	Seed bed			1s		90+2		1s		91+2	17		9-10	88+3	19	2	9-10	83+2	22	3	6	73+4	24	4	6	67+3
C.tenuis	Seed tray	Aug,17th	8	1s	-	99±1	10	1	6	100±0	13	2	6	100±0	14	2	6	100±0	15	3	6	99±1	16	4	6	99±1
	Seed bed			1s		81+2		1	6	98+2	14		6	96+2	15	2	6	90+3	15	3	6	83+4	17	4	6	75+4
C travencoricus	Seed tray	Jul,3rd	12	1s	-	98±2	13	1s	-	98±2	16	1	9-10	98±2	18	2	9-10	98±2	20	3	9	97±1	22	4	10	96±4
	Seed bed			1s		79+3		1s		81+3	18		9-10	79+3	19	2	9-10	77+4	21	3	9	71+5	23	4	10	65+5
C.vim'nalis	Seed tray	Jun,23rd	7	1s	-	99±1	7.4	1s	-	100±0	8	1	4-6	100±0	10	2	4-6	99±1	11	3	6	98±2	13	4	6	97±3
	Seed bed			1s		90+2		1s		95+2	8	1	4-6	100±0	10.3	2	4-6	94+3	11	3	6	82+3	13	4	6	71+5
D.jenkinsiana	Seed tray	Apr,11th	8	1s	-	98±2	11	1s	-	99±1	15	1	9-10	99±1	16	2	9-10	98±2	17	3	9	98±1	19	4	10	96±4
	Seed bed			1s	-	88+3		1s	-	95+3	17	1	9-10	84+5	17	2	9-10	80+4	18	3	9	73+5	20	4	10	68+6

Legend: 1s = Stick (unopened leaf); ±SEM

5.10. *Ex situ* growth performance of seedlings at three months interval up to one year (grown in poly bags of sandy loam soil under shade house conditions) in ten rattan species of Bangladesh : Result as shown in Table-22 and Figure-12 demonstrate that root-shoot length of transferring seedlings varied with species even though the seedlings raised under same conditions. These differences in root-shoot length and leaf

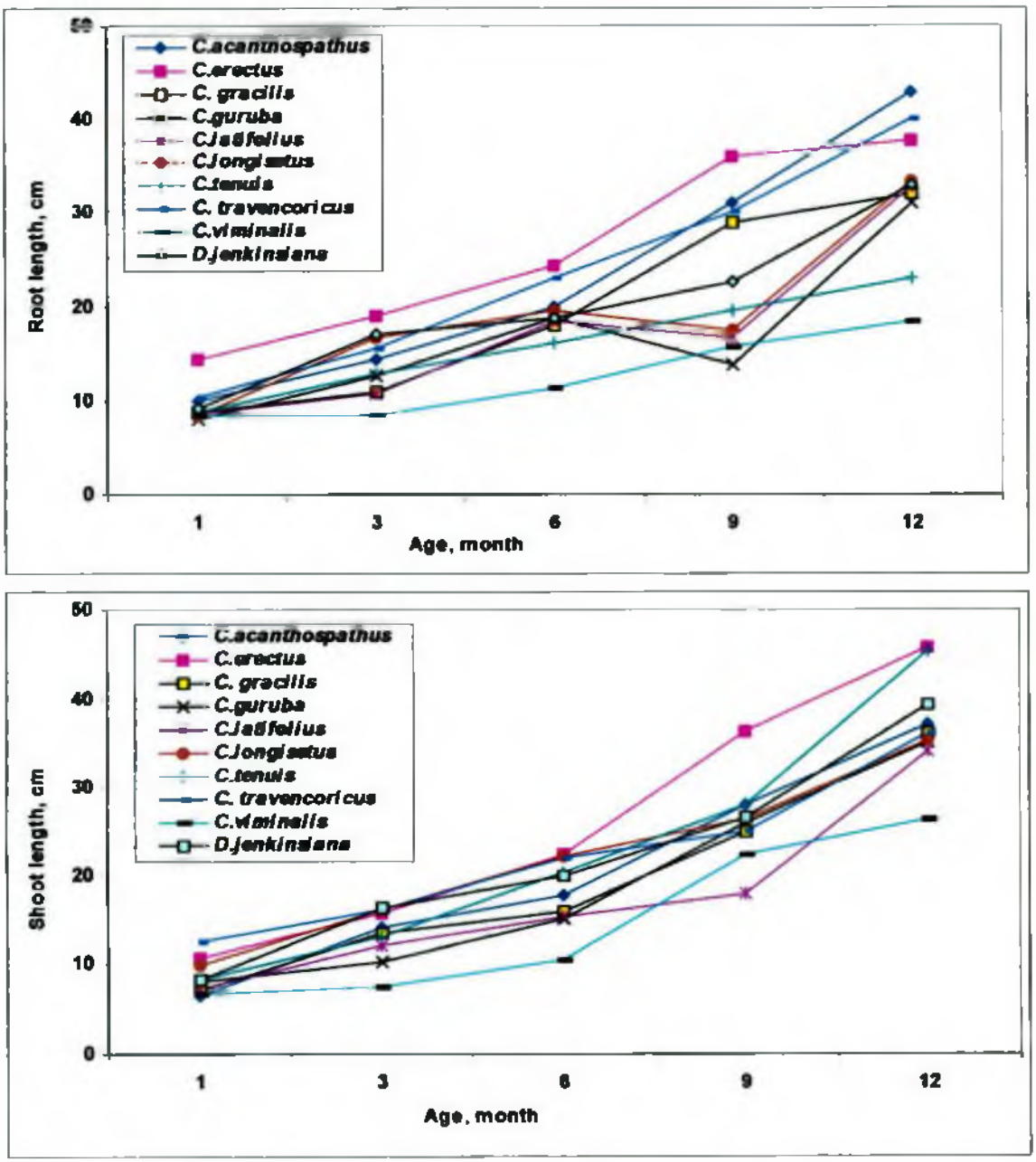


Figure 12 : Root-shoot relationship of seedlings (of seed bed and seed tray transferred to poly bags of sandy loam soil grown under shade house condition) at three months interval up to one year in ten rattan species of Bangladesh.

Table 22 : *Ex situ* growth performance of seedlings at three months interval up to one year (grown in poly bags of sandy loam soil under shade house conditions) in ten rattan species of Bangladesh.

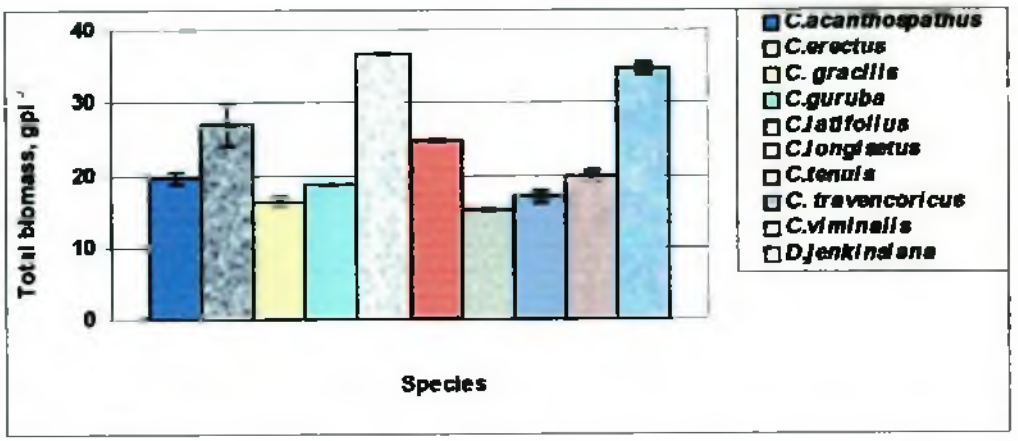
Species	During transfer			Age of the seedling, month											
				Three			Six			Nine			Twelve		
	Root length, cm	Shoot length, cm	Leaf number	Root length, cm	Shoot length cm	Leaf number	Root length, cm	Shoot length, cm	Leaf number	Root length, cm	Shoot length, cm	Leaf number	Root length, cm	Shoot length cm	Leaf number
C.acanthospathus	10±0.2	6.5±0.2	1s	14.3±0.4	14.2±0.3	1.0±0	20.0±1.0	17.8±1.5	2.0±0	31±2.0	28±1.0	3.0±0	43±4.0	37.0±5.0	3.0±1.0
C.erectus	14.4±0.4	10.7±3.2	1s	19.0±1.2	15.7±0.7	1.0±0	24.3±0.5	22.3±2	2.0±0	36.0±1.2	36.3±2.0	3.0±0	37.7±1.2	45.7±1.7	3.6±0.3.0
C.gracilis	8.9±0.3	7.1±0.4	1s	11.0±0.3	13.5±0.3	1.0±0	18.0±1.0	16.0±1.0	2.0±0	29±4.0	25±3.0	2.0±0	32.0±5.0	36.0±6.0	2.5±1.0
C.guruba	8.1±0.2	8.0±0.2	1s	12.7±1.2	10.3±1.0	2.0±0	18.7±1.1	15.1±0.3	4.0±0	13.7±0.7	26.0±1.0	4.3±0.3	31.0±2.2	35.0±0.5	7.0±0.5
C.latifolius	8.6±0.3	7.2±3.0	1s	10.8±0.3	12.0±0.5	1.0±0	18.3±0.5	15.3±0.3	1.0±0	16.6±1.2	18±0.8	3.7±1.0	32.7±3.0	34.0±0.5	4.3±0.3
C.longisetus	8.4±1.4	9.8±1.0	1s	16.7±1.9	16.1±0.6	1.0±0	19.5±2.0	22.2±1.3	2.0±0	17.5±1.5	26.4±2.1	3.0±0	33.3±2.0	35.3±0.7	3.0±0
C.tenuis	8.8±1.1	8.2±2.1	1s	12.9±1.0	13.2±0.5	2.2±0.2	16.0±0.5	20.3±0.3	3.3±0.3	19.5±0.5	28.0±0.5	4.7±0.3	22.9±2.0	45.3±1.6	4.7±0.3
C.travencoricus	10.3±1.3	12.4±0.9	1s	15.6±0.7	16.1±0.4	1.0±0	23.0±2.0	22.0±1.0	2.0±0	30.0±4.0	25.0±3.0	1.0±0	40.0±6.0	36.0±7.0	4.0±1.0
C.viminalis	8.4±0.5	6.6±0.6	1s	8.5±1.0	7..5±0.5	1.0±0	113±1.0	10.5±0.4	2.0±0	15.7±1.1	22.3±1.0	5.0±0	18.3±0.3	26.5±1.2	4.3±0.3
D.jenkinsiana	9.1±0.6	8.2±1.3	1s	17.1±0.5	16.3±0.5	1.0±0	18.7±0.3	20.0±1.3	2.0±0	22.7±0.7	26.7±1.2	4.0±0	33±3.9	39.3±3.6	4.0±0

number could be due to genetical difference of species as well as sowing time of fresh seeds. The differences in root-shoot length and leaf number in transferred seedlings continued to increase with the increase of age until the age of twelve months in each species when maximum leaf number (7.0±0.5) was measured in *C. guruba* and was minimum (2.5±1.0) in *C.gracilis*. On the basis of leaf number, the *ex situ* growth of ten rattan species can be ranked as *C.guruba*> *C.tenuis*> *C.latifolius*≥ *C.viminalis*> *C.travencoricus*≥ *D.jenkinsiana*> *C.erectus*> *C.acanthuspathus*> *C.longisetus*> *C.gracilis*. Maximum shoot length (45.7±1.7 cm) was measured in *C.erectus* and was minimum (26.5±1.2 cm) in *C.viminalis*. On the basis of shoot length, the *ex situ* growth of ten rattan species can be ranked as *C.erectus*> *C.tenuis*> *D.jenkinsiana*> *C.acanthuspathus*> *C.travencoricus* > *C.gracilis*> *C.longisetus*> *C.guruba* >*C.latifolius* > *C.viminalis*.

5.11. *Ex situ* growth attributes, total biomass, photosynthetic pigments and nutrients (NPK) status of leaves of plantable seedlings (~2 years old) in ten rattan species of Bangladesh : Rattan seedlings of about two years old were used for out planting. The

Table 23 : Growth and biomass of ~ two years plantable seedlings (grown in poly bags of sandy loam soil under shade house condition) in ten rattan species of Bangladesh.

Species	Plant height, cm	Leaf no.	Biomass, g pl^{-1}						MC%
			Fresh Weight			Dry Weight			
			Root	Shoot	Total	Root	Shoot	Total	
C.acanthospathus	141±5	8±1	22.5±1.7	49.4±2.9	71.9±2.6	6.2±08	13.4±0.8	19.6±0.9	72.7±2.9
C.erectus	193±4	6±1	30.4±2.6	63.4±3.2	93.8±3.3	8.2±0.6	18.7±0.6	26.9±1.8	71.3±3.5
C.gracilis	51±3.5	7±1	14.4±1.4	25.7±4.0	40.1±3.3	5.7±0.7	10.7±0..5	16.4±1.5	59.1±2.3
C.guruba	109±7	6±1	29.0±4.4	51.5±0.6	80.0±3.7	6.6±0.5	10.2±0.6	18.8±1.3	76.5±2.9
C.latifolius	108±4	7±1	40.7±2.1	81.5±3.8	122.2±4.1	9.6±0.6	26.0±0.7	36.6±1.4	70.0±5.3
C.longisetus	103±5	6±1	30.8±2.1	58.6±6.3	89.4±5.0	8.9±0.3	15.8±0.2	24.7±0.6	72.4±4.1
C.tenuis	119±6	7±1	25.4±1.5	57.6±2.2	83.0±2.1	5.0±0.6	15.0±0.4	15.1±0.5	81.9±2.3
C.travencoricus	131±7	8±1	20.5±2.1	42.6±3.3	63.1±2.1	5.5±0.3	11.5±0.2	17.0±1.0	73.0±3.5
C.viminalis	92±3	7±1	14.7±0.9	39.8±2.8	54.5±2.1	5.5±0.8	14.3±0.8	19.8±1.8	63.7±2.3
D.jenkinsiana	128±4	8±1	43.3±2.2	64.9±3.2	108.1±3.1	14.6±0.6	20.1±0.9	34.7±1.7	67.9±2.0



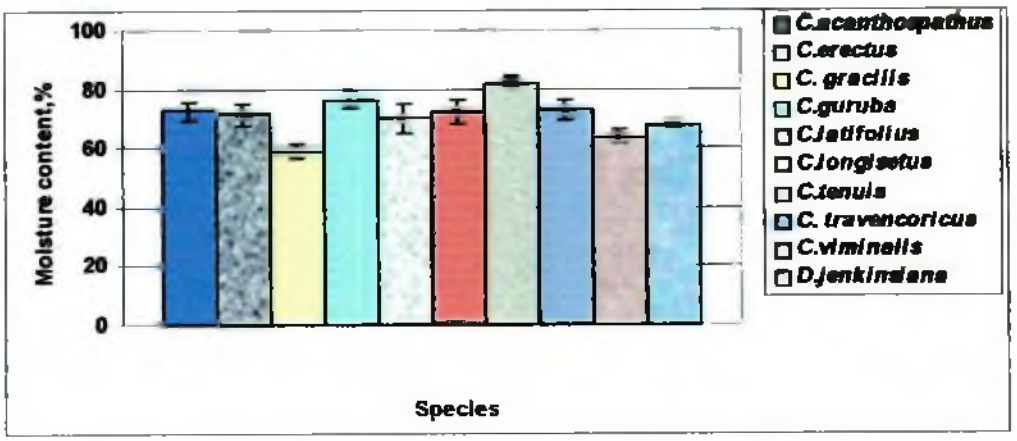


Figure 13: Variation in total biomass production and moisture contents of ~2 years plantable seedlings (of seed bed and seed tray transferred to poly bags in sandy loam soil grown under shade house condition) in ten rattan species of Bangladesh.

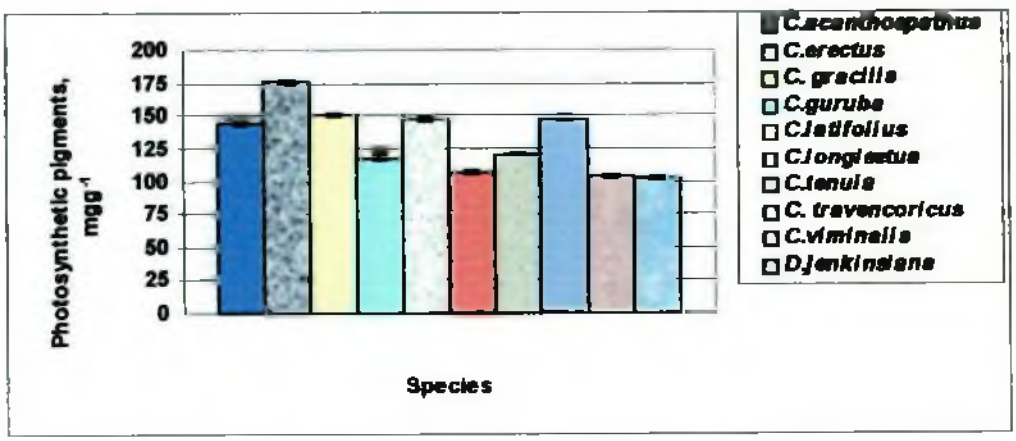


Figure 14 : Variation in photosynthetic pigments of leaves of plantable ~2 years seedlings (of seed bed and seed tray transferred to poly bags in sandy loam soil grown under shade house condition) in ten rattan species of Bangladesh.

result as presented in Table-23 and Figure-13 indicate that seedling height varied with species and maximum height was measured in *C. erectus* (193.0±4.0 cm) and minimum height in *C.gracilis* (51.0±3.5 cm). On the basis of plantable seedling height, ten rattan species can be ranked as *C.erectus*>*C.acanthospathus*>*C.travencoricus*> *D.jenkinsiana*> *C.tenuis*> *C.guruba*> *C.latifolius*> *C.longisetus*> *C.viminalis*> *C.gracilis*. Total fresh weight and dry weight of both root-shoot of about 2 years old plantable seedlings varied with species. Biomass on total dry weight basis ranged from 15.1±0.5 to 36.6±1.4 gm plant^{-1} and ten rattan species can be ranked as *C. latifolius*> *D.jenkinsiana*> *C.erectus*> *C.longisetus*>*C.viminalis*> *C.acanthospathus*> *C.guruba*> *C.travencoricus*> *C.gracilis*> *C.tenuis*. While moisture content (%) also varied with species and maximum (81.9±2.3%) moisture content was determined in *C.tenuis* and minimum (59.1±2.3%) in *C.gracilis*. On the basis of moisture content per cent, plantable seedlings of ten rattan species can be ranked as *C.tenuis*> *C.guruba*> *C.travencoricus*> *C.acanthospathus*> *C.longisetus*> *C.erectus*> *C.latifolius*> *D.jenkinsiana*> *C.viminalis*> *C.gracilis*.

Table 24 : Photosynthetic pigments and nutrients (NPK) status of leaves of ~ two year plantable seedlings (grown in polybags of sandy loam soil under shade house condition) in ten rattan species of Bangladesh.

Species	Photosynthetic pigments µgg^{-1} (FW)				Foliar NPK µgg^{-1}(DW)		
	Chlo-a	Chlo-b	Carot	Total	N	P	K
C.acanthospathus	53±2.0	62±1.5	29±2	144±1.8	4361±278	0.82±0.2	198±52
C.erectus	59±2.0	31±1.0	86±1.2	176±1.4	3630±331	0.59±0.2	162±31
C.gracilis	66±1.5	48±1.3	36±1.5	150±1.4	3942±282	0.92±0.3	220±18
C.guruba	49±1.0	39±2.0	30±1.8	118±1.6	4962±218	0.92±0.2	182±21
C.latifolius	69±1.0	35±1.0	43±1.7	147±1.2	4421±343	0.43±0.2	281±19
C.longisetus	49±2.0	30±2.0	28±1.3	107±1.7	4764±460	0.72±0.1	438±22
C.tenuis	50±1.0	43±2.0	28±1.0	121±1.3	4394±381	0.56±0.2	398±52
C.travencoricus	53±1.5	66±2.0	29±1.5	148±1.7	4864±532	0.82±0.2	188±36
C.viminalis	42±1.2	29±1.6	33±1.4	104±1.4	4231±438	0.57±0.2	232±22
D.jenkinsiana	48±1.0	22±1.6	32±1.8	102±1.5	4021±372	0.44±0.1	173±56

Legend: Chlo= Chlorophyll; Carot= Carotinoid

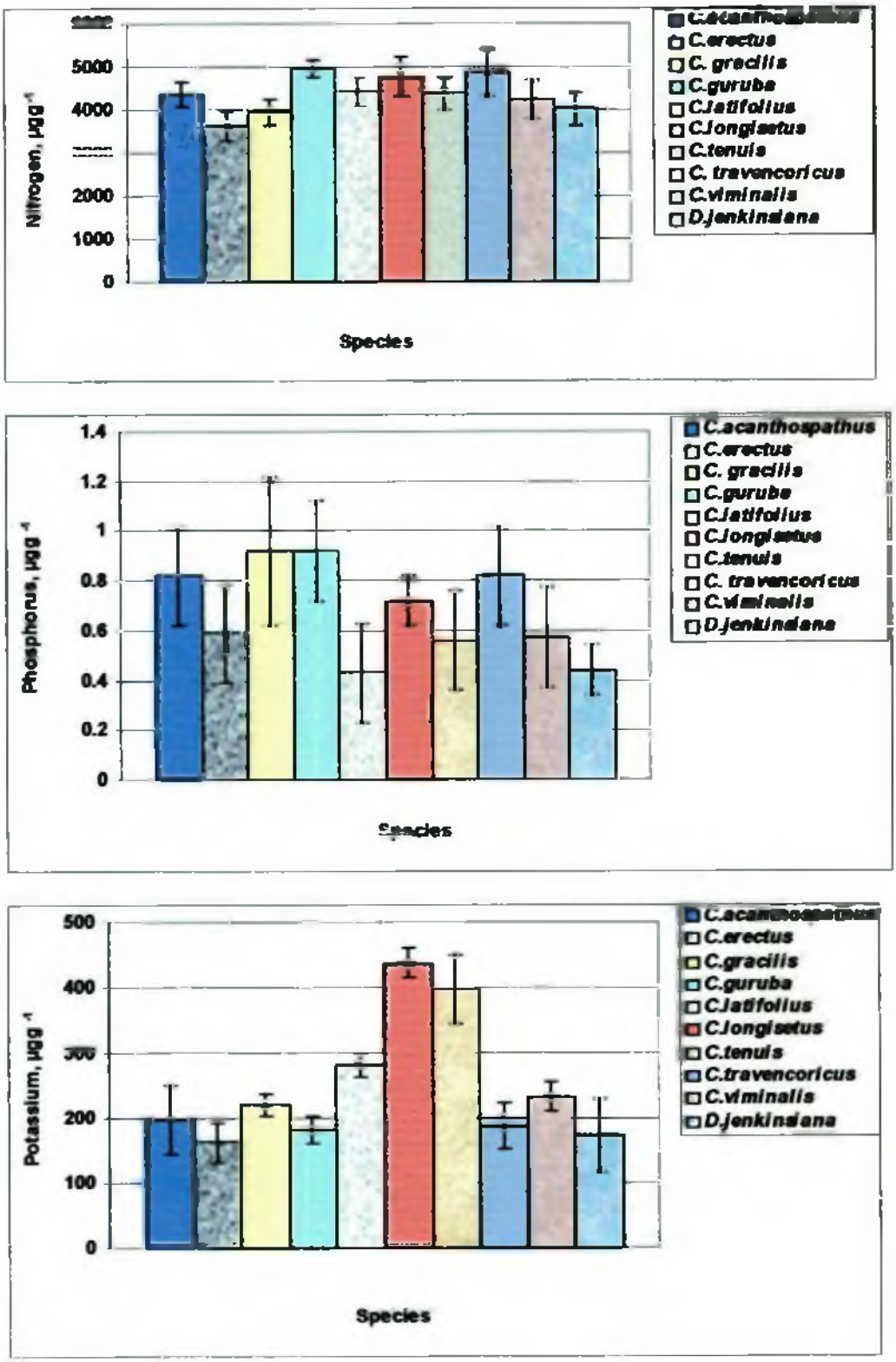


Figure 15 :Variation in foliar nitrogen, phosphorus and potassium content of ~ 2 years old plantable seedlings (of seed tray and seed bed transferred to poly bags of sandy loam soil grown under shade house condition) in ten rattan species of Bangladesh.

The result on photosynthetic pigments *viz.* chlorophyll a, b and carotenoids as shown in Table-24 and Figure-14 show that all these parameters varied with species even though the sampled leaves were of almost same age. Total photosynthetic pigments was maximum (176±1.4μgg^{-1}) in *C.erectus* and minimum (102±1.5μgg^{-1}) in *D.jenkinsiana*. On the basis of photosynthetic pigments, plantable seedlings of ten rattan species can be ranked as *C.erectus* > *C.gracilis*> *C.travencoricus*> *C.latifolius*> *C.acanthospathus*> *C.tenuis*> *C.guruba*> *C.longisetus*> *C.viminalis*> *D.jenkinsiana*. While the result of foliar NPK as shown in Table-24 and Figure-15 exhibit that NPK status of sampled foliage varied with species. Maximum (4962±218μgg^{-1}) nitrogen was determined in *C.guruba* and minimum (3630±331μgg^{-1}) in *C.erectus*. On the basis of foliar nitrogen status, the plantable seedlings of ten rattan species can be ranked as *C.guruba*>*C.travencoricus*> *C.longisetus*> *C.tenuis*> *C.latifolius*> *C.acanthospathus*> *C.viminalis* > *D.jenkinsiana*> *C.gracilis*> *C.erectus*. Foliar phosphorus content was maximum (0.9±0.2μgg^{-1}) both in *C.gracilis* and *C.guruba* and minimum (0.43±0.2 μgg^{-1}) in *C.latifolius*. Foliar potassium content was maximum (438+22μgg^{-1}) in *C.longisetus* and minimum (162+31μgg^{-1}) in *C.erectus*. On the basis of foliar potassium content the plantable seedlings of ten rattan species can be ranked as *C.longisetus*> *C.tenuis*> *C.latifolius*> *C.viminalis*>*C.gracilis*>*C.acanthospathus*>*C.travencoricus*>*C.guruba*> *D.jenkinsiana*> *C.erectus*. It seems that foliar NPK are not proportionate, where determined value for phosphorus contents were very low. But the higher nitrogen content leads to rapid growth of culm in the successive year after out planting.

5.12. Phenology and periodicity of flowering, fruiting, fruit maturity and fruiting cycles in ten rattan species of Bangladesh : The result as shown in Table-25 and Figure-16 express that all rattan species were observed to be hepaxanthic and dioecious. Four rattan species *viz. C.erectus, C.gracilis, C.guruba,* and *C.viminalis* were found to be diphasic -flower twice a year while other six rattan species *viz. C.acnthospathus, C.latifolius, C.longisetus, C.tenuis, C.travencoricus* and *D.jenkinsiana* were monophasic -flower once in a year. Ten rattan species were observed to have a regular periodicity of flowering. The periodicity of flowering of each rattan species was either advanced or delayed by one or two month with the commencement of seasons. Male inflorescence initiated about a month earlier then those of female in all rattan species. Duration of male flowering was maximum (5 months) in *D.jenkinsiana* and minimum (3 months) in other

rattan species excepting *C.latifolius* and *C.longisetus* where it was observed to be 4 months. Fruiting was observed to start about a month after the opening of female inflorescence in all rattan species. But the duration of fruiting was observed maximum (9 months) in *D.jenkinsiana* and minimum (2 months) in *C.gracilis*. Fruit maturity and ripen time varied with species and maximum duration was observed to be 4 months in four species *viz. C.latifolius, C.longisetus, C.tenuis* and *D.jenkinsiana* and minimum duration 3 months in rest of the species. Flowering-fruiting cycle also varied with species where the shortest (8 months) cycle was observed in most of the diphasic rattan compared to the monophasic ones. The longest (15 months) flowering-fruiting cycle was observed in *D.jenkinsiana*. Manokaran (1982 and 1989) reported that the species flower once in a year generally flower between April to May, and then fruits become mature one year and three months later approximately in June or July of the following years. Renuka and Seethalakshmi (1988) also reported that in Kerala wild populations of *Calamus* sp generally flower annually usually between September to January. Biswas and Dayal (1995) observed two flowering seasons in India for *C.viminalis*. Alloysius (1999) reported that emergence of inflorescence occurred in October-December and fruit matured after 16-17 months in case of *C.manan* in Malaysia. He also reported that anthesis of male plant was longer (41 days) than female plant (25 days). Present investigation recorded that all the species producing flower twice in a year had 3 months flowering period in both the seasons. The female clumps of these species had never been emptied *i,e*. never without flower or fruit. Round the year they had flower, young fruit or matured fruits. Abdullah and Jusoh (1999) reported that *C.palustris, C.scipionum* and occasionally *C.manan* produce flower twice in a year in Malaysia.

Abdullah and Jusoh (1999) also reported that *C.scipionum* and *C.ornatus* took 12-13 months and *C.palustris* took 8-9 months for fruit production. Manokaran (1989) found that both in *C.caesius* and *C.scipionum* flowering is annual and fruit maturation takes 16 months after inflorescence emergence. Banik and Nabi (1979) observed that *C.viminalis* took 160-170 days for fruit maturation after flower initiation in Bangladesh. Alloysius (1994) reported that *C.caesius* took 2 months for emergence of inflorescence to anthesis stage and it took 1.5-2 months for *C.manan* in Malaysia. The period from inflorescence emergence to fruit maturity in *C.manan* has been reported to be 16 months (Alloysius 1994). Alloysius also reported that *C.subinermis* takes 10 month from emergence of inflorescence to fruit maturity.

Table 25 : Reproductive features and reproductive potentials with season in ten rattan species of selected clumps and natural habitats of Bangladesh.

Name of sp	Age of clump,yrs	Flowering period	Flowering seasons	Length of flowering culm, m	Number of inflorescence culm^{-1}	Number of partial infln.inflorescence^{-1}	Inflorescence flushing period, month	Number of MP culm^{-1}	Number of FF culm^{-1}	MF:FF	Number of Frs culm^{-1}	FF:Frs culm^{-1}	Fruit collection period month	Fruiting season	Seed out put culm^{-1}	Seed out put %	Frs:SP culm^{-1}	Dormancy breaking period, days	Flushing period, days	Germination per cent	Reproductive capacity culm^{-1}
C.acanthospathus	6-7	Sep-Dec	LM	15-18	3-4	5-6	3-4	13785 ±1067	5650 ±648	2.4:1	3090 ±339	1.8:1	Feb-Apr	EM	2105 ±317	68	1.5:1	42±5	28±7	84±6	1768 ±92
C.erectus	10-12	May-Jul	M	4-5	2-3	5-6	2-3	10314 ±1564	1823 ±325	5.6:1	597 ±175	3:1	Oct-Dec	LM	314 ±31	52	1.9:1	112±14	35±7	55±10	163 ±10
	,,	Nov-Jan	W	,,	2-3	6-10	2-3	18872 ±2554	3218 ±431	5.9:1	1042 ±104	3:1	Apr-Jun	EM	613 ±66	59	1.7:1	42±7	28±6	82±7	502 ±31
C gracilis	6-7	Mar-May	EM	,,	2-3	2-3	2-3	9721 ±1012	3814 ±929	2.5:1	1146 ±122	3.3:1	Jul-Sep	M	191 ±21	17	6:1	77±14	56±14	41±11	71 ±18
	,,	Oct-Dec	LM	11-13	3-4	8-11	2-3	14815 ±833	5585 ±836	2.7:1	1709 ±208	3.3:1	Feb-Apr	EM	343 ±38	20	5:1	43±10	35±8	75±5	275 ±14
C.guruba	11-12	Jan-Mar	W	15-18	2-3	3-4	2-3	6420 ±997	2561 ±109	2.5:1	1023 ±421	2.5:1	Jun-Aug	M	377 ±99	40	2.7:1	84±8	63±7	47±9	177 ±17
	,,	Aug-Oct	LM	,,	3-4	4-5	2-3	15224 ±506	5782 ±667	2.7:1	1160 ±105	4.9:1	Dec-Feb	W	466 ±58	40	2.5:1	44±5	36±6	74±6	344 ±21
C.latifolius	10-12	Sep-Nov	LM	28-30	3-4	8-11	2-3	28457 ±2113	4717 ±546	6:1	1667 ±189	2.8:1	May-Jul	M	1087 ±116	65	1.5:1	70±7	48±7	73±5	793 ±47
C.longisetus	12-14	Sep-Nov	LM	13-15	3-4	8-15	2-3	19513 ±1429	6383 ±757	3:1	4557 ±502	1.4:1	May Aug	M	1970 ±241	43	2.3:1	77±8	49±8	77±7	1516 ±82
C tenuis	10-11	Jul-Sep	M	14-16	3-4	4-5	2-3	7506 ±557	3739 ±437	2:1	1676 ±186	2.2:1	Apr-Jul	EM-M	1430 ±198	85	1.2:1	35±5	42±6	90±9	1287 ±64
C.travencoricus	5-6	Jul-Sep	M	18-22	3-4	3-4	2-3	4423 ±517	2256 ±409	2:1	1424 ±217	1.6:1	Mar-May	EM	788 ±82	56	1.8:1	49±6	36±8	82±5	646 ±36
C. vim nalis	10-14	Mar-May	EM	14-17	3-4	6-7	2-3	10217 ±1102	4027 ±499	2.5:1	2398 ±535	1.7:1	Jul-Sep	M	1482 ±127	62	1.6:1	147±8	47±6	49±7	726 ±19
	,,	Sep-Nov	LM	,,	3-4	6-8	2-3	19443 ±2208	7736 ±1104	2.5:1	4634 ±530	1.7:1	Jan-Mar	W	3814 ±297	82	1.2:1	70±8	28±8	62±6	2364 ±174
D jenkinsiana	11-13	Jul-Nov	M-LM	20-25	3-4	4-6	3-4	11321 ±1301	3014 ±350	3.8:1	1053 ±94	2.9:1	Jun-Sep	M	846 ±96	80	1.3:1	147±7	70±9	71±10	600 ±38

Legend: MF=Male flower; FF=Female flower; Frs=Fruit setting; EM= Early monsoon (Mar-May), M=Monsoon (Jun-Aug), LM= Late monsoon (Sep-Nov), W=Winter (Dec-Feb.

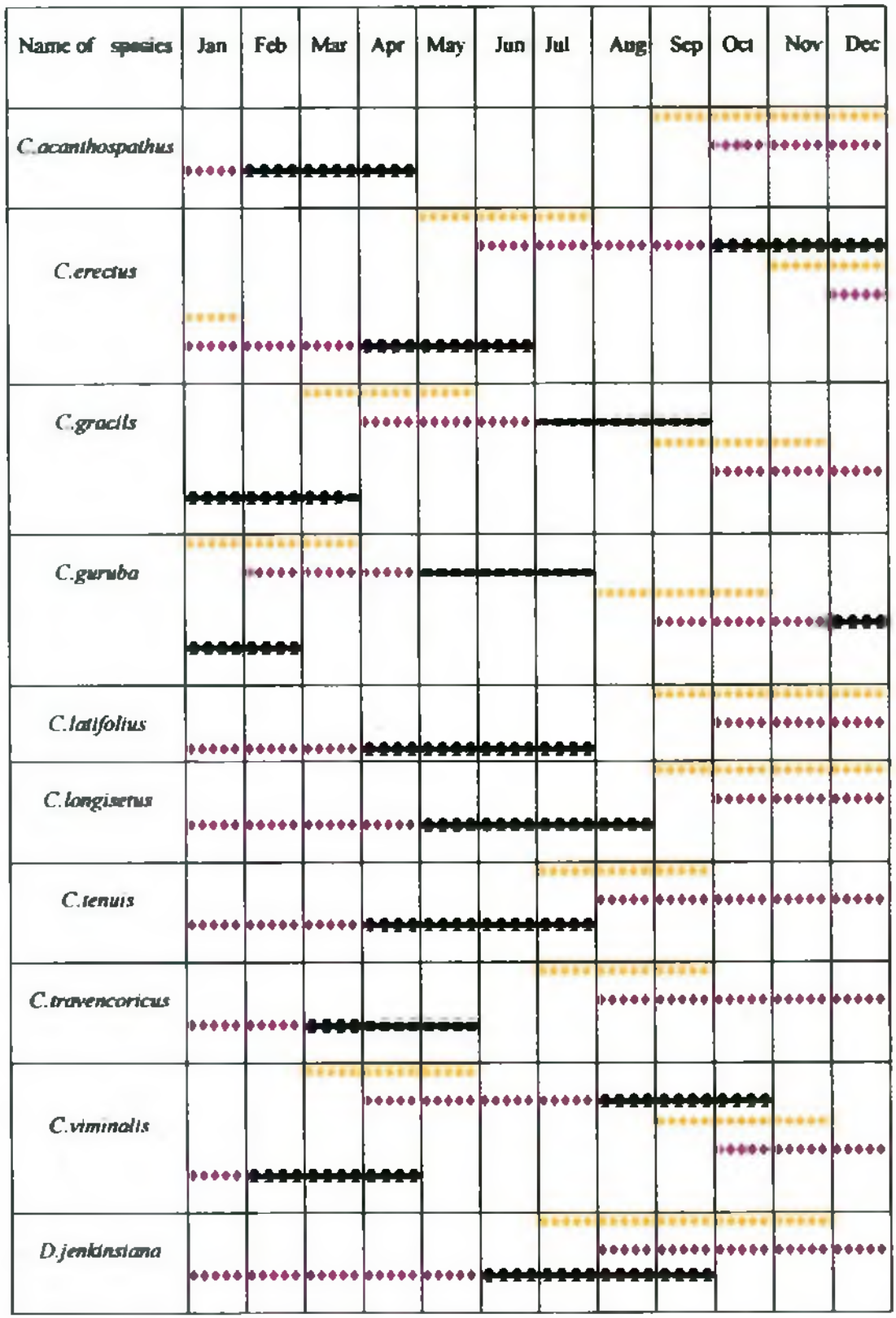


Figure 16 : Phenology and periodicity of flowering, fruiting, fruit maturity and fruiting cycles in ten rattan species of Bangladesh.

Legend: ***** **Flowering,** ***** **Fruiting,** **0 0 0 0 Fruit maturity and ripen**

5.13. Reproductive features and effects of seasons on reproductive potential in ten rattan species of selected clumps and natural habitats of Bangladesh : Reproductive features of rattan species of Bangladesh have not yet been worked out and very little information are available in literature. Besides, rattan species have been depleting at an

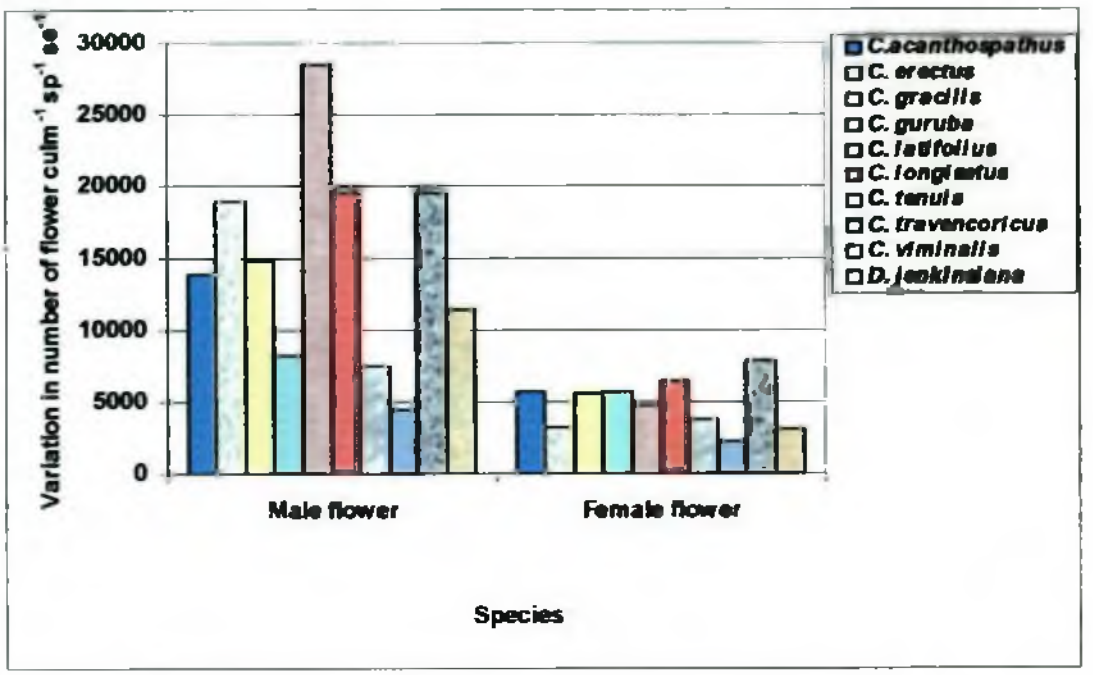


Figure 17 : Comparison of male and female flower in ten rattan species of Bangladesh.

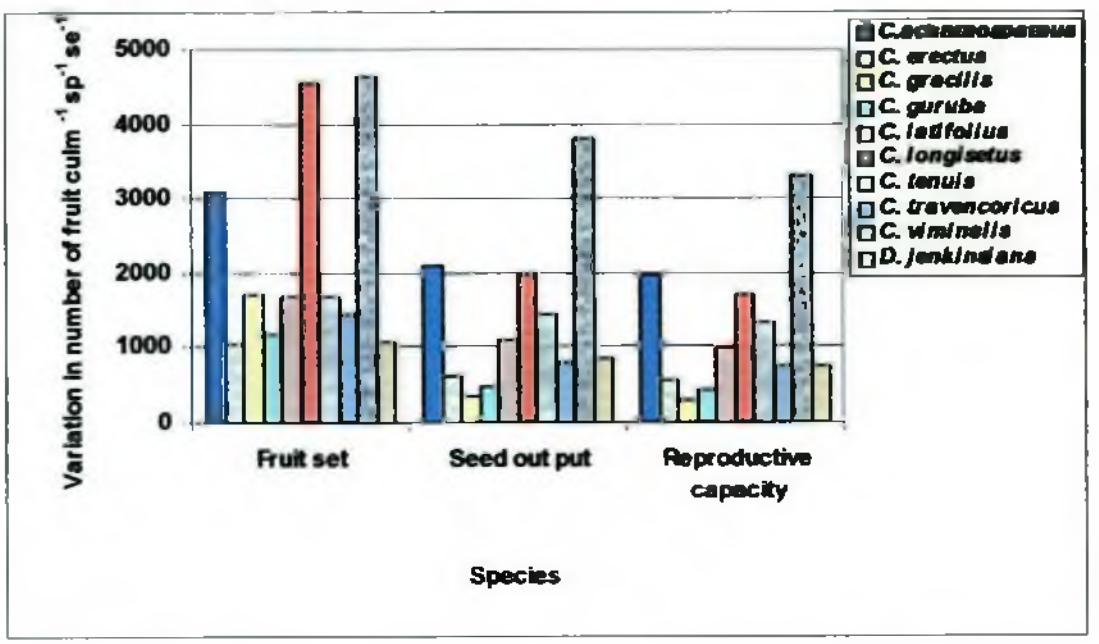


Figure 18 : Comparison of fruit set, seed out put and reproductive capacity in ten rattan species of Bangladesh.

alarming rate from the nature due to over exploitation, which is considered as one of the prime factor. Reproductive potential rattan species is a prerequisite of mass scale propagation. The result as presented in Table-25, Figure-17-18 and Appendix-8.7 indicate that all ten rattan species were observed to have excellent reproductive potential under natural conditions. Both reproductive features and reproductive potential in ten rattan species showed periodicity and plasticity with species, seasons and habitat. Fruit setting was recorded and ranged from 1053-7032 culm^{-1} species^{-1} year^{-1} depending on species and habitat. On the basis of number of fruit set culm^{-1} year^{-1}, ten rattan species can be ranked as *C.viminalis*> *C.acanthospathus*> *C.longisetus*> *C.gracilis*> *C.guruba*> *C.tenuis*> *C.latifolius*> *C.erectus*> *C.travencoricus*> *D.jenkinsiana*. Seed out put was recorded and ranged from 788-5296 culm^{-1} species^{-1} year^{-1} and on the basis of seed out put, ten rattan species can be ranked as *C.viminalis*> *C.acanthospathus*> *C.longisetus*> *C.tenuis*> *C.latifolius*> *C.erectus*> *D.jenkinsiana*> *C.guruba*> *C.travencoricus*> *C.gracilis*. Dormancy breaking period flushing period and germination per cent of fresh seeds of all rattan species were recorded to range from 42-147 days, 28-70 days and 41-90 % respectively under shade house condition. Reproductive capacity was recorded and found to range from 352-3090 culm^{-1} species^{-1} year^{-1}. On the basis of reproductive capacity culm^{-1} species^{-1}year^{-1}, recorded ten rattan species can be ranked as *C.viminalis*> *C.acanthospathus*> *C.longisetus*> *C.tenuis*> *C.latifolius*> *C.erectus*> *C.travencoricus*> *D.jenkinsiana*> *C.guruba*> *C.gracilis*. Figure-18 clearly shows that three species *viz. C.acanthospathus*, *C.longisetus* and *C.viminalis* were detected to be more potential in terms of fruit setting, seed out put and reproductive capacity compared to others during this investigation. Sengdala and Evans (1999) reported that each stem of *C.tenuis* could produce thousands of fruits per year. Table-25 and Appendix-8.7 demonstrate that four diphasic rattan species had more germination per cent of fresh seeds obtained from the fruits harvested in the early season of diphesic rattans compared to fruit harvested in the late season of the year under shade house conditions. t-test clearly states that germination per cent and reproductive capacity (*viz. C.erectus*, t=45.9, $P<0.001$; *C.gracilis*, t=44.3, $P<0.001$; *C.guruba*, t=36.3, $P<0.001$; *C.viminalis*, t=9.2, $P<0.05$) of fruits harvested in the early season was significantly higher than fruit harvested in the late season of the year. So, germination per cent of fruits harvested in the early season was considered as the standard one.

PROPAGATION

Introduction: All recorded rattan species of Bangladesh are under threat due to lack of knowledge in silvicultural management, indiscriminate cutting and over exploitation The knowledge of propagation of threatened rattans for large scale plantation is a demand of time. So, systematic attempts were made to understand the mode of propagation of fruits, seeds, seedlings, wildings, rhizomes, suckers and other plant parts to be used for large scale plantation.

5.14. Germination potential of whole fruits, unclean and clean seeds in ten rattan species of Bangladesh : The result as presented in Table-26, Figure-19 and Appendix-8.8 demonstrate that clean seeds of all rattan species had higher germination per cent

Table 26: Fruit and seed conditions effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

Species	Collection seasons	Sowing date	Nature of propugules	Dormancy breaking period,wks	Flushing period, wks	Germination per cent
C.acanthospathus	Early monsoon	Mar,27th	CS UCS WF	6±1 7±1 7±1	4±1 5±1 5±1	84±4.7 54±6 6 22±4.7
C.erectus	Early monsoon	Apr,22nd	CS UCS WF	6±1 7±1 7±1	4±1 5±1 5±1	82±6.6 52±3.7 38±5.6
C.gracilis	Early monsoon	Feb,28th	CS UCS WF	6±1 6±1 7±1	5±1 5±1 6±1	75±4.7 43±3.8 29±4.7
C.guruba	Winter	Jan,19th	CS UCS WF	6±1 11±1 13±1	5±1 8±1 9±1	74±5.6 46±3.8 20±2.8
C.latifolius	Monsoon	Jun,7th	CS UCS WF	10±1 10±1 11±1	7±1 7±1 7±1	73±4.7 60±2.8 22±3.8
C.longisetus	Monsoon	Jun,6th	CS UCS WF	11±1 12±1 12±1	7±1 7±1 8±1	77±8 5 57±2.8 34±2.8
C.tenuis	Early monsoon	Apr,17th	CS UCS WF	5±1 5±1 6±1	6±1 6±1 7±1	90±2.8 58±2 8 28±2.8
C.travencoricus	Early monsoon	Apr,19th	CS UCS WF	7±1 7±1 7±1	5±1 5±1 6±1	82±4.7 50±4.7 32±3.8
C.viminalis	Early monsoon	Mar,9th	CS UCS WF	8±1 8±1 9±1	4±2 4±1 5±1	62±5.6 41±6.7 24±5.6
D.jenkinsiana	Late monsoon	Sept,25th	CS UCS WF	21±1 21±1 21±1	10±1 11±1 13±1	71±3 8 46±6 5 28±5.6

Legend: Clean seed (CS), unclean seed (UCS) and whole fruits (WF); ± SEM.

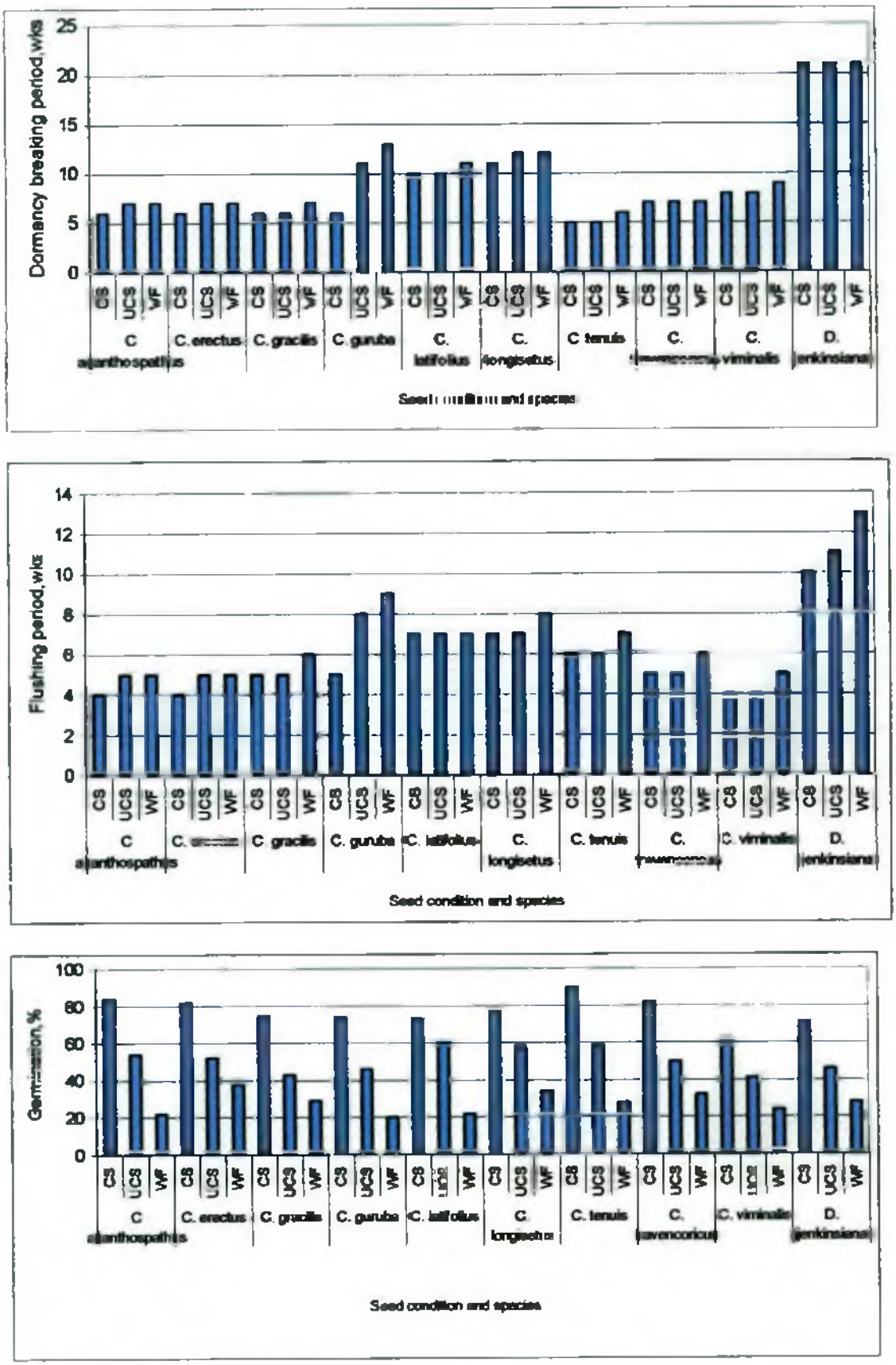


Figure 19 : Fruit and seed conditions effect on dormancy breaking period, flushing period and germination per cent in fresh fruit and seed of ten rattan species of Bangladesh.

compared to unclean seeds and whole fruits under shade house conditions. Germination per cent in clean seeds, unclean seeds and whole fruits were recorded to range from 62-90%, 41-60% and 20-38% respectively. Dormancy breaking period and flushing period of clean seeds, unclean seeds and whole fruits did not have marked variation with in the species under shade house conditions. Appendix-8.8 demonstrate the difference of dormancy breaking period, flushing period and germination per cent of clean seeds, unclean seeds and whole fruits of both diphasic and monophasic rattan species and showed a marked variation in germination per cent of four diphasic rattan species. Similar result was reported in *C.viminalis* (Banik and Nabi 1979). Alim and Kamaluddin (1985) found 61% germination for clean seeds of *C.tenuis* in nursery bed. In the present study the fruits collected and sown in temperature increasing season (*i.e.* fruits collected and sown in the early season of the year) had highest germination per cent with short dormancy breaking and flushing period. However, the fruit collected and sown in temperature falling season had lower germination per cent with long dormancy breaking and flushing period which was thought to be due to low temperature of the sowing medium. The result also shown that the seed conditions had highly significant effect on germination per cent ($F_{2,60}$=172.9; P<1.25) where clean seeds (CS), unclean seeds (UCS) and whole fruits (WF) condition recorded as best, good and fair respectively in respect to germination per cent. So, clean seeds were regarded as the standard seed condition for rattan seed germination.

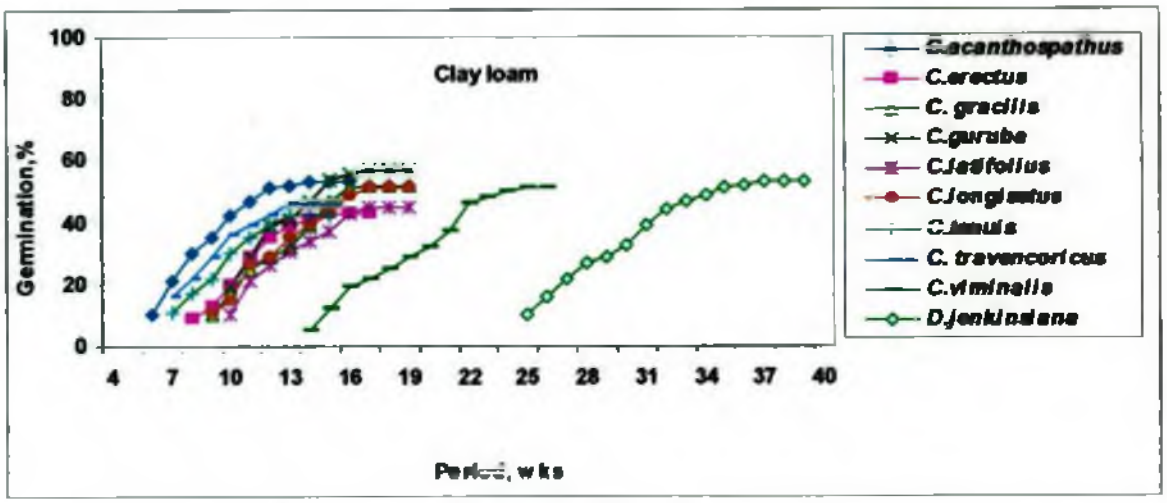
5.15. Sowing media effect on dormancy breaking period, flushing period and germination per cent in clean seeds of ten rattan species of Bangladesh : The result as shown in Table-27, Figure-20-21 and Appendix-8.9 exhibit that dormancy breaking period, flushing period and germination per cent varied with species as well as sowing media under same growing condition. It was recorded that same species had different rate of germination per cent with clay loam, sandy loam and fine sand under shade house condition. Seed sown in fine sand had higher germination per cent in comparison to sandy loam and clay loam soil in all rattan species and can be ranked as fine sand> sandy loam> clay loam soil. It is remarkable that dormancy breaking and flushing period were higher in clay loam in comparison to sandy loam and fine sand in all rattan species. Significant difference ($F_{9,60}$=14.4; P<7.58E-06) was found on germination per cent in three sowing media. No significant difference was found in germination per cent among

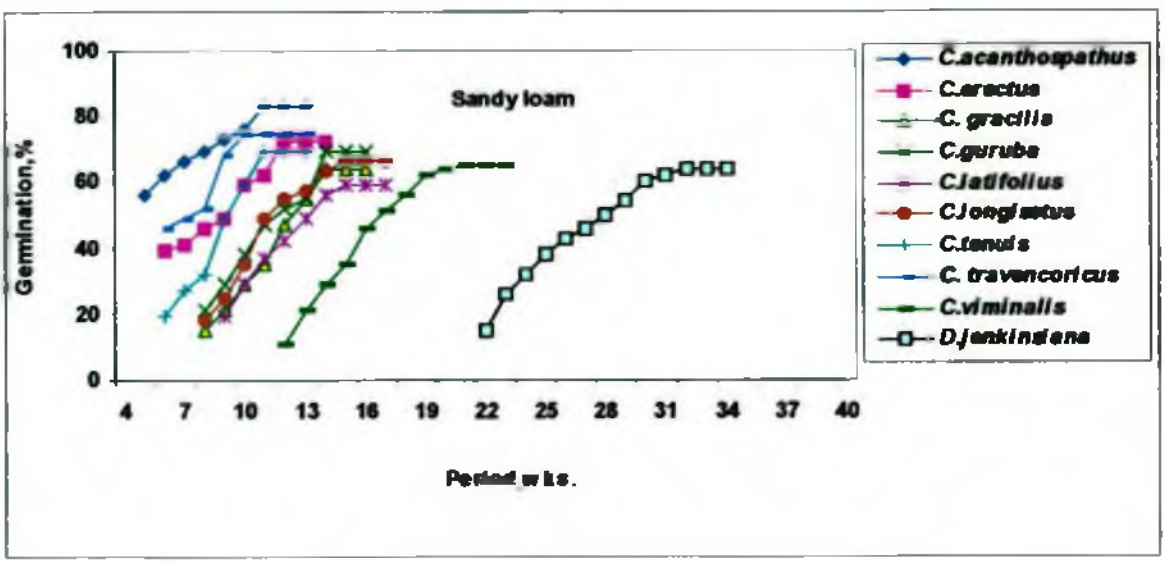
Table 27: Sowing media effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

Sowing media		Clay loam			Sandy loam			Fine sand		
Germination parameter / Species	Sowing time	Dormancy breaking period, wks	Flushing period, wks	Germination per cent	Dormancy breaking period, wks	Flushing period, wks	Germination per cent	Dormancy breaking period, wks	Flushing period, wks	Germination per cent
C.acanthospathus	27th Mar	6±2	7±1	48±7.5	6±1	6±1	76±9.4	6±1	4±1	84±4.7
C.erectus	22nd Apr	8±1	8±1	43±9.4	6±1	6±1	72±5.6	6±1	4±1	82±6.6
C.gracilis	28th Feb	9±2	7±2	62±10.4	6±1	6±1	64±6.6	6±1	5±1	75±4.7
C.guruba	19th Jan	10±2	7±2	67±6.7	8±2	7±1	69±4.7	6±1	5±1	74±5.6
C.latifolius	7th Jun	11±2	8±2	65±7.5	10±1	7±1	68±5.6	10±1	7±1	73±4.7
C.longisetus	6th Jun	13±2	10±1	61±6.6	11±1	8±1	66±6.8	11±1	7±1	77±6.8
C.tenuis	17th Apr	7±2	7±2	72±9.4	6±1	6±1	79±8.5	5±1	6±1	90±2.8
C.travencoricus	19th Apr	9±1	7±2	46±7.5	8±1	6±1	75±9.4	7±1	5±1	82±4.7
C.viminalis	9th Mar	10±2	7±1	51±6.6	9±2	6±1	55±6.6	8±1	4±2	62±5.6
D.jenkinsiana	25th Sep	25±2	13±2	53±7.5	22±2	11±2	64±7.5	21±1	10±1	71±3.8

Legend: ± SEM

the species ($F_{9,60}$=1.6; P<0.15). But the species can be ranked as *C.tenuis*> *C.acanthospathus*> *C.erectus*> *C.travencoricus*> *C.longisetus*> *C.gracilis*> *C.guruba*> *D.jenkinsiana* > *C.latifolius*> *C.viminalis*. Ahmad (1983) reported that *C.manan* prefers a medium of high water retention capacity such as saw dust or a mixture of 3:1 soil:sand, where as *C.caesius* germinates equally well in i) saw dust ii) soil:sand 3:1 iii) soil:sand 1:1 and iv) soil:sand 1:3. Mohiuddin and Ara (1995) suggested equal amount of moist sawdust and fine sand as suitable media for maximum germination per cent of *C.tenuis*. Seeds of ten rattan species were of various sizes and sowing depth was thought to have an effective role in changing the dormancy breaking period, germination rate, flushing period and germination per cent in all sowing media.





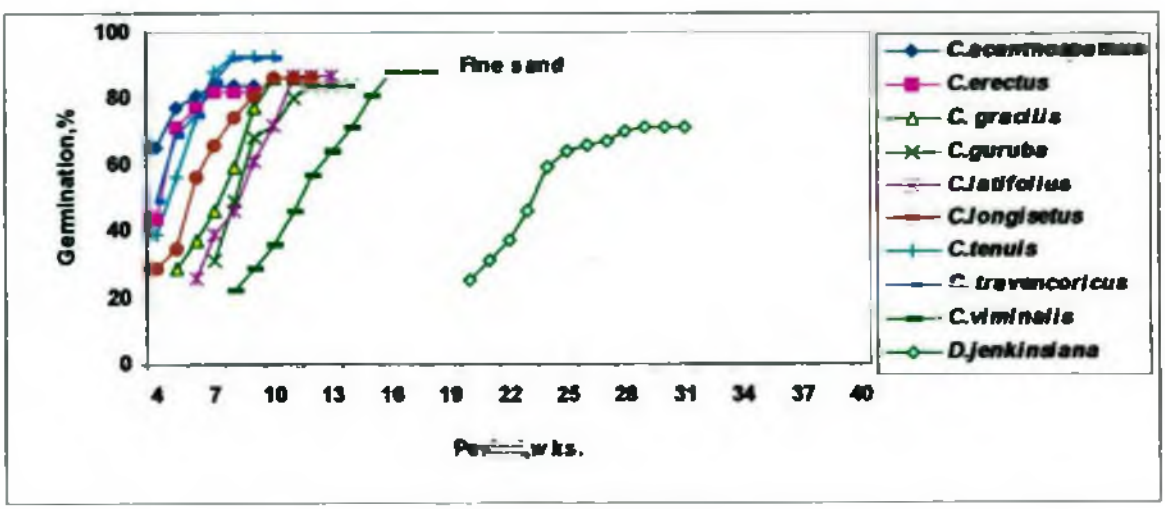


Figure 20 : Sowing media effect on rate of dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

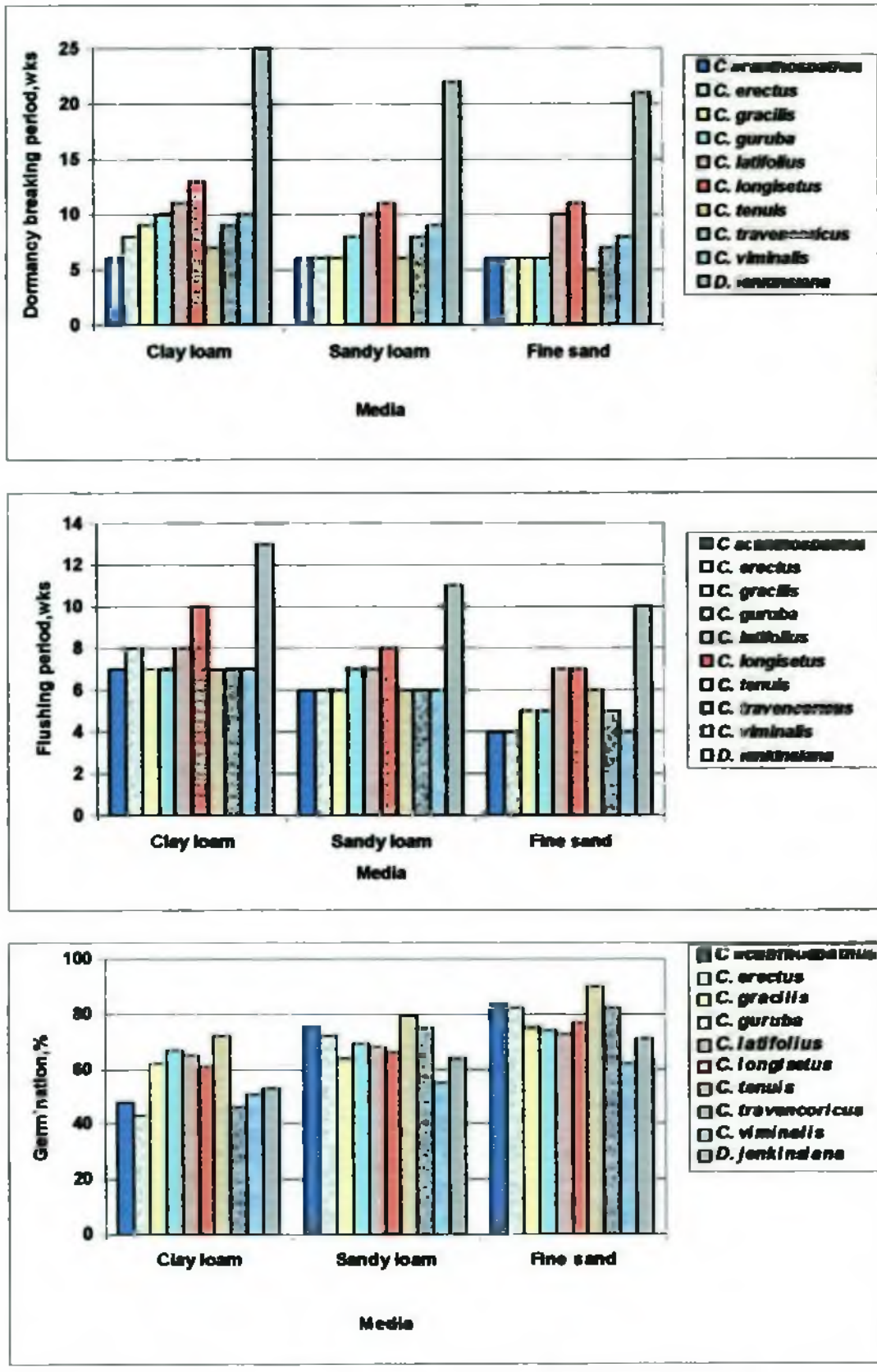


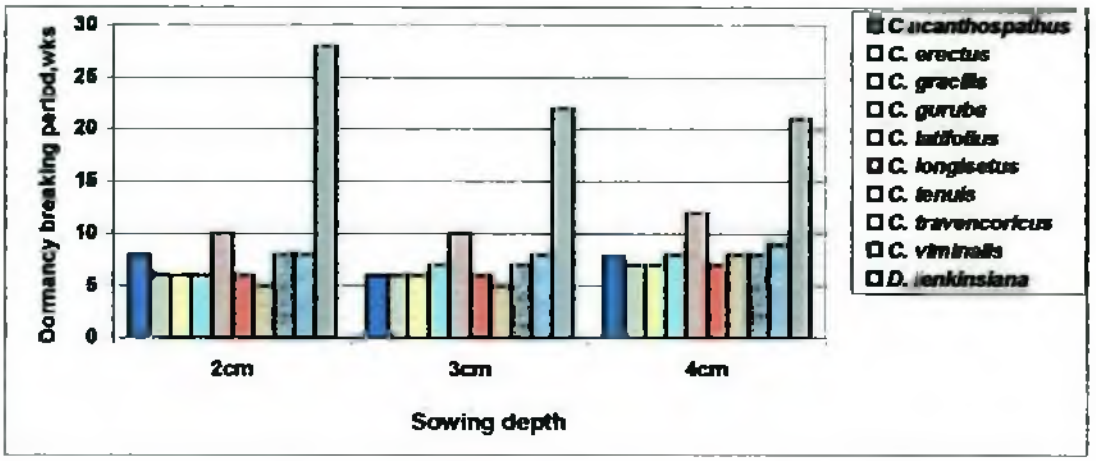
Figure 21 : Sowing media effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

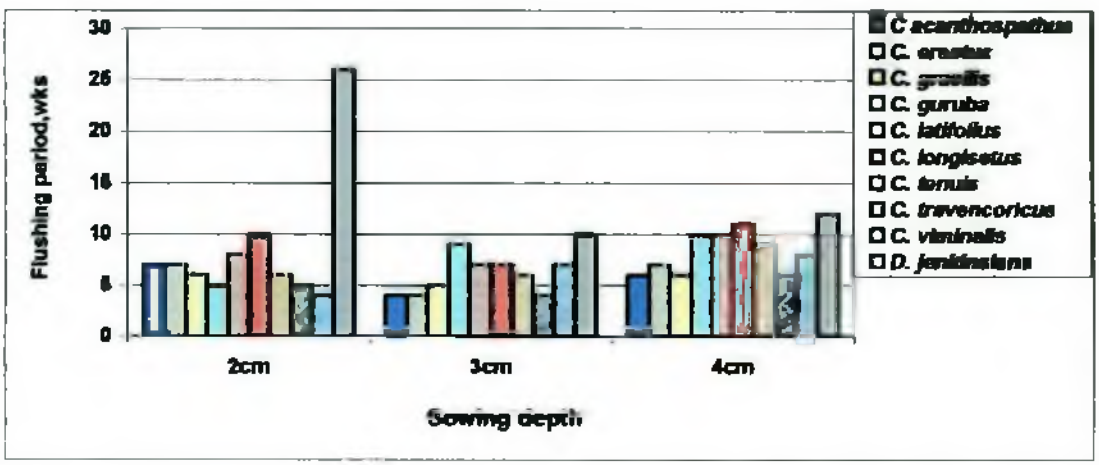
5.16. Sowing depth effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh : The result as presented in Table-28 and Figure-22 demonstrate that dormancy breaking

Table 28 : Sowing depth effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

Species	Seed collection-sowing time	Seed size		Sowing depth, cm								
				2			3			4		
		Size	Volume, cm³	Dormancy breakin period, wks	Flushing period, wks	Germination per cent	Dormancy breakin period, wks	Flushing period, wks	Germination per cent	Dormancy breaking period wks	Flushing period, wks	Germination per cent
C.viminalis	Apr,9th	Small	0.13	8±1	4±2	62±5.6	8±1	7±1	58±6.6	9±1	8±1	50±5.5
	Sep,7th			21±1	11±	43±6.6	25±1	12±	38±4.7	25±1	12±1	31±6.6
C.guruba	Jan,19th		0.14	6±1	5±1	74±4.7	7±1	9±1	72±4.7	8±1	10±1	62±5.5
	Jul,10th			12±1	9±1	58±5.6	13±1	9±1	46±2.8	15±1	11±2	46±7.5
C.tenuis	Jun,27th	Medium	0.25	5±1	6±1	83±5.6	5±1	6±1	90±2.8	8±1	9±1	87±6.7
	-			-	-	-	-	-	-	-	-	-
C.gracilis	Feb,28t		0.26	6±1	6±1	71±6.6	6±1	5±1	75±4.7	7±1	6±1	72±8.5
	Jul,31st			11±1	8±2	42±10.	11±2	8±1	48±10.	15±2	9±2	46±9.5
C.latifolius	Jun,27th		0.72	10±2	8±1	73±3.8	10±1	7±1	73±4.7	12±1	10±2	72±6.6
	-			-	-	-	-	-	-	-	-	-
D.jenkinsiana	Sept,25th		1.40	28±1	26±	69±5.6	22±1	10±1	71±3.8	21±2	12±1	64±8.5
	-			-	-	-	-	-	-	-	-	-
C.acanthospathus	Mar,27th	Large	3.0	8±1	7±1	62±4.7	6±1	4±1	72±4.6	8±1	6±1	84±7.5
	-			-	-	-	-	-	-	-	-	-
C.travencoricus	Apr,19th		3.12	8±1	5±1	66±8.5	7±1	4±1	73±4.6	8±1	6±1	82±6.5
	-			-	-	-	-	-	-	-	-	-
C.longisetus	Jun,26th		3.45	8±2	10±	72±7.5	11±1	7±1	73±6.6	11±1	11±2	77±6.5
	-			-	-	-	-	-	-	-	-	-
C.erectus	Apr,22nd		5.01	6±1	7±1	62±7.5	6±1	4±1	72±6.7	7±1	7±2	82±7.5
	Oct,2nd			16±1	5±1	42±6.6	16±1	3±1	58±8.5	16±2	4±1	55±5.6

Legend : ±SEM





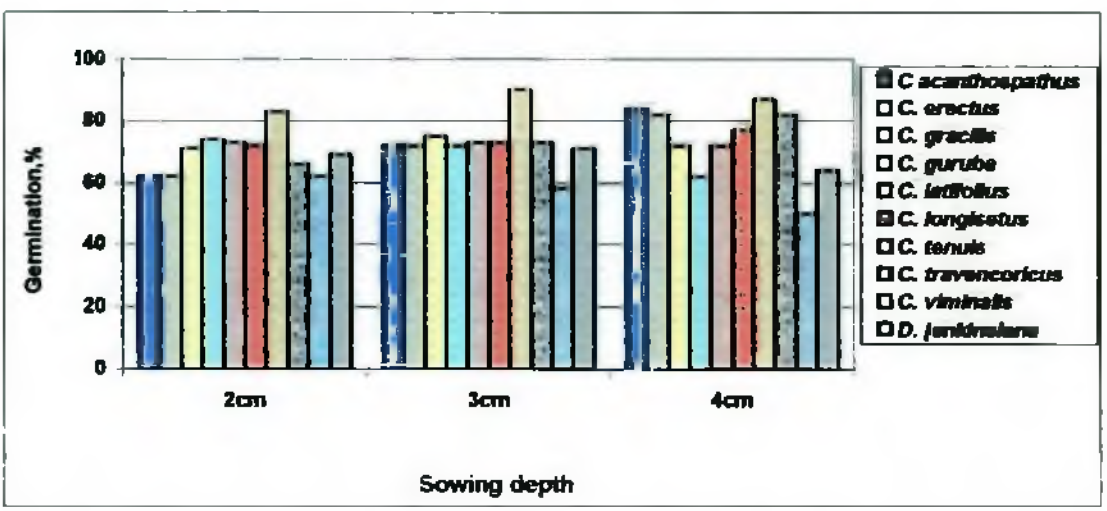


Figure 22 : Sowing depth effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

period, flushing period and germination per cent had a relationship both with sowing depth and seed sizes in fine sand under shade house condition. Seeds of three sizes *viz.* small (0.13-0.14 cm^3), medium (0.25-1.4 cm^3) and large (3.0-5.01 cm^3) sown at three depths (2, 3 and 4 cm) revealed that rattan species (*viz. C.viminalis* and *C.guruba*) of small sized seeds were recorded to have maximum germination per cent at a depth of 2 cm compared to medium and large sized seeds. While rattan seeds (*viz. C.tenuis, C.gracilis, C.latifolius* and *D.jenkinsiana*) of medium sized were recorded to have maximum germination per cent at a depth of 3 cm in comparison to other rattan species. Rattan species (*viz. C.longisetus, C.travencoricus, C.acanthospathus* and *C.erectus*) were recorded to have maximum germination per cent at depth of 4 cm in comparison to other species.

Present investigation revealed that germination per cent of rattan seeds was very much related to sowing depth in fine sand under shade house condition. It was experienced that large sized rattan seeds come out from the media by slight rain or watering which might have caused seed desiccation resulting low germination per cent while small sized rattan seeds sown at a depth of 3 cm or more resulted long dormancy breaking period and flushing period with low rate of germination per cent. Besides, rattan seeds collected in the early and late season of the year was thought to have seasonal effect in dormancy breaking, flushing and germination per cent even in same sowing medium under shade house condition.

5.17. Sowing seasons effect on dormancy breaking period, flushing period and germination per cent in clean seeds of ten rattan species of Bangladesh : The result as shown in Table-29, Figure-23-24 demonstrate that recorded ten rattan species were observed to produce mature fruits through out the year. On the basis of maturity, fruits were collected on four seasons *viz.* early monsoon (Mar-May), monsoon (Jun-Aug), late monsoon (Sep-Nov) and winter (Dec-Feb) to verify the effect of fruit collection season on germination per cent. It was observed that the fruit collected in 1^{st} half of the year (*i.e.* Jan-Jun) showed higher germination per cent with shorter dormancy breaking period and flushing period in comparison to fruits collected in 2^{nd} half of the year except in *D.jenkinsiana* which had a prolonged dormancy breaking period of about five months with high germination per cent ($71\pm3.8\%$). It was observed that seeds of *D.jenkinsiana* usually obtained in September and seeds sown in sowing media under shade house

Table 29 : Sowing seasons effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

Species	Collection Season	Sowing date	Dormancy breaking period,wks	Flushing period, wks	Germination per cent
C.acanthospathus	EM	Mar,27th	6+1	4+1	84+4.7
C.erectus	LM	Oct,2nd	16+2	3+1	55+7.5
	EM	Apr,22nd	6+1	4+1	82+6.6
C.gracilis	M	Jul,2nd	11+2	8+2	41+5.6
	EM	Feb,28th	6+1	5+1	75+4.7
C.guruba	M	Jul,10th	12+1	9+1	47+2.8
	W	Jan,19th	6+1	5+1	74+5.6
C.latifolius	M	Jun,7th	10+1	7+1	73+4.7
C.longisetus	M	Jun,6th	11+1	7+1	77+8.5
C.tenuis	EM-M	Apr,17th	5+1	6+1	90+2.8
C.travencoricus	EM	Apr,19th	7+1	5+1	82+4.7
C.viminalis	EM	Mar,9th	8+1	4+2	62+5.6
	LM	Sep,7th	21+1	11+1	49+6.6
D.jenkinsiana	LM	Sep,25th	21+1	10+1	71+3.8

Legend: EM=Early monsoon (Mar-May); M=Monsoon (Jun-Aug); LM=Late monsoon (Sep-Nov); W=Winter (Dec-Feb); ± SEM.

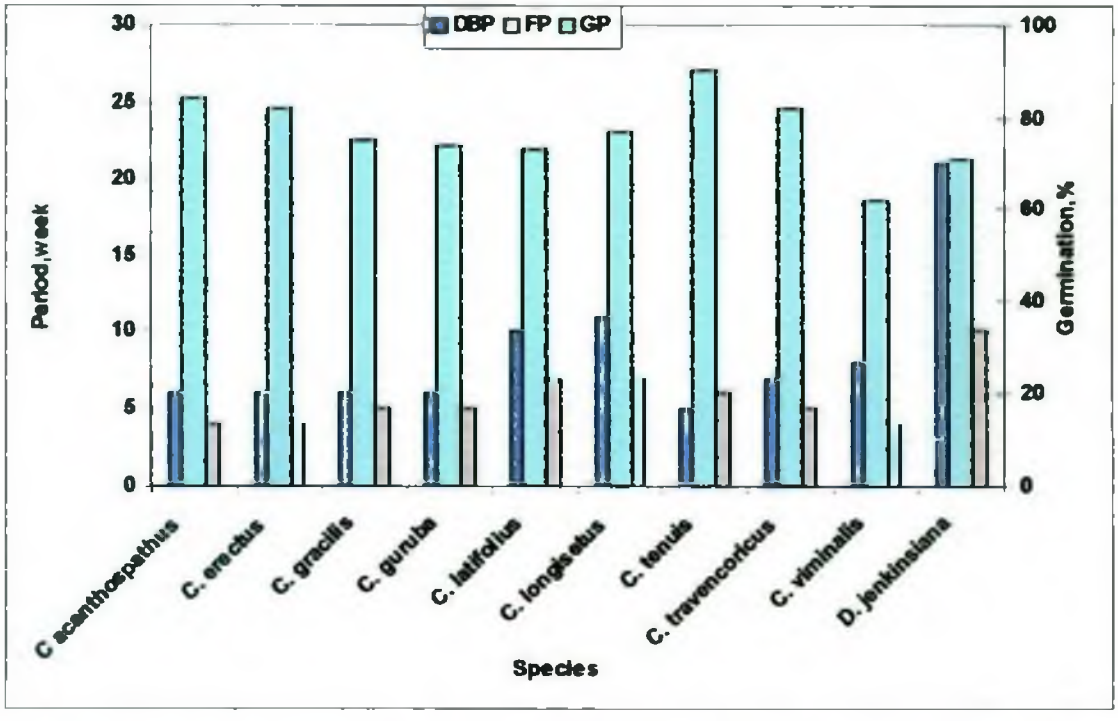


Figure 23 : Sowing seasons effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds both monophasic and diphasic rattan species of Bangladesh.

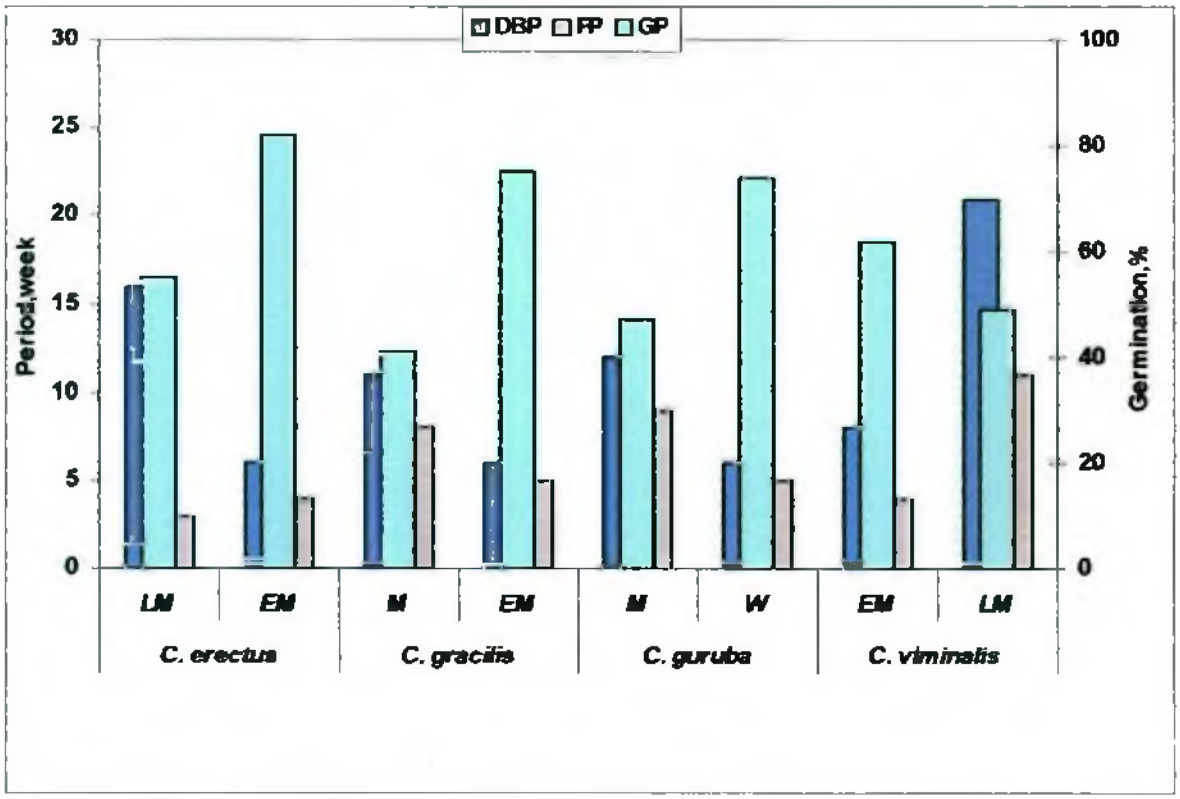


Figure 24 : Sowing seasons effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of four diphasic rattan species of Bangladesh.

condition were observed to germinate at the end of month of February when the weather condition start to become warmer which seems to fulfill the requirements of dormancy breaking, flushing period and germination per cent.

5.18. Pretreatments effect of soaking period of water (a), sulfuric acid (b), potassium nitrate (c) and gibberellic acid (d) on dormancy breaking period, flushing period and germination per cent in clean seeds of ten rattan species of Bangladesh : The result as shown in Table-30a-d demonstrate that seeds of three rattan species *viz. C. tenuis, C.viminalis* and *D.jenkinsiana* pretreated with soaking periods (*viz.* 48, 72 and 96 hours) with normal water, conc. H_2SO_4 (*viz.* 5, 10 and 20 N), KNO_3 (*viz.* 250, 500 and 1000 ppm) and GA_3 (*viz.* 250 ,500 and 1000 ppm) did not have higher germination per cent compared to their controls maintained in distilled water for 24 hours. Three soaking periods were not observed to enhance dormancy breaking period, flushing period and germination per cent compared to the control in pretreated seeds of each species. Three

Table 30 : Pre-treatments effect of soaking period of water (a),sulfuric acid (b), potassium nitrate (c) and gibbrellic acid (d) on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

30a

Species	Control			Soaking period in tap water, hr								
	24 hr (distilled water)			48			72			96		
	DBP	FP	GP	DBP	FP	GP	DBP	FP	GP	DBP	FP	GP
C. tenuis	28±5	42±6	92±2.8	30±6	43±5	90±3.8	32±6	45±5	89±1.7	31±6	43±5	88±1.6
C.viminalis	56±6	28±7	62±5.7	57±7	25±8	59±3.7	61±7	29±4	58±2.8	61±7	29±4	59±2.8
D.jekinsiana	142±8	70±6	71±4.7	140±9	68±10	58±5 6	146±5	66±4	32±5.7	143±5	69±4	32±5.7

30b

Species	Control			Concentration of sulfuric acid (H_2SO_4), N								
	Distilled water			5			10			20		
	DB	FP	GP	DBP	FP	GP	DBP	FP	GP	DB	FP	GP
C.tenuis	28±5	42±6	92±2.8	30±6	36±5	90±3.8	38±6	35±5	49±1.7	-	-	-
C.viminalis	56±6	28±7	62±5.7	57±7	25±8	51±3.7	61±7	29±4	28±2.8	-	-	-
D.jekinsiana	142±8	70±6	71±4.7	140±9	66±10	58±5.6	156±5	46±4	32±5.7	-	-	-

30c

Species	Control			Concentration of potassium nitrate (KNO_3),ppm								
	Distilled water			250			500			1000		
	DB	FP	GP	DBP	FP	GP	DBP	FP	GP	DB	FP	GP
C.tenuis	30±3	40±5	93±1.8	27±5	45±7	91±3.7	29±4	42±3	90±2.8	28±5	42±3	94±2.8
C.viminalis	55±6	31±6	60±4.7	59±4	32±5	63±4.5	61±3	30±7	62±3.8	58±4	32±5	65±3.7
D.jekinsiana	138±7	72±7	70±6.5	143±6	72±6	68±3.8	142±6	70±6	68±2.7	146±3	72±5	71±3.8

30d

Species	Control			Concentration of gibberellic acid (GA_3), ppm								
	Distilled water			250			500			1000		
	DB	FP	GP	DBP	FP	GP	DBP	FP	GP	DB	FP	GP
C.tenuis	27±6	38±5	89±2.8	29±3	36±4	88±4.7	30±4	35±3	91±2.5	29±5	30±3	92±2.6
C.viminalis	56±7	32±5	59±3.7	58±4	30±5	61±4.8	59±5	30±6	60±4 6	60±6	37±4	63±3.5
D.jekinsiana	140±6	68±6	68±2 7	142±3	72±6	66±6.6	140±3	70±5	70±2.8	138±5	58±3	2±2.6

Legend: DBP=Dormancy breaking period, FP=Flushing period and GP=Germination per cent; ±SEM

concentration of H_2SO_4 were also observed not to enhance the dormancy breaking period, flushing period and germination per cent compared to the control rather the seeds pretreated with 20N H_2SO_4 deformed the seeds of three rattan species, and did not have marked change in any sign to germinate. Ara *et al.* (1994) observed 50% germination in *D.jenkinsiana* seeds with or without using H_2SO_4. While seeds pretreated with three different concentration of both KNO_3 and GA_3 also did not show any marked change on dormancy breaking period, flushing period and germination per cent compared to the control even with the increase of concentration 4 times in each treatments. In the present investigation, pretreatments of recalcitrant seeds of three rattan species were not found to be favorite to used concentration of the chemicals. It was worked out that apparently there was no pretreatment effect on germination.

5.19. Storage conditions effect on dormancy breaking period, flushing period and germination per cent in clean seeds of ten rattan species of Bangladesh : The result as shown in Table-31 and Figure-25 explain that three storage conditions *viz.* moist fine sand, refrigerator and indoor were observed to have marked effect in the change of germination per cent rather than dormancy breaking period and flushing period in seeds of each rattan species sown in fine sand under shade house condition excepting *C.travencoricus*, *C.acanthospathus* and *C.erectus* where the seeds were not found viable in either of these storage conditions until the experiment was set. The seeds of these three species were observed to become damaged-black in indoor and refrigerator, and partially black in fine sand. In the present investigation moist fine sand was found as a favorite storage condition to be used for mass scale propagation programme. Mean germination per cent of viable seeds in 7 rattan species *viz. C.gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis, D.jenkinsiana* species in three storage conditions showed highest germination per cent (74.43%) in moist fine sand compared to refrigerator (46.57%) and indoor (20.42%). Significant difference ($F_{2,42}$=131.8; P<7.94E-19) was found on germination per cent in three storage conditions. But no significant difference was found on germination per cent among the species. Most seeds of the Palmae family show very short viablility. It is reported that rattan seeds remain viable for 1-2 months (Badhwar *et al.* 1961; Gulati and Sharma 1983). Ahmad and Hamzah (1985) reported that proper storage conditions can extend the viability to about 6 months. Similarly, Pritchard and Davies (1999) mentioned about hydrated storage of rattan seed

for periods of up to 6 months. Bogaloyos (1988) reported that reduction of moisture content adversely affects the viability of rattan seeds. Zoysa and Vivekandan (1989) reported that the seeds can be kept alive for up to two years if they are buried about 15 cm deep in moist soil. The present study confirms that all rattan seeds can be stored in moist fine sand for a maximum period of about one year (except *C.erectus*, *C.acanthospathus* and *C.travencoricus*) until the favorite season for the germination of seeds.

Table 31: Storage conditions effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

Species	Fruit-seed collection date	Storage conditions	Sowing date and air temp	Germination parameters		
				Dormancy breaking period,days	Flushing period, days	Germination per cent
C.acanthospathus	27th Mar'01	M FS RG ID	25th Feb 02 22+6°C	- - -	- - -	- - -
C.erectus	22nd Apr' 01	M FS RG ID	25th Feb 02 22+6°C	- - -	- - -	- - -
C.gracilis	28th Feb' 01	M FS RG ID	25th Feb 02 22+6°C	45±3 50±3 52+3	32±5 33±5 35±2	79±6.6 42+2.8 18+1.9
C.guruba	9th Jan'01	M FS RG ID	25th Feb 02 22+6°C	45±7 48±6 52+3	30±6 35+3 36+3	66+5.6 48±2 8 20+1.9
C.latifolius	27th Jun' 01	M FS RG ID	25th Feb 02 22+6°C	48±7 47±3 46+4	40+5 42+5 39+3	68±6.6 42+2.8 22+1.9
C.longisetus	27th Jun' 01	M FS RG ID	25th Feb 02 22+6°C	72+7 68+7 60+5	38+8 45±3 47+4	76±8.5 41+3.8 19+3.8
C.tenuis	27th Jun' 01	M FS RG ID	25th Feb 02 22+6°C	48±6 53±4 59+6	36±7 39+3 36+4	82+17.5 47+1.9 22+4.7
C.travencoricus	19th Apr' 01	M FS RG ID	25th Feb 02 22+6°C	- - -	- - -	- - -
C.viminalis	9th Apr' 01	M FS RG ID	25th Feb 02 22+6°C	52±7 53+7 56+6	32+7 33+4 35+5	74+7.5 48+2.8 14+5.6
D.jenkinsiana	25th Sep' 01	M FS RG ID	25th Feb 02 22±6°C	55±7 61±5 69±4	32+6 39+4 38+3	76±8.5 58+4.7 28+3.8

Legend: MFS= Moist fine sand (12±4°C); RG= Refrigerator aluminum foil sealed (3±1°C) and ID=Indoor (aluminum foil 20±4°C); ±SEM.

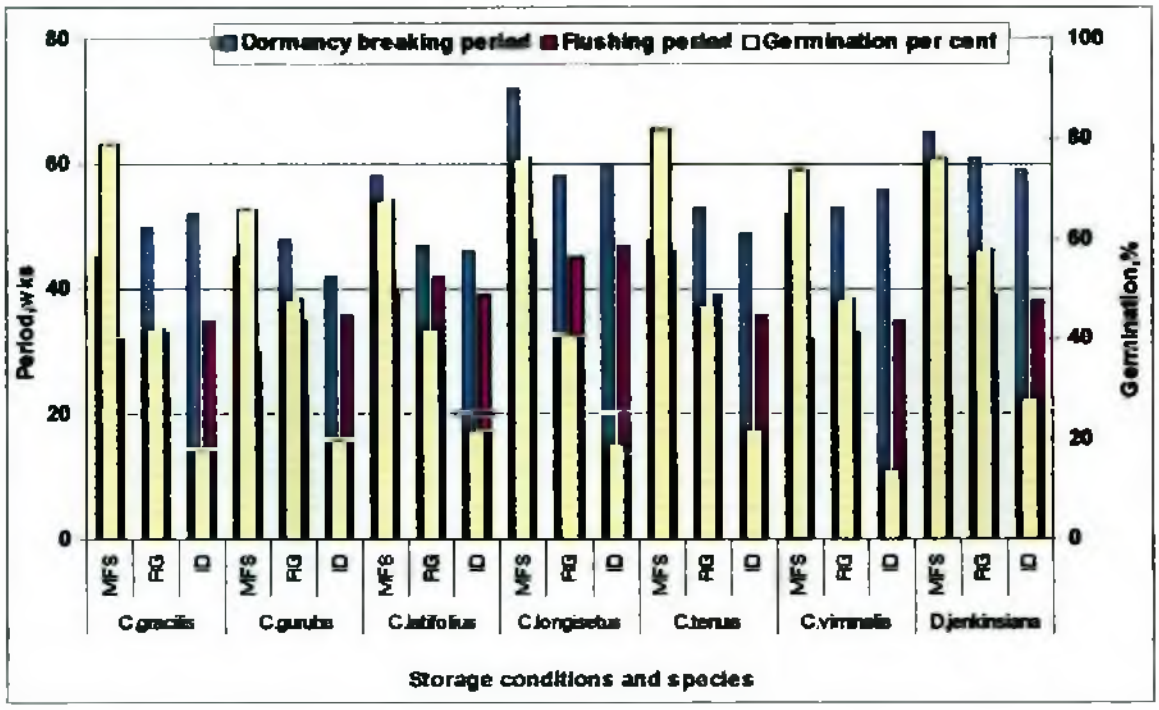


Figure 25 : Storage conditions effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

5.20. Storage period effect on dormancy breaking period, flushing period and germination per cent in clean seeds of ten rattan species of Bangladesh : The results as shown in Figure-26 and Appendix-8.10 demonstrate that fresh seeds of all rattan species were observed to remain viable for more than a year from the date of their collection excepting *C.erectus*, *C.acanthospathus* and *C.travencoricus* where the seeds did not show any sign of germination even after three months of storage period. The seeds of these three species were observed to loose their viability even in moist fine sand with the deformation of embryo and endosperm. Stored seeds of hard seeded rattan species *viz. C.gracilis*, *C.guruba*, *C.latifolius*, *C.longisetus*, *C.tenuis*, *C.viminalis*, *D.jenkinsiana* were observed to have more or less the same germination per cent with a long dormancy breaking period and flushing period during August-December within the same species over a storage period of one year.

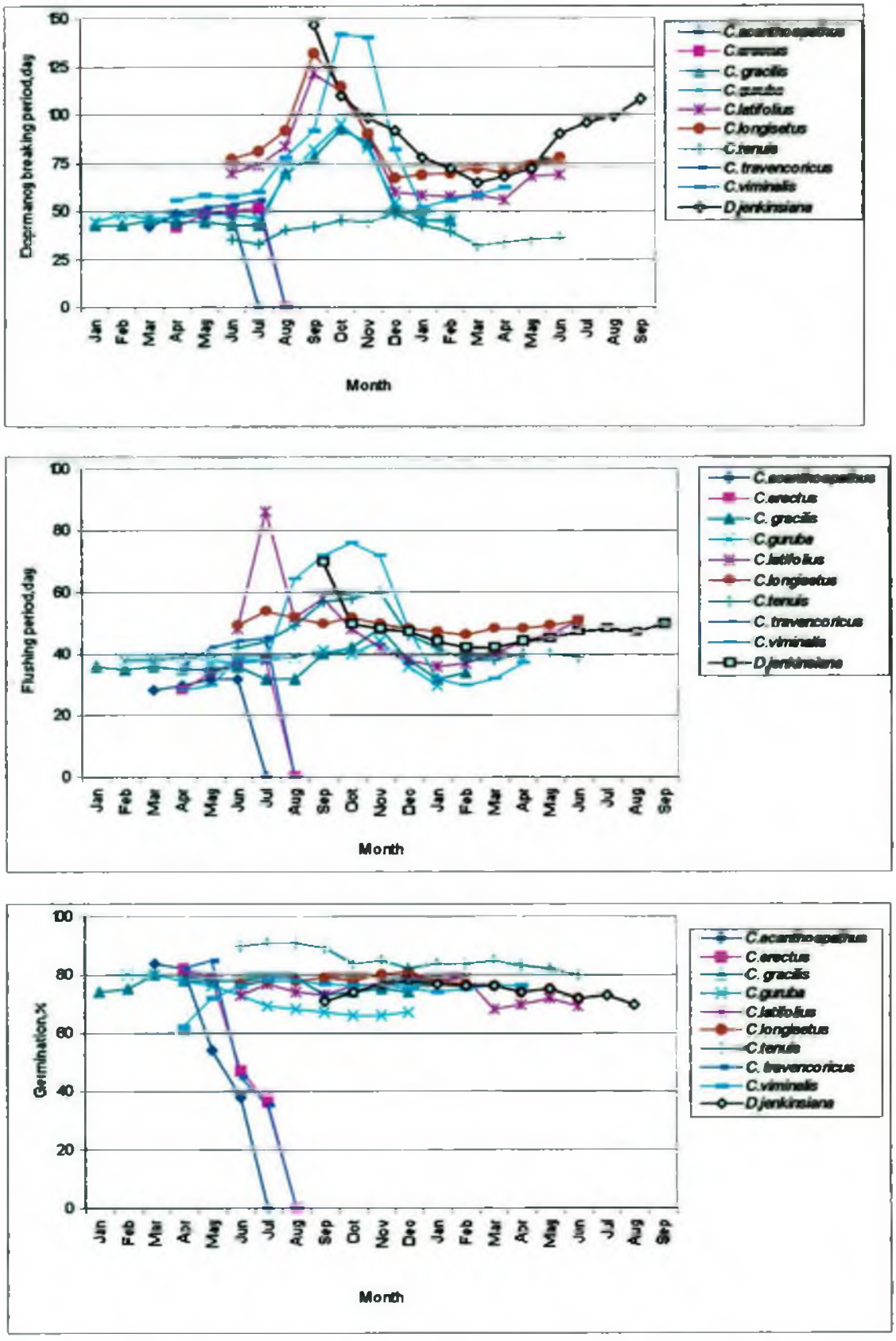


Figure 26 : Storage period effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

5.21. Tetrazolium trichloride (TTC) effect on viability of embryo and living tissue of endosperm of fresh clean seeds (stored in moist fine sand at two months interval over a period of one year) in ten rattan species of Bangladesh : The result as shown in Table-32 demonstrate that the seeds of all rattan species were found to remain viable in moist fine sand over a storage period of one year except those of *C.erectus*, *C.acanthospathus* and *C.travencoricus* where the seeds could not have retained the viability of embryo and endosperm tissue even after three months of storage period. Freshly prepared tetrazolium tri chloride solution of 0.1% was found to be favorite compared to 0.2 and 0.3% to test seed viability in all rattan species in present investigation. While appearance of both embryo and endosperm was clear white in control and sharp pink in 0.1% TTC solution indicated as the best condition for viability of seeds irrespective to species.

5.22. Germination condition-temperature effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh : It was evident from the previous experiment of storage period effect on germination per cent in stored seeds of ten rattan species that low temperature had bad effect on dormancy breaking and flushing period which delayed germination. The result as presented in Table-33 and Figure-27 demonstrate that seeds germinated under three conditions *viz.* incubator (30 ± 1^0C), indoor (20 ± 5^0C) and outdoor (25 ± 10^0C) varied with species and germination conditions. Dormancy breaking period and flushing period of all ten rattan species were found longer in outdoor followed by indoor and incubator where the germination per cent was maximum in incubator (96%) followed by indoor (94%) and outdoor (77%) germination conditions. The statistical analysis revealed that germination per cent in these three conditions were found highly significant ($F_{2,60}$=20.5; P<1.59E-0.7). Rao (1999) reported that germination per cent of *C.latifolius* and *C.guruba* varies from 90-95% and 42-71% with in 12-31 and 4-9 weeks respectively under 27-30^{0}C temperature. Dormancy breaking period in *D.jenkinsiana* was significantly different compared to the other nine species. Longest flushing period was observed in *D.jenkinsiana* in three conditions compared to the other species. Significant difference ($F_{9,60}$=26.05; P<1.42E-17) was found in dormancy breaking period among the species.

Table 32 :Tetrazolium trichloride effect on viability of embryo and living tissue of endosperm of fresh clean seeds (stored in moist fine sand at two months interval for one year) in ten rattan species of Bangladesh.

Treatments	Control							Conc .of Tetrazolium, %																						
Storage, month	Distilled water							0.1							0.2							0.3								
	1	2	4	6	8	10	12	1	2	4	6	8	10	12	1	2	4	6	8	10	12	1	2	4	6	8	10	12	
Species																														
C.acanthospathus	w^+	w^+	w	-	-	-	-	p	p	p^-	-	-	-	-	p^+	p^+	p^{++}	-	-	-	-	p^+	p^+	p^{++}	-	-	-	-		
C.erectus	w^+	w^+	w^+	-	-	-	-	p	p	p^-	-	-	-	-	p^+	p^+	p^{++}	-	-	-	-	p^+	p^+	p^{++}	-	-	-	-		
C.gracilis	w^+	w^+	w^+	w^+	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+		
C.guruba	w^+	w^+	w^+	$^+$	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^{++}	p^{++}	p^{++}		
C.latifolius	w^+	w^+	w^+	w^+	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}		
C.longisetus	w^+	w^+	w^+	$^+$	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}		
C.tenuis	w^+	w^+	w^+	w^+	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}		
C.travencoricus	w^+	w^+	w	-	-	-	-	p	p	p^-	-	-	-	-	p^+	p^+	p^{++}	-	-	-	-	p^+	p^+	p^{++}	-	-	-	-		
C.viminalis	w^+	w^+	w^+	w^+	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}	p^{++}		
D.jenkinsiana	$^+$	w^+	w^+	w^+	w^+	w^+	w^+	p	p	p	p	p	p	p	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+	p^+		

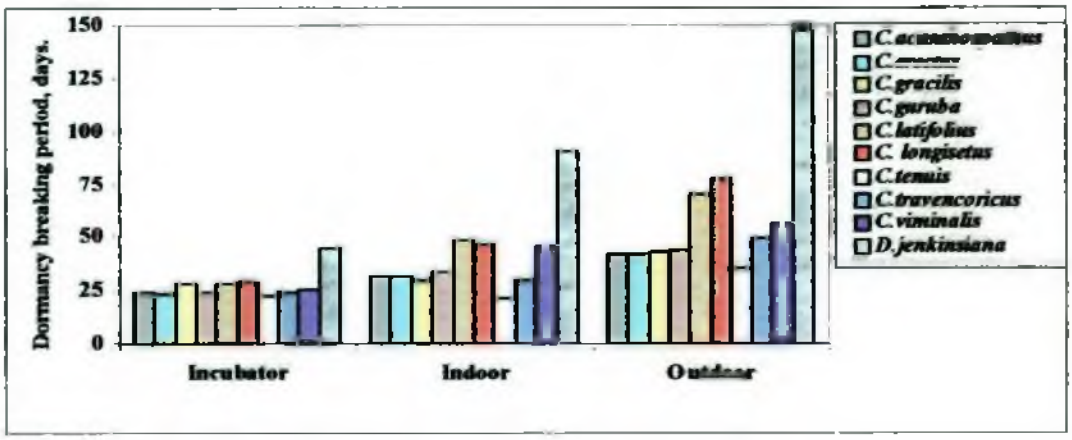
Legend: w^+=White; w=Dull white; p= Sharp pink; p^+=Deep pink; p^{++}=Dark pink; p^- = Light pink.

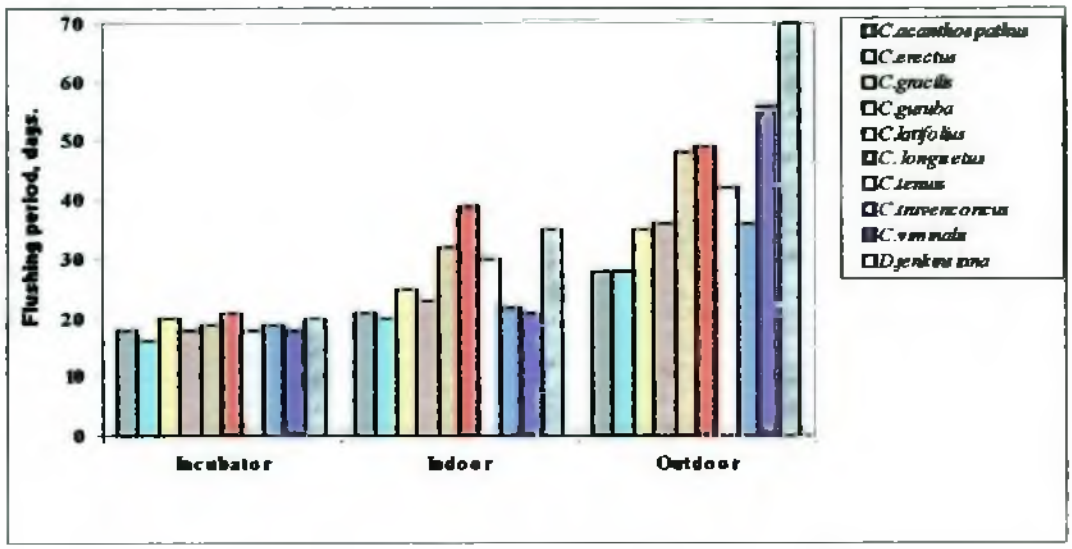
Table 33 : Germination condition-temperature effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

Species	Fruit-seed collection-sowing time	Germination conditions	Germination parameters		
			Dormancy breaking period, days	Flushing period, days	Germination per cent
C.acanthospathus	27th Mar. 03	INCUBATOR (30±1°C)	24±3	18+2	95±2.8
		INDOOR (20±5°C)	32±6	21±5	90±3.8
		OUTDOOR (25±10°C)	42±5	28+7	84+4.7
C.erectus	22nd Apr. 03	INCUBATOR (30±1°C)	23±4	16±3	94±2.8
		INDOOR (20±5°C)	32±5	20±4	88±2.8
		OUTDOOR (25±10°C)	42+7	28+6	82+6.6
**C.gracilis*	28th Feb. 03	INCUBATOR (30±1°C)	28±4	20±3	89±4.7
		INDOOR (20±5°C)	30±8	25±6	82+3.8
		OUTDOOR (25±10°C)	43±10	35±8	75+4.7
C.guruba	9th Jan. 03	INCUBATOR (30±1°C)	24±3	18±3	92±2.8
		INDOOR (20±5°C)	34±6	23±5	86±1.9
		OUTDOOR (25±10°C)	44+5	36+6	74+5.6
C.latifolius	27th Jun. 03	INCUBATOR (30±1°C)	28±3	19±2	92±2.8
		INDOOR (20±5°C)	48±5	32+3	89+2.8
		OUTDOOR (25±10°C)	70+7	48+7	73+4.7
C.longisetus	27th Jun. 03	INCUBATOR (30±1°C)	29±3	21±2	93±1.9
		INDOOR (20±5°C)	47±6	39±7	88±2.8
		OUTDOOR (25±10°C)	77+8	49+8	77+6.6
C.tenuis	27th Jun. 03	INCUBATOR (30±1°C)	22±2	18±3	96+2.8
		INDOOR (20±5°C)	21±3	30±3	94±2.7
		OUTDOOR (25±10°C)	35+5	42+6	90+2.8
C.travencoricus	19th Apr. 03	INCUBATOR (30±1°C)	24±3	19±2	92±1.9
		INDOOR (20±5°C)	30±5	22+3	86±1.8
		OUTDOOR (25±10°C)	49+6	36+8	82+4.7
C.viminalis	9th Apr. 03	INCUBATOR (30±1°C)	42+3	18±2	92±1.9
		INDOOR (20±5°C)	46+4	21±5	88+2.8
		OUTDOOR (25±10°C)	56+8	56+8	62+5.6
D.jenkinsiana	25th Sep. 03	INCUBATOR (30±1°C)	55±5	20±3	94±1.9
		INDOOR (20±5°C)	90+5	35±7	88±3.8
		OUTDOOR (25±10°C)	147+7	70+9	71+3.7

Legend: ± SEM.

Highly significant difference ($F_{2,60}$=123.52; P<5.36E-22) was found in dormancy breaking period at three different conditions. Incubator germination condition (30±1°C) was identified as the best temperature for rattan seed germination followed by indoor and outdoor in the present investigation. Precision temperature for minimization of dormancy breaking and flushing period in incubator was felt necessary to be verified at least for two common rattan species *viz. C.viminalis* and *D.jenkinsiana* which required long dormancy breaking period 42 and 55 days respectively even in incubator (30±1°C).





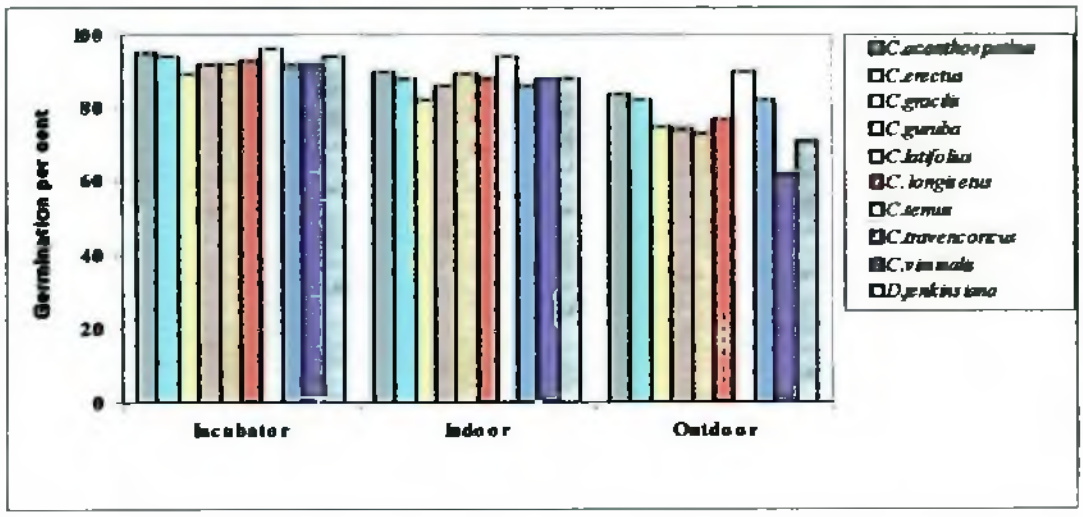
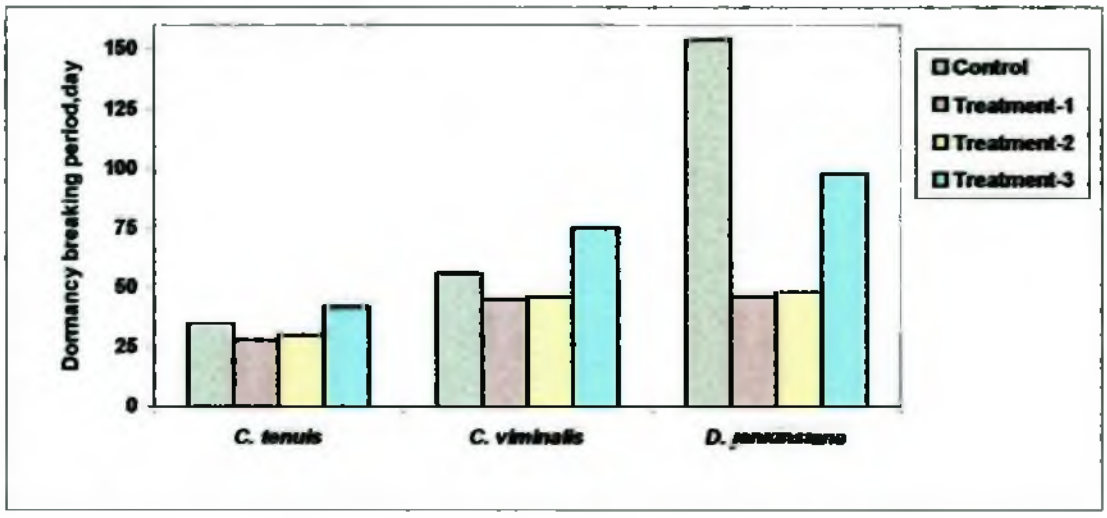


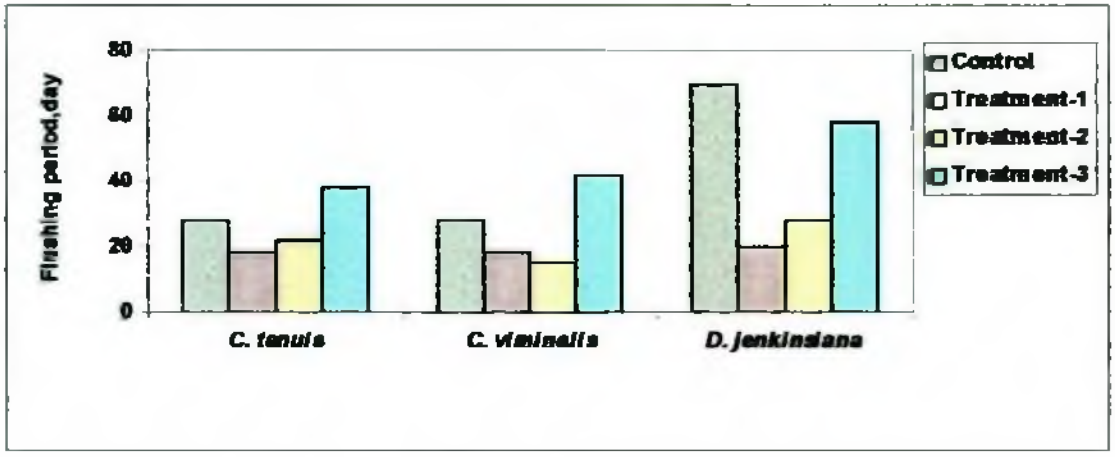
Figure 27 : Germination condition-temperature effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of ten rattan species of Bangladesh.

5.23. Constant temperature (incubator) effect on dormancy breaking period, flushing period and germination per cent in clean seeds of three rattan species of Bangladesh : The result as presented in Table-34 and Figure-28 revealed that treatment T_2 (25 ± 1^0C) was the optimum germination condition for the above three species (*viz. C.tenuis*, *C.viminalis* and *D.jenkinsiana*) compared to control, T_1 and T_3. Germination per cent, dormancy breaking and flushing period in each of these three species were found maximum compared to control and other three treatments as a whole which clearly indicated that a précised temperature of 25 ± 1^0C was found suitable for maximization of germination per cent in the present study. Significant difference ($F_{2,18}$=13.03; P<0.0003) on germination per cent was found with constant temperatures.

Table 34: Constant temperature (incubator) effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of three common rattan species of Bangladesh.

Name of species	Date of collection of fruits-seeds	Storage period, days	Date of sowing	Treatments	Temperature imposed in incubator, ^{0}C	Germination parameters		
						Dormancy breaking period, days	Flushing period, days	Germination, %
C.tenuis	27 thJune, 02	246	1stFeb, 03	Control	25+7	35+6	28+3	89+5.8
				Treatment-1	30+1	28+2	22+3	93+3.5
				Treatment-2	25+1	20+4	18+4	98+3.5
				Treatment-3	20+1	42+6	38+8	80+4.2
C.viminalis	9thApril, 02	217	1st Feb, 03	Control	25+7	56+7	28+4	62+6.9
				Treatment-1	30+1	45+3	18+2	87+3.5
				Treatment-2	25+1	46+5	15+3	91+5.8
				Treatment-3	20+1	75+8	32+5	52+4.8
D.jenkinsiana	26thSept, 02	127	1st Feb, 03	Control	25+7	154+8	70+10	79+5.8
				Treatment-1	30+1	56+7	30+4	94+4.6
				Treatment-2	25+1	48+4	28+3	95+4.6
				Treatment-3	20+1	98+7	58+4	56+3.9





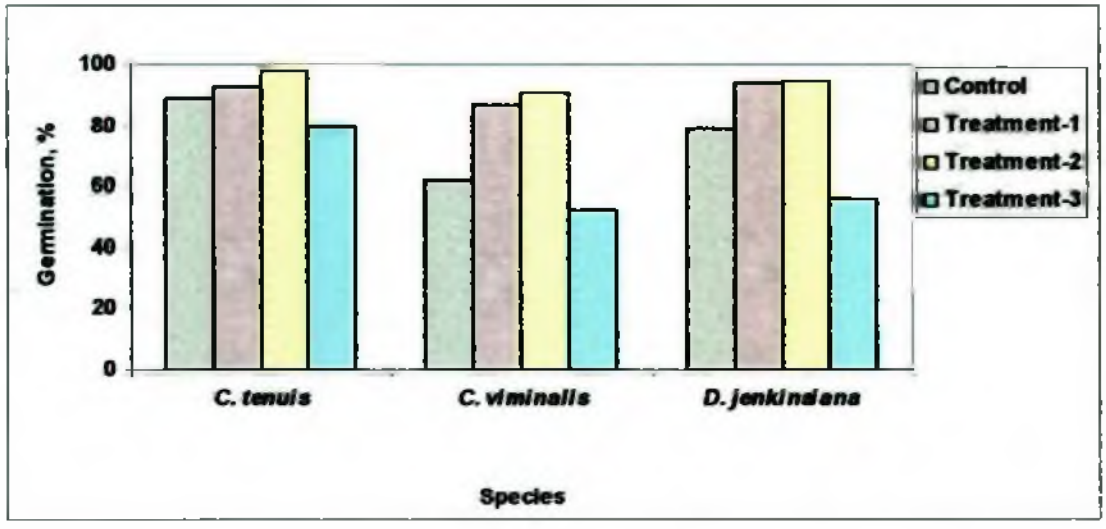


Figure 28 : Constant temperature (incubator) effect on dormancy breaking period, flushing period and germination per cent in fresh clean seeds of three common rattan species of Bangladesh.

5.24. Propagational potentials and survival per cent of seedlings, rhizomes, suckers and wildings (grown in poly bags of sandy loam soil under shade house condition) in ten rattan species of Bangladesh : The result as shown in Table-35 and Figure-29-30

Table 35 : Propagational potentials and survival per cent of seedlings, rhizomes, suckers and wildings (grown in poly bags of sandy loam soil under shade house condition) in ten rattan species of Bangladesh.

Name of Species	Propagules	Age of propagules, yr /months	Survival (%) of propagules after one year of planting	Number of culm emerged $Sd^{-1}/R^{-1}/Su^{-1}/W^{-1}$, yr^{-5}					
				1st	2nd	3rd	4th	5th	Total
C.acanthospathus	Sd	9-12 m	94.6±1.3	-	0.5	2.3	3.1	4.7	4.7±1.3
	R	2-3 yr	53.3±4.7	-	1	1.5	2.3	3.8	3.8±1.0
	Su	9-12 m	46.7±3.0	-	0.5	1.4	1.9	2.9	2.9±0.7
	W	9-12 m	85.3±2.5	-	-	-	1.5	2.4	2.4±0.7
C.erectus	Sd	9-12 m	95.7±1.3	-	-	1.8	2.1	3.2	3.2±0.9
	R	2-3 yr	54.7±2.5	0.8	1.2	2.1	2.4	2.9	2.9±0.5
	Su	9-12 m	38.7±2.5	-	0.6	1.2	2.4	2.7	2.7±0.6
	W	9-12 m	81.3±2.5	-	-	1.4	1.7	1.8	1.8±0.2
C.gracilis	Sd	9-12 m	96.3±1.6	-	-	1.2	2.9	4.0	4.0±1.0
	R	2-3 yr	81.3±2.5	1.2	1.8	2.3	3.3	3.9	3.9±0.7
	Su	9-12 m	64.0±2.7	-	-	1.3	2.2	3.4	3.4±0.6
	W	9-12 m	89.3±3.4	-	1.2	1.8	2.0	2.9	2.9±0.4
C.guruba	Sd	9-12 m	94.3±1.6	-	-	2.6	4.6	6.9	6.9±1.3
	R	2-3 yr	65.3±2.5	1.8	4.2	4.9	5.9	5.5	5.5±1.2
	Su	9-12 m	52.0±2.5	-	-	1.8	2.4	4.1	4.1±1.1
	W	9-12 m	91.7±2.5	-	-	2.1	2.9	3.5	3.5±0.9
C.latifolius	Sd	9-12 m	93.3±2.1	-	-	1.4	2.3	3.3	3.3±0.7
	R	2-3 yr	58.7±2.5	-	1.6	2.1	2.3	3.0	3.4±0.5
	Su	9-12 m	41.3±2.5	-	0.5	0.8	1.9	2.2	2.2±0.4
	W	9-12 m	84.0±1.6	-	0.4	1.1	2.4	2.9	2.9±0.5
C.longisetus	Sd	9-12 m	95.0±1.7	-	-	1.1	2.5	6.7	6.7±1.8
	R	2-3 yr	38.7±2.5	0.6	1.3	2.1	3.5	4.8	4.8±1.3
	Su	9-12 m	36.0±1.6	-	0.3	0.9	2.6	3.9	3.9±0.9
	W	9-12 m	92.0±2.5	-	-	0.5	2.1	3.7	3.7±0.8
C.tenuis	Sd	9-12 m	96.0±1.6	-	2.3	3.2	7.5	10.4	10.4±1.9
	R	2-3 yr	77.3±4.5	2.0	3.0	4.2	6.9	8.6	8.6±1.0
	Su	9-12 m	49.3±3.4	-	2.0	3.2	4.3	6.4	6.4±0.9
	W	9-12 m	90.7±3.4	-	-	-	2.0	3.6	4.6±0.7
C.travencoricus	Sd	9-12m	94.7±2.5	-	0.7	2.2	3.9	4.5	4.5±1.0
	R	2-3 yr	61.3±2.5	0.8	1.3	2.6	3.2	3.4	3.4±0.8
	Su	9-12 m	40.0±2.1	-	0.8	1.0	2.3	2.9	2.9±0.3
	W	9-12 m	89.3±3.4	-	0.3	0.3	1.2	3.4	3.4±0.2
C.viminalis	Sd	9-12 m	94.7±2.5	-	-	1.8	2.9	3.9	3.9±0.3
	R	2-3 yr	42.7±1.6	0.5	1.4	1.7	2.4	2.5	3.5±0.2
	Su	9-12 m	37.3±2.7	-	-	1.2	2.9	3.7	3.7±0.3
	W	9-12 m	86.5±2.1	-	-	1.7	2.5	3.1	3.1±0.2
D.jenkinsiana	Sd	9-12 m	93.7±2.5	-	1.2	3.2	5.4	7.7	7.7±1.0
	R	2-3 yr	56.0±1.6	2.6	3.2	3.8	4.1	5.5	5.5±0.9
	Su	9-12 m	40.0±2.1	-	-	1.1	3.9	4.9	4.9±0.8
	W	9-12 m	95.0±2.2	-	-	1.8	3.7	4.5	4.5±0.6

Legend: Rooting medium=Sandy loam soil; Sd=Seedling, R=Rhizome, Su=Sucker, W=Wilding; ± SEM

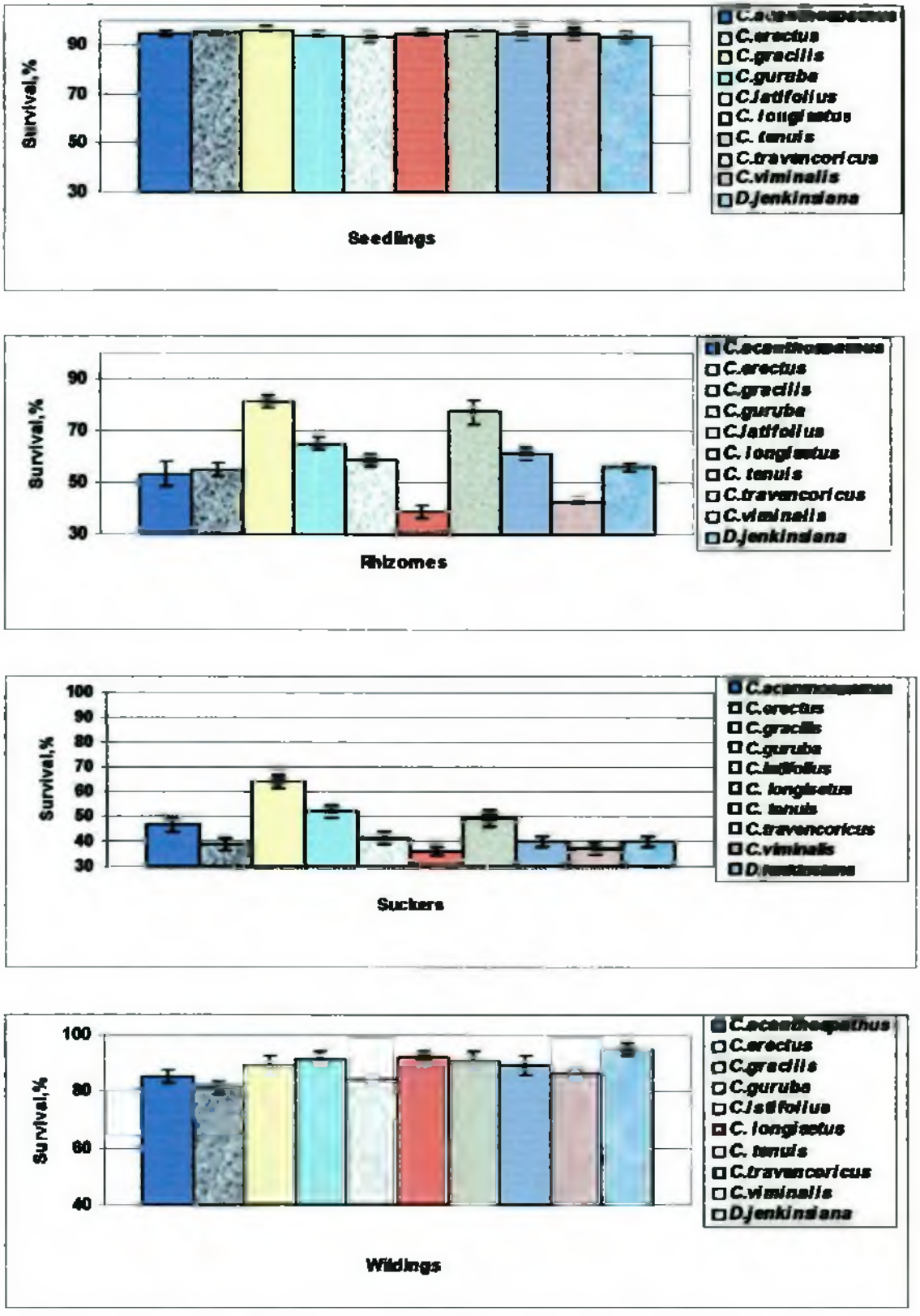


Figure 29 : Variation in survival per cent of seedlings, rhizomes, suckers and wildings (grown in poly bags of sandy loam soil under shade house condition) in ten rattan species of Bangladesh.

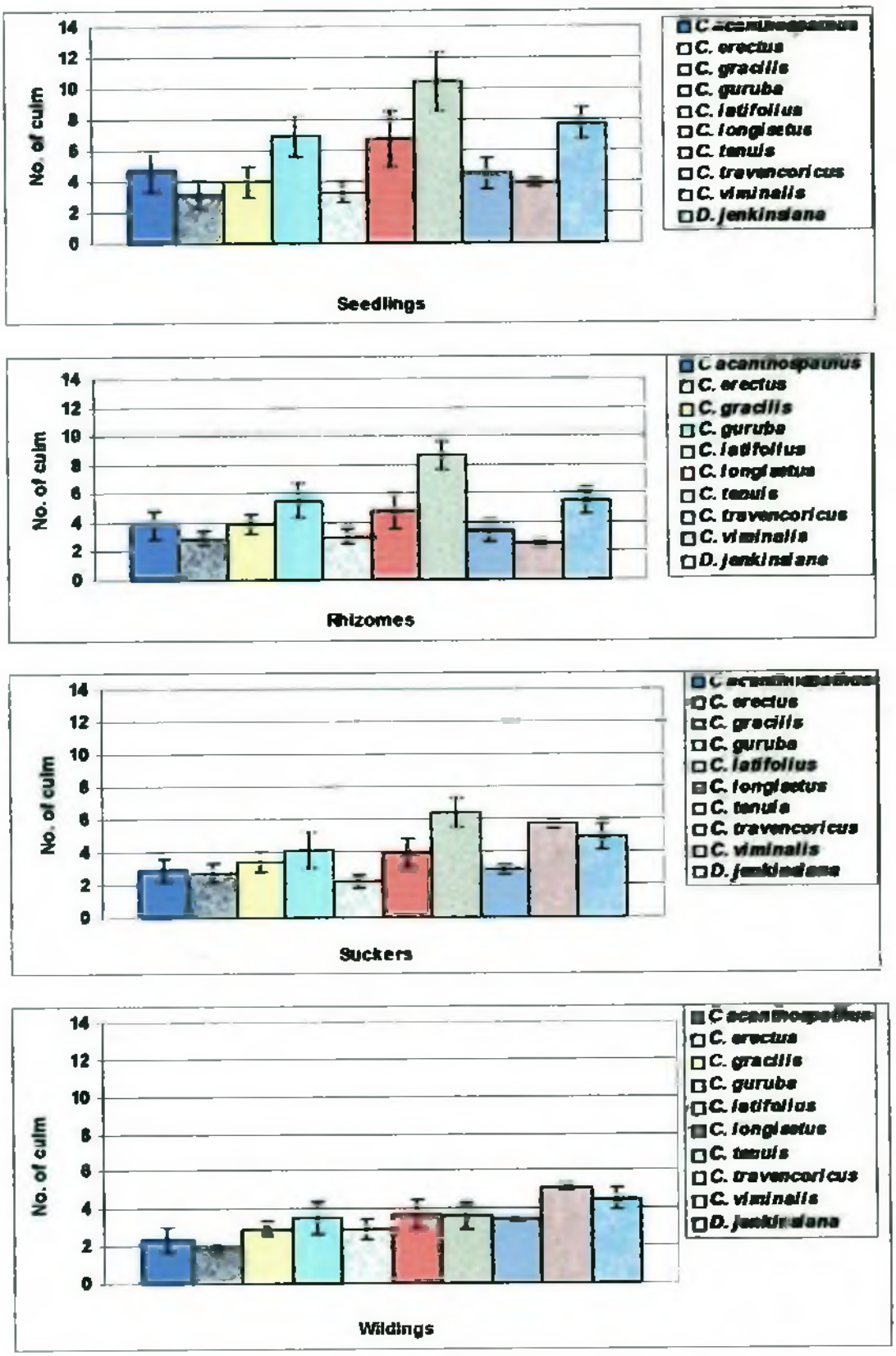


Figure 30 : Variation in number of culm emerged in seedlings, rhizomes, suckers and wildings (grown in poly bags of sandy loam soil under shade house condition) in ten rattan species of Bangladesh.

exhibit that all propagules were observed to have enough potential for propagation. Seedling propagules of recorded ten rattan species were found to have maximum potential for propagation compared to wildings, rhizomes and suckers. Survival per cent in four types of propagules ranged from 96-36% and on the basis of survival per cent propagulels can be ranked as seedlings> wildings> rhizomes> suckers. Over all survival per cent was found highest in *C.gracilis* (82.7%) and lowest in *C.viminalis* (65.3%). Statistical analysis clearly states that difference of survival per cent in recorded ten species was significant ($F_{3,80}$=14.9; P<7.18E-14). Seethalakshmi (1992) reported that depending on the species 50-60 per cent of the sucker could establish in the nursery by using growth regulator (NAA).

Number of culm emerged year^{-1} in ten rattan species was found significantly different with species. *C.tenuis* showed maximum (10.4) and *C.erectus* showed minimum (2.65) emergence of culm compared to other eight rattan species. Number of emergence of culm in four types of propagules of all rattan species was found significantly different ($F_{3,80}$=10.67; P<5.61E-06) from each other. The result of present study as revealed from Table-35 and Figure-29-30 indicate that seedlings are the best propagule for large scale plantation compared to rhizomes, suckers and wildings both from practical as well as socioeconomic point of view.

CONSERVATION

5.25. Distribution and present *in situ* conservation status of recorded rattan species in eight RGFD of Bangladesh : The result as presented in Table-36 and Figure-31-33 demonstrate that both extensive and intensive survey were made on recorded ten rattan species (*viz. C.acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus C.tenuis, C.travencoricus, C.viminalis* and *D.jenkinsiana*) in eight rattan growing forest divisions of Bangladesh. Distribution of recorded rattan species varied with forest divisions. Studied forest divisions can be ranked on the basis of distribution of number of species as CHT> Chittagong> Sylhet> Cox's Bazar> Dhaka> Tangail> Dinajpur> Khulna. The result as shown in Figure-32 exhibit that recorded ten rattan species were found to be distributed over a wide range of habitat from sea level to an altitude of about 1000 m. It was a remarkable fact that two new species *viz. C.acanthospathus* and

Table 36: Distribution and present *in situ* conservation status of recorded ten rattan species in eight rattan growing forest divisions of Bangladesh.

Division	Nature-status	*C. acanthospathus*	*C. erectus*	*C. gracilis*	*C. guruba*	*C. latifolius*	*C. longisetus*	*C. tenuis*	*C. travencoricus*	*C. viminalis*	*D. jenkinsiana*	No. of genus	Total no. of genus	No. of species	Total no. of species
Chittagong	NF(USF+RF)	0	2	0	1	1	1	3	0	3	3	2	2	7	7
	HSF(SF+VF)	0	0	0	1	0	0	3	0	0	0	1		2	
Cox's Bazar	NF(RF+PF)	0	0	0	1	0	3	2	0	2	2	2	2	5	5
	HSF(SF+VF)	0	0	0	0	0	0	2	0	0	0	1		1	
CHT	NF(RF)	0	1	0	1	1	1	2	0	1	2	2	2	7	9
	HSF(SF+VF)	1	1	0	1	0	0	2	2	1	0	1		5	
Dhaka	NF(PF)	0	0	0	1	1	0	2	0	1	1	2	2	5	5
	HSF(SF+VF)	0	0	0	0	0	0	2	0	0	0	1		1	
Dinajpur	NF(RF+PF)	0	0	0	0	0	0	3	0	1	1	2	2	3	3
	HSF(SF+VF)	0	0	0	0	0	0	1	0	0	0	1		1	
Khulna	NF(RF+PF)	0	0	0	0	0	0	2	0	0	2	2	2	2	2
	HSF(SF+VF)	0	0	0	0	0	0	2	0	0	0	1		1	
Sylhet	NF(RF+PF)	0	0	3	2	0	1	3	0	1	3	2	2	6	6
	HSF(SF+VF)	0	0	0	1	0	0	3	0	0	0	1		2	
Tangail	NF(RF+PF)	0	0	0	1	0	0	1	0	2	1	2	2	4	4
	HSF(SF+VF)	0	0	0	1	0	0	1	0	0	0	1		2	
Total		**1**	**2**	**1**	**6**	**3**	**4**	**8**	**1**	**7**	**8**	**2**	**2**	**10**	**10**

Legend: Nature: NF=Natural Forest, USF=Unclass State Forest, HSF=Homestead Forest, VF=Village Forest; Status: 0=Absent; 1=Restricted to a very few localities but found in fair numbers; 2=Found in small numbers but occurring in several areas; 3=Occurring gregariously in pure form.

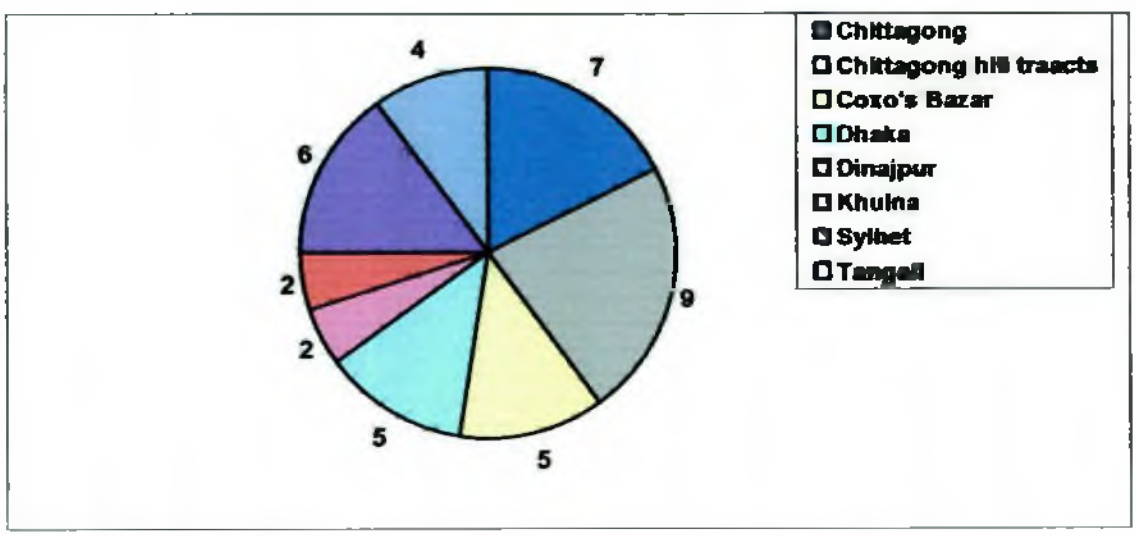


Figure 31 : Distribution of recorded ten rattan species (in number) in eight rattan growing forest divisions of Bangladesh.

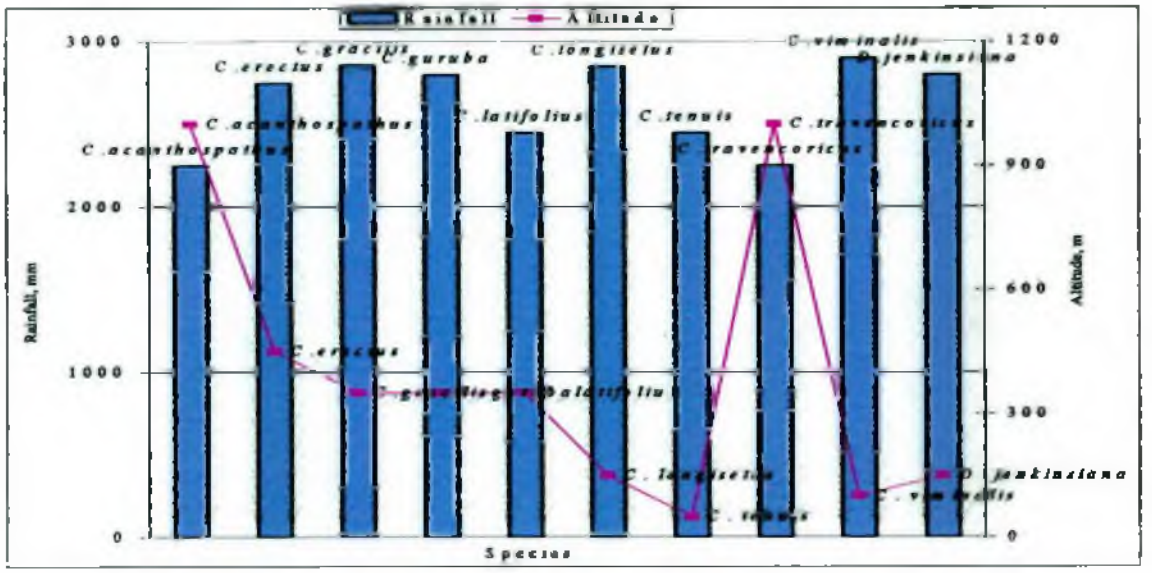


Figure 32 : Species distribution and *in situ* conservation status of ten recorded rattan species in major rattan growing forests based on altitude and rainfall of Bangladesh.

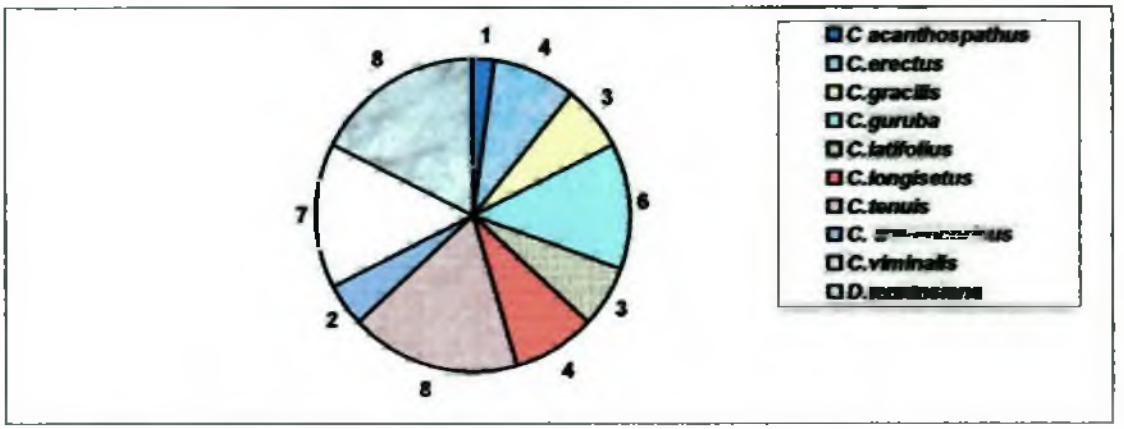


Figure 33 : *In situ* conservation status of recorded ten rattans (species wise) in eight rattan growing forest divisions of Bangladesh.

C.travencoricus were found to grow under natural forest of lowest rainfall and highest altitude of about 1000 m at Ampupara, Bandarban. The occurrence of these two rattan species were never reported before from any part of the present territory of Bangladesh. So, the present study testifies these two rattan species as new records for Bangladesh. The result as shown in Figure-33 illustrate that *in situ* conservation status in number of species of ten recorded rattans in eight rattan growing forest divisions of Bangladesh can be ranked in the sequence of *C.tenuis*≥ *D.jenkinsiana*> *C.viminalis*> *C.guruba*> *C.longisetus*> *C.latifolius*> *C.erectus*>*C.gracilis*≥*C.travencoricus*≥ *C.acanthospathus*.

5.26. Occurrence and *in situ* conservation status of recorded ten rattan species in forty seven studied sites of eight RGFD of Bangladesh : The result as shown in Table-37 and Figure-34-36 indicate that frequency of occurrence of species in per cent varied with sites and ranged from 1- 43. Five species were found to be *in situ* conserved in only 0-5 sites, which indicate their limited occurrence. These five species may become disappeared unless proper conservation measures are being taken immediately. The frequency of total occurrence and *in situ* conservation of recorded ten rattan species can be ranked (species wise) in the sequence of *C.tenuis*> *D.jenkinsiana*> *C.viminalis*> *C.guruba*> *C.longisetus*> *C.erectus*> *C.gracilis*≥ *C.latifolius*> *C.travencoricus*> *C.acanthospathus*. On the other hand the frequency of total occurrence and *in situ* conservation of recorded ten rattan species (site wise) can be ranked in the sequence of CHT> Chittagong> Sylhet> Cox's Bazar > Dhaka≥ Tangail> Dinajpur≥ Khulna. Table-37 also indicates that a total of nine rattan species were recorded from fifteen sites, forty

Table 37: Occurrence and *in situ* conservation status of recorded ten rattan species in 47 studied sites of eight rattan growing forest divisions of Bangladesh.

Name of sp		Rattan growing forest divisions								
		Chittagong	CHT	Cox's Bazar	Dhaka	Dinajpur	Khulna	Sylhet	Tangail	Total occurrence
C.acanthospathus		-	01	-	-	-	-	-	-	**01**
C.erectus		02	02	-	-	-	-	-	-	**04**
C.gracilis		-	-	-	-	-	-	03	-	**03**
C.guruba		06	12	01	03	-	-	07	02	**31**
C.latifolius		01	01	-	01	-	-	-	-	**03**
C.longisetus		01	02	05	-	-	-	01	-	**09**
C.tenuis		11	14	05	03	01	01	06	02	**43**
C.travencoricus		-	02	-	-	-	-	-	-	**02**
C.viminalis		09	11	05	04	-	-	05	02	**36**
D.ienkinsiana		09	12	06	03	01	01	07	01	**40**
Total occurrence/ RGF		39	57	22	14	02	02	29	07	**172**
Total sub-site studied/RGF		40	47	21	08	02	02	27	08	**155**
Total sites studied/ RGF		12	15	05	03	01	01	07	03	**47**
Total number observed / RGF	Species/	**07**	**09**	**05**	**05**	**02**	**02**	**06**	**04**	**10**
	Genus	**02**	**02**	**02**	**02**	**02**	**02**	**02**	**02**	**02**

seven sub-sites and fifty seven occurrences of Bandarban area of CHT which claims as the richest rattan species diversity (*in situ* occurrence of species) area in Bangladesh. Further survey may increase the number of *in situ* occurrence of rattan species in future. Apart from these ten rattan species, no other previously reported species was observed to occur in any sub sites of eight rattan growing forest divisions of Bangladesh.

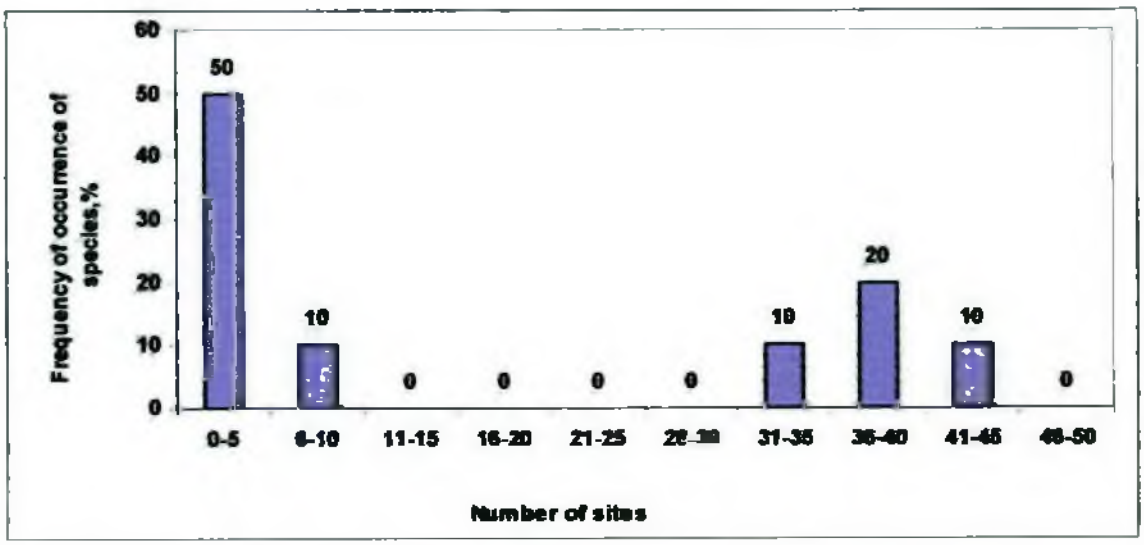


Figure 34 : Frequency of occurrence of ten rattan species at 47 studied sites in eight rattan growing forest divisions of Bangladesh.

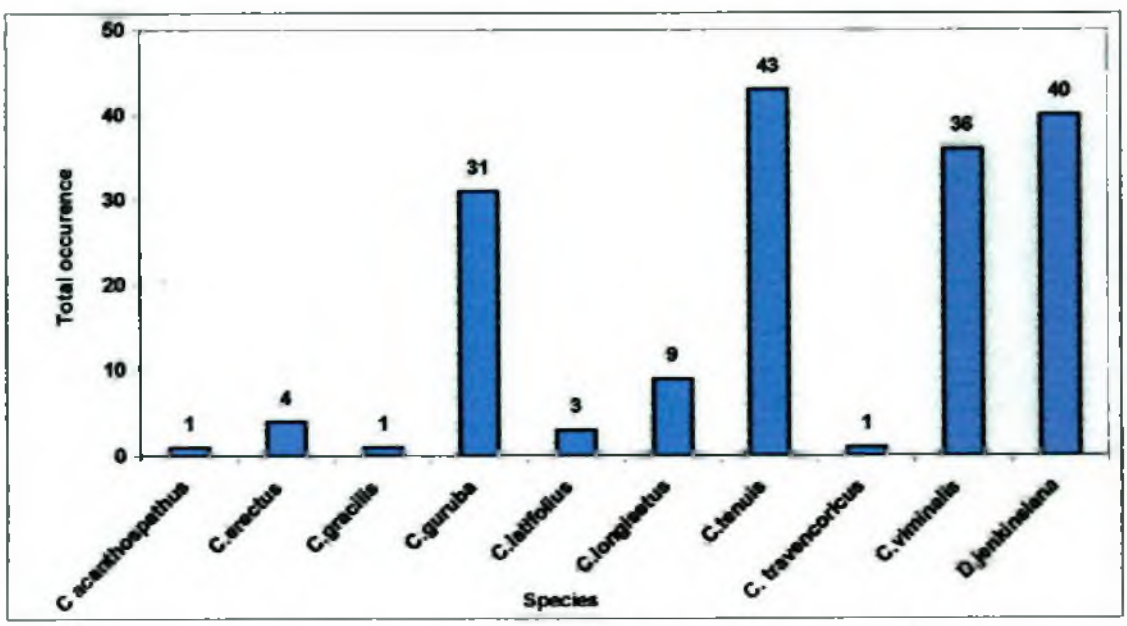


Figure 35 :Total occurrence and *in situ* conservation status of recorded ten rattan species in 155 studied sub-sites of eight rattan growing forest divisions of Bangladesh.

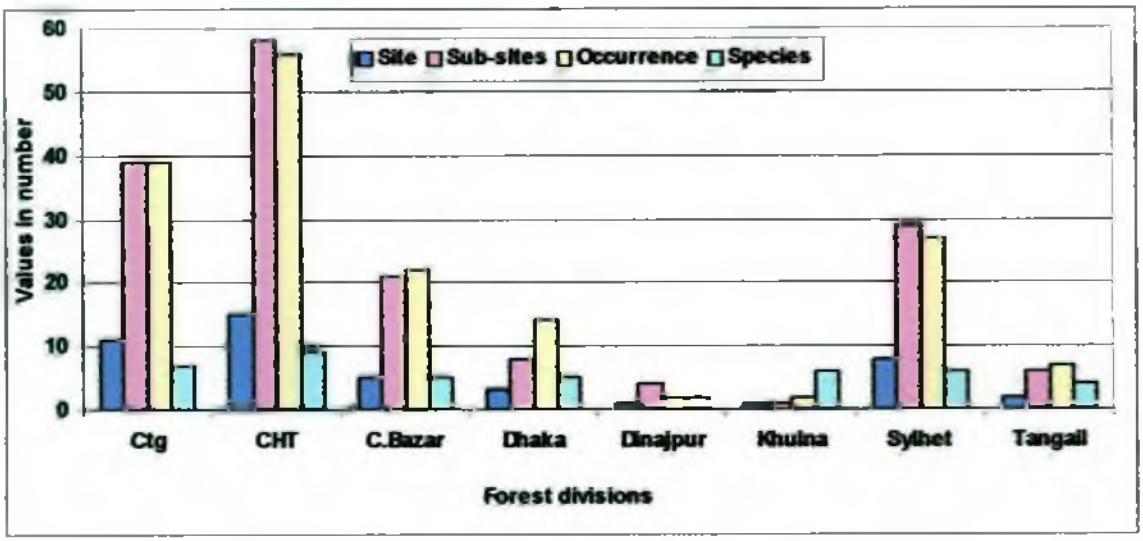


Figure 36 : *In situ* comparison of rattan species diversity and their distribution in 47 sites and 155 sub-sites of eight rattan growing forest divisions of Bangladesh.

5.27. Rattan species index of eight RGFD of Bangladesh and its comparison with other rattan growing countries of the world : The result as shown in Table-38-39 and Figure-37-38 indicate that rattan species index value varied with RGFD of Bangladesh and ranged from 0.45 to 3.41 1000 km^{-2}. On the basis of rattan index value, eight studied RGFD of Bangladesh can be ranked in the order of Dhaka> Cox's Bazar> Chittagong> Tangail> CHT> Sylhet> Dinajpur> Khulna. The over all rattan species index of RGFD of Bangladesh was calculated to be as 0.24 1000 km^{-2} . But the rattan index of Bangladesh was calculated to be 0.067. The result as shown in Table-39 demonstrate that number of rattan species varied with rattan growing countries and ranged from 6 to 201 in fourteen major rattan growing countries of the world. Malaysia was found to be the richest in number of rattan species among the rattan growing countries of the world while Nepal is seen to be the poorest in number of rattan species. On the basis of number of species, the rattan growing countries of the world can be ranked in the order of Malaysia> Philippines> Thailand> India> Indonesia>Vietnam> China> Myanmar> Celebes> T.Africa> Bangladesh> Sri Lanka>Australia>Nepal. On the other hand, rattan species index also varied with countries and ranged from 0.00001 to 0.605 1000 km^{-2}. On the basis of rattan species index, the rattan growing countries can be ranked in the sequence of Malaysia> Philippines> Sri Lanka> Thailand> Vietnam> Bangladesh> China>

Table 38 : Rattan species index of eight rattan growing forest divisions of Bangladesh.

Forest divisions	Area of district sq.km.	No. of rattan species	Rattan index	Numerical ranking
Chittagong	5283	7	1.33	3
Cox's Bazar	2492	5	2.00	2
CHT	13275	9	0.68	5
Dhaka	1464	5	3.41	1
Dinajpur	3438	2	0.58	7
Khulna	4395	2	0.45	8
Sylhet	8926	6	0.67	6
Tangail	3414	4	1.17	4
Total	42687	10	0.24	

Table 39 : Comparison of rattan species index of Bangladesh with other rattan growing countries of the world.

Country	Area sq. km.	Rattans (species)	Rattan's index (species)	Numerical ranking
Bangladesh	1,48,397	10	0.067	6
Malaysia	3,32,665	201	0.605	1
India	32,87,590	62	0.019	11
Sri Lanka	65,610	10	0.153	3
Myanmar	6,76,577	30	0.044	8
China	95,60,900	45	0.047	7
Thailand	5,13,120	78	0.152	4
Nepal	1,47,121	06	0.040	9
Indonesia	19,19,445	62	0.033	10
Philippines	3,00,000	91	0.303	2
Vietnam	3,29,565	50	0.152	5
Australia	76,82,300	08	0.00001	12
Celebes	-	28	-	-
Tropical Africa	-	24	-	-

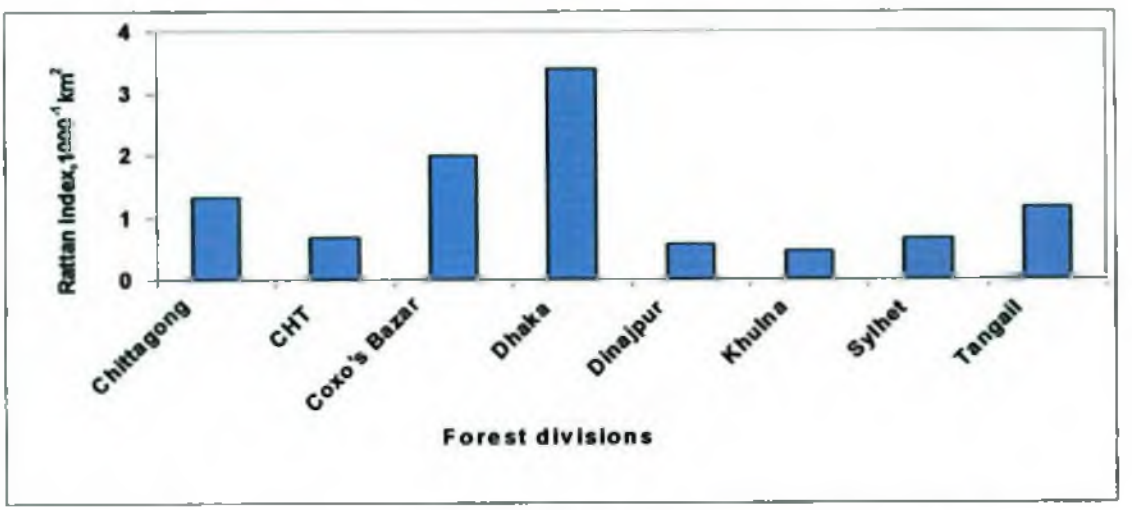


Figure 37 : Rattan index of eight rattan growing forest divisions of Bangladesh.

Myanmar> Nepal> Indonesia> India> Australia. Though the number of rattan species of Celebes and Tropical Africa were recorded from the literature yet the rattan species index of this two country could not have been calculated due to the discrepancy in distribution with in the territory. In the present investigation Bangladesh has occupied the sixth position in its rattan species index potential compared to major rattan growing countries of the world.

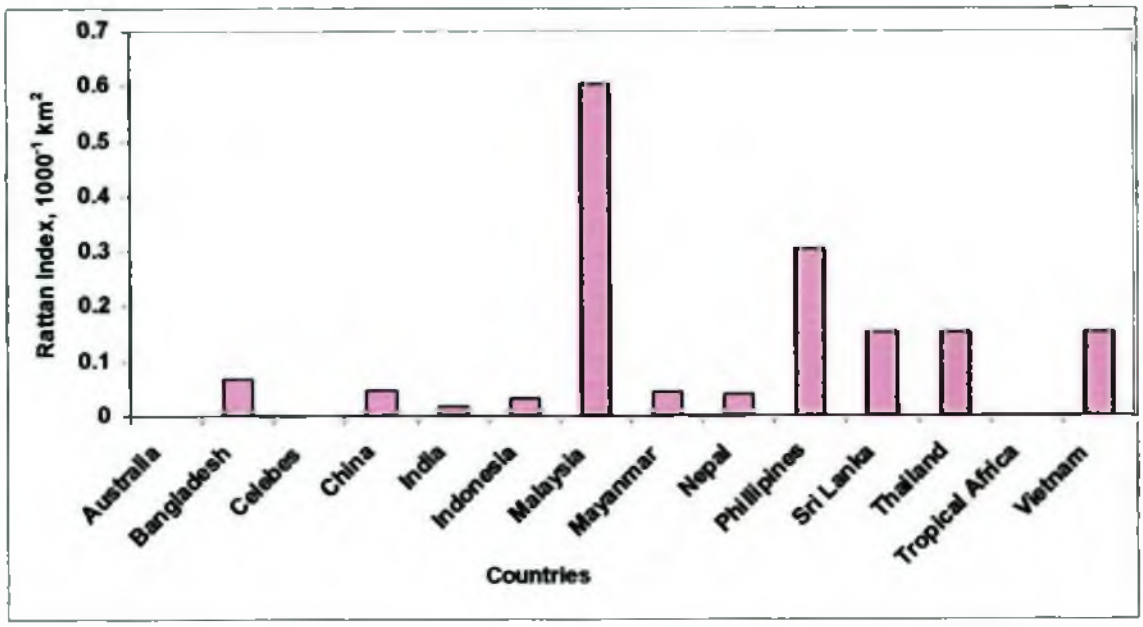


Figure 38 : Comparison of rattan index of Bangladesh with other rattan growing countries of the world.

5.28. Diversity of rattan species and their numerical indices in eight RGFD of Bangladesh : The result as shown in Table-40 reveal that a total of ten rattan species (*viz. C.acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.travencoricus, C.viminalis* and *D.jenkinsiana*) were recorded in eight RGFD of Bangladesh. Diversity of rattan species varied with RGFD and number of species ranged from 2 to 9. Highest diversity of rattan species was recorded in CHT and lowest was in Khulna. On the basis of species diversity, the RGFD of Bangladesh can be grouped in the order of CHT> Chittagong> Sylhet> Cox's Bazar ≥ Dhaka> Tangail> Dinajpur> Khulna. It is expected that further exploration in the interior of restricted areas of south eastern part of Bangladesh may increase the number of species diversity.

Table 40 : Diversity of rattan species and their numerical indices in eight rattan growing forest divisions of Bangladesh.

Species / Divisions	*C.acanthospathus*	*C.erectus*	*C.gracilis*	*C.guruba*	*C.latifolius*	*C.longisetus*	*C.tenuis*	*C.travencoricus*	*C.viminalis*	*D.jenkinsiana*	Species diversity of rattans
Chittagong	-	√	-	√	√	√	√	-	√	√	7
CHT	√	√	-	√	√	√	√	√	√	√	9
Cox'sBazar	-	-	-	√	-	√	√	-	√	√	5
Dhaka	-	-	-	√	√	-	√	-	√	√	5
Dinajpur	-	-	-	-	-	-	√	-	√	√	3
Khulna	-	-	-	-	-	-	√	-	-	√	2
Sylhet	-	-	√	√	-	√	√	-	√	√	6
Tangail	-	-	-	√	-	-	√	-	√	√	4

5.29. Present status of recorded rattan species in Bangladesh : The result as presented in Table-41 exhibits that a total of fifteen rattan species *viz. C.erectus, C.flagellum, C.floribundus, C.giminalis, C.gracilis, C.guruba, C.jenkinsianus, C.latifolius, C.longisetus, C.rotentum, C.rotang, C.tenuis, C.quinquenervius, C.viminalis, D.jenkinsiana* were reported from Bangladesh since 1984. Of these fifteen species, eight species *viz. C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.viminalis, D.jenkinsiana* were recorded in the present investigation with an extra addition of two new reports *viz. C.acanthospathus* and *C.travencoricus*. These two species are regarded as new records for Bangladesh. *C.gracilis* - a previously recorded (Roxburgh 1832) rattan species was not found any where in the area of Chittagong as mentioned in the reports (Griffith 1850, Hooker 1894). But this rattan species was found to occur in Tilagar beat of Sylhe during this investigation. A checklist of ten rattan species is reported to occur naturally in the present territory of Bangladesh under the present investigation. Present *in situ* conservation status of recorded ten rattan species justifies that *C.tenuis, D.jenkinsiana* and *C.viminalis* as cultivated (common) and *C.erectus, C.guruba, C.longisetus* and *C.latifolius* are vulnerable. Whilst *C.acanthospathus, C.gracilis* and *C.travencoricus* are extremely rare. Remaining seven *viz. C.flagellum, C.floribundus, C.giminalis, C.jenkinsianus, C.rotentum, C.rotang* and

C.quinquenervius were not found in present investigation and seems to be disappeared/ lost/ unexplored from the nature of rattan growing forests of Bangladesh.

Table 41: Present status of recorded rattan species in Bangladesh.

Cultivated	Vulnerable	Rare	Disappeared / lost/ unexplored
+*C.temuis* *C.viminalis* *D.jenkinsiana*	*C.erectus* *C.guruba* *C.longisetus*	***C.acanthospathius* * *C.gracilis* *C.latifolius* ***C.travencoricus*	*C.floribundus*, *C.rotemtum* *C.flagellum*, *C.giminalis* *C.quinquenervius*, *C.rotang* *C.jenkinsiana*

Legend: + Domesticated; * Rediscovered; ** New records for Bangladesh.

Four rattan species *viz. C.erectus, C.guruba, C.latifilius* and *C.longisetus* were reported to be as DD (data deficit) as defined by IUCN (1994) in the red data book of vascular plants of Bangladesh (Khan *et al.* 2001). But the present investigation recorded these four species as vulnerable, possibly the workers could not have worked out the biology of these species

5.30.Present *in situ* conservation status of population of recorded five rattan species in eight RGFD of Bangladesh : The result as shown in Table-42, Figure-39-41 and Appendix-8.11 demonstrate that Forest Department started plantations of rattan species since 1981 in Sylhet and continued in major rattan growing areas of Bangladesh. Though Forest Department initiated rattan plantation in 1981 but the progress was very slow and intensity of plantation was not increased until 1991.Virtually rattan plantation initiated extensively in RGFD of Bangladesh in 1991 and was continued until 2002. A record of rattan plantation in seven RGFD for last twenty years until 2002 was accounted to cover an area of 6,146.4 acres planted with five rattan species (*viz. C.temuis, C.guruba, C.longisetus, C.viminalis* and *D.jenkinsiana)*. A total of 27,41,338 seedlings of five rattan species were reported to be planted in seven RGFD of Bangladesh. On the basis of number of planted seedlings, the seven studied RGFD can be ranked in the order of Sylhet> Chittagong> Cox's Bazar> Dhaka> Tangail> Dinajpur> CHT. The number of planted rattan species varied with RGFD and ranged from 2-4. All these five rattan species were not recorded together in plantation of any one of these seven RGFD. On the basis of number of planted rattan species, the studied eight RGFD can be ranked as Cox's Bazar≥ Sylhet≥ Tangail> Chittagong ≥ CHT ≥ Dhaka≥ Dinajpur> Khulna. The results in

Table-37 also demonstrate that three rattan species *viz. C.tenuis, C.viminalis* and *D.jenkinsiana* were found to be common as planted rattan species in all eight studied

Table 42: Present *in situ* conservation status of population of recorded five rattan species in eight rattan growing forest divisions of Bangladesh.

Division	Plantation period	Total planted area (acre)	Total no. of seedlings planted	Number of species	Name of species
Chittagong	1993-02	1056.2	471065	3	*C.tenuis C.viminalis, D.jenkinsiana*
CHT	1986-95	110.0	49060	3	*C.tenuis, C.viminalis, D.jenkinsiana*
Cox'sBazar	1996-02	845.5	377093	4	*C.tenuis C.longisetus, C.viminalis, D.jenkinsiana*
Dhaka	1991-01	487.8	217559	3	*C.tenuis, C.viminalis, D.jenkinsiana*
Dinajpur	1990-02	452.7	201904	3	*C.tenuis, C.viminalis, D.jenkinsiana*
Khulna	-	-	-	2	*C.tenuis, D.jenkinsiana*
Sylhet	1981-01	2723.9	1214859	4	*C.tenuis, C. guruba, C.viminalis, D.jenkinsiana*
Tangail	1991-02	470.4	209798	4	*C.tenuis, C.guruba, C.viminalis, D.jenkinsiana*
Total	20yrs	6146.4	2741338	5	*C.tenuis,C. guruba, C.longisetus, C.viminalis, D.jenkinsiana*

Source: Mr. M. Atikullah; (Per. commu. DFO, FD, 2003)

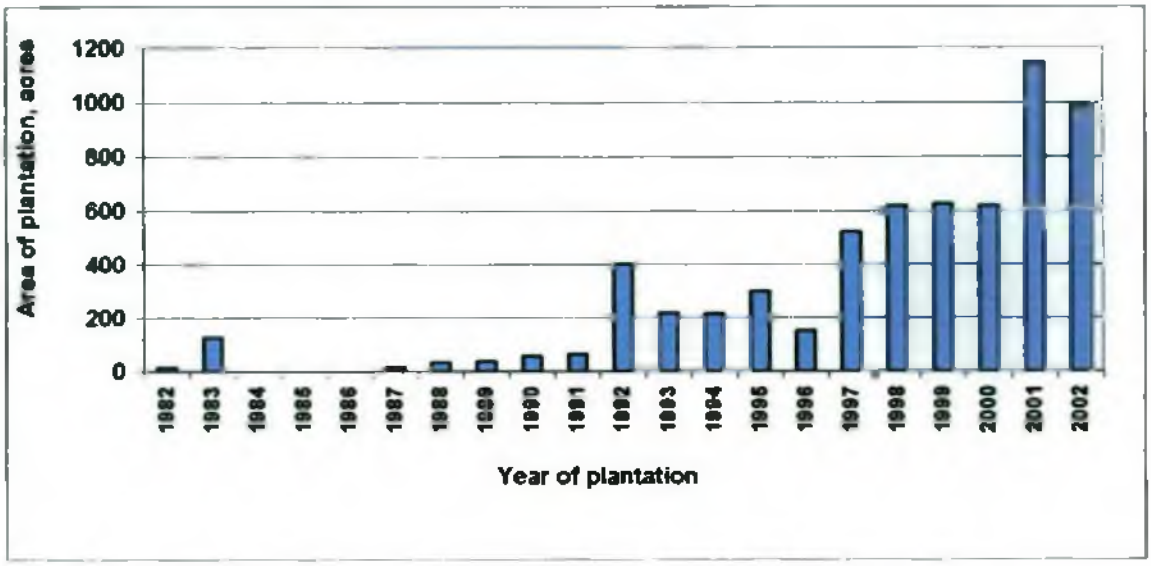


Figure 39 : Records of *in situ* conservation status of five rattan species in plantations (year wise) of eight rattan growing forest divisions of Bangladesh.

RGFD except that of Khulna where *C.viminalis* was not reported to be planted any where. *C.longisetus* - a vulnerable species was only found in plantation of Razarkul, under RGFD of Cox's Bazar. On the other hand, *C.guruba*- another vulnerable species was found in plantation of RGFD of Sylhet and Tangail. This discrepancy in the number

of species distribution in plantation of eight RGFD might have been due to either lack of proper knowledge of identification or silvicultural management practice of plantation species. Which may be overcome in near future with proper attention of the Forest Department of Bangladesh.

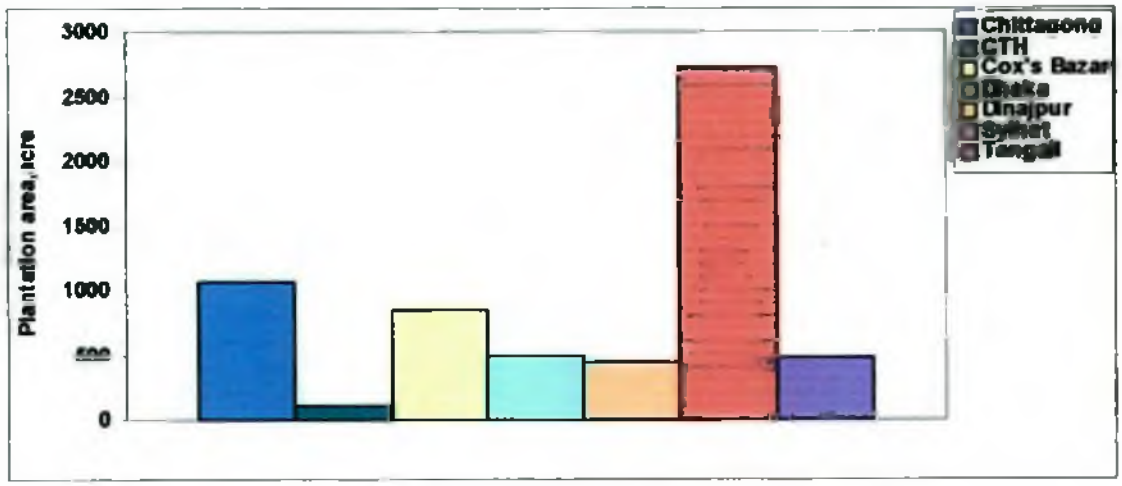


Figure 40 : Records of *in situ* conservation status of five rattan species in plantations (area) of eight rattan growing forest divisions of Bangladesh.

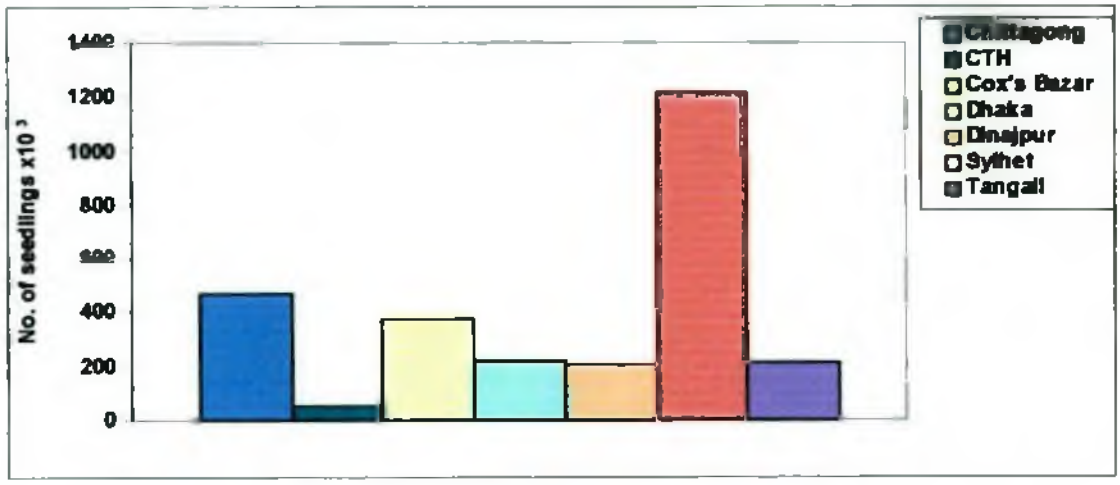


Figure 41: Records of *in situ* conservation status of five rattan species in plantations (seedling no.) of eight rattan growing forest divisions of Bangladesh.

5.31. Records of *in situ* conservation of seedlings and establishment of canetum of ten rattan species (common, vulnerable and rare) in nine official reserves of Bangladesh : The result as shown in Table-43 and Figure-42 represent that a total of 1,105 seedlings of ten recorded rattan species were conserved in nine official reserved areas *viz.* Bangladesh Forest Research Institute (BFRI), Botanical Garden, Chittagong

Table 43: Records of *in situ* conservation of seedlings and establishment of canetum of ten rattan species (common, vulnerable and rare) in nine official reserves of Bangladesh.

Reserve areas	Year of planting	Name of species conserved										
		C.acanthospathus	*C.erectus*	*C.gracilis*	*C.guruba*	*C.latifolius*	*C.longisetus*	*C.tenuis*	*C.travencoricus*	*C.viminalis*	*D.jenkinsiana*	Total
Bangladesh Forest Research Institute (BFRI)	2000*	-	1	-	13	3	1	15	-	37	23	93
	2001	5	5	-	5	5	5	5	5	5	5	45
	2004	5	5	5	5	5	5	5	5	5	5	50
	2005	10	10	5	10	10	10	10	10	10	10	95
	Sub total											283
Botanical Garden Chittagong University (BGCU)	2000*	-	-	-	-	-	-	60	-	25	60	145
	2001	5	5	3	5	5	5	10	5	10	10	63
	2003	10	10	3	10	10	10	10	10	10	10	93
	2005*	5	5	3	5	5	5	5	10	10	10	63
	Sub total											364
Institute of Forest and Environmental. Sciences, Chittagong University (IFESCU)	2003*	-	-	-	-	-	-	7	-	4	3	14
	2004	10	10	-	10	10	10	10	10	10	10	90
	2005	5	5	-	5	5	5	5	5	5	5	45
	Sub total											149
Keochia Silviculture Research Station, Chittagong KSRSC)	2000*	-	-	-	3	-	-	11	-	115	18	147
	2002	5	5	-	5	5	5	5	5	5	5	45
	Sub total											192
Eco-park Sitakunda, Chittagong (EPSC)	2003*	-	-	-	5	-	-	9	-	6	23	43
	2004	10	10	3	10	10	10	10	10	10	10	93
	2005	5	5	3	5	5	5	5	5	5	5	48
	Sub total											184
National Botanical Garden,Mirpur (NBGM)	2000*	-	-	-	-	-	-	10	-	10	10	30
	2005	10	10	-	10	10	10	10	10	10	10	90
	Sub total											120
Bhawal National Park, Gajipur (BNPG)	2000*	-	-	-	7	18	-	42	-	13	21	101
	2005	10	10	-	10	10	10	10	10	10	10	90
	Sub total											191
Dulahazara Safari-park, Cox's Bazar (DSPCB)	2000*	-	-	-	13	-	13	122	-	70	90	308
	2005	5	5	-	5	5	5	5	5	5	5	45
	Sub total											353
Hazi Danesh Sci. and Tech. University, Dinajpur (HDSTUD)	2005*	-	-	-	-	-	-	50	-	50	50	**150**
Grand Total (species wise)		**100**	**101**	**25**	**141**	**121**	**114**	**431**	**105**	**440**	**408**	**198**
Survival %		83	87	82	94	92	90	98	91	94	95	91

Legend: Survival per cent of each species, except those of *marked year, which indicate the number of previously existed clump of different species and was calculated after 1 year of plantation of seedling.

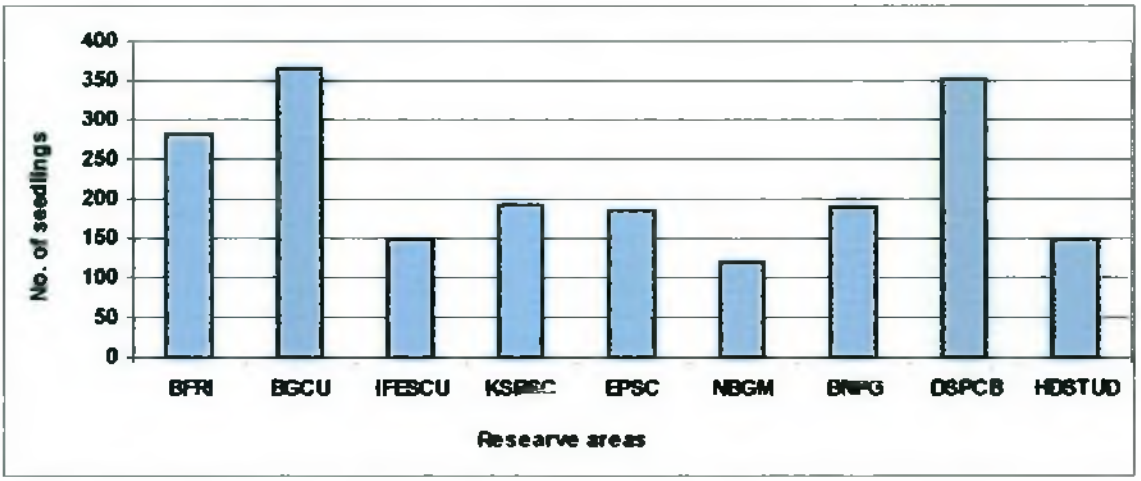


Figure 42 : Records of *in situ* conservation of seedlings (number of seedling - location wise) of ten rattan species (common, vulnerable and rare) in nine official reserves of Bangladesh.

University (BGCU), Institute of Forestry and Environmental Sciences of Chittagong University (IFESCU), Keochia Silviculture Research Station, Chittagong (KSRSC), Eco-park, Sitakunda, Chittagong (EPSC), National Botanical Garden, Mirpur (NBGM), Bhawal National Park, Gajipur (BNPG), Dulahazara Safari Park, Cox's Bazar (DSPCB) and Hazi Danesh Science and Technology University, Dinajpur (HDSTUD) during 2001-2005 along with 881 previously existed clumps of seven species. The number of previously existed species varied with reserved areas and ranged from 3 to 7. On the basis of the number of previously existed species, the reserved areas can be ranked in the order of BFRI> DSPCB≥ BNPG> KSRSC≥ EPSC> BGCU≥ IFESCU≥ NBGM> HDSTUD. On the other hand, on the basis of number of ex *situ* conservation of species, the reserved areas can be ranked in the sequence of BGCU> BFRI> HDSTUD> ECPSC> IFESCU> NBGM≥ BNPG> KSRSC≥ DSPCB.A total of 1,986 seedlings-clumps were conserved in nine reserved areas and the number of conserved seedlings-clumps varied with reserved areas and ranged from 120 to 364. On the basis of *in situ* conservation of number of seedlings-clumps the nine reserved areas can be ranked in the order of BGCU> DSPCB> BFRI> KSRSC> BNPG> EPSC> IFESCU>HDSTUD>NBGM. On the basis of population of each of ten recorded rattan species, the species can be ranked in the order of *C.viminalis*> *C.tenuis*> *D.jenkinsiana*> *C.guruba*> *C.latifolius*> *C.longisetus*> *C.travencoricus*> *C.erectus*> *C.acanthospathus*> *C.gracilis*. The plantable age of *ex situ*

seedlings in the nursery varied with species due to the variation in fruit collection season and ranged from 18 to 24 months. Besides, all the seedlings were not planted in the same reserved areas in the same season of the same year. As a result, the survival per cent of the planted seedling of ten recorded rattan species varied with species as well as reserved areas and ranged from 82-98 % with an average of 91%. On the basis of survival per cent the species can be ranked as *C.tenuis*> *D.jenkinsiana*> *C.guruba*≥ *C.viminalis*> *C.latifolius*> *C.travencoricus*> *C.longisetus*> *C.erectus*> *C.acanthospathus*> *C.gracilis*. *In situ* conservation of ten recorded rattan species in nine reserves can be used as canetum for further research work in future. The concerned authorities must take initiatives to maintain the canetum as a source of mass scale seed production for commercial plantation to enrich the rattan based cottage industries of Bangladesh.

CHAPTER 6 : SUMMARY

Both extensive and intensive investigations on Biology, Propagation and Conservation of naturally occurring, readily available and recorded ten rattan species *viz. Calamus acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C. travencoricus, C.viminalis* and *Daemonorops jenkinsiana* of Bangladesh were carried out in eight rattan growing forests of Bangladesh during 1998-2004. Major experimental works (related to canetum, nursery and trial plantation) on biology, propagation and conservation were done at Bangladesh Forest Research Institute (BFRI) and Chittagong University Campus (CUC). Soil samples were collected from six rattan plantation-forests (*viz*; BFRI, CUC, Dulahazara, Hinguli, Lawachara, Modhupur and Tilagar) and analysed for major physico-chemical properties (*viz*; texture, WHC, pH, OM, CEC and nutrients *viz*; N,P,K,Ca and Na). Soils of all rattan plantation-forests were found to be sandy loam to clay loam (SMC 17 to 26 and WHC 25 to 34 %), acidic (pH- 4.6 to 5.4) and moderately fertile. Average rainfall, relative humidity and temperature data of the study areas were collected, which ranged from 2240 to 3680 mm year^{-1}, 68 to 94% and 26-28°C month^{-1} respectively during the study period.

Present study recorded two rattan genera *viz*, *Calamus* and *Daemonorops* with ten species *viz*; *Calamus acanthospathus*, *Calamus erectus*, *Calamus gracilis*, *Calamus guruba*, *Calamus latifolius*, *Calamus longisatus*, *Calamus tenuis*, *Calamus travencoricus*, *Calamus viminalis* var. *fasciculatus* and *Daemonorops jenkinsiana* and were studied for most biological characters of these species from a wide range of habitat ranging from sea level to an altitude of about 1000m. All recorded rattan species were identified as both loose and compact clump forming, dioecious, pleonanthic, perennial, evergreen, economically valuable, commercially important and socially highly aesthetic ones. *Calamus erectus* is erect and robust with culm mean diameter of ~13 cm and from aesthetic view point is regarded as ornamental. Whilst other nine rattan species were high climber, slender, canopy-crown forming occupier and fast growing with annual increment of 0.30 to 3.2m culm^{-1}species^{-1} year^{-1}. Shape, diameter and length of ten rattan species, which were recorded from clumps of 10-15 years old, ranged from slender-robust, 1.0 to 15.0 cm and 3.0 to 43.0 m respectively. All rattans were found to produce wildings. Periodicity and plasticity of wildings were noticed and varied from 8-30 m^{-2} clump^{-1}

year^{-1} with species and habitats. In nature, phenotypically population of male and female clump of the same species were not distinguishable until and unless they produce inflorescence. Flowering age of both seedling/wilding and rhizome/sucker raised clump were observed to range from 4-5 and 3-4 year irrespective to species. Occurrence of male clumps was more frequent than female ones (about 3:1). Male clumps of almost all species were observed to show inflorescence and were recorded to flower at least about one month earlier than female ones. Phenology of flowering showed periodicity, which was observed to occur throughout the year irrespective to species and habitat. Four species *viz. C.erectus, C.gracilis, C.guruba* and *C.viminalis* were recorded to be diphasic (produce flower twice in a year). Whilst other six species *viz. C.acanthospathus, C.latifolius, C.longisetus, C.tenuis* and *D.jenkinsiana* were recorded to be monophasic (produce flower once in a year). Length of inflorescence, number of inflorescence, number of partial inflorescence, inflorescence flushing period were recorded and ranged from 0.3 to 1.5m, 2 to 4, 2 to 11 and 2 to 4 months respectively depending on species, seasons and also habitat. Flowers were observed to be very small (1.5 to 2.5 mm in length), sessile and trimerous. Female flowers were observed to be of different size and the ovary being monolocular with basal placentation. Number of male and female flower, ratio of male and female flower, number of fruit setting, ratio of female flower and fruit setting were enumerated as 4423 to 28457 and 1823 to 7736, 2:1 to 6:1; 597 to 4636; 1.4:1 to 4.9:1 culm^{-1} species^{-1} season^{-1} respectively depending on species, seasons and also habitat. Species were ranked in term of plasticity of fruit setting in the order of *Calamus viminalis> C.longisetus> C.acanthospathus> C.gracilis> C.tenuis> C.latifolius> C.travencoricus> C.guruba> Daemonorops jenkinsiana> C.erectus.*

Whilst fruiting and fruit ripening were noticed to occur throughout the year irrespective to species. Fruits ripen between 7 to 15 months after the emergence of flower. Plasticity of seed output and reproductive capacity in number usually ranged from 191-3814 and 71-2364 corresponding to 17-82% and 11-77% culm^{-1} species^{-1} season^{-1} respectively. Compared to fruit set and seed out put these can be ranked in per cent culm^{-1} species^{-1} season^{-1} as *C.tenuis> D.jenkinsiana> C.viminalis> C.acanthospathus> C.latifolius> C.travencoricus> C.erectus> C.longisetus> C.guruba> C.gracilis.* Where seed dormancy breaking period, seedling flushing period and germination per cent were evaluated to vary

from 42-147 days, 28-70 days and 41-90% respectively depending on species, lot of collection, season, locality and sowing media under shade house condition, and the species were ranked in order of reproductive capacity culm^{-1} species^{-1} season^{-1} as *Calamus tenuis*> *C.acanthospathus*> *D.jenkinsiana*> *C.latifolius*> *C.travencoricus*> *C.viminalis*> *C.erectus*> *C.longisetus*> *C.guruba*> *C.gracilis* respectively. It is concluded that recorded rattan species were highly potential to reproduce propagules both sexually (*viz.* seed, seedling and wildings) and vegetatively (*viz.* sucker, rhizome, offset, aerial shoot and multiple tip shoot). Ripen fruits of early season of the year exhibited higher reproductive potential compared to ripen fruits of late season of the year in all species except that *D.jenkinsiana* -an excellent but exceptional rattan species of Bangladesh.

Though all recorded rattan species propagate both sexually and vegetatively, yet propagation through seed has been considered as essential for large scale propagation programme which is much easier compared to all sorts of vegetative propagation. But limited seed supply due to indiscriminate harvesting even in the interior of forest and village groves, seedling raising has been remained an unsolved problem to the rattan grower-researcher. The present study took initiative to innovate seed dormancy breaking techniques to shoot the livelong trouble in seed propagation and seedling raising relating to fruit maturing, fruit type, seed size, sowing time, sowing media, sowing depth, seed pretreatments (*viz.* abrassion, hot water, soaking period with normal water, different conc. of H_2SO_4, KNO_3 and GA_3), storage conditions, storage period, germination conditions-temperature and constant temperature effect to enhance dormancy breaking period, germination rate, flushing period and germination per cent in fresh and stored seeds of all rattan species round the year under seed propagator-shade house conditions. Present study exhibited that seed dormancy breaking period, germination rate, flushing period and germination per cent ranged from 5-25 weeks, 6-27% week^{-1}, 4-13 weeks and 43-90% species^{-1} season^{-1} respectively irrespective to three sowing media (*viz.* fine sand, sandy loam and clay loam) under shade house conditions. Seedling raised in fine sand at an average temperature of 28 ± 5^0C with an average relative humidity (RH) of 90%$\pm$10 increased germination up to 62-90% compared to other sowing media in all species. Seed dormancy breaking period and flushing period reduced to about 16-45% and 13-43% respectively irrespective to species. Hence, fine sand was found and considered as the

best amongst the used sowing media. The propagation potential in ten rattan species was ranked in order of germination per cent as *C.tenuis*> *C.acanthospathus*> *C.travencoricus*> *C.erectus*> *C.longisetus*> *C.gracilis*> *C.guruba*> *C.latifolius*> *D.jenkinsiana*> *C.viminalis* respectively.

Of all storage conditions, moist fine sand was found excellent to store seeds. In the pit of moist fine sand where seeds remained viable and germination per cent of seeds of most rattan species did not get reduced even by 10% after a year except those of soft seeds *viz. C.erectus, C.travencoricus* and *C.acanthospathus*. The viability of seeds of these three species started to reduce even after three months in moist fine sand storage condition. TTC test confirmed the viability of moist fine sand stored seeds for a storage period of more than a year.

Pricking age of 1-2 months from fine sand of seed tray and seed bed raised seedlings, transferred to sandy loam soil in polybags and nursed under shade house conditions showed highest survival per cent (97 to 100%) compared to 4, 5 and 6 months of pricking age and of transfer to polybags even after one year. Seedling raised with fine sand in seed tray had maximum survival per cent (96 to 100%) compared to seed bed raised seedling (65 to 97%). Survival per cent of propagules of seedling, wilding, sucker and rhizome of all ten rattan species of 1-3 year of age planted in sandy loam soil varied and ranged from 37-97% irrespective of propagules in same sized polybags and pots even after 1 year of planting irrespective of species. Similarly, number of emerged culm of these propagules for long five years both in large plastic pots and nursery bed exhibited variation and ranged from 1.8 to10.4 year^{-5} irrespective of propagules and species. Where seedling propagules was found to produce maximum (3.2 to 10.4 year^{-5}) culm compared to other propagules irrespective of species. It is concluded that rattan seedlings may be ranked in order of culm emergence potential as *Calamus tenuis*> *D.jenkinsiana*> *C.guruba*> *C.longisetus*>*C.acanthospathus*> *C.travencoricus*> *C.gracilis*> *C.viminalis*> *C.latifolius*> *C.erectus*. The seedling propagules of all species exhibited as the best in all aspects for large scale plantation and conservation.

Information based extensive and intensive survey made in 172 occurrence at 155 subsites and 47 sites of NF(USF+RF) and HSF (SF+AF+VF) in eight rattan growing forests *viz*; Chittagong-south and north, CHT (Rangamati, Khagrachari and Bnadarban), Cox's Bazar, Dhaka, Dinajpur, Khulna, Sylhet (Hobigonj, Moulavi Bazar and Sylhet sadar) and Tangail recorded the distribution, frequency of occurrence, and *in situ* conservation status of ten recorded rattan species in Bangladesh. Recorded rattan species can be ranked in term of frequency of occurrence-distribution of species in the order of *C.tenuis*> *D.jenkinsiana*> *Cviminalis*>*C.guruba*>*C.longisetus*>*C.erectus*>*C.latifolius*≥*C.gracilis*>*C.travencoricus*> *C.acanthospathus*. Whilst these rattan species in respect of *in situ* conservation in these eight rattan growing forests were ranked (in order of potential of richness particularly in term of number of species) as CHT> Chittagong> Sylhet> Dhaka≥ Cox's Bazar> Tangail>Dinajpur≥ Khulna. Rattan index of eight rattan growing forests of Bangladesh ranged from 0.45-3.41. Calculated indices of species justify the ranking of all rattan growing forests as Dhaka> Cox's Bazar> Chittagong> Tangail> CHT> Sylhet> Diunajpur> Khulna. Out of 14 countries of the world, calculated rattan index varied from 0.0001 to 0.605 where Bangladesh has occupied 6th position in her rattan index. Forest Department of Bangladesh started planting rattan species since 1981 and planted over 2.74 millions seedling in 61,146 acres of land until 2002 in eight rattan growing forests (RGF). *In situ* conservation, number of rattans seedling ranged from 49,060-12,14,859 and rattan growing forests may be ranked in order of number of planted seedling as Sylhet> Chittagong> Cox's Bazar> Dhaka> Tangail> Dinajpur> CHT. Whilst *in situ* conservation, rattan species in respect to number ranged from 3-5 (*viz. C.tenuis, D.jenkinsiana, C.viminalis, C.guruba* and *C.longisetus*) and ranked in order of richness as *C.tenuis*> *D.jenkinsiana*> *C.viminalis*> *C.guruba*> *C.longisetus*. Present *in situ* conservation status of recorded ten rattan species also justify that *C.tenuis, D.jenkinsiana* and *C.viminalis* as cultivated (common) and *C.erectus, C.guruba, C.longisetus* and *C.latifolius* are vulnerable. Whilst *C.acanthospathus, C.gracilis* and *C.travencoricus* are extremely rare, where the *C.acanthospathus,* and *C.travencoricus* are the new records and *C. gracilis* is rediscovered one from Bangladesh.

In situ conservation measures of recorded ten rattan species have been initiated in nine reserve areas *viz.* Bangladesh Forest Research Institute (BFRI), Botanical Garden

Chittagong University (BGCU), Institute of Forestry and Environmental Sciences Chittagong University (IFESCU), Keochia Silviculture Research Station,Chittagong (KSRSC), Eco-park of Sitakunda, Chittagong (EPSC), National Botanical Garden, Mirpur (NBGM), Bhawal National Park,Gajipur (BNPG), Hazi Danesh Science and Technology University, Dinajpur (HDSTUD) and Dulahazara Safari Park Cox's Bazar (DSPCB) as canetum. It is concluded that out of fifteen reported rattan species, only eight species *viz*, *C.erectus*, *C.gracilis*, *C.guruba*, *C.latifolius*, *C.longisetus*, *C.tenuis*, *C.viminalis* var. *fasciculatus* and *Daemonorops jenkinsiana* were recorded in this investigation with an extra addition of two new reports *viz*. *C.acanthospathus*, *C.travencoricus*. Remaining seven species (*viz*. *C.flagellum*, *C.floribundus*, *C.giminalis*, *C.jenkinsiana*, *C.quinquenervius*, *C.rotang* and *C.rotentum*) were not found and seems to be disappeared / lost / unexplored from the nature of rattan growing forests of Bangladesh. So, the present investigation initiates the necessity of further extensive survey in more remote and restricted areas of Bangladesh to record more new or rediscover the lost rattan species resource immediately to bring back the past glory of the country to enrich the rattan-cane based cottage industry of Bangladesh.

CHAPTER 7: CONCLUSIONS AND SUGGESTIONS

7.1. Conclusions:

- Fiftteen rattan species *viz. Calamus erectus, C.flagellum, C.floribundus, C.giminalis, C.gracilis, C.guruba, C.jenkinsiana, C.latifolius, C.longisetus, C.quinquenervius, C.rotang, C.rotemtum, C.tenuis, C.viminalis* and *Daemonorops jenkinsiana* were previously reported to occur in Bangladesh. But present extensive study has revealed that ten rattan species *viz. Calamus acanthospathus, C.erectus, C.gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.travencoricus, C.viminalis* and *Daemonorops jenkinsiana* are available in Bangladesh.

- All these ten species are dioecious, pleonanthic, perennial, evergreen, clump forming and both economically and commercially important. One species is erect (*C.erectus*) but robust, with mean diameter of 13 cm and from aesthetic viewpoint is ornamental. Other nine *viz. C.acanthospathus, C. gracilis, C.guruba, C.latifolius, C.longisetus, C.tenuis, C.travencoricus, C.viminalis* and *Djenkinsiana* are high climber and fast growing in a wide range of habitat from sea-level to an altitude of 1000 m with culm mean diameter and length ranging from 0.8-4.0 cm and 4-43 meter respectively.

- Phenotypically male and female clump of the same species are not distinguishable even in the same habitat until and unless they produce inflorescence. General occurrences of male clumps are frequent than female ones (about 3:1). Male culms flower earlier and produce more flower than female ones. All rattan culms flower between 3-7 years in seedling raised clump.

- All species are potential enough to reproduce themselves both sexually (*viz.* seed) and vegetatively (*viz.* rhizome, sucker aerial shoot and shoot tip). Flowering and fruiting of ten recorded rattans show periodicity as well as plasticity. Four species (*viz. C.erectus, C.gracilis, C.guruba* and *C.viminalis*) are diphasic whilst other six species (*viz. C.acanthospathus, C.latifolius, C.longisetus, C.tenuis, C.travencoricus* and *D. jenkinsiana*) are monophasic.

- Techniques are evolved to shoot the livelong unsolved problem in seed propagation relating to fruit maturity, seed condition, collection time, sowing time, seed size, seed sowing media, sowing depth, storage period, storage condition, mechanical and chemical pretreatments and temperature effect to enhance seed dormancy breaking

period, germination rate, flushing period, germination per cent, seedling nursing, seedling pricking age, seedling transferring techniques and transplanting age.

- Maximum propagation in all species through seedling has been achieved and both from economic and practical viewpoint, seedling is preferred and has made successful for large-scale commercial plantation.

- Forest Department, Bangladesh raised more than 6146 acres of rattan plantation comprising of more than 2.75 millions of seedlings of five species in different forest divisions during 1981-2002 and has made possible three species (*viz. C.tenuis. C.viminalis* and *D.jenkinsiana*) through cultivation as common. *C.tenuis* and *C.guruba* have been reported as domesticated rattan species in rural Bangladesh from time immemorial. But they have been miss-understood to be single species and already have been disappearing from their abode due to over-exploitation, indiscriminate cutting and careless felling for agricultural extension or ignoring the socio economic and ecological importance.

- All ten rattan species are environmentally threatened. Of which four (*viz. C.acanthospathus, C.gracilis, C.latifolius, C.travencoricus*) species are extremely rare, three are vulnerable (*viz. C.erectus, C.guruba, C.longisetus*) and other three (*viz. C.tenuis. C.viminalis* and *D.jenkinsiana*) have been brought under cultivation-plantation for conservation and sustainable uses in our every day life.

- Recorded ten rattan species are being planted in eight canetum like reserve areas of forests and earmarked areas of public institutions *viz.* Botanical Garden Chittagong University (BGCU), Institute of Forestry and Environmental Sciences Chittagong University (IFESCU), Eco-park of Sitakunda,Chittagong (EPSC), National Botanical Garden, Mirpur (NBGM), Bhawal National Park, Gajipur (BNPG), Hazi Danesh Science and Technology University, Dinajpur (HDSTUD) and Dulahazara Safari Park Cox's Bazar (DSPCB) as canetum for *in situ* conservation as well as further research programme.

- Reported other eight species are not readily available and seems to be disappeared from their natural abode of Bangladesh.

7.2. Suggestions:

- National rattan arboretum (canetum) is to be maintained in Bangladesh Forest Research Institute for further study.
- All available rattans are to be conserved in all National Parks, National Botanical Gardens, Sanctuaries, Safari Parks and social forests as homesteads, agroforest and village groves of Bangladesh.
- Suckers and rhizomes of identified female clumps can be used as sources of female culm for mass scale seed production even in the canetum.
- *In vitro* germplasm collection may be used for very rare rattans.
- Commercial rattans are to be cultivated and domesticated in homesteads and social forests for long term supply of planting stock and raw materials to feed rattan based cottage industries of the country to promote export for earning foreign currency.
- Some commercial exotic species are to be introduced in our plantation forest to enrich our germplasm of commercial importance.
- Ministry of Environment and Forest, Bangladesh (MEFB) should frame effective policy for long-term conservation and sustainable use of rattans through selection cum improvement management system.
- More extensive survey is to be continued to bring back the lost rattan species and proper care must be undertaken to conserve them in forest reserves as well as in canetum.
- Anatomical studies of culm of different species must be done to authenticate and to evaluate maturity for harvesting.

CHAPTER 8 : APPENDICES

Appendix-8.1 : Classification of rattan genera (Uhl and Dransfield 1987).

Palmae(Arecaceae)
Subfamily Calamoideae
Tribe Calameae
Subtribe Ancistrophllinae
Laccosperma (Syn. Ancistrophyllum)
c. 7 species, humid tropical Africa
Eremospatha
c. 12 species, humid tropical Africa
Subtribe Metroxyline
Korthalsia
c. 26 species, Indochina and Burma to New Guinea
Subtribe Calaminae
Daemonorops
c. 115 species, India and to Westernmost New Guinea
Calamus
c. 370-400 species, tropical Africa, India and Sri Lanka, China, South and to Fiji, Vanture, and eastern Australia
Calospatha
1 species, endemic to Peninsular Malaysia
Pogonotium
3 species, one in Peninsular Malaysia and Borneo, the other two endemic to Borneo
Ceratolobus
6 species, Malay Peninsular, Sumatra, Borneo, Java
Retispatha
1 species, endemic to Borneo
Subtribe Plectomiinae
Plectonia
c. 16 species, Himalayas and South China to Western Malesia
Plectocomiopsis
c. 5 species, Thailand, Peninsular Malaysia, Sumatra, Borneo
Myrialepis
1 species, Indochina, Thailand, Burma, Peninsular Malaysia and Sumatra
Subtribe Oncocalaminae
Oncocalanus
1-3 species, humid tropical Africa

Appendix-8.2: Monthly average maximum-minimum temperature relative humidity and rainfall in eight rattan growing forest divisions of Bangladesh.

RGFDB	Measured parameter	MONTHS											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Cox.	MAMT. °C	27.5	31.5	32.3	33.8	32.3	32.3	32.3	31.9	31.0	32.1	31.0	28.1
	MAmt. °C	14.5	17.5	21.2	25.4	24.7	25.4	25.2	25.5	25.4	24.9	24.3	16.8
	MARH.%	78	71	77	78	83	87	86	88	86	85	79	80
	MARF.mm	00	00	00	00	463	879	491	848	203	201	002	107
CHT	MAMT. °C	27.5	32.3	34.5	34.6	32.1	30.8	31.1	30.9	31.7	31.6	29.9	26.4
	MAmt.°C	13.0	15.9	20.3	24.7	26.6	24.7	24.9	24.7	24.4	23.9	18.9	15.6
	MARH.%	76	67	66	70	82	88	88	89	86	86	83	84
	MARF.mm	00	00	03	00	379	1117	590	474	201	149	03	115
C. Bazr	MAMT.°C	28.5	32.1	33.3	34.8	32.8	31.8	31.2	30.5	31.6	32.5	31.6	28.7
	MAmt °C	16.1	19.1	21.9	25.3	25.1	25.6	25.3	25.0	24.9	24.7	20.6	17.5
	MARH.%	72	69	77	77	84	89	90	91	89	86	77	77
	MARF.mm	00	00	00	08	578	853	919	1134	391	227	01	124
Dhaka	MAMT.°C	26.9	31.2	34.8	36.0	32.8	32.5	31.5	31.7	31.6	31.8	30.4	27.1
	MAmt.°C	12.7	16.5	21.0	26.0	25.1	26.5	26.2	26.4	25.9	24.5	19.0	14.9
	MARH.%	72	65	58	79	79	83	86	84	84	83	76	71
	MARF.mm	00	00	00	21	428	348	553	282	361	368	13	00
Dinajpur	MAMT.°C	23.9	30.4	32.9	33.5	31.9	33.1	31.8	31.2	31.0	30.9	29.6	26.5
	MAmt.°C	10.5	14.9	17.8	23.4	23.8	26.2	26.2	25.8	25.2	23.4	17.6	13.3
	MARH.%	79	74	61	78	84	86	87	89	89	87	81	80
	MARF.mm	00	00	00	68	367	283	403	587	589	234	05	00
Khulna	MAMT.°C	26.5	30.4	34.8	35.5	34.0	32.9	31.7	32.1	32.0	31.8	30.8	28.4
	MAmt.°C	12.5	15.8	21.1	25.9	25.4	26.0	25.8	26.1	25.8	24.6	19.2	15.6
	MARH.%	77	73	68	73	83	85	89	87	89	87	79	79
	MARF.mm	00	00	00	014	172	185	420	371	374	160	14	00
Tangail	MAMT.°C	26.3	29.9	32.3	33.3	31.1	31.9	30.9	31.0	30.9	31.2	30.5	27.5
	MAmt.°C	12.0	16.0	19.0	24.5	24.1	26.0	26.1	26.1	25.9	24.0	18.5	14.1
	MARH.%	77	72	69	76	84	86	88	88	88	87	81	81
	MARF.mm	00	00	01	108	415	211	401	349	175	513	01	00
Sylhet	MAMT.°C	27.4	31.9	33.2	33.2	31.2	32.1	32.0	32.0	32.0	31.2	30.3	27.7
	MAmt.°C	13.6	16.5	19.2	23.2	23.3	25.1	25.4	25.4	25.0	23.0	19.3	15.4
	MARH.%	72	66	65	76	84	86	88	87	87	86	78	73
	MARF.mm	00	00	49	207	731	472	775	503	253	344	00	00

Legend: MAMT=Monthly average maximum temperature; MAmt=Monthly average minimum temperature; MARH=Monthly average relative humidity; MARF=Monthly average rainfall.

Appendix-8.12: Records of extracted canes, royalty and market price of rattan resource in Bangladesh during 1992002.

Circle/Year	Valuation of canes	1997-98	1998-99	1999-2000	2000-2001	2001-2002
Chittagong	Quantity of cane,Rft	2,37,000	17,76,675	14,56,145	3,46,750	96,800
	Royalty, Tk	4,740	35,533	29,287	6,935	1,936
	Market price, Tk.	3,55,500	26,65,012	21,84,217	5,20,125	1,45,200
CIFT (Rangamati)	Quantity of cane,Rft	3,88,200	17,800	5,72,450	11,308	6,260
	Royalty, Tk	7,764	356	11,449	226	125
	Market price, Tk.	5,82,300	26,700	8,58,675	16,962	9,390
Dhaka	Quantity of cane,Rft	1,20,000	72,800	40,600	18,300	15,200
	Royalty, Tk	2,400	14,560	8,120	3,660	3,040
	Market price, Tk.	1,80,000	1,09,200	60,900	27,450	22,800
Khulna	Quantity of cane,Rft	1,80,000	80,900	58,000	38,600	24,600
	Royalty, Tk	3,600	16,180	11,600	7,720	4,920
	Market price, Tk.	2,70,000	1,21,350	87,000	57,900	36,900
Sylhet	Quantity of cane,Rft	1,80,400	1,20,000	1,90,000	1,82,400	1,98,600
	Royalty, Tk	36,080	2,500	38,000	36,480	39,720
	Market price, Tk.	2,70,600	1,80,000	2,85,000	2,73,600	2,97,900

Source: Per. Comm. Hossain,Z. (2003) . Conservator, Bana Bhaban, FD,GOB.

Appendix-8.3: Physico-chemical properties of plantations, trial plots and nursery soils.

Type	Location	SMC %	WHC %	Texture	OC mgg^{-1}	OM mgg^{-1}	EC μSm^{-1}	pH	CEC μeqg^{-1}	Nitrogen μgg^{-1}	Available nutrients μgg^{-1}	
											P	K
Plantations	Dulahazara	19.3±3.3	29.6±1.6	SL	8.4±1.5	14.4±1.3	382±160	4.6±0.4	47±6	692±92	6.2±2.4	72±15
	Tilagar	18.5±3.6	24.6±2.1	SL	6.8±1.5	11.7±1.3	345±120	4.8±0.2	43±7	712±102	11.4±4.3	68±18
	Lawachara	26.2±3.6	33.6±2.2	SCL	9.6±2.2	16.5±1.8	398±152	5.4±0.4	52±9	892±132	14.4±4.8	88±19
Trial plots	BFRI	19.4±2.3	26.2±3.2	SL	8.7±1.4	15.3±2.1	403±78	4.8±0.4	39±11	618±102	15±2.8	58±21
	BGCU	17.3±5.2	25.4±2.0	SL	6.5±1.4	11.2±1.4	335±132	4.6±0.6	32±9	595±72	10±3.4	42±15
	Hinguli	21.2±3.8	29.3±2.1	SL	7.5±1.8	12.9±1.4	392±121	5.1±0.3	41±8	642±81	8.4±2.3	62±13
Nursery	SM_1	9.0±1.9	14.2±1.8	FS	1.2±0.3	2.1±0.4	148±12	4.2±0.3	10±3	79±15	4.2±1.8	10±3
	SM_2	16.2±4.3	24.5±1.2	SL	6.4±1.1	11.0±1.2	322±112	4.9±0.4	34±7	610±83	9.6±2.6	79±13
	SM_3	23.8±3.2	35.6±1.5	SCL	8.1±1.3	13.9±1.2	390±132	5.4±0.3	49±8	812±102	12±2.8	110±21

Legend: Soil samples were collected on dry season. SM_1, SM_2 and SM_3 are different seed sowing media corresponding to fine sand, sandy loam and clay loam.

Appendix-8.4: Evaluation of rate and number of shoot emergence (month wise-on fifth year) in seedling raised clumps of ten rattan species in canetum of Bangladesh.

Species \ Period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Culm. emergence period (month)	No.of emerged culm clump^{-1} yr^{-1}
C. acanthospathus	0	0	0	0	0	0.4±0.2	0.7+0.2	0.7±0.2	0.9±0.2	1.0±0.2	0	0	5	1.0±0.2
C.erectus	0	0	0	0	0.2±0.2	0.4±0.2	0.5±0.2	0.7±0.2	0.7±0.2	0.8±0.2	0	0	6	0.8±0.1
C.gracilis	0	0	0	0	0.2±0.2	0.4±0.2	0.8±0.2	1±0.2	1±0.3	1.1±0.2	1.2±0.2	0	7	1.2±0.2
C.guruba	0	0	0	0	0.4±0.2	0.8±0.2	1.2±0.2	1.6±0.2	2.2±0.2	2.4±0.2	2.4±0.2	0	7	2.4±0.2
C.latifolius	0	0	0	0.2+0.01	0.4±0.2	0.6±0.2	1±0.3	1.3±0.4	1.5±0.4	1.7±0.4	1.8±0.4	0	8	1.8±0.4
C.longisetus	0	0	0	0	0.4±0.2	0.6±0.2	1±0.3	1.2±0.2	1.2±0.2	1.4±0.4	1.6±0.2	0	7	1.6±0.2
C.tenuis	0	0	0	0	1±0.3	1.2±0.2	2±0.3	2.1±0.5	2.4±0.4	2.8±0.4	0	0	7	2.8±0.4
C.travencoricus	0	0	0	0	0.4±0.2	0.8±0.2	0.8±0.2	1.0±0.2	1.2±0.2	1.4±0.2	0	0	6	1.4±0.2
C.viminalis	0	0	0	0	0.2±0.01	0.4±0.2	0.6±0.2	1±0.3	1.2±0.3	1.4±0.2	1.4±0.2	0	7	1.4±0.2
D.jenkinsiana	0	0	0	0	1±0.3	1.4±0.2	1.6±0.2	1.9±0.3	2.2±0.2	2.5±0.2	2.6±0.2	0	7	2.6±0.2

Appendix-8.5 :*In situ* growth performance of three common rattan species of ten different ages in seedling raised plantation of Forest Department in five rattan growing forests divisions of Bangladesh.

Species	Location	Supporting tree	Age of plantation (year)	Width of clump, cm	Shoot number culm^{-1}	Height of main shoot culm^{-1},m	Dia.(cm) of main shoot
C. tenuis	Sylhet	*Tectona grandis, Shorea robusta , Xylia delabriformis, Cassia siamea*	1	17+3..2	2..3+0.4	0.5+0.01	-
			2	25+5.8	5..9+0.9	0.7+0.03	1.4+0.1
			3	40+7.9	9.1+0.8	1.9+0.03	1.4+0.1
			4	85+12.7	13.3+0.3	2.7+0.04	1.3+0.3
			5	11.5+10.9	16.4+0.8	3.2+0.03	1.2+0.1
			6	143.7+11.4	25.9+4.9	4.9+0.2	1.4+0.1
			7	126.0+2.9	29.4+4.2	6.4+1.0	1.5+0.1
			8	127.4+2.6	33.0+3.7	6.5+1.1	2.1+0.1
			9	162.0+37.8	44.9+4.5	10.8+1.8	2.2+0.2
			10	194.0+11.4	43.2+5.4	11.3+1.2	2.4+0.2
	Chittagong	*Bombax ceiba Lanmea coromandelicc*	1	19+3.4	2..3+0.28	1.6+0.01	-
			2	30+5.1	6..9+0.4	3.8+0.3	1.3+0.3
			3	48+11.6	12.3+0.9	5.13+0.8	1.4+0.4
			4	95+17.2	14.9+0.8	6.4+1.3	1.4+0.1
			5	130+21..3	16..2+0..2	7.9+2.3	1.4+0.2
			6	130.0+ 9.5	15.2+ 3.9	8.4+.8.0	1.3+0.1
			7	137.5 + 6.7	20.7+ 5.7	9.9+1.4	1.5+0.2
			8	149.1 + 3.9	23.5+5.9	11.7+1.7	1.7+0.1
			9	161.3 + 7.8	22.6 +7.4	13.7+1.3	2.0+0.2
			10	185.7+ 6	31.3+3.9	14.6+1.5	2.4+0.2
	Dhaka	*S. robusta, C. siamea, Terminalia arjuna, Anthocephalus chinensis*	1	21+3.1	1.5+0.2	0.3+0	-
			2	32+10	3.2+0.9	0.6+0	1.4+0.2
			3	50+5.2	5..3+0.8	1.4+0.01	1.4+0.3
			4	69+17.0	7.1+0.5	2.0+0.1	1.3+0.2
			5	83+18.2	10+0..9	2..2+0.1	1.3+0.2
			6	85.3+10.2	10.0+1.6	2.9+0.1	1.4+0.1
			7	90.0+2.1	20.4+2.2	3.0+0.9	1.4+0.1
			8	92.1+5.5	19.0+2.4	5.0+1.2	1.8+0.2
			9	111.8+22.5	25.3+8.1	8.1+0.2	1.9+0.1
			10	148.0+21.4	59.0+9.0	9.0+0.9	2.6+0.1
	Tangail	*S. robusta, Acacia auriculiformis Cassia siamea A. chinensis*	1	17+3..9	1.3+0.8	0.8+0.08	-
			2	25+5	2.9+0.9	1.2+0.8	1.4+0.1
			3	35+4.1	3.2+0.7	2.9+0.9	1.4+0.1
			4	48+6.2	4.8+0.7	4.1+1.0	1.4+0.2
			5	53+4.1	5.7+0.9	5.2+1.5	1.5+0.2
			6	55.3+10.2	5.1+1.0	6.0+0.2	1.9+0.1
			7	81.4+3.1	16.5+2.2	6.9+1.2	1.9+0.3
			8	86.0+4.1	18.4+1.9	7.9+1.1	2.1+0.1
			9	90.1+13.6	17.1+2.3	8.5+0.7	2.4+0.1
			10	102.0+9.0	49.0+6.9	9.4+1.9	2.8+0.2
C. viminalis	Dhaka	*S. robusta, C. siamea T. arjuna, A. chinensis A. auriculiformis*	1	19+4.1	1+0	0.4+0.01	-
			2	27+3.2	1.0+0	0.9+0.01	-
			3	41+3.9	1.0+0	1.8+0.09	-
			4	53+4.2	1.6+0.8	3.1+0.1	2.2+0.1
			5	63+5.1	2.1+0.7	4.3+0.7	2.2+0.1
			6	71.9+5.2	2.9+0.4	4.0+0.9	2.2+0.2
			7	76.6+3.0	3.3+0.15	6.1+0.7	2.9+0.5
			8	85.8+0.4	3.9+1.4	6.2+1.6	3.5+0.2
			9	91.4+6.2	4.6+0.7	7.8+0.7	3.9+0.5
			10	110.2+10.0	5.0+1.1	17.0+3.3	3.9+0.1

	Chittagong	*Bombax ceiba* *Lanmea coromandelica*	1	15+7.3	1.0+0	0.7+0	-
			2	24+8.1	1.0+0	1.9+0.08	-
			3	30+4.1	1.0+0	3.1+0.9	-
			4	39+3.9	1.9+0.8	3.9+1.1	2.4+0.1
			5	51+6.3	2.4+0.3	4.8+1.9	3.1+0.2
			6	68.5+6.9	3.0+2.5	5.6+0.8	3.4+0.1
			7	80.9+8.5	3.6+2.6	6.1+0.9	3.8+0.3
			8	101.0+12.4	4.5+2.6	9.2+2.6	4.2+0.6
			9	118.6+19.7	5.3+3.1	12.8+4.7	4.3+0.3
			10	156.7+16.9	5.7+5.3	17.0+3.9	4.3+0.3
	Tangail	*S .robusta,* *C. siamea* *Anthocephalus chinensis*	1	14+3.7	1.0+0	0.6+0.01	-
			2	20+2.1	1.0+0	1.2+0.07	-
			3	29+2.1	1.0+0	2.9+0.1	-
			4	47+4.2	1.1+0.9	4.2+1.2	2.3+0.6
			5	55+4.9	1.8+0.7	5.1+1.4	2.3+0.7
			6	55.8+4.9	2.7+0.1	5.9+0.5	2.9+0.2
			7	35.0+2.2	3.2+0.4	7.7+1.2	3.0+0.2
			8	61.0+0.4	3.8+1.4	6.2+1.6	3.5+0.2
			9	71.1+8.8	4.4+1.2	8.8+0.1	3.5+0.3
			10	99.2+18.9	4.9+0.9	9.5+1.5	4.0+0.1
D. jenkinsiana	Sylhet	*T.grandis,* *S. robusta,* *X. dolabriformis* *C. siamea*	1	10+1.6	1.0+0.03	0.9+0.07	-
			2	18+1.2	1.0+0.4	2.8+0.6	-
			3	26+1.1	3.2+0.7	3.9+1.1	-
			4	33+1.2	5.2+0.9	4.9+1.6	3.2+0.6
			5	47+1.4	9.1+0.7	5.1+1.7	3.3+0.6
			6	63.7+1.5	12.3+1.8	6.5+1.6	3.9+0.0
			7	87+11.4	22.4+2.1	9.0+2.1	4.2+0.9
			8	110.6+23.1	29.2+3.3	16.8+3.8	4.7+0.2
			9	145+35.6	31.0+8.1	19.0+2.8	4.9+0.1
			10	173.0+32.5	33.1+7.8	14.3+2.4	5.5+0.3
	Chittagong	*B. ceiba* *L. coromandelica*	1	10+1.7	1.0+0	0.8+0	-
			2	16+1.9	1.0+0.2	1.9+0.08	-
			3	24+2	3+0.3	3.2+0.2	-
			4	32+2	5+0.8	5.1+1.5	2.7+0.5
			5	43+3.1	8.2+1.1	5.7+1.8	2.7+0.5
			6	61.1+1.6	10.3+1.3	7.3+1.2	3.5+0.4
			7	89.0+10.2	14.0+0.9	9.5+2.1	3.6+0.8
			8	100.2+28.2	19.2+4.2	16.9+3.0	4.1+0.2
			9	121.8+25.9	18.0+6.1	19.0+2.4	4.9+0.3
			10	149.0+22.5	26.1+6.2	24.9+5.4	5.8+0.4
	Tangail	*S. robusta,* *A. auriculiformis* *A. chinensis*	1	3.8+1.1	1.0+0	0.9+0.01	-
			2	14.2+1.1	1.1+0.2	1.7+0.1	-
			3	20.4+1.9	2.9+0.4	3.1+0.2	-
			4	29.5+1.3	4+0.9	4.7+1	2.4+0.8
			5	39.7+1.1	6.1+0.2	5.2+1.7	2.9+0.8
			6	45.2+0.2	7.2+1.8	6.3+1.5	3.5+0
			7	55.0+3.1	9.8+1.2	6.9+0.2	4.4+0.8
			8	83.4+3.2	21.8+3.8	6.6+0.8	5.3+0.8
			9	102.0+9.9	24.5+4.5	6.7+2.03	5.4+0.2
			10	121+19	27.0+4.2	9.2+1.1	5.8+0.3

Appendix-8.6 : *In situ* growth performance of three common rattan species up to five years of age in three seedling raised trial plantation of three different habitats in south-east of Bangladesh.

Name of specie	Site	Circumference of clump, cm	No. of culm/shoot Clump^{-1}				Mean ht of culms, clump^{-1} ,cm	Average mean ht. of culms, clump^{-1},cm	No of node, culm^{-1}	Average no. of node culm^{-1}	No. of flagella or cirrus, culm^{-1}	Average no of flagella or cirrus culm^{-1}
			Age	Number	Average	Total			Number			
C.tenuis	Chittagong University	199±26	1Y	4+0.3		15±1.7	32+11		5+1		-	
			2Y	3+0.6			147+24		10+2		1+0	
			3Y	3+0.5			258+40		19+3		3+1	
			4Y	3+0.2			315+52		27+9		7+2	
			5Y	2+0.1			502+69		39+14		12+3	
	Dulahazara	237±47	1Y	3+0.5	3.7+0.2	14.0±1.4	42+13	35+4	9+2	7+0.8	-	-
			2Y	3+0.4	3.0+0.1		130+38	134+9.5	14+5	12+1.2	1+0	1.3+0.2
			3Y	3+0.2	3.0+0.1		260+42	249+11.6	28+10	22+2.5	4+1	4.7+0.7
			4Y	2+0.2	2.3+0.2		399+39	365+18.1	32+10	31+ 2.7	9+2	9.0+1.2
			5Y	2+0.1	2.0+0		570+51	520+21.1	45+16	42+4	14+2	13.7+1.2
	Hinguli	213±30	1Y	4+0.4		14.0±1.6	30+13		6+2		-	
			2Y	3+0.3			125+29		11+3		2+1	
			3Y	3+0.4			230+25		20+6		7+2	
			4Y	2+0.3			380+41		34+6		11+3	
			5Y	2+0.2			488+52		42+10		15+3	
	Average	216±11				14.4±0.5						
C. viminalis	Chittagong University	127±32	1Y	3+0.5		6.0±1.8	53+ 5		3+1		-	
			2Y	2+0.6			143+11		7+2		-	
			3Y	1+0.7			260+20		9+2		-	
			4Y	-			370+27		14+3		4+1	
			5Y	-			457+30		17+5		8+4	
	Dulahazara	197±30	1Y	3+0.4	3.0+0.1	8.0±1.4	33+14	49+4.8	5+1	4+0.4	-	-
			2Y	2+0.3	1.7+0.2		101+17	118+7.7	8+1	7+0.4	-	-
			3Y	2+0.5	1.3+0.2		198+18	212+13.1	14+4	11+1.1	-	-
			4Y	1+0.2	0.3+0.2		288+30	312+20.5	19+4	16+1.2	5+2	5.1+0.7
			5Y	-	0.0+0.0		350+25	402+17.5	21+4	19+1.3	10+3	9.7+1.1
	Hinguli	169±37	1Y	3+0.2		5.0±0.5	60+5		5+1		-	
			2Y	1+0.1			109+13		7+1		-	
			3Y	1+0.2			185+22		11+2		-	
			4Y	-			300+24		16+3		5+3	
			5Y	-			399+30		20+3		11+3	
	Average	164±20				6.3± 0.5						
D.jenkinsiana	Chittagong University	260±37	1Y	3+0.4		10.0±1.3	67+7		2+1		-	
			2Y	3+0.2			125+12		7+2		-	
			3Y	2+0.2			243+17		10+2		-	
			4Y	1+0.3			390+21		15+3		-	
			5Y	1+0.2			491+27		17+3		4+2	
	Dulahazara	301±34	1Y	3+0.5	3.0+0.1	9.0±1.5	73+7	72+2.4	4+1	3+0.4	-	-
			2Y	2+0.3	2.3+0.2		180+19	160+10.1	9+1	8+0.5	-	-
			3Y	2+0.4	2.0+0.1		318+21	287+12.6	14+2	12+0.8	-	-
			4Y	1+0.1	2.0+0.1		450+31	440+14.4	17+3	15+ 1	-	-
			5Y	1+0.2	1.7+0.1		528+32	536+17.1	20+5	19+1.3	5+2	5+0.6
	Hinguli	292±40	1Y	3+0.3		9.0±0.9	77+ 6		4+1		-	
			2Y	2+0.2			175+19		8+1		-	
			3Y	2+0.1			299+21		12+2		-	
			4Y	1+0.2			478+25		13+3		-	
			5Y	1+0.1			590+33		19+4		6+2	
	Average	284.4±12.5				9.4±0.3						

Appendix-8.7: Phenology, periodicity, plasticity and reproductive potential with seasons in ten rattan species of Bangladesh (Data collected during 1999-2004).

Species	~Early monsoon flowering									~Late monsoon flowering								
	Flowering period	Flowering season	Fruit collection & sowing period	Fruit collection & sowing season	Seed out put culm^{-1}	Dormancy breaking period, days	Flushing period ,days	Germination per cent	Reproductive capacity culm^{-1}	Flowering period	Flowering season	Fruit collection & sowing period	Fruit collection & sowing season	Seed out put culm^{-1}	Dormancy breaking period, days	Flushing period ,days	Germination per cent	Reproductive capacity culm^{-1}
C acanthospathus	-		-	-	-	-	-	-	-	Sep-Dec	LM	Feb-Apr	EM	2105±317	42±5	28±7	84±5.6	1768±92
*C erectus**	May-Jul	M	Oct-Dec	LM	314±31	112±14	35±7	55±9.4	163±10	Nov-Jan	W	Apr Jun	EM	613±66	42±7	28±7	82±6.6	502±31
*C gracilis**	Mar-May	EM	Jul-Sep	M	191±21	77±14	56±14	61±10.6	71±8	Oct-Dec	LM	Feb-Apr	EM	343±38	43±10	35±8	75±4.7	275±14
*C guruba**	Jan-Mar	W	Jun-Aug	M	377±99	84±8	63±7	47±8.5	177±17	Aug-Oct	LM	Dec-Feb	W	466±58	44±5	36±6	74±5.6	344±21
C latifolius	-	-	-	-	-	-	-	-	-	Sep-Nov	LM	May-Jul	M	1082±116	70±7	48±7	73±4.7	793±47
C longisetus	-	-	-	-	-	-	-	-	-	Sep-Nov	LM	May-Aug	M	1970±241	77±8	49±7	77±6.8	1516±82
C tenuis	-	-	-	-	-	-	-	-	-	Jul-Sep	M	Apr-Jul	EM-M	1430±198	35±5	42±5	90±3.8	1287±64
C travencoricus	-	-	-	-	-	-	-	-	-	Jul-Sep	M	Mar-May	EM	788±52	49±6	36±8	82±4.7	646±36
*C viminalis**	Mar-May	EM	Jul-Sep	M	1482±27	147±8	47±8	49±6.6	726±19	Sep-Nov	LM	Jan-Mar	W	3814±297	70±8	28±8	62±5.6	2364±174
D jenkinsiana	- -	-	-	-	-	-	-	-	-	Jul-Nov	M-LM	Jun-Sep	M	846±96	147±7	70±9	71±9.4	600±38

Legend: Seeds were sown in fine sand; EM= Early monsoon (Mar-May), M=Monsoon (Jun-Aug), LM= Late monsoon (Sep-Nov), W= Winter (Dec-Feb)
* marked species were found to show two flowering cycle.

Appendix-8.8 : Sowing season effect of on dormancy breaking period, flushing period and germination per cent in clean seeds, unclean seeds and whole fruits of ten rattan species of Bangladesh.

Species	Nature of seeds	Expt. set in winter				Expt. set in early monsoon				Expt. set in monsoon				Expt. set in late monsoon			
		Sowing time	Dormancy breaking period(wks)	Flushing period (wks)	Germination per cent	Sowing time	Dormancy breaking period(wks)	Flushing period (wks)	Germination per cent	Sowing time	Dormancy breaking period(wks)	Flushing period (wks)	Germination per cent	Sowing time	Dormancy breaking period(wks)	Flushing period (wks)	Germination per cent
C.acanthospathus	CS	-	-	-			6±1	4±1	84±5	-	-	-	-	-	-	-	-
	UCS					Mar, 27th	7±1	5±1	54±7								
	WF						7+1	5+1	22±5								
C.erectus	CS	-	-	-			6±1	4±1	82±7	-	-	-	-		16±2	3±1	58±8
	UCS					Apr, 22nd	7±1	5±1	52±4					Oct, 2nd	16±2	4±1	29±6
	WF						7+1	5+1	38+6						17+1	4+1	28+5
C.gracilis	CS		6±1	5±1	75±5	-	-	-	-		11±1	8±1	48±6	-	-	-	-
	UCS	Feb, 28th	6±1	5±1	43±4					Jul, 2nd	11±1	8±1	31±4				
	WF		7+1	6+1	29+5						12+1	9+1	22+3				
C.guruba	CS		6±1	5±1	74±6	-	-	-	-		12±1	9±1	58±3	-	-	-	-
	UCS	Jan,19th	11±1	8±1	46±4					Jul,10th	12±1	9±1	32±2				
	WF		13+1	9+1	20+3						12+1	9+1	20+4				
C.latifolius	CS	-	-	-	-	-	-	-	-		10±1	7±1	73±5	-	-	-	-
	UCS									Jun,7th	10±1	7±1	60±3				
	WF										11+1	7+1	22+4				
C.longisetus	CS	-	-	-	-	-	-	-	-		11±1	7±1	77±9	-	-	-	-
	UCS									Jun,6th	12±1	7±1	57±3				
	WF										12+1	8+1	34+3				
C.tenuis	CS	-	-	-	-	Apr,17th	5±1	6±1	90±3	-	-	-	-	-	-	-	-
	UCS						5±1	6±1	58±4								
	WF						6+1	7+1	28+3								
C.travencoricus	CS	-	-	-	-	Apr,19th	7±1	5±1	82±5	-	-	-	-	-	-	-	-
	UCS						7±1	5±1	50±5								
	WF						7+1	6+1	32+4								
C.viminalis	CS	-	-	-	-	Mar,9th	8±1	4±2	62±6	-	-	-	-	Sep,7th	21±1	11±1	43±7
	UCS						8±1	4±1	41±7						23±1	12±1	28±2
	WF						9+1	5+1	24+6						23+1	12+1	22+2
D.jenkinsiana	CS	-	-	-	-	-	-	-	-	-	-	-	-	Sept,25th	21±1	10±1	71±4
	UCS														21±1	11±1	46±7
	WF														21+1	13+1	28+6

Legend: CS=Clean seed, UCS=Unclean seed, WF=Whole fruit Winter (W)=Dec-Feb, Early monsoon (EM)=Mar-May, Monsoon (M)=Jun-Aug, Late monsoon(LM)=Sep-Nov.

Appendix-8.9: Sowing media effect on germination initiation time, rate, flushing period and percentage in fresh seeds of ten rattan species of Bangladesh.

Species	Collection-sowing time	Clay loam				Sandy loam				Fine sand			
		Initiation time,wks	Germination rate, per cent wk^{-1}	Flushing period, wks	Germination per cent	Initiation time, wks	Germination rate, per cent wk^{-1}	Flushing period, wks	Germination , per cent	Initiation time, wks	Germination rate, per cent wk^{-1}	Flushing period, wks	Germination per cent
C.acanthospathus	27th Mar	6±2	10,21,35,42,43, 45,48,48,48	7±1	48±8	6±1	56,62,66,69,73, 76,76,76	6±1	76±10	6±1	65,77,81,84,84, 84	4±1	84±5
C.erectus	22nd Apr	8±1	13,20,29,38,41, 43,43,43	8±1	43±10	6±1	16,43,55,62,,72, 72,72	7±1	72±6	6±1	44,71,77,82,82,82	4±1	82±7
C.gracilis	28th Feb	9±2	10,23,31,44,53, 59,62,62,62	7±2	62±11	6±1	15,21,36,47,55,64, 64,64	6±1	64±7	6±1	29,37,49,68, 75,75,75	5±1	75±5
C.guruba	19th Jan	10±2	19,30,38,47 57,64,67,67,67	7±2	67±7	8±2	21,29,38,47,52,55 ,69,69,69	7±1	69±5	6±1	31,49,68,70, 74,74,74	5±1	74±6
C.latifolius	7th Jun	11±2	10,21,30,41,54 ,59,61,65,65,65	8±2	65±8	10±1	19,29,37,42,49, 56,68,68,68	7±1	68±6	10±1	26,34,46,58,67,7 3,73,73	7±1	73±5
C.longisetus	5th Jun	13±2	11,15,20,27,36, 46,55,57,59,61, 61,61	10±1	61±7	11±1	18,25,35,49,55,57, 63,66,66,66	8±1	66±7	11±1	29,35,59,66, 71,75,77,77,77	7±1	77±7
C.tenuis	17th Apr	7±2	11,17,22,43,59 ,68,72,72,72	7±2	72±10	6±1	21,37,51,67,75,79, 79,79	6±1	79±9	5±1	39,53,68,79, 88,90,90,90	6±1	90±3
C.travencoricus	19th Apr	9±1	16,22,29,36, 39,42,46,46	7±2	46±8	8±1	46,49,52,68,74,75, 75	6±1	75±10	7±1	49,69,75 ,80,82,82	5±1	82±5
C.viminalis	9th Mar	10±2	5,19,22,30,43, 50,51,51,51	7±1	51±7	9±2	19,29,36,48,53,55, 55,55	6±1	55±7	8±1	22,46,57,62, 62,62	4±2	62±6
D.jenkinsiana	25th Sep	25±2	10,16,22,27,29, 33,39,44,47,49, 51,52,53,53 53	13±2	53±8	22±2	15,26,32,38,43,50, 46,54,60,62,64,64, 64	11±2	64±8	21±1	25,31,37,46,59,64,6 5,67,70,71,71,71	10±1	71±4

Appendix-8.10 : Storage period effect on dormancy breaking period, flushing period and germination per cent of clean seeds (stored in moist fine sand and grown in fine sand under shade house condition at one month interval) in ten rattan species of Bangladesh.

Species	Storing time	DBP-RP	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
C.acanthospathus	Mar27, 01	DBP,d			42+5	48±8	47±7	49±10	-	-													
		FP,d			28+7	30±6	32±5	32±9	-	-													
		GP,%			84+6	82±7	54+8	38+5	-	-													
C.erectus	Apr 22, 01	DBP,d				42±7	48±9	49±6	52±8	-	-												
		FP,d				28±6	34±8	37±8	38±5	-	-												
		GP,%				82+7	79+9	47+6	35+10	-	-												
C.gracilis	Feb28, 01	DBP,d	43±10	45±7	45±8	44±7	40±5	45±4	43±8	70±5	78±9	93±7	85±9	54±6	45±3								
		FP,d	35±8	36±7	35±6	35±9	36±8	32±5	32±8	32±7	40±5	42±9	48±7	36±5	32±5								
		GP,%	75+5	80+7	78+8	78±6	78+5	79+7	73+5	73+9	74±8	75+9	74+8	79+6	79+7								
C.guruba	Jan19, 01	DBP,d	44±5	48±8	46±9	47±8	48±9	48±7	46±6	68±8	82±9	95±10	83±9	54±9	45±7								
		FP,d	36±6	38±8	38±6	39±6	38±6	37±5	38±9	39±4	41±6	40±7	44±6	35±8	30±6								
		GP,%	74+6	80+7	80+8	78+7	78+6	73+5	69+5	68+5	67+7	66+9	66+5	67+9	67+6								
C.latifolius	Jun27, 01	DBP,d						70±7	74±9	84±6	121±8	112±9	90±9	60±9	58±10	57±9	58±7	56±8	68±9	69±8			
		FP,d						48±7	45±8	52±9	58±9	48±4	42±8	36±6	36±5	37±7	40±5	44±5	46±6	51±7			
		GP,%						73+5	77+6	74±6	73±8	76+7	77+6	82+5	78+5	79+4	68+7	70+6	72+6	69+8			
C.longisetus	Jun 26, 01	DBP,d						77±8	81±9	92±8	132±9	115±9	90±6	67±5	69±12	72±8	72±7	70±9	74±8	78±5			
		FP,d						49±8	54±6	52±6	50±6	52±5	50±4	48±7	47±9	46±6	48±8	48±6	49±7	51±8			
		GP,%						77+7	78±8	78+5	79+9	78+7	80+6	81+6	78+6	77+4	76+9	74+4	75+4	72+11			
C.tenuis	Jun 27, 01	DBP,d						35±5	33±7	40±10	42±8	45±7	44±6	48±6	43±6	39±6	32±7	34±6	35±6	36±6			
		FP,d						42±6	44±5	49±5	57±7	58±5	60±4	46±7	42±5	38±8	38±9	40±5	40±5	39±8			
		GP,%						90+6	91+5	91+6	89+7	84+4	85+6	82+11	84+7	86±5	85+6	83+4	82+6	80+6			
C.travencoricus	Apr.19, 01	DBP,d				49+6	52±9	53±4	56±8	-	-												
		FP,d				36±8	42±8	54±5	45±9	-	-												
		GP,%				82+5	85+7	45+6	35+10	-	-												
C.viminalis	Apr.9, 01	DBP,d				56±8	58±9	57±9	60±8	78±7	92±8	142±7	140±9	82±9	52±7	56±8	58±8	62±11					
		FP,d				28±8	30±6	38±8	38±9	64±5	72±9	76±10	72±8	48±8	32±7	30±6	32±5	37±5					
		GP,%				62±6	72+8	76+5	78+7	78+6	77+6	76+7	76+7	75+7	74+10	75+7	76+6	76+6					
D.jenkinsiana	Sep.25, 01	DBP,d									147±7	110±9	98±8	92±7	78±10	72±9	65±7	68±11	72±9	90±7	96±9	99±8	108±7
		FP,d									70±9	50±10	48±6	47±8	44±8	42±7	42±6	44±7	45±8	47±8	48±7	47±6	50±4
		GP,%									71±10	74±6	97±8	78+7	77+9	76+7	76+9	74+9	75+9	72+9	73+8	70+5	70+7

Legend: DBP=Dormancy breaking period; FP=Flushing period; GP=Germination per cent ;RP=Reproductive potential.

Appendix-8.11: Statistics of rattan plantation of Forest Department in rattan growing forest divisions of Bangladesh (1982-2002).

Division	Range	Beat	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	Total
Chittagong North	Korarhat	Andharmanik																		15.6				15.6
		Koila													5.0	4.0		10.0						19.0
	Hathazari	Ichamoti																				37.5		37.5
		Shorta																		15.2		25.0		40.2
		Shovonchari																		15.2	37.5			52.7
	Mirasorai	Hinguli																20.0	10.0					30.0
	Narayanhat	Balukhali																	10.0	30.4		50.0		90.4
		Datmara																			12.5	25		37.5
	Hazarikhill	Hazarikhill																		50.7				50.7
	Hasnabad	Hasnabad														1.0				10.1	12.5			23.6
Sub-total																								397.2
Chittagong South	Rangunia	Chiringa														5.0			5.0					10.0
		Narischa																10.0						10.0
	Khuruchia	Duthpukuria																25.0	8.1		12.5		50.0	95.5
	Dohazari	Lalutia																					50.0	50.0
		Boitoroni																					50.0	50.0
		Sangu																					62.5	62.5
		Dhopachari																					62.5	62.5
	Podua	Dolu														4.0								4.0
		Boroduara																10.0		20.2		25.0		55.2
		Tonkaboti																					50.0	50.0
	Chinati	Chinati																					50.0	50.0
		Harbang														4.0	10.0						25.0	39.0
		Sathgar																		10.1		25.0	25.0	60.1
	Jaldi	Puchari																	10.1					10.1
	Kalipur	Pukuria																				50.0		50.0
Sub-total																								559.0
Dhaka	B. N. Park												12.5				10.0				5.0			27.5
	Kaliakoir												12.5		37.5	50.0		25.0				50.0		175.0
	Kachighata																				10.0	37.5		47.5
	Razenrapur												37.5	37.5	12.5							50.0		137.5
	Sripur																	25.0		20.3	5.0	50.0		100.3
Sub-total													62.5	37.5	55.0	68.0	20.0	125.0	43.2	187.8	95.0	425.0	425.0	1487.8
GT																								2544.0

Division	Range	Beat	82	83	84	85	86	87	88	89	90	91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	Total
CHT South	Kaptai	Bangchari												11.0										11.0
CHT North																								
Bandarban	Khachalong							5.0		3.0	2.0			10.0	10.0	8.0								38.0
	Balaghata										0.25													0.25
	Paindhu										1.75	5.0		10.0	10.0	10.0								36.75
	Tonkaboti										3.0													3.0
	Ruma																	10.0	11.0					21.0
Sub-total																								99.0
Cox's Bazar South	Hoaykang																				25.2	12.5	150.0	187.7
	Teknaf																						50.0	50.0
	Dhoapalong																						87.5	87.5
	Ramakul																		62.5	70.0	150.3	87.5	200.0	520.3
Sub-total																								845.5
Mymensingh												10.0	4.0	20.0	20.0	20.0	20.0	20.0	20.0	101.2	62.5	125.0	30.0	452.7
Sub-total																								452.7
Sylhet	Sylhet North-1	Khadimnagar	15.0										136.0			46.0	9.0	30.0	60.0	25.0	47.0	19.40		416.4
		Ranikhai		50.0																				50.0
		Tilagar						9.0	5.0	15.0	15.0	50.0												89.0
	Sylhet North-2	Goainghat		50.0				10.0	27.0	10.0														97.0
		Ratarkul		25.0															20.0			24.70		69.7
		Kanaighat																	50.0	25.0				75.0
	Moulovibazar	Lawachara								10.0				30.0		75.0			50.0		17.29	37.5		219.8
		Kalachara											50.0	10.0			50.0	100.0	83.0	30.0	59.16	74.10		426.3
	Hobigong-1	Putijuri												30.0				29.0						59.0
	Hobigong-2	Kelanga									10.0		30.0				10.0	30.0	42.0	75.0	24.60			341.6
		Rashidpur											20.0											20.0
		Rema																			19.76	61.75		81.5
	Sathchari	Sathchari															9.0	50.0	50.0		10.0			117.0
	Rajakanthi	Adamrur									15.0		25.0	30.0	100.0	50.0	24.60	47.05						281.7
		Kurma											25.0					10.0						35.0
		Kamarchara															10.0	10.0	26.0	15.0		24.70		85.7
	Raghunanda	Saluia																20.0	10.0	70.0	12.35			122.4
	Juri	Matila									10.0								15.0			51.75		86.8
		Sagarnala																	15.0					15.0
		Ghutichara																		10.0		24.70		34.7
Sub-total			15	125				18.0	33.0	38	57	55	289	161	140	209	130.6	366.1	574.5	1212	438.2	533.6	517.5	2723.9
																								4131.7

Division	Range	Beat	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	'98	'99	'00	'01	'02	Total
Tangail	Bashtol												8.0		10.0						12.5	17.5	2.5	50.5
	Hotaia												7.0								10.0	17.5	2.5	37.0
	Boheratoli												7.0		5.0						10.0	17.5	2.5	42.0
	Dholapara												7.0	10.0		5.0					12.5	17.5		52.0
	Arankhola												7.0											7.0
	Dokhola												7.0					15.0		10.1	12.5	50.0	5.0	99.6
	Modhupur												7.0			5.0		10.0			12.5	30.0	5.0	69.5
	N. Park													10.0	5.0	10.0		5.0		5.1	15.2	37.5	25.0	112.8
Sub-total													50.0	20.0	20.0	20.0		30.0		15.2	85.2	187.5	42.5	470.4
G. total																								470.4
																								6146.1

Appendix 8.13: Comparative account in salient features of habitat and biology in ten recorded rattan species of Bangladesh.

Selected salient features	*C.acanthospathus*	*C. erectus*	*C.gracilis*	*C. guruba*	*C. latifolius*	*C.longisetus*	*C.tenuis*	*C.travencoricus*	*C.viminalis*	*D.jenkinsiana*
A.Clump habitat										
Outside Bangladesh	Assam; Kerala	India, Myanmar, Thailand	Meghalaya, Assam	E India; Myanmar	E.India; Myanmar	Myanmar; Thailand; Andaman isl	India; Myanmar	E.India; Kerala	India; Thailand; Java	W.Bengal; Assam; Tripura
Inside Bangladesh	Bandarban	BFRI;Kaptai; Sitakunda; Bandarban	Sylhet	Chittagong; Cox's bazar; Sylhet	BFRI Gazipur; Bandarban	BFRI;Rama Teknaf;Ukhia Sylhet	Widely distributed	Bandarban	Chittagong; Cox's bazar	Chittagong; Cox's bazaar; Sylhet
Distribution	SEGF	SEGF	SEGF	SEGF	SEGF	SEGF	SEGF	SEGF	SEGF and DF	SEGF
Edaphic conditions	Dry; Sandy loam	Moist-wet; Sandy-clay loam	Dry; Sandy loam	Moist-wet; Sandy-clay loam	Dry-moist; Sandy loam	Dry-moist; Loamy sand-sandy loam	Moist-wet; Loam-clay loam	Dry; Sandy loam	Drained; Sandy loam	Moist-wet; Sandy loam-loam
Altitude, m	~1000	~250-400	~330	~100-350	~50-420	~150-330	~50-250	~1000	~150-200	~150-350
Annual rainfall, cm	~220	~260	~300	~280-300	~250-270	~280	~260-300	~220	~290	~280-300
Light range, %	Partial shade ~75%	Partial shade ~90%	Partial shade ~75%	Partial shade ~75%	Partial shade ~50%	Direct light ~90%	Partial shade ~75%	Partial shade ~75%	Direct light ~90%	Partial shade ~75%
Avr. Temp. ^{0}C	~24	~23	~23	~23	~24	~23	~24	~24	~24	~24
B.Clump habits (vegetative phase)										
Shoot-crown colour	Deep green	Light green	Deep green	Deep green	Bottle green	Deep green	Glossy green	Light green	Light green	Green
Shoot-crown size	Small	Giant	Small	Medium	Large crown	Giant	Medium	Small	Large	Large
Culm-stem nature	Slender	Giant	Slender	Medium	Large	Robust	Medium	Slender	Large	Robust
Climbing habit	High climbing and crawling	Erect like bamboos	High climbing and crawling	High climbing and crawling	High climbing and crawling	High climbing and crawling	High climbing and crawling	High climbing and crawling	High climbing and crawling	High climbing and crawling
Climbing organs	Flagella	-	Flagella	Flagella	Cirri	Flagella	Flagella	Flagella	Flagella	Cirri

Thorn style	Broad based with sharp spines	Flat, sharp, long arranged in semicircular ring	Irregular, long and thin with black spines	Irregular, flattened, and conical with thin spines	Broad based very strong and curved with thick spines	Slightly broad based long sized with black spines	Irregular horizontal spines with black tip	Organised very thin rudimentary sharp and curved spines	Irregular Flattened, horizontal thin and long spines	Slender conical, brittle semi-circularly arranged
Thorn length (cm)	0.1-0.2	2.0-2.5	1.5-2.0	1.0-1.5	2.0-2.5	3.0-4.0	1.0-1.3	0.1-0.3	2.5-3.0	2.5-3.5
Clump shoot arrangement	Clusterous; loosely arranged	Clusterous; loosely arranged with sub-aerial shoot	Clusterous; loosely arranged	Clusterous; compactly arranged	Clusterous; loosely arranged	Clusterous; compactly arranged	Clusterous; loosely arranged; shoot stoloniferous	Clusterous; loosely arranged; Multiple shoot at cut shoot ti >	Clusterous; loosely arranged	Clusterous; compactly arranged.

Leaf sheath nature	Dull green with white powdery covering	Deep green	Deep green	Glossy green covered with rusty brown indumentum	Yellowish green to deep green	Greenish yellow	Glossy green with deep brown patches	Dull green with white powdery cover	Dull green with white floccose	Dull gree to brown
Knee	Conspicuous	Absent	Inconspicuous	Inconspicuou	Conspicuous	Slightly conspicuous	Conspicuous	Inconspicuous	Conspicuous	Conspicuous
Ocrea	Inconspicuous	Conspicuous	Conspicuous with prominent hairy projection	Membraneou -lacerated	Papery	Fibrous	Inconspicuous	Inconspicuous	Inconspicuous	Inconspicuous
No. of shoot clump^{-1}	12.0±0.6	12.7±0.9	22.7±1.8	22.4±0.9	20.3±1.2	32.0±5.0	28.0±1.5	18.7±1.8	15.3±0.9	34.0±1.2
No. of culm clump^{-1}	4.7±0.3	3.4±0.3	8.7±0.7	12.0±1.2	4.3±0.3	6.7±0.7	11.3±0.7	6.7±0.7	4.6±0.3	8.0±0.6
Length of main culm,m	25.3±1.8	4.2±0.4	18.0±1.2	19.0±1.5	25.7±0.9	29.0±0.6	35.4±1.2	28.0±1.2	29.0±1.2	37.0±3.6
Length of petiole,cm	33.3±4.4	81.7±4.4	17.3±2.9	34.4±2.3	55.0±2.9	80.0±10.4	33.4±4.4	35±2.9	41.7±4.4	58.7±6.3
Length of rachies,cm	35.0±2.9	240±5.8	53.4±4.4	56.7±4.4	133.3±12.0	193.3±8.8	63.3±4.4	53.3±4.4	153.3±14.5	206.7±8.8
No. of leaflets rachies^{-1}	29.3±2.4	59.3±7.5	10.7±0.3	70.0±5.8	25.7±2.6	90.3±5.5	40.0±11.5	43.3±8.8	25.0±2.9	100.0±11.5
Colour and shape of leaflets	Deep green; oblanceolate	Green;elongat-ed-ensiform	Deep green; oblanceolate	Glossy green linear	Bottle green; elliptic	Deep green; linear-ensiform	Glossy green;linear	Deep green;linear	Light green;linear	Glossy green; linear-oblong
Length of flagella/cirri,cm	169.0±11.5	-	133.4±12.0	116.7±56.1	140.0±5.8	430±65.6	150.0±28.9	116.7±20.3	250.4±28.9	143.3±12.0
Arrangement of spine on flagella/cirri	Recurved	Recurved	Recurved	Recurved	Recurved	Recurved	Recurved	Recurved	Recurved	Recurved

Dropping age of leaf sheath, year	3.3±0.3	3.3±0.3	4.0±0.6	3.0±0.6	3.0±0.6	3.0±0.6	43±0.9	3.33±0.3	4.3±0.3	4.3±0.9
Length of internode, cm	20.7±6.1	9.7±0.9	15.3±2.4	20.0±5.8	21.3±5.2	22.0±7.6	27.7±9.5	22.3±5.8	16.7±3.5	30.3±7.8
Annual ht. increment	1.6±0.6	0.3±0.05	1.3±0.5	1.6±0.5	2.7±0.6	1.4±0.4	2.1±0.5	1.9±0.3	1..9±0.6	3.1±0.5
Diameter of internode with sheath, mm	9.0±0.6	130±11..5	6.0±1.1	12.7±1.4	35.0±2.9	45.0±2.9	16.3±2.0	7.0±0.6	22.7±1.4	32.7±4.0
C. Clump habits (reproductive phase)										
Flowering age, yr^{-1}	4.7±0.3	5.3±0.9	4.7±0.3	4.7±0.3	5.3±0.3	5.7±0.3	4.3±0.3	4.3±0.3	4.0±0	4.33±0.3
Nature of flowering, $life^{-1}$	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic	Pleonanthic
Mode of flowering, yr^{-1}	Monophasic	Diphasic	Diphasic	Diphasic	Monophasic	Monophasic	Monophasic	Monophasic	Diphasic	Monophasic
Inflorescence initiation period, months	Sep-Dec	May-Jul / Nov-Jan	Mar-May / Oct-Dec	Jan-Mar / Aug-Oct	Sep-Dec	Sep-Dec	Jul-Sep	Jul-Sep	Mar-May/ Sep-Nov	Jul-Nov
No. of inflo. $culm^{-1}$	3.3± 0.33	2.7±0.3	3.3±0.33	3.0±0.58	3.3±0.6	3.3±0.3	3.3±0.3	3.3±0.3	3.3±0.3	3.7±0.3
Length of inflo. ,cm	50.0± 0.96	150± 2.13	70.0± 0.96	173.3± 6.9	193.3	450± 2.13	150± 2.13	70.0± 96	150± 2.13	45.0± 0.68
No.of partial inflo.$inflo^{-1}$	4.0±0.6	9.0±0.6	9.0±0.6	6.0±0.6	9.0±0.6	5.0±0.6	7.3±1.2	4.3±0.6	8.0±1.1	8.0±1.1
Nature of inflorescence	Slender,tubular	Slender-tubular	Slender-tubular	Slender-tubular	Slender-tubular	Slender-tubular	Slender-tubular	Slender-tubular	Slender-tubular	Erect-boat shaped
Length of partial inflo.,cm	10.0±1.1	16.0±3.0	7.0±0.6	7.0±0.6	10.0±1.1	15.0±1.7	14.0±1.1	7.0±0.6	10.0±1.1	4.0±0.6
No. of rachilla, par. $inflo^{-1}$	7.7±1.2	8.0±0	7.7±0.9	11.0±0.6	8.0±0.6	7.7±0.3	7.3±1.2	6.3±0.3	8.7±0.9	10.0±0.6
Length of rechilla, cm	5.0±0.6	12.3±1.4	5.0±0.6	5.0±0.6	6.0±1.1	8.0±1.1	8.0±1.7	6.0±1.1	7.7±0.9	6.0±1.1
Tenure of male inflorescence, months	Sep-Dec	May-Jul / Nov-Jan	Mar-May / Oct-Dec	Jan-Mar / Aug-Oct	Sep-Dec	Sep-Dec	Jul-Sep	Jul-Sep	Mar-May/ Sep-Nov	Jul-Nov
No. of male flower, $culm^{-1}$	13786±1067	18872±2554	4815±833	15224±506	28457±2113	19513±1429	7506±557	4423±517	19443±2208	11321±1301

Duration of anthesis of male flower, hr	12-24	12-24	12-24	12-24	12-24	12-24	12-24	12-24	12-24	12-24
Tenure of female inflorescence, months	Oct-Jan	Jun-Sep/ Dec-Mar	April-Jun/ Oct-Dec	Feb-Apr/ Sep-Nov	Oct-Mar	Oct-Apr	Aug-Feb	Aug-Feb	Apr-Jul/ Oct-Dec	Aug-May
Duration of pollination of female flower, hr	48-72	48-72	24-48	24-48	24-48	48-72	24-48	24-48	24-48	48-72
Flower colour	Pale yellow	Yellowish	Greenish	Off white	Greenish	Whitish	Dull yellow	Yellow	Whitish	Yellow
No. of female flower; culm^{-1}	9650±648	3218±491	5585±836	5702±667	4717±546	6383±757	3739±437	2266±409	7736±904	3014±350
Viability time of stigma, hr	48-72	48-72	24-48	24-48	24-48	48-72	24-48	24-48	24-48	48-72
Ratio of male and female flower	2.4:1	5.9:1	2.7:1	2.7:1	6:1	3:1	2:1	2:1	2.5:1	3.8:1
Fruit setting and maturity time, months	Nov-Dec	Jul-Sep/ Jan-Mar	May-Jun/ Nov-Dec	Mar-Apr/ Oct-Nov	Dec-Apr	Nov-Apr	Sep-Mar	Sep-Feb	May-Jul/ Nov-Jan	Nov-May
Fruit ripen time, months	Feb-Apr	Oct-Dec/ Apr-Jun	Jul-Sep/ Dec-Mar	May-Jul/ Dec-Feb	Apr-Jul	May-Aug	Apr-Jul	Mar-May	Aug-Oct/ Feb-Apr	Jun-Sep
Fruit harvesting season	EM	LM / EM	M / EM	M / W	M	M	EM-M	EM	M/W	M/LM
Colour of ripen fruits	Straw; scaled	Brown; scaled	White; scaled	Greenish brown, scaled	White; scaled	Dark brown with black band, scaled	Whitish;scaled	Orange; scaled	Light green, scaled	Yellow brown scaled
Shape of fruit	Ellipsoid –oval stalked	Ellipsoid and shortly stalked	Broadly Ovoid; sessile	Roundish; sessile or very shortly stalked	Sub-globose; sessile	Ellipsoid-oval; stalked with beak	Oblong, stalked	Oblong; stalked	Pea-like; sessile	Globose; stalked
Ripen fruit size, cm^3	7.8±0.9	22.6±1.8	5.4±0.3	0.3±0.04	2.3±0.6	11.3±1.4	2.2±0.5	10.2±1.1	0.8±0.3	3.1±0.4
Weight of 100 fruits, gm	441.0±2.4	1057.0±19.7	58.3±3.7	23.0±1.1	75.3±2.9	886.0±13.4	71.0±1.7	298.3±4.3	27.7±1.4	322.0±11.3
Size of seeds, cm^3	3.5±0.3	5.3±0.5	0.3±0.05	0.2±0.01	0.8±0.2	3.7±0.7	0.2±0.02	3.3±0.6	0.1±0.02	1.05±0.2
Shape of seed	Elliptic;	Elliptic;	Ovoid;	Sub-	Sub-globose;	Oblong-	Sub-globose	Elliptic;smooth	Sub-globose	Globose;

	smooth walled	smooth walled	ornamented	globose; ornamented	ornamented	ovoid	ornamented	walled	ornamented	smooth walled
Wt. of 100 seeds, gm	182±4.8	45.2±4.2	26.6±1.5	14.0±1.4	32.7±2.8	301±5.1	26.7±2.6	248±6.8	17.1±1.7	112±5.5
Seed moisture content, %	29.5±0.3	29.7±0.4	28.0±0.4	14.4±0.3	24.4±0.3	30.4±0.4	30.0±0.3	29.4±0.4	29.7±0.2	25.7±0.1
Placentation	Basal	Epibasal	Lateral	Basal	Basal	Basal	Basal	Basal	Basal	Basal
Ovule type	Orthotropus	Anatropus	Anatropus	Anatropus	Anatropus	Anatropus	Anatropus	Orthotropus	Anatropus	Anatropus
Germination mode	Hypogeal	Hypogeal	Hypogeal	Hypogeal	Hypogeal	Hypogeal	Hypogeal	Hypogeal	Hypogeal	Hypogeal
Seed out put, culm^{-1}	2105±317	314±31/ 613±66	191±21/ 343±38	377±99/ 466±58	1087±116	1970±241	1430±198	788±82	1482±127/ 3814±297	846±96
Seed sowing time, m	Mar	Nov/May	Aug/Mar	Jul/Feb	June	June	May	April	Aug/Feb	Sep
Seed sowing depth, cm	3	3	1	1	2	3	2	3	1	3
Dormancy breaking period, days	42±5	42±7/ 122±14	43±10/ 77±14	44±5/ 84±8	70±87	77±88	35±6	49±7	48±7/ 147±7	147±7
Flushing period, days	28±6	21±7/ 28±7	48±13/ 35±6	35±6/ 63±7	49±6	49±7	42±7	35±7	28±14/ 47±7	70±7
Germination ,%	84±4.7	82±6.6/ 55±7.5	75±4.7 41±5.6	74±5.6/ 47±2.8	73±4.7	77±8.5	90±2.8	82±4.7	62±5.6/ 49±6.6	71±3.8
Reproductive capacity culm^{-1}	1768±106	163±412/ 902±21	71±18/ 275±17	177±20/ 344±25	793±65	1516±95	1287±80	646±42	726±22/ 2364±201	600±44
Seed viability-storing period, m	<2	<2	>12	>12	>12	>12	>12	<2	>12	>12
D. Silviculture and Management										
Seedling transferring age, month	1	1	1-2	1-2	1-2	1-2	1-2	1	1-2	1-2
Total foliar photosynthetic pigment µgg^{-1}	144.8±1.8	176±1.4	150±1.4	118±1.6	147±1.2	107±1.2	121±1.3	148±1.7	104±1.4	102±1.5
Foliar nitrogen contentµgg^{-1}	4361±131	3630±153	3942±141	4962±109	4421±173	4764±230	4394±179	4864±261	4231±208	4021±207
Seedling out	12-15	18-24	18-24	12-15	18-24	12-15	12-15	12-15	15-18	15-18

planting age, m										
Present *in situ* distribution status	Wild - -	Wild - -	Wild - -	Wild Planted Domesticate	Wild Planted -	Wild Planted -	Wild Planted Domesticated	Wild - -	Wild Planted -	Wild Planted -
Present conservation status	Rare	Vulnerable	Rare	Vulnerable	Rare	Vulnerable	Common	Rare	Common	Common
R.market values, Tk m^{-1}	5	-	5	6	16	15	5	5	10	15
Socio-economic status	Special	Occasional	Special	Frequent	Special	Special	Frequent	Special	Frequent	Frequent
Remarkable uses	Fruit pulp edible; Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder, hedge, wild lives conservation etc.	Seed used as substitute of betel nut; Canes as pole; Clump as sacred Ornamental, soil binder, hedge Wild lives Conservation etc.	Fruit pulp edible Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder, hedge, wild lives conservation etc.	Fruit pulp edible; Canes for heavy duty furniture frame, manufacturing novelty items; Clumps as soil binder, hedge and wild lives conservation etc.	Fruit pulp edible; Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder, hedge and wild lives conservation etc.	Canes for furniture frame and ruling stick; Clumps as soil binder, hedge, wild lives conservation etc.	Fruit pulp edible; Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder, hedge and wild lives conservation	Fruit pulp edible; Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder, hedge and wild lives conservation.	Fruit pulp edible; Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder,hedge, wild lives conservation etc.	Canes for furniture frame, weaving, binding and manufacturing novelty items; Clumps as soil binder, hedge, Wild lives conservation.

Appendix-8.14: Proposed scheme on biology propagation and conservation of studied rattans in Bangladesh. (Data collected during 1998-2005)

A. Genetical aspects:

1.Culm habit ----------clusterous, multiple stemed, climbing
2. Culm size(dia), cm ----------slender-giant/thin-thick (0.4 -14.0)
3. Culm size (length), m ----------4 - 43
4. Flowering cycle, $pl^{-1}yr^{-1}$ ----------hepaxanthic,monophasic-diphasic
5. Fruiting potential, $pl^{-1}yr^{-1}$ ----------once- twice
6.Fruit maturation period, $pl^{-1}cu^{-1}$ ----------10 - 14 months
7. Fruit nature ----------Fleshy – highly acidic
8. Moisture content of fresh seed,%----------14 - 30
9. Fruit size, cm^{-3} ----------0.8 - 2 2.6
10. Seed size,cm^{-3}----------0.1 - 5.3
11. Seed dormancy breaking period, wks---------- 4 -25
12. Seed viability period, wks ----------10 - 50
13. Seed dormancy breaking period, wks----------4 - 21
14. Seedling flashing period, wks ----------4 - 12
15. Wilding establishment potential, $m^{-2}cl^{-1}yr^{-1}$----3 - 12
16. Seed storage temperature, ^0C ----------4 - 10
17. Seed storage period, month ----------2 - 12
18. Seed storage medium / material ----------moist fine sand.
19. Moisture content of stored seed, % ----------35 - 40 (above moisture content of fresh seed).
20. Seed storage conditions----------Dark, low temp, moist, low O_2
21. Moisture content of moist fine sand, % --------10 - 15.
22. Culm harvesting age,yr.---------- ~5 -7
23. Cyto-taxonomy----------to be studied.
24. Anatomical----------to be studied.

B. Silvicultural aspects:

1. Seed sowing media ----------fine sand / sandy loam.
2. Seed propagator----------shade house.
3. Seed sowing depth, cm ----------1/ 2 / 3
4. Seedling raising technique ----------seed tray/seed bed/poly bag under shade house.
5. Seedling pricking age,month----------1 - 3
6. Seedling pricking technique ----------uprooting.
7. Seedling transferring technique ----------whole/cutting root system.
8. Nursing of transferring technique---------- shade/partial shade with regular requisite watering.
9. Seedling transplanting age,month----------15 - 24
10.Seedling transplanting seasons ----------monsoon
11.Seedling transplanting technique ----------poly bag/hole/pit
12.Seedling planting sites ----------afforested/deforested with supporting trees
13.Transplanting space in planting sites,meter--------2 - 3

C. Ecological aspects:

1. Plantation site ---------- plain / slope / low land/coastal zone
2. Site aspects----------south / south east/east

3. Soil type ----------sandy loam / clay loam
4. Shade tree ----------evergreen / semi evergreen
5. Support tree ---------- branched with rough bole surface
6. Rainfall, mm yr^{-1} ----------2260 - 3680
7. Relative humidity, % ----------70 - 96
8. Light intensity,lux ----------25 - 35000
9. Soil surface---------- rough, humid
10.Soil moisture content, %----------25 - 50
11. Soil pH----------acidic, 4 - 5
12. Soil fertility ----------infertile, low organic matter
13. *In situ* conservation status of rattans----------Domesticated/cultivated/wild/vulnerable/ rare/disappeared.

D. Management and socio-economic aspects:

1. Pre-planting of shade & support trees, ----------tall, long lived, branched and semi evergreen.
2. Nursing of planted seedlings----------weeding, mulching, thinning and leaning support.
3. Gap filling time of lost seedling,month----------6 - 12
4. Weeding and mulching----------early and late monsoon of 1st and 2nd yr.
5. Protection of fruit from animals----------nylon net trap
6. Fruit collection technique----------climbing/long stick pruner/pruner
7. Culm extraction technique----------selection-cum-improvement
8. Culm processing technique----------unsheathing-cleaning-straightening
9. Culm seasoning technique----------sun dry/fumigating
10.Culm preserving technique---------- sorting- packing- dehydrating
11.Culm storing technique----------stacking- dehydrating- fumigating-polybag/ gunny covering.
12.Production and manufacturing of marketable items----------canes, stem strips, furniture, novelty items.
13.Marketing and trading of raw and marketable products ----------valuable and luxurious furniture; novelty items; weaving and binding strips
14. Exportable rattan products ---------- ~ hundred updated furniture and novelty items.
15. Evaluated product value (Tk) yr^{-1}---------- ~ 60-65 millions.
16. Future prospects of rattans----------promising and encouraging
17.Longterm effect----------soil binder, hedge and abode of wild lives for conservation and thus ecological balance of our nature, in addition to, sustainable management for continuous supply of raw materials for cottage industry - rattan product entrepreneurs.
18.Employment prospects in updated cottage industry-rattan product entrepreneurs ----------more than 2000 skilled worker all over Bangladesh.
19.Remarks----------rattan cultivation-cottage industry-updated technology for rattan products must be encouraged at private sector like other industrial products.

Appendices - 8.15: Present distribution and area (ha) of different forest types under different forest divisions of Bangladesh.

	Reserved forest	Acquired forest	Protected forest	Vested forest	Unclassed state forest	Khas	Total
Hill forest	5,94,383	11,004	32,303	2,636	7,21,344	---	13,61,670
CHT(North)	1,59,379	—	—	—	1,53,063	---	3,12,442
CHT(South)	82,161	---	---	---	1,72,721	—	2,54,882
Bandarban USF	40,198	---	—	---	78,592	---	1,18,790
Pulpwood Bandarban	---	—	---	—	58,236	—	58,236
Lama	---	—	---	---	75,149	—	75,149
USF Rangamati	12,801	—	—	—	89,694	—	1,02,495
Jhum Control	12,903	---	—	—	9,600	---	22,503
Pulpwood Kaptai	29,279	---	—	---	---	---	29,279
Khagrachari USF	1,409	—	---	—	82,073	---	83,482
Chittagong	82,307	5,096	19,873	2,636	—	---	1,09,912
Cox's Bazar	1,04,103	1,241	12,430	---	---	---	1,17,774
Sylhet	69,843	4,667	—	---	2,215	—	76,725
Inland forest	68,140	31,198	2,689	19,985	---	---	1,22,012
Dhaka	26,221	—	---	—	---	—	26,221
Tangail	22,460	27,287	—	—	---	---	49,747
Mymensingh	13,467	—	---	15,019	—	---	28,486
Dinajpur	5,037	387	—	4,681	---	—	10,105
Rangpur	763	1,697	263	---	---	—	2,723
Rajshahi	192	11	2,426	276	---	---	2,905
Comilla Extn	—	1,696	—	—	---	—	1,696
Dhaka Extn (south)	---	—	—	9	---	---	9
Kushtia Extn	---	8	---	—	---	—	8
Bogra Extn	—	7	—	---	---	---	7
Faridpur Extn	---	10	---	—	—	---	10
Jessore Extn	—	9	---	—	---	—	9
Botanical garden, Dhaka	—	86	---	—	---	---	86
Littoral forest	6,56,579	6	—	—	—	101,526	75,811
Sundarbans	5,57,285	—	—	—	—	---	5,77,285
Bhola CA	2,236	---	---	—	--	24,304	26,540
Patuakhali CA	8,571	—	—	—	---	13,293	21,864
Noakhali CA	35,741	6	—	—	--	54,618	90,365
Chittagong CA	32,746	---	—	—	---	9,311	42,057
Total	13,19,102	42,208	34,992	22,621	7,21,344	1,01,526	22,41,793

(**Source**: Bangladesh Forest department 1999)

CHAPTER 9 : GLOSSARY

Acaulescent	stemless *i.e.* very short-stemmed
Acotile	the sterile male flower present in dyads
Acropetal	referring to the maturity of rattan flowers and fruits proceeding from the base to the apex
Acute	sharp
Adjacent-ligular	a small plug emerges from the seed
Adventitious	not in usual place
Anatropous	an ovule bent parallel to its stalk(stem) so that the micropyle is adjacent to the hilum.
Anther	a part of a stamen containing the pollen
Anthesis	stalk of the leaflet
Antipetalous	opposite the petal
Apocarpus	with free carpels
Arcuate	curved
Arecaceae	alternate name for the family Plamae
Attenuate	tapering to a point
Auricle	an ear shaped part or appendage
Axillary	borne in an axil
Basifixed	attached to the base
Basipetal	development from top to bottom
Bifid	divided into two halves
Bisexual	having both sexes present and functional in the same flower
Bract	a modified leaf associated with the inflorescence
Bristiled	having a bristle
Bristle	a stiff hair
Caducous	quick falling or shed
Calix	the outermost whorl of floral organs
Cane	the bare stem of a rattan
Carpel	the single unit of the gynoecium
Caudiform	tail-like
Cirrate	bearing a cirrus
Cirrus	whip-like extension of rachis with thorn
Cleaned seed	rattan seed from which the fruit scales (pericarp) and the fleshy sarcotesta are removed before sowing
Clustered	having multiple stems
Connate	united or joint
Cross-cutting	cutting harvested canes into desired lengths; large-diameter canes are usually cut into 3 m lengths; small-diameter canes into 9 m lengths
Culm	a rattan stem or stalk
Cutting cycle	the interval between harvests of wild or cultivated canes to allow them to regenerate naturally; a 5-12 year cycle is suggested, varying in accordance with species.
Cymbospatha	boat shaped outer bract of inflorescence
Dioecious	male and female flowers in separate plants

Diospore	portion of the seed without sarcotesta
Distichous	borne strictly in two opposite rows
Divericate	widely divergent
Dyad	in the female the flowers are arranged in pairs known as dyads along each side of the rachilla in the axils of the rachilla bracts
Ecirrate	without cirrus
Eflagellate	without flagella
Embryo	the rudimentary plant within a seed
Endocarp	the innermost layer of the fruit wall
Endosperm	the storage organ of the seed
Ensiform	sword-shaped
Entire	an even margin without tooth-like or lobed (rounded) edges
Eophyll	first foliage leaf of the seedling
Epicarp	the outermost layer of the fruit wall
Epipetalous	united with and often appearing to be borne on the petals
Erose	said to a margin when appearing eroded
Flabellate	fan-like
Flagellate	bearing a flagellum
Flagellum	a sterile inflorescence modified as a whipe-like climbing organ developed from leaf sheath
Floccose	covered with tufts of soft wooly hears that usually rub off readily
Forest plantation	cultivation of different tree species underplanted with rattan
Foveolate	pitted
Frimbriate	fringed
Fruit	the ripened ovary with adnate parts
Genus	a taxonomic grouping of species believed to be closely related to each other
Glabrous	not hairy
Hapaxanthic	mode of flowering when stem growth is terminated by the production of inflorescences
Hardening off	removal of rattan seedlings from the nursery into direct sunlight a few days or a week before transplanting
Homogeneous	referring to the endosperm; not ruminate
Indumentum	covering of hairs
Induplicate	folded like 'V'
Inflorescence	the branch that bears the flowers, including all its bracts and branches
Infructance	an inflorescence bearing fruit
Intercropping	cultivation of two or more perennial or annual species in rows or other complementary patterns such that production is maximised per unit area
Internode	the space between two nodes
Involucate	bracteole immediately surrounding the flower
Keel	a central dorsal ridge
Knee	swelling of the leaf sheath just below the petiole
Lacerate	torn, irregularly cleft or cut
Lanceolate	shaped like a lance
Leaflet	a division of the blade of the leaf

Linear	several times longer than wide, usually narrow
Mesocarp	the central layer of the fruit wall
Micropyle	an opening through the envelope enclosing the ovule
Monocarpic	flowering once in the life time
Monoecious	male and female flowers separate but borne on same plant
Node	the point on the stem where the leaf is attached, after leaf fall marked by a circular scar
Oblanceolate	inversely lance shaped
Oblong	longer than broad with sides more or less parallel
Ocrea	outgrowth on the upper part of the vegetative growth
Ovate	egg-shaped; a flate surface which is scarcely twice as long as broad with the widest portion below the middle.
Palmae	the palm family; alternate name Arecaceae
Partial inflorescence	the branches of inflorescence
Perianth	a collective term for sepals and petals if both are present
Petiolate	having petiole
Petiole	the stalk of a leaf
Phenology	the study of the behavior of plants in relation to environmental conditions; *i.e.* flowering and fruiting patterns
Phyllotaxy	the arrangement of leaves on a stem
Pinnate	feather formed; with the leaflets of a compound leaf placed on either side of the rachis
Pistil	the organ of the flower which contains the ovule
Planting materials	seeds, wildings, suckers or tissue cultured material for rattan propagation
Pleonanthic	method of flowering in which life of a stem is not termed by flowering
Pollination	the transfer of pollen from the dehiscing anther to the receptive stigma
Polybag nursery	germination of rattan seed in polythene bags filled with fertile topsoil.
Prophyll	first sterile bract on the base of inflorescence or on lower branches
Protandrous	stamens shedding pollen before the stigma is receptive
Protogynous	stigma as receptive before pollen is shed
Rachilla	ultimate flower bearing axis of an inflorescence
Rachis	the main axis of the leaf that holds leaflets
Radicle	the first root formed by the embryo
Rattan	a climbing palm belonging to the subfamily Calamoideae
Receptacle	the central axis of a flower to which the floral organs are attached
Recurved	bent or curved downward or backward.
Reduplicate	folded like reverse 'V'
Rhizome	an underground stem which is distinguished from the adjoining roots by the presence of nodes with buds and leaves or scales.
Rosette stage	said of rattan seedlings when the seedling leaves are fully expanded, at which time they may be transplanted.
Royalty	a payment made to the landowner, in the case of rattan most

	commonly the government, for the right to harvest canes; the royalty amount is determined by the cane type and quality harvested.
Ruminate	referring to a surface with deep irregular channels
Saccate	bag shaped
Sarcotesta	a fleshy layer developed from the outer seed coat
Scales	vertical rows of reflexed cover
Scanded	climbing
Seed	the reproductive unit formed from a fertilized ovule
Seed bed	a bed for germinating seed
Sessile	without a stalk
Setose	covered with bristles
Sheath	the basal tubular part of the leaf which enclosed the stem
Shoot	a young growing stem
Solitary	single stemmed, not clustered.
Sorting	the selection in the field of rattans acceptable in the trade
Spadix	inflorescence
Species	the fundamental taxonomic unit consisting of the populations of a breeding group
Spine	a short stiff straight sharp-pointed hard structure
Stamen	the male organ of a flower
Stem	the part of the plant that is usually above ground and bears the branches, leaves and reproductive parts
Stemless	referring to rattans with very short, often subterranean stems
Sterile	failing to complete fertilization and produce seed as a result of defective pollen or ovules
Stolon	a shoot that bends to the ground and takes roots; a horizontal stem at or below the surface of the ground that gives rise to new plants at its tip
Sub-cirrate	leaf with small cirrus
Sucker	a branch formed at the base of a rattan stem
Support trees	naturally-occurring or cultivated trees providing support and shade for the cultivated rattans
Terete	Rounded, cylindrical
Transplanting	removal of wildings or nursery seedlings from their original location to a planting site in the forest
Tribe	a division of a subfamily
Underplanting	planting any desirable economic species such as rattan beneath the forest canopy
Unisexual	referring to flowers of one sex
Variety	a taxonomic division of a species
Vegetative propagation	propagation of rattan by suckers, whole rhizomes and by tissue culture
Wilding	self sown seedling

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