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RESOURCE ENHANCEMENT AND PROCESSING OF CANE & BAMBOO SPECIES SUITABLE FOR HANDICRAFTS

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PREFACE

Recently, bamboo and cane based industries have been identified as potential sunrise industries in India and a significant amount is earmarked for the development of this sector. Bamboos, popularly known as giant grasses, with more than 1575 species in the world, occurring in a wide variety of soil and climatic conditions, play an important role in providing livelihood, ecological and food securities to mankind. Canes are spiny trailing and climbing palms of tropical rain forests with about 600 species predominantly found in South East Asia mainly used for handicrafts and furniture.

The cane and bamboo project, initiated by the Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and the United Nations Development Programme (UNDP), is one of the holistic programmes with the intention of development of cane and bamboo handicraft sector. The programme, which involved a network of institutions and agencies, covered a wide spectrum of activities including resource enhancement, product diversification, partial mechanization of raw materials processing and promotion of marketing. The project was implemented in four states in north-eastern India (Assam, Arunachal Pradesh, Manipur and Tripura) and one state in southern India (Kerala). The programme for resource enhancement was implemented by the Kerala Forest Research Institute (KFRI) as a nodal agency with the association of the Rain Forest Research Institute, Jorhat, Assam and the State Forest Research Institute, Itanagar, Arunachal Pradesh. During the course of the project, the possibilities for development of bamboo resources in these states were examined critically and species suitable for handicrafts were identified. Packages of practice for cultivation, planting stock production by both micro and macropropagation methods, establishment of joint-venture nurseries and demonstration plots with user groups are some of the outcome of the project towards organized cultivation. Technology transfer through training programmes, series of user-friendly publications and workshops on focal themes like policy and legal issues have resulted in setting up a platform for promotion of cultivation of bamboo and cane and value addition of their products. I congratulate all the team members of the project and all those directly or indirectly involved in planning and implementation of this integrated programme and hope the deliverables are of help in planning future steps in this direction.

Peechi
27 January 2004

Dr. J. K. Sharma
Director, KFRI

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Participation of interest groups such as farmers, NGOs, Self Help Groups, artisans, media persons etc. was a vital part of the project and their input helped to fulfil the objectives of the project. We are indebted to each one of them for their enthusiasm and for extending continuous support.

ABSTRACT OF PROJECT PROPOSAL

Project code : KFRI 336/2000

Project title : Resource enhancement and processing of cane and bamboo species suitable for handicrafts

Objectives

1. To undertake survey and documentation of cane and bamboo species used in handicrafts
2. To adopt techniques like macro-propagation for large-scale multiplication of bamboo species used in handicraft industry.
3. To develop packages for nursery and silviculture techniques for important species.
4. To establish germplasm banks for conservation and propagation of species widely used in handicrafts.
5. To set up tissue culture unit for scaling up of successful protocols for large scale production.
6. To establish mother plant collection and plant multiplication nurseries of selected species used in handicrafts.
7. Selection of interest groups (like farmers, NGOs) and set up farms.
8. To set up Oil-curing units for improving the quality and appearance of harvested canes.
9. Conduct training in cultivation, harvesting and processing of cane and bamboo species used in handicrafts.
10. To produce materials for publicity about cane and bamboo in different forms to create awareness about cane and bamboo cultivation.

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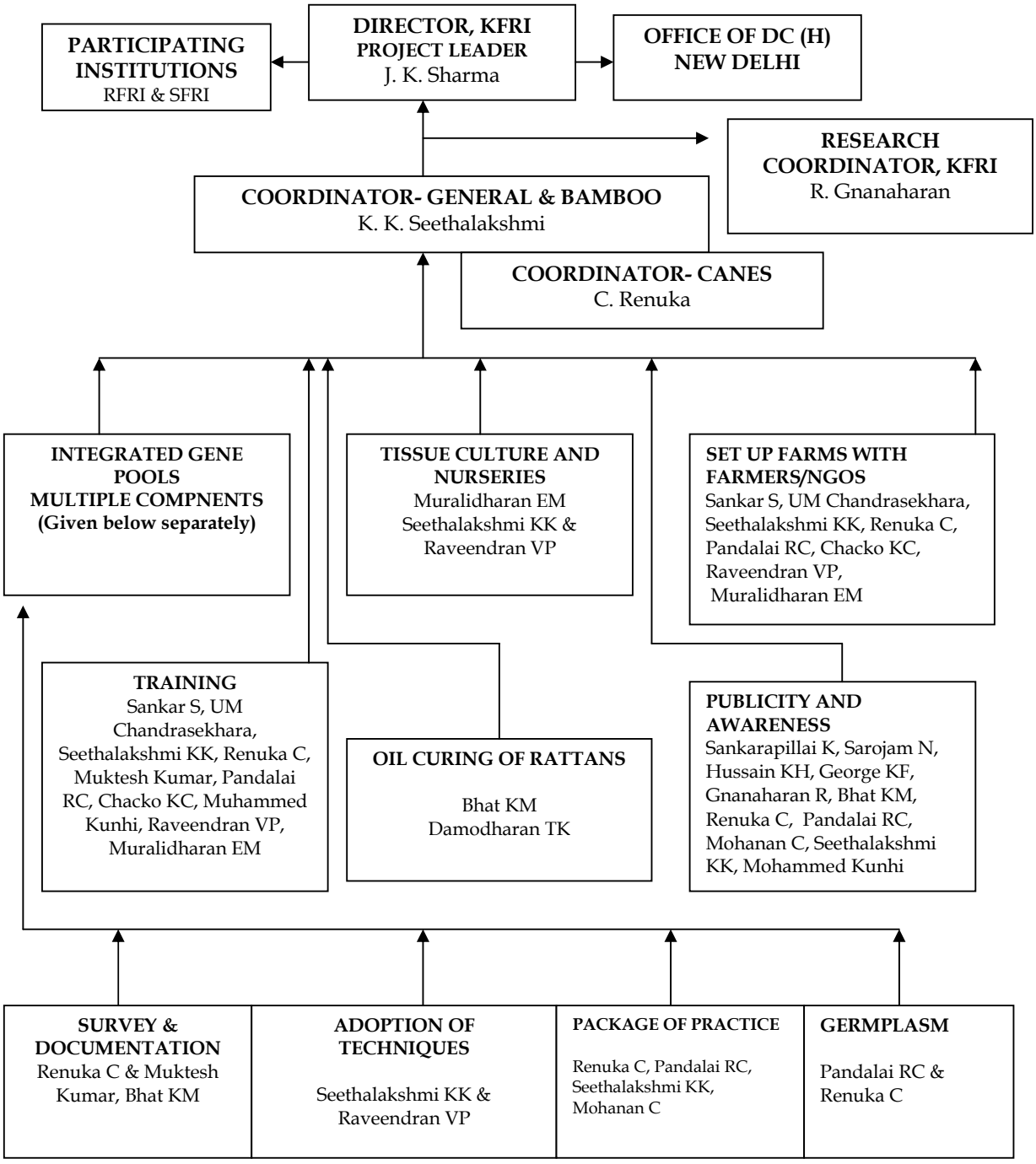
PROJECT ORGANIZATION



EXECUTIVE SUMMARY

The integrated Cane and Bamboo project initiated by the Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and the United Nations Development Programme, in collaboration with a network of institutions in India, covered a wide spectrum of activities including resource enhancement, product diversification, mechanization of processing and enhanced marketing. The project was implemented in four states in northeastern region (Assam, Arunachal Pradesh, Manipur and Tripura) and one state in southern India (Kerala). The programme for resource enhancement has been implemented by the Kerala Forest Research Institute (KFRI) as a nodal agency with the association of the Rain Forest Research Institute (RFRI), Jorhat, Assam and the State Forest Research Institute (SFRI), Itanagar, Arunachal Pradesh. The major components of the resource enhancement part included survey and documentation of species used in handicrafts, adoption of propagation techniques, packages of practice for cultivation, germplasm establishment, planting stock production through tissue culture and macro-propagation methods, and, nurseries and demonstration plots establishment, in collaboration with user groups. Capacity building for cultivation and value added utilization through a series of training programmes and technology transfer was another important objective. Organization of workshops and meetings and publication of handbooks, directory and bibliographies were an integral part of the project to create awareness among all stakeholders and to emphasize the potential of bamboo and cane development.

A total of 18 species of cane are used by the handicraft industries in Kerala. Of these, nine species (*Calamus brandisii* Becc., *C. delessertianus* Becc., *C. gamblei* Becc., *C. hookerianus* Becc., *C. pseudotenuis* Becc. ex. Becc. & Hook f., *C. rotang* Linn., *C. thwaitesii* Becc. & Hook f., *C. travancoricus* Bedd. ex. Becc. & Hook. f. and *C. vattayila* Renuka.) are native to southern India. Seven species (*C. acanthospathus* Griff., *C. erectus* Roxb., *C. flagellum* Griff., *C. gracilis* Roxb., *C. guruba* (Buch.-Ham.) ex Mart., *C. leptospadix* Griff. and *C. tenuis* Roxb.) are imported from north-eastern states. Two species of cane (*Calamus andamanicus* Kurz. and *C. pseudorivalis* Becc.) belong to the Andaman and Nicobar Islands.

Nine species of bamboo viz., *Bambusa bambos* (L.) Voss, *Dendrocalamus strictus* (Roxb.) Nees, *Ochlandra ebracteata* Raizada & Chatterjee, *O. scriptoria* (Dennst.) C. E. C. Fisch., *O. setigera* Gamble, *O. travancorica* var. *travancorica* (Bedd.) Benth. ex Gamble, *O. wightii* (Munro) C. E. C. Fisch., *Pseudoxytenanthera bourdillonii* (Gamble) H. B. Naithani and *P. ritcheyii* (Munro) H. B. Naithani) are used in handicraft industry.

Dendrocalamus brandisii, *D. giganteus*, *D. membranaceous*, *Ochlandra beddomei* and *Pseudoxytenanthera bourdillonii* are commercial bamboos suitable for

cultivation. As seeds are not easily available for these species, suitable vegetative propagation methods were tried for production of planting stock. Of these, three species viz., *D. brandisii*, *D. giganteus* and *D. membranaceous* could be propagated using culm cuttings and with the help of growth regulating substances. The other two species viz., *O. beddomei* and *P. bourdillonii*, although showed good sprouting response, did not produce roots.

KFRI bambusetum, which hosted 25 species of sympodial bamboos at the onset of the project, was strengthened with collections from all over India, especially from northeastern region and at present accommodates 59 sympodial and five monopodial species. Growth records revealed that species from Assam like *Bambusa balcooa, B. nutans, Dendrocalamus asper, D. sikkimensis, Drepanostachyum khassiana* and species from Arunachal Pradesh like *Bambusa affinis, B. pallida* and *Gigantochloa macrostachya* are well established. It is very early to judge the performance of these species, especially the monopodial bamboo species introduced to bambusetum during the project period.

In addition to the existing canetum, a germplasm of nine cane species (*Calamus brandisii, C. delessertianus*, *C. gamblei*, *C. hookerianus*, *C. pseudotenuis*, *C. rotang, C. thwaitesii*, *C. travancoricus* and *C. vattayila*) used by the handicraft industries was established.

Production of planting stock of species in high demand is still a challenge especially for bamboos even after the long-term research undertaken in this field. Both micro and macro-propagation techniques were used during this investigation to solve the problem of planting stock production.

Four species of bamboo and nine species of cane (rattan) were selected for developing rapid micropropagation techniques. In bamboo, nodes taken from both seedlings as well as mature clumps were used to start the cultures. Shoot cultures were established from nodal explants taken from mature clumps of *Thyrsostachys oliveri, Dendrocalamus giganteus* and *Bambusa balcooa.* In canes the immature and mature embryos and shoot tips from 1- to 2-year-old seedlings were used as explants.

Large-scale seedling production through conventional method of rooting of culm cuttings of bamboo species was taken up simultaneously. Totally, 11 bamboo nurseries were established of which three are in KFRI and eight under joint-venture nursery programme in collaboration with interest groups like other institutions, NGOs, SHGs and Planters. Totally, 1, 77, 240 seedlings belonging to six species (*Bambusa bambos, B. tulda, Dendrocalamus giganteus*, *D. strictus, Ochlandra ebracteata* and *O. travancorica*) and 5375 rooted cuttings of 13 species (*B. balcooa, B. pallida, B. polymorpha, B. striata, B. tulda, B. vulgaris* (green), *D. brandisii, D. giganteus, D. longispathus, D. membranaceus*, *P. ritcheyi, P. stocksii* and *T. oliveri)* were produced by different nurseries. An area of 5 ha

for a mother plant collection with 15 selected species was established in KFRI-FRC, Veluppadam for collection of culm cutting for rooting in future.

The experience in bamboo and cane gained by KFRI through long-term research of about two decades was shared with resource persons from partner institutions at northeastern region through a training workshop organized at RFRI, Jorhat. Through a series of 24 training programmes, technology for cultivation and processing of cane and bamboo was transferred to 1014 participants such as farmers, NGOs, SHGs, department officials and local body members from Kerala. Also, the potential cultivators were familiarized with various species through field visits to bambusetum and nurseries. Through the feedback received from participants, the following species *Dendrocalamus giganteus*, *Thyrsostachys oliveri*, *Bambusa nutans*, *Dendrocalamus brandisii* and *Bambusa bambos* in this order were highly preferred for cultivation.

Along with supply of required planting stock of bamboo and rattan, KFRI had also established 14 demonstration plots in collaboration with user groups. In addition, steps to form an organized group such as Bamboo and Cane Club, interaction meeting of potential large-scale farmers, publication of a newsletter in Malayalam *Muladhwani* (Voice of Bamboo*),* and All India Radio programme on the theme Bamboo: Tomorrow's Crop (*Mula, Nalathe Vila*) under the `Farm and Home Programme (in Malayalam) were some of the important milestones covered for popularization of organized cultivation of bamboo and cane.

In a meeting with the Development Commissioner (Handicrafts), farmers expressed the difficulties they face with the forest laws which discourage transport of forest trees and bamboo from private lands. They projected this as one of the impediments for cultivation of bamboo in homesteads. The National Workshop on Policy and Legal Issues in Cultivation and Utilization of Bamboo, Rattan and Forest Trees in Private and Community Lands, organized with invited participants representing all stakeholders came out with fruitful recommendations, which were disseminated throughout the country for favourable consideration by policy makers.

The Interaction Meeting organized towards the end of the project period helped to disseminate the outcome of the project and to invite the attention of various stakeholders such as policy makers, officials of industry, forest and agricultural departments, scientists, farmers, artisans and NGOs and agencies involved in marketing to plan an integrated development of cane and bamboo sector in Kerala. Logical support was provided to ICA Domus Trust, New Delhi, a participating NGO, to organize a workshop on Self-help and community mobilization into community based enterprise.

Both improved processing and value addition are required for improvement of the quality of bamboo and cane products. Oil curing (curing in a 9:1 mixture of hot diesel or kerosene and coconut oil) is a post-harvest processing technique that has to be applied immediately after harvesting the canes for improving the colour and for reducing the susceptibility to fungal attack. This technology, which was standardised by KFRI, was transferred through demonstration cum training in Kerala and Arunachal Pradesh. The newly established charitable society, "CANEFED" in Kerala and SFRI in Arunachal Pradesh were entrusted with the popularisation of the technology in Kerala and northeastern region respectively. KFRI also sponsored 13 master trainees for a training programme to acquire practical experience in the use of hand tools designed by IIT Bombay and furniture items developed by NID, Ahmedabad.

The handbooks, directory and bibliographies, an outcome of the project, served as a ready reference of information to stakeholders involved in development of bamboo sector. The handbooks, particularly, are an interface between technical experts and user groups in transferring technologies. Handbooks on Commercial bamboos and rattans of Kerala provide information for scientific identification of the species of raw material used along with their properties. Handbooks on Nursery and Silvicultural Techniques for Rattans and Bamboos are user-friendly to potential bamboo and cane growers. The Handbook on Micropropagation of bamboo and rattan will form a consolidated ready reference for the amateurs in this field. Handbooks on Oil curing technology for value-added rattan (cane) products, Preservative treatment of bamboo and bamboo products and Protection of Rattan against fungal staining and bio-deterioration provide information on processing and preservative treatments and provide techniques for improvement of the quality of raw material and products.

Information resources for bamboo and cane development in Kerala provide all available sources of relevant information handy for planners and other user groups. Both annotated bibliographies cover world literature on these two groups. The extensive work done by KFRI in the field of bamboo and cane research is brought to limelight through hosting a separate site exclusively for this which is linked to KFRI website (www.kfri.org).

INTRODUCTION

Bamboos, popularly known as giant grass, with more than 111 genera and 1575 species, occur in a wide variety of soil and climatic conditions around the globe playing a critical role in providing ecological, livelihood and food securities to mankind. In India, although bamboos occur throughout the country, largest area under bamboos is found in north-eastern India followed by the Western Ghats. There are about 1500 traditional uses of bamboo broadly classified under household, industry, weapons, energy, transportation, fisheries, agriculture, medicine and construction. Recently, in East and Southeast Asia, especially in China there has been a rapid growth of bamboo industries. The major reasons may be ascribed to development of new products like laminated bamboo, parquet flooring, ply bamboo, bamboo composites and bamboo charcoal. Mechanization of the traditional sectors like bamboo shoots for food, chopsticks, toothpicks and bamboo handicrafts are other possible reasons. Considering the large bamboo resources of India, which is second only to China, the potential for developing bamboo sector appears to be very high. The Prime Minister has launched an integrated bamboo development programme in 1999 on the World Environment day.

Rattans, generally known as canes, are the spiny, trailing and climbing palms of tropical rain forests comprising about 13 genera and 600 species. The maximum distribution of rattans is in Southeast Asia. In India, rattans are distributed in three major regions, the Western Ghats, the eastern and north-eastern parts and the Andaman and Nicobar Islands. Rattans are found in the evergreen, semi-evergreen and moist deciduous forests in the country, and comprise about 60 species under four genera *Calamus, Daemonorops*, *Plectocomia* and *Korthalsia*. Rattans are an important source of income and employment for the tribes and locals residing near the forest areas. It contributes to 25-35 per cent of the total household income of the tribal communities in north-eastern India. Uses of rattan vary from furniture and other household items to food. In many Asian countries, tribals are using both fruits and young shoots (rich in protein) of some species of rattan as food items. Leaves of some of the rattans are used for thatching.

A rediscovery of the potentials of bamboo and rattan during the early 1980s in India, promoted development of bamboo and rattan sectors in a holistic manner starting from organized cultivation to product innovation and marketing by various agencies. Although substantial information was generated through research by institutions and forest departments, the transfer of successful technologies was slow due to several reasons. Recent evaluation of market potential of Indian cane and bamboo sector mainly based on the data from north-eastern India has shown that currently it accounts for Rs. 360 crores and most of the products are general household

items, furniture and package materials. There is tremendous scope for value addition and innovation and an untapped potential exists for export market. It is likely to be a Rs. 3000 crores market, provided adequate investment is made in skill up-gradation, creation of infrastructure and availability of quality raw material in abundant quantities.

In this context, the Cane and Bamboo project is a remarkable initiative by the Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and the United Nations Development Programme. The programme covers a wide spectrum of activities including resource enhancement, product diversification and partial mechanization of raw material processing and promotion of marketing. The area of implementation of the project covers four states in north-eastern India (Assam, Arunachal Pradesh, Manipur and Tripura) and one state in southern India (Kerala). The programme for resource enhancement has been implemented by the Kerala Forest Research Institute (KFRI) as a nodal agency with the association of the Rain Forest Research Institute (RFRI), Jorhat, Assam and the State Forest Research Institute (SFRI), Itanagar, Arunachal Pradesh. The project was undertaken with the following 10 objectives.

1. To undertake survey and documentation of cane and bamboo species used in handicrafts.

2. To adopt techniques like macro-propagation for large-scale multiplication of bamboo species used in handicraft industry.

3. To develop packages for nursery and silviculture techniques for important species.

4. To establish germplasm banks for conservation and propagation of species widely used in handicrafts.

5. To set up tissue culture unit for scaling up of successful protocols for large scale production.

6. To establish mother plant collections of selected species and plant multiplication nurseries of selected species used in handicrafts.

7. Selection of interest groups (like farmers, NGOs) and set up farms of bamboo and cane species suitable for handicrafts.

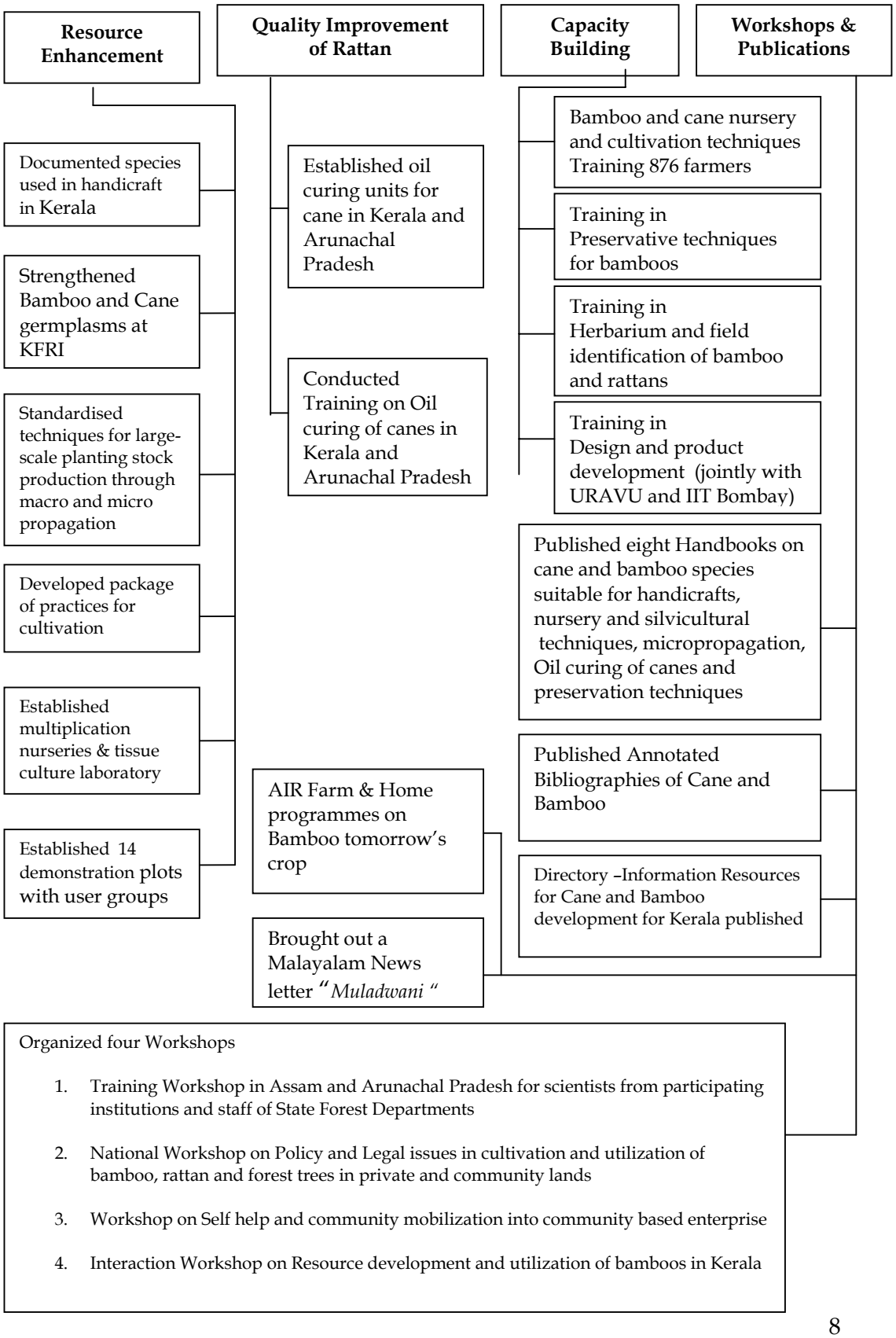
8. To set up Oil-curing units for improving the quality and appearance of harvested canes.

9. Conduct training in cultivation, harvesting and processing of cane and bamboo species used in handicrafts.

10. To produce materials for publicity about cane and bamboo in different forms to create awareness about cane and bamboo cultivation.

The major achievements of the project in the areas of resource enhancement, quality improvement of harvested cane and capacity building through training are given in the flow chart below. Details of work carried out under each objective are provided separately. Besides the training workshops conducted to train scientists from partner institutions in north-east, a National Workshop on Policy and Legal Issues in Cultivation and Utilization of Bamboo, Rattan and Forest Trees in Private and Community Lands, a Workshop on Self-Help and Community Mobilization into Community Based Enterprise and an Interaction Workshop on Bamboo Resource Development and Utilization in Kerala were organized as part of the project.

Major Achievements



SETTING UP OF INTEGRATED GENE POOLS

The base material to enhance bamboo and rattan resources is the gene pool, which consists of different species and variations within species. The objective of the establishment of the gene pool is conservation of all species with their variants in a selected location outside their natural habitats (*ex-situ*) so that threats in their natural habitat will not result in their annihilation. The material will be accessible and, also, any events like flowering can be tracked by observing the representative samples in the gene pool. Four sub-projects were undertaken under this component viz.

1. Survey and documentation of cane and bamboo species suitable for handicrafts

2. Adopting techniques like macro propagation for production of planting stock

3. Package of practices for the nursery and plantation activities for cane and bamboo

4. Establish germplasm banks of bamboo and cane

The details of work carried out under each sub-project are given below in detail.

SURVEY AND DOCUMENTATION OF CANE SPECIES SUITABLE FOR HANDICRAFTS

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Divisions of [1] Botany and [2] Wood Science

Abstract

With a view to document the detailed information on the species of canes (rattans) used in handicraft industry in Kerala, a survey was undertaken mainly covering the artisans and industries. Details of cane imported from north-eastern states and Andamans into Kerala were also taken into account during the survey. A proforma to collect relevant information was developed and shared with partner institutions from north-east (SFRI and RFRI). The materials collected were identified in comparison with the authentic samples maintained at KFRI. The information collected by KFRI has been brought out as a handbook entitled "Commercial Rattans of Kerala" in Kerala. A total of 18 species of canes are used by the handicraft industries. Of these, nine species (*Calamus brandisii* Becc., *C. delessertianus* Becc., *C. gamblei* Becc, *C. hookerianus* Becc, *C. pseudotenuis* Becc. ex. Becc & Hook f, *C. rotang* Linn., *C. thwaitesii* Becc. & Hook f., *C. travancoricus* Bedd. ex. Becc & Hook. F., *C. vattayila* Renuka) are native to southern India. Seven species (*C. acanthospathus* Griff., *C. erectus* Roxb., *C. flagellum* Griff., *Calamus gracilis* Roxb., *C. guruba* (Buch.-Ham.) ex Mart., *C. leptospadix* Griff. and *C. tenuis* Roxb.) are imported from north-eastern states. Two species of cane (*Calamus andamanicus* Kurz., *C. pseudorivalis* Becc.) belong to Andaman & Nicobar Islands.

Introduction

Canes (rattans) form one of the most useful forest resources used in manufacture of a wide variety of furniture and handicraft items. In India, canes distributed in Peninsular India, north-eastern parts of India and Andaman and Nicobar Islands are represented by about 60 species under four genera *Calamus*, *Daemonorops*, *Korthalsia* and *Plectocomia*. Kerala has 15 species of canes belonging to the genus *Calamus*. A survey conducted with industrial units and artisans in Kerala revealed that there is not enough raw material supply from the forests of Kerala. A considerable quantity of the raw material is procured from the north-eastern states and Andaman Nicobar Islands. Hence, resource enhancement is urgently needed for which identification of the species used by industries is essential. The sustainable exploitation of the cane resources also is hindered by the lack of a sound taxonomic base.

Objective

Inventory of the species of cane used in handicraft industry, identification and preparation of handbooks.

Methodology

A proforma was developed for collection of information on rattan species used in handicrafts (Appendix–1). The proforma was provided to partner institutes in north-eastern region for collection of information in uniform pattern. A survey was undertaken in the clusters of artisans to ascertain the cane species used for handicraft in Kerala. Details of the materials used by them and samples were collected. The samples were identified scientifically in comparison with the voucher specimens maintained in KFRI Herbarium.

Results

A document on cane species with scientific details such as botanical characters, phenology, anatomical and mechanical properties, local names, distribution, was published as a handbook on Commercial rattans of Kerala (Appendix-2).

Nine species of canes belonging to the genus *Calamus* are commercially used in Kerala. The list of species along with Malayalam names is given in Table 1.

These species are mainly used commercially based on their working quality and pliability. Many other species such as *Calamus metzianus,* which is easily breakable, are not used even though they are available.

Table 1. Cane species used in handicrafts in Kerala

Sl No.	Scientific name	Vernacular (Malayalam) name
1	*Calamus brandisii* Becc.	*Cheru-chooral*
2	*C. delessertianus* Becc.	*Ottamoodan, Pacha chural*
3	*C. gamblei* Becc.	*Pacha chural, Tannikodi, Narikodi*
4	*C. hookerianus* Becc.	*Velichural, Kallan, Kakkachural, Vanthal, Chentakara*
5	*C. pseudotenuis* Becc. ex. Becc. & Hook. f.	*Chural*
6	*C. rotang* Linn.	*Cheruchural*
7	*C. thwaitesii* Becc. & Hook .f.	*Pannichural, Thadiyanchural, Vandichural, Anachural*
8	*C. travancoricus* Bedd. ex. Becc. & Hook. F.	*Arichooral*
9	*C. vattayila* Renuka	*Vattayila, Ottaman*

In addition to the species available in Kerala, cane is imported from North-eastern India and Andaman and Nicobar islands for furniture. The details of cane species imported from other states in India to Kerala are given in Table 2.

Table 2. Cane species imported to Kerala from North-East, Andaman & Nicobar Islands.

Sl No.	Scientific name	Vernacular names
Canes imported from North-East		
1	*Calamus acanthospathus* Griff.	*Adi - Jati, Tassar, Esong Assamese – Jati*
2	*C. erectus* Roxb.	*Assamese – Jeng*
3	*C. flagellum* Griff.	Assamese – Raidang; Adi – Ramang, Nishi – Thou
4	*C. gracilis* Roxb.	Assamese – Chuli bet; Hill Miri – Reme
5	*C. guruba* Buch.-Ham.ex Mart.	Assamese - Sundibet
6	*C. leptospadix* Griff.	Assamese – Lejai, Adi Jeyying
7	*C. tenuis* Roxb.	Assamese – Jati bet
Canes imported from Andaman & Nicobar Islands		
1	*C. andamanicus* Kurz.	Not available
2	*C. pseudorivalis* Becc.	Not available

SURVEY AND DOCUMENTATION OF BAMBOO SPECIES SUITABLE FOR HANDICRAFTS

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Abstract

A survey was undertaken mainly to document the detailed information on various species of bamboos used in handicrafts by artisans and the industries in Kerala. A proforma with illustrations was developed to collect information on useful bamboo species and shared with SFRI and RFRI. The materials of different bamboo collected were identified in comparison with the voucher specimens from different herbaria like KFRI, MH (BSI, Coimbatore, CAL (Kolkota) and maintained at KFRI herbarium. A handbook entitled "Commercial Bamboos of Kerala" was brought outgiving details of species used in handicrafts. Twenty-two species of bamboos belonging to six genera occur naturally in Kerala and 10 species are in cultivation in homesteads. Only nine species viz., *Bambusa bambos* (L.) Voss**,** *Dendrocalamus strictus* (Roxb.) Nees, *Ochlandra ebracteata* Raizada & Chatterjee, *O. scriptoria* (Dennst.) C. E. C. Fisch**.,** *O. setigera* Gamble. *O. travancorica* var**.** *travancorica* (Bedd.) Benth. ex Gamble *O. wightii* (Munro) C. E. C. Fisch**.** *Pseudoxytenanthera bourdillonii* (Gamble) H. B. Naithani**,** *P. ritcheyii* (Munro) H. B. Naithani**)** are used in handicraft industry. The criteria for the utilization of these species are mainly the availability of the species in proximity to industry units.

Introduction

In India, 128 species of bamboos belonging to 18 genera have been reported (Seethalakshmi and Kumar, 1998). In a recent compilation Kumar and Remesh (2001) have recorded 99 species and three varieties belonging to 15 genera as native to India. Kerala part of the Western Ghats is an abode for 22 species and two varieties of native bamboos belonging to six genera such as, *Bambusa, Dendrocalamus, Pseudoxytenanthera, Schizostachyum*, *Sinarundinaria* and *Ochlandra*. In addition, over 10 species such as, *Bambusa vulgaris, B. vulgaris* var. *wamin, B. multiplex, B. polymorpha, B. balcooa, Dendrocalamus brandisii, D. giganteus, D. longispathus, D. hamiltonii, Thyrsostachys oliveri, T. regia*, etc. are being cultivated in the homegardens and forest plantations. The majority of bamboos in Kerala are found at an elevation of 50-1500 m above sea level. The species belonging to the genera such as *Ochlandra, Bambusa, Dendrocalamus* are seen extensively growing as bamboo brakes and reed brakes. The species like *Bambusa bambos* and *Dendrocalamus strictus* are adapted to the dry plains and hilly tracts. Their distribution is abundant in the moist deciduous forests. *Bambusa bambos* is generally found at an elevation between 50 and 1000 m and distributed throughout Kerala. *Dendrocalamus strictus* is distributed in the forests of Attappady, Nelliampathy, Nilambur and Chinnar at an altitude of 150-750 m above sea level.

A survey was conducted involving handicraft units and artisans of bamboo craft industry to identify the species being used by them for various purposes. For collection of information and easy scientific identification, a proforma was developed to be used by non technical persons.

Objective

Inventory of the species of bamboos used in handicraft industry, identification and preparation of handbooks.

Methodology

A proforma with detailed illustrations on culm habit, clump characteristics, culm, culm sheaths, leaf, inflorescence and fruits was developed for collection of bamboo specimens used in handicrafts (Appendix–4). This proforma was provided to partner institutes in NE. A survey was undertaken in the clusters of artisans to ascertain the bamboo species used for handicraft in Kerala. Details of the materials used by them and samples were collected. The samples were identified scientifically with the expertise available at KFRI.

Results

A document with scientific details such as botanical characters, local names, distribution, properties and products was prepared and published as a handbook on Commercial bamboos of Kerala. The handbook contains general introduction and habit of bamboos in Kerala and species specific information such as synonyms, description, distribution, extraction methods, traditional treatments for bamboo and bamboo products and uses (Appendix– 5). The proforma is included in the handbook for collection of material by non-technical persons for scientific identification and reference with authentic specimens.

Nine species of bamboos belonging to the genera *Bambusa*, *Dendrocalamus, Ochlandra* and *Pseudoxytenanthera* have been found to be in use in different regions. Of these *Bambusa bambos* and *Ochlandra travancorica* are common. The details of species are given in Table 3 along with vernacular names. The list of bamboo societies and craft units is given in Appendix -6

Table 3. List of Bamboo species used for handicraft in Kerala

Sl No.	Scientific name	Vernacular (Malayalam) name
1	*Bambusa bambos* (L.) Voss	*Mula,Pattil, Illy, Paruva*
2	*Dendrocalamus strictus* (Roxb.) Nees	*Kallanmula, Lathimula*
3	*Ochlandra ebracteata* Raizada & Chatterjee	*Velleetta*
4	*Ochlandra scriptoria* (Dennst.) C. E. C. Fisch.	*Amei, Eeta*
5	*Ochlandra setigera* Gamble	*Eera, Odai*
6	*Ochlandra travancorica* var. *travancorica* (Bedd.) Benth. ex Gamble	*Pothoda, eeta*
7	*Ochlandra wightii* (Munro) C. E. C. Fisch.	*Eerakalli*
8	*Pseudoxytenanthera bourdillonii* (Gamble) H. B. Naithani	*Arayambu*
9	*Pseudoxytenanthera ritcheyii* (Munro) H. B. Naitha	*Erankol*

MACRO-PROPAGATION OF SELECTED COMMERCIAL BAMBOOS: ADOPTION OF SUITABLE TECHNIQUES

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Abstract

About 20 species of bamboos are suitable for cultivation in India. Of these, seeds are available on a regular basis only for *Bambusa bambos*, *Dendrocalamus strictus* due to the occurrence of multiple cohorts. Hence, planting stock of the other bamboo species has to be produced through conventional vegetative propagation methods such as rooting of cuttings. A simple method of rooting cuttings with the use of plant growth regulating substances was found suitable for a variety of bamboo species. The suitability of this method was tested for five bamboo species viz., *Dendrocalamus brandisii*, *D. giganteus*, *D. membranaceus*, *Ochlandra beddomei* and *Pseudoxytenanthera bourdillonii* which are preferred by farmers for cultivation in their homesteads and have multiple uses. The results showed that *D. brandisii*, *D. giganteus* and *D. membranaceus* can be propagated successfully using rooting of cuttings. Maximum rooting response was 50%. Further improvement is necessary to commercialise this method for bulk propagation. Major limitations experienced were the bulk of material and non–availability of parent culms in sufficient quantity. The other two species, *O. beddomei* and *P. bourdillonii* did not respond to any of the growth regulator treatments tried. The planting stock of three species produced was maintained in mother beds for further proliferation.

Introduction

Majority of commercial bamboo species used in traditional and modern industries is monocarpic (flowers once in lifetime and die after seed set). The flowering cycle varies from 25 to 120 years. Although seeds are produced in bulk during gregarious flowering, seed viability is short and varies from one to six months based on the particular bamboo species. Non-availability of seeds is the major constraint for large-scale bamboo planting programme. Though many simple macro-propagation methods using mature rhizomes and culm cuttings have been developed for several commercial bamboos (Gopal *et al*., 1972; Surendran and Seethalakshmi, 1985; Adarsh Kumar 1991; Banik, 1994) but they cannot be utilized for large-scale multiplication of planting stock. This activity was taken up to test and adopt simple species-specific macro-propagation techniques for large-scale multiplication of selected commercial bamboos of Kerala. Based on their suitability for cultivation in Kerala and use in handicrafts, five species of bamboos viz., *Dendrocalamus brandisii, D. giganteus, D. membranaceus, Pseudoxytenanthera bourdillonii* and *Ochlandra beddomei* were selected for standardization of propagation protocols. All five species are used for construction, handicrafts and basketry and also shoots are edible.

Objective

To test and adopt suitable macro-propagation techniques like rooting of culm cuttings and rhizome planting for selected bamboo species.

Methodology

Dendrocalamus brandisii

Two to three-year-old culms were collected from KFRI Bambusetum established at Field Research Centre at Veluppadam. The bamboos were divided into base, middle and top parts. Two-noded cuttings were prepared from each of these three parts separately. Five concentrations of NAA and IBA each (100, 200, 300, 400 and 500 ppm) along with a control was used for root induction in cuttings. Three replicates of 10 cuttings each were used per treatment. Observations on percentage of rooting, number of shoots, number of roots and girth of shoots were recorded after six months.

Dendrocalamus giganteus

The culms were collected from Maniyankode Estate, Kalpetta, Wyanad. Based on visual estimation, culms belonging to three age groups (1, 2 and 3) were selected. The total length of the culms was measured and cut to three equal portions, base, middle and top. Two nodded cuttings were prepared from each part separately. Cuttings were treated with two concentrations (100 and

200 mg/l aqueous solution) of two growth-regulating substances (naphthyl acetic acid - NAA and indole butyric acid- IBA) for root induction. Control without growth regulating substances was also maintained. Due to the limitation in availability of parent material number of replicates was limited to 10 cuttings in each category and a total of 45 treatment combinations were used including three variables, age, position and growth regulator.

Dendrocalamus membranaceus

Two- to three-year-old culms were collected from the Field Research Centre, Veluppadam during March. Cuttings from basal two-third portion were used and treated with NAA 200mg/l for root induction. Observations on percentage of rooting were recorded after six months.

Ochlandra beddomei

Culms were collected from KK junction, Thrikkaipetta, Wyanad, Kerala in April 2000. A factorial experiment was done to ascertain the effect of age, position, growth regulating substances and their concentration on rooting success. Three age groups 1, 2 and 3 years; three positions, base, middle, and top; two growth regulating substances, NAA and IBA and three concentrations 100, 250 and 500 mg/l in aqueous solution were used. Monthly observations were recorded on sprouting, growth of sprouts and rooting.

Pseudoxytenanthera bourdillonii

One to three-year-old culms were collected from the populations at Nelliampathy, Nemmara Forest Division. Two nodded cuttings were made from base, middle and top parts of the culm separately. Treatments with two concentrations (100 and 200 mg/l aqueous solution) of two growth-regulating substances (naphthyl acetic acid - NAA and indole butyric acid -IBA) along with control were given for root induction. Due to the limitation in availability of parent material the number of replicates was limited to 10 cuttings in each category and a total of 45 treatment combinations were used including three variables, age, position and growth regulator.

Results

Dendrocalamus giganteus

Percentage of rooting varied from 0 to 50 in different treatments. Treatments, which gave rooting in excess of 40 per cent, can be utilized for large-scale production of planting stock. Top and middle parts of the culm treated with IBA 100 and 200 ppm of two and three-year-old culms gave 40 and 50 per cent rooting respectively.

The rooted cuttings were planted in the beds to produce a rhizome bank for further multiplication. The details on rooting in response to various position and age and treatments are given in table below.

Table 4. Percentages of rooting in culm cuttings of *Dendrocalamus giganteus* in response to growth regulating substances and age of culm

Treatment/Position	Year - 1			Year -2			Year - 3		
	Base	Mid.	Top	Base	Mid.	Top	Base	Mid.	Top
Control	10	30	0	5	25	25	30	35	20
NAA –100 mg/l	0	25	10	0	30	25	0	35	5
NAA – 200 mg/l	5	15	5	0	35	15	5	30	25
IBA –100 mg/l	0	25	10	5	30	40	0	25	35
IBA – 200 mg/l	10	20	15	10	20	20	**0**	**45**	**50**

Similar treatments were given to branch cuttings and nodal bud chips. Although sprouting was observed there was no indication of root development even after six months and within this period the sprouts wilted and cuttings dried up.

Dendrocalamus brandisii

Cuttings used from base and middle parts of the culm performed better than top. Both the growth-regulating substances were equally effective for rooting. The details of rooting response are given in Table 5. Maximum rooting obtained was 50% with NAA 100 ppm in culm cuttings from the middle part.

Table 5. Rooting of *D. brandisii* culm cuttings in response to various treatments

Treatment/Position	Base	Middle	Top
Control	13.33	30	26.67
NAA – 100	33.33	10	6.7
NAA - 200	36.67	26.67	40
NAA -300	36.67	20	13.33
NAA -400	33.33	**50**	16.67
NAA -500	3.33	20	16.67
IBA - 100	30	**46.67**	16.67
IBA -200	33.33	33.33	13.33
IBA - 300	26.67	36.67	6.67
IBA - 400	10	**46.67**	3.33
IBA -500	0	13.33	6.67

Dendrocalamus membranaceus

Cuttings used from the base and middle parts of the culms performed better for rooting. Since the experiments were conducted only during February to May, the rooting response during other part of the year needs further investigation. Maximum rooting obtained was 50% in NAA 400 treatment.

Ochlandra beddomei

Rooting response of *O. beddomei* was very poor. Although sprouting was observed initially no rooting occurred in any of the 63 treatment combinations used. Further work is required for evolving a method for root induction in cuttings.

Pseudoxytenanthera bourdillonii

Although 45 different combinations considering the age, position and growth regulating substances and season was tried for this species none of them gave positive response with regard to rooting. The major difficulty was the availability of sufficient quantity of experimental material for the trial since the species is restricted in occurrence with only 9 populations in Kerala. Of these only two were accessible.

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PACKAGE OF PRACTICES FOR CULTIVATION OF BAMBOOS AND CANES

Pandalai RC [1], Renuka C [2], Seethalakshmi KK [3] and Mohanan C [4]
Divisions of [1] – Silviculture, [2] – Botany, [3] – Plant Physiology, [4] – Plant Pathology

Abstract

Various techniques standardized for cultivation of cane (rattans) and bamboos is scattered in several scientific publications, and hence not easily accessible for non-technical persons who intend to take up organized cultivation. The required information on nursery and silvicultural techniques on cane and bamboo species were compiled and two separate handbooks on Nursery and Silvicultural Techniques for Rattans and Bamboos brought out. In bamboos, although seedling production is the best method for propagation, non-availability of seeds at regular intervals to long flowering period of commercial bamboo species is the main limitation. The vegetative propagation methods like rooting of cuttings and offset planting caters to the planting stock requirement only to a limited extent. Based on the growth habits and utility 21 species belonging to the genera *Bambusa* (9 species) *Dendrocalamus* (7 species), and one species each of *Melocanna*, *Ochlandra*, *Pseudoxytenathera*, *Schyzostachyum* and *Thyrsostachys* were identified for cultivation. The flowering period of rattans vary with locality and species. Rattans are dioecious. Propagation by seed was the best, although limited success is obtained with suckers treated with growth regulating substances. Duration for germination of seeds varied with species and maturity of seeds. Initial growth of seedlings was very slow and one-year nursery care prior to out planting in the field was found to be mandatory for field establishment.

Introduction

Large-scale cultivation of cane and bamboo in forest and non-forest areas covering entire country is planned to meet the increasing demand for raw material from the envisaged industrial development. Package of practices suitable for non-technical users is necessary for this. Hence, this activity was targeted towards collection of information on nursery and silviculture techniques of bamboo and cane and preparation of handbooks useful to all stakeholders to take up bamboo and cane cultivation.

Objective

To prepare package of practices for nursery and silvicultural techniques for bamboo and cane species used in handicrafts.

Methodology

The information available on nursery and plantation practices of bamboo and cane species were collected from the scientific publications brought out by KFRI, other institutions and Forest Departments. Different cane and bamboo areas were visited to gather species-specific information. Some of the important know-how that was lacking in publications was augmented from the field experiences of respective investigators through present discussion.

Results

Two handbooks viz., Nursery and Silvicultural Techniques of Bamboos (Appendix-7) and Nursery and Silvicultural Techniques of Rattans (Appendix–8) were prepared. In bamboo handbook, an introduction on morphology and growth of bamboo, nature of flowering and death, propagation through seeds and vegetative methods, nursery and plantation establishment and management has been include in detail with information on 21 bamboo species (*Bambusa affinis*, *B. balcooa, B. bambos, B. nutans, B. pallida, B. polymorpha, B. pallida*, *B. tulda*, *B. wamin*, *B. vulgaris*, *Dendrocalamus asper*, *D. brandisii*, *D. giganteus*, *D. hamiltonii*, D. *longispathus, D. membranaceus*, *D. strictus*, *Melocanna baccifera*, *Ochlandra travancorica*, *Pseudoxytenanthera stocksii*, *Schizostachyum pergracile* and *Thyrsostachys oliveri* that are economically important and suitable for cultivation.

The handbook on rattans contains a general introduction on rattans, information on flowering and fruiting period of various species, propagation techniques, nursery details, method of establishing plantations along with calendar of operations.

ESTABLISHMENT OF GERMPLASM BANKS OF BAMBOO AND CANE

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Divisions of [1]. Silviculture and [2]. Botany

Abstract

The number of species in KFRI Bambusetum at Field Research Centre, Veluppadam, Thrissur, was increased from 25 species of sympodial bamboos to 59 species with additions of bamboo species from different parts of the country, especially from north–eastern states of India. In addition, for monopodial and amphipodial bamboo species another Bambusetum was established at high elevation site at Devikulam, Munnar with five species viz., *Chimnobambusa callossa*, *Phyllostachys assamica*, *Phyllostachys pubescence*, and *Phyllostachys reticulata*. Long duration regular observations at least to harvesting stage are necessary to evaluate the potential of introducing them to sites of high elevations in Kerala. Of the 74 species collected, in total, 64 bamboo species established. The KFRI Bambusetum is one of the largest in India.

A new site of 1.5 ha was identified in the KFRI Sub centre campus at Nilambur for germplasm of cane and nine species (*Calamus brandisii, C. delessertianus*, *C. gamblei* , *C. hookerianus*, *C. pseudotenuis*, *C. rotang, C. thwaitesii*, *C. travancoricus* and *C. vattayila*) used for handicraft industries were planted. Observations are being continued.

Observations on growth of bamboos at Velupadam reveal that species from Assam like *Bambusa balcooa, B. nutans, Dendrocalamus asper, D. sikkimensis, Drepanostachyum khassiana* and species from Arunachal Pradesh like *Bambusa affinis, B. pallida*, and *Gigantochloa macrostachya* have established well indicating that these species can be successfully introduced in Kerala.

Introduction

India is rich in species diversity of bamboo and cane. Bamboo diversity consists of 18 genera and 134 species. The distribution of bamboo in different forest types and agro climatic regions indicate the tremendous potential of bamboos to grow in a wide variety of soil and climatic conditions. The live collection of bamboo in the form of germplasm banks will enable the local artisans, bamboo growers and farmers to get first-hand information about the morphological features, aesthetic properties and growth characteristics of these plants. The germplasm banks will also serve as *ex situ* conservation plots for the preservation of the invaluable resource base for propagation, multiplication and cultivation needs of farmers, bamboo growers and artisans. KFRI has already established a Bambusetum for sympodial bamboos at Field Research Centre, Velupadam, Chalakudy Forest Division of the Central Forest Circle, Thrissur. This activity was undertaken to strengthen the bamboo germplasm at KFRI by adding more species and to establish a new germplasm for species of sympodial bamboo and those of cane used in handicrafts.

Cane is distributed in three major regions, Western Ghats, North Eastern States and Andaman & Nicobar Islands. Of these, 25 species occur in Western Ghats, 19 species in North Eastern States and 18 species in Andaman & Nicobar Islands. Each region has its own cane flora and the species are not overlapping. Due to habitat destruction and over exploitations many of the species have become endangered and some of the species are even under the threat of genetic erosion. A live collection of different species is essential for conservation and propagation.

Objective

Establishment of germplasm of cane and bamboo species used for handicrafts in Kerala.

Methodology

Exploratory trips were undertaken to different forest areas of Kerala, Karnataka, Orissa and North Eastern states of India. Bamboo rhizome, offsets, culm cuttings and seeds were collected for planting in the Bambusetum.

All the species collected were identified in consultation with the voucher specimens in the KFRI Herbarium and other published literature (Gamble, 1978; Munro, 1983; Tewari, 1992; Seethalakshmi and Muktesh Kumar, 1998; Muktesh Kumar, 2002). Details of different bamboo species introduced in the Bambusetum during the project along with the location are given in Table 6. below.

Table 6. Details of bamboo species collected during 2000-2003

Sl. No.	Bamboo species	Locality and state of collection	Type of propagules collected
1	*Bambusa affinis*	Chessa, Arunachal Pradesh	Offsets
2	*Bambusa albociliata*	Wayanad, Kerala	Offsets
3	*Bambusa albostriata*	*Wayanad, Kerala*	Offsets
4	*Bambusa balcooa*	Guwahati, Assam	Offsets
		Jorhat, Assam	Offsets
		Bhuvaneswar, Orissa	Offsets
5	*Bambusa bambos*	Attappadi, Kerala	Offsets
6	*Bambusa bambos* var. *gigantea*	Attappadi, Kerala	Offsets
7	*Bambusa blumeana*	Wayanad, Kerala	Offsets
8	*Bambusa disimilator*	Wayanad, Kerala	Offsets
9	*Bambusa glaucescence*	Chessa, Arunachal Pradesh	Offsets
10	*Bambusa longispiculata*	Chessa, Arunachal Pradesh	Offsets
11	*Bambusa membranaceus*	Thailand	Seeds
12	*Bambusa multipex " albo striata"*	Jorhat, Assam	Seedling
13	*Bambusa multiplex*	Nilambur, Kerala	Offsets
		Bhuvaneswar, Orissa	Offsets
14	*Bambusa multiplex (yellow)*	Wayanad, Kerala	Offsets
15	*Bambusa multiplex "albo varigata"*	*Bhuvaneswar, Orissa*	Offsets
16	*Bambusa multiplex* var *varigata*	Thrissur, Kerala	Offsets
17	*Bambusa nutans*	Guwahai, Assam	Offsets
18	*Bambusa oldhami*	Wayanad, Kerala	Offsets
19	*Bambusa pallida* (two varieties)	Chessa, Arunachal Pradesh	Offsets
20	*Bambusa polymorpha*	Kozhikod, Kerala	Offsets
		Chessa, Arunachal Pradesh	Offsets
21	*Bambusa striata*	Mannar, Kerala	Offsets
22	*Bambusa textilis*	Wayanad, Kerala	Offsets
23	*Bambusa tulda*	Nilambur, Kerala	Offsets
24	*Bambusa vulgaris*		
25	*Bambusa wamin*	Kozhikode, Kerala	Offsets
26	*Cephalostachym pergracile*	Kozhikode, Kerala	Offsets
		Chessa, Arunachal Pradesh	
27	*Cephalostachym* species	Bhuvaneswar, Orissa	Offsets
		Chessa, Arunachal Pradesh	
28	*Cephalostachyum fusianum*	Chessa, Arunachal Pradesh	Offsets
29	*Chimnobambusa callosa*	Arunachal Pradesh	Rhizome
30	*Chimnobambusa griffithiana*	Assam Agriculture University, Assam	Offsets
31	*Davidsea attenuata*	Kottiyoor, Kerala	Offsets
32	*Dendrocalamus asper*	Guwahati, Assam	Offsets
33	*Dendrocalamus brandisii*	Thailand	Seeds
34	*Dendrocalamus giganteus*	Changanasseri, Kerala	Offsets
35	*Dendrocalamus hamiltonii*	West Bengal	Offsets
36	*Dendrocalamus longispathus*	Nilambur, Kerala	Offsets
37	*Dendrocalamus sikkimensis*	Guwahati, Assam	Offsets
38	*Dendrocalamus species*	Chessa, Arunachal Pradesh	Offsets
		Vyppin, Ernakulam, Kerala	Offsets
39	*Dendrocalamus strictus*	Attappadi , Kerala	Offsets
40	*Dinochloa maclellandii*	Bhuvaneswar, Orissa	Offsets
41	*Drepanostachyum khassiana*	Jorhat, Assam	Offsets
42	*Gauda angustifolia*	Bangalore, Karnataka	Propagule
43	*Giantochloa atter*	Bhuvaneswar, Orissa	Offsets
44	*Gigantochloa atroviolacea*	Wayanad, Kerala	Offsets
45	*Gigantochloa species* (Four collections)	Wayanad, Kerala	Offsets
		Wayanad, Kerala	Offsets

		Wayanad, Kerala	Offsets
46	*Gigantochloa macrostachya*	Chessa, Arunachal Pradesh	Offsets
47	*Gigantochloa mangong*	Thiruvananthapuram, Kerala	Offsets
48	*Melocanna baccifera*	Chessa, Arunachal Pradesh	Offsets
49	*Ochlandra eabracteata*	Thiruvananthapuram, Kerala	Offsets
50	*Ochlandra scriptoria*	Vazhachal, Kerala	Offsets
51	*Ochlandra talboltii*	Veerajpet, Karnataka	Offsets
52	*Ochlandra travancorica*	Thiruvananthapuram, Kerala	Offsets
53	*Ochlandra wightii*	Agasthyamala, Kerala	Offsets
54	*Oxytenanathera abissinica*	Chessa, Arunachal Pradesh	Offsets
55	*Oxytenanthera albociliata*	Chessa, Arunachal Pradesh	Offsets
56	*Oxytenanthera species* (Five collections)	Bhuvaneswar, Orissa (3 collections)	Offsets
		Chessa, Arunachal Pradesh (2 Collections)	Offsets
57	*Peudosasa japonica* (3 collections)	Chessa, Arunachal Pradesh (1) Wayanad, Kerala (2)	Offsets
58	*Phyllostachys assamica*	Hong Village, Arunachal Pradesh	Rhizome
59	*Phyllostachys bambusoides*	Near, Ziro, Arunachal Pradesh	Rhizome
60	*Phyllostachys pubescence*	Yactually, Arunachal Pradesh	Rhizome
61	*Phyllostachys reticulata*	Ittanagar, Arunachal Pradesh	Rhizome
62	*Phyllostachys sp.* (Four Collections)	Jorhat, Assam (3 collections) Shillong, Meghalaya (2 Collections)	Rhizome
63	*Phyllostchys sulphurea*	Wayanad, Kerala	Offsets
64	*Psedoxytenanthera bourdilonii*	Nelliyampathy, Kerala	Offsets
65	*Pseudoxytenanthera ritcheyi (2 Collections)*	Vyppin, Kerala Nilambur, Kerala	Offsets
66	*Pseudoxytenanthera stocksii*	Thiruvananthapuram, Kerala	Offsets
67	*Pseudoxytenanthera species* (3 collections)	Vyppin, Kerala	Offsets
68	*Sasa fortunii*	Bangalore, Karnataka	Rhizome
69	*Sasa* species (4 collections)	Japan Nilambur, Kerala (2 collections) Chessa, Arunachal Pradesh	Rhizome
70	*Schizostachyum pergracile*	Chessa, Arunachal Pradesh	Offsets
71	*Thyrsostachys oliveri*	West Bengal	Offsets
72	*Thyrsostachys siamensis*	Thailand	Seeds
73	*Tienostachyum dullooa*	Chessa, Arunachal Pradesh	Offsets
74	*Tienostachyum species* (3 collections)	Jorhat, Assam	Offsets

Planting stock of various bamboo species mentioned in Table 6 were produced for planting in the Bambusetum using seed, offset and culm cuttings. Details of propagation methods are given in the handbook "Nursery and Silvicultural techniques for bamboos" (Appendix-7).

Sympodial bamboos were planted in the existing Bambusetum at Veluppadam (5 m asl; 10^{o}. 21'-10^{o} 28' N and 76^{0}.7'–76^{o}. 37'E). An area of 12 ha was demarcated, cleared, weeded and fenced for field planting of bamboos in the Bambusetum. The terrain is undulating with mild slope and elevation 5 m asl. Rainfall varies from 2400 mm to 2900 mm, distributed over June-September and November–December as South West and North East Monsoons. Temperature ranges from 26^{o} C to 38^{o} C. The area has dry gravelly and lateritic type of soil.

For monopodial bamboos at area of 3-4 ha was selected at Devikulam, a high elevation site (1575 m asl; 9^{o}. 52'–10^{o}. 13'N and 76^{o}.58'–77^{0}. 16'E) near Munnar, which comes under the high range circle of Kerala Forest Department. The terrain is undulating with moderate slope. The area receives rainfall in the range of 1622 mm to 2222 mm distributed over June to September and November to December as South West and North East Monsoons. The mean temperature varies from 12.23^{o} C to 22.38^{o} C.

The propagules of sympodial bamboos were planted during the onset of South-West Monsoon in pits of 45 cm x 45 cm x 45 cm spaced at a distance of 10m x 10m in Veluppadam. Propagules of monopodial bamboos were retained in the nursery at Devikulam for planting during June-July 2003. Three and two knife weeding were carried out during first and second years respectively in the Bambusetum at Veluppadam. NPK fertilizer (17:17:17) was applied @ 300 g/clump for the older clumps and half the dose for younger clumps.

Observations on growth parameters like number of culms per clump, maximum and minimum culm length, maximum and minimum culm girth (at the 6th internode) and internodal lengths of all clumps including those planted during the study period were recorded at regular intervals.

Twenty-five species belonging to genera like (*Bambusa*, *Cephalostachyum*, *Dendrocalamus*, *Psedoxytenanthera*, *Thyrsostachys* and *Ochlandra*) were planted in the Bambusetum during 1992. Of these, 20 species suitable for handicraft industries were selected for multiplication and distribution to farmers. These species were also subjected to detailed studies on growth characteristics like productivity (number of culms per clump) maximum culm length, maximum culm girth (at the 6th inter node), and maximum inter nodal length during the study period.

An area of 1.5 ha was selected at the KFRI Sub centre campus, Nilambur and nine species of *Calamus viz., C. brandisii, C. delessertianus, C. gamblei, C. hookerianus, C. pseudotenuis, C. rotang, C. thwaitesii, C. travancoricus, C. vattayila* were planted. Seeds of these rattan species were collected from forest areas population wise and seedlings raised. Seedlings were hardened for one year in the nursery under partial shade and outplanted in rows during the onset of monsoon. For each species 20 seedlings were planted and casualty replacement was carried out during second year. The details of seed collection, handling and nursery practice and plantation techniques were followed as per the information provided in the handbook on Silvicultural and nursery techniques for rattans (Appendix-8).

Results

The existing Bambusetum at FRC, Veluppadam was strengthened by adding species from different geographical areas of India and currently it consists of 291 clumps belonging to 59 species. For establishing another Bambusetum for monopodial bamboos an area was selected at Devikulam, Munnar where propagules of eight species of bamboos were maintained for planting.

The Bambusetum at Veluppadam and Munnar together is represented by 18 genera and 64 species. The details of genera and number of species are given below.

Table 7. Genera and species of bamboos in KFRI Bambusetum at Veluppadam and Munnar

Sl No.	Genera	No. of species	Sl. No.	Genera	No. of species
1	*Bambusa*	21	10	*Melocanna*	1
2	*Cephalostachyum*	2	11	*Ochlandra*	5
3	*Chimnobambusa*	2	12	*Oxytenanthera*	3
4	*Davidsea*	1	13	*Pseudosasa*	1
5	*Dendrocalamus*	9	14	*Phyllostachys*	4
6	*Dinochloa*	1	15	*Pseudoxytenanthera*	3
7	*Drepanostachyum*	1	16	*Schizostachyum*	1
8	*Gauda*	1	17	*Thyrsostachys*	2
9	*Gigantochloa*	4	18	*Teinostachyum*	2

The details of species, area of collection, year of planting and the number of existing clumps in each species planted in the two Bambusetum are given in Table 8.

Table 8. Bamboo species in the KFRI Bambusetum of at Veluppadam

Sl. No	Name of the species (synonyms in parenthesis)	Locality and state of collection	Type of propagules & year of planting	Number of existing clumps
1	*Bambusa affinis* Munro	Chessa, Arunachal Pradesh	Offsets – 2002	1
2	*Bambusa albostriata (*McClure) Ohrnb.	Wayanad, Kerala	Offsets – 2001	1
3	*Bambusa balcooa* Roxb.	Guwahati, Assam	Offsets 1993	9
		Jorhat, Assam	Offsets 2001*	0
		Bhuvaneswar, Orissa	Offsets 2002 *	0
4	*Bambusa bambos* (L.) Voss (*B. arundinacea* Retz.)	Attappadi, Kerala	Offsets 1992 @	7
5	*Bambusa bambos var. textilis* Bennet and Gaur (*B. arundinacea* var. *textilis (*Bahadur and Jain)	Attappadi, Kerala	Offsets 1992 @	8
6	*Bambusa textiles tor* McClure	Wayanad, Kerala	Offsets 2001	1
7	*Bambusa longispiculata* Gamble ex Brandis	Chessa, Arunachal Pradesh	Offsets 2002	3
8	*Bambusa membranaceus* (*Dendrocalamus membranaceus* Munro)	Thailand	Seedlings 1992 @	4
9	*Bambusa multiplex* f. *albostriata* Munro and Sujimoto	Jorhat, Assam	Seedling 2002	1
	Bambusa multipex f. *albostriata* Munro and Sujimoto	Wayanad, Kerala	Offsets 2002 *	0
10	*Bambusa multiplex* (Loureiro) Racuschel Ex Schultes & J. H. Schultes	Nilambur, Kerala	Offsets 1992 @	8
		Wayanad, Kerala	Offsets 2002 *	0
		Chessa, Arunachal Pradesh	Offsets 2002	3
11	*Bambusa multiplex* yellow stripe Chia and C.Y.Sia	Wayanad, Kerala	Offsets 2001	1
12	*Bambusa multiplex "albovarigata"*	Bhuvaneswar, Orissa	Offsets 2002	1
13	*Bambusa multiplex* var *varigata*	Thrissur, Kerala	Tillers 2001	20
14	*Bambusa nutans* (Lour.) Raeusch ex Schult. And Schult. F.	Guwahai, Assam	Offsets 1992 @	4
15	*Bambusa pallida* Munro	Chessa, Arunachal Pradesh	Offsets 2002	9
16	*Bambusa polymorpha* Munro	Kozhikod, Kerala	Offsets 1992 @	6
		Chessa, Arunachal Pradesh	Offsets 2002 *	0
17	*Bambusa ∥ extiles* McClure	Wayanad, Kerala	Offsets 2001	2
18	*Bambusa tulda* Roxb.	Nilambur, Kerala	Offsets 2001	3
		Wayanad, Kerala	Offsets 2001 *	0
19	*Bambusa vulgaris* var. vulgaris *(Bambusa vulgaris* Schrad. Ex Wendl)	Thailand	Seedlings 1993 @	21
20	*Bambusa vulgaris* var. *striata* (Lodd. Ex Lindl.) Gamble	Mannar, Kerala	Offsets 1992 @	8
21	*Bambusa vulgaris var.wamin* McClure (syn; *B. wamin* Camus)	Kozhikod, Kerala	Offsets 1993 @	3
22	*Cephalostachyum fuchsianum* Gamble	Chessa, Arunachal Pradesh	Offsets 2002	2
23	*Cephalostachyum species*	Chessa, Arunachal Pradesh	Offsets 2002	1
24	*Chimnobambusa callosa* (Munro) Nakai	Arunachal Pradesh	Rhizome 2002	1

25	*Chimnobambusa griffithiana (B. griffithiana* (Munro) Nakai	Assam Agriculture University Assam	Offsets 2002	1
26	*Davidsea attenuata* (Thwaites) Soderstrom & Ellis	Kottiyoor, Kerala	Offsets 2001	1
27	*Dendrocalamus asper* (J.H. Schultes) Backer Ex K. Heyne	Guwahati, Assam	Offsets 1992 @	2
28	*Dendrocalamus brandisii* (Munro) Kurz.	Thailand	Seedlings 1993 @	9
29	*Dendrocalamus giganteus* Munro	Changanasseri, Kerala	Offsets 1993 @	9
30	*Dendrocalamus hamiltonii* Nees and Arn. Ex Munro	West Bengal	Offsets 1992 @	4
31	*Dendrocalamus longispathus* Kurz	Nilambur, Kerala	Offsets 1992 @	9
32	*Dendrocalamus oldhami (syno; Bambusa oldhami* Munro)	Wayanad, Kerala	Offsets 2001	3
33	*Dendrocalamus sikkimensis* Gamble	Guwahati, Assam	Offsets 1992 @	6
34	*Dendrocalamus species*	Chessa, Arunachal Pradesh	Offsets 2002	1
		Vyppin, Eranakulam, Kerala	Offsets 2001 *	0
35	*Dendrocalamus strictus* (Roxb.) Nees	Attappadi , Kerala	Offsets 1993 @	13
36	*Dinochloa maclellandii* (Munro) Kurz	Bhuvaneswar, Orissa	Offsets 2002	1
37	*Drepanostachyum khassianum* (Munro) Keng f.	Jorhat, Assam	Offsets 2002	1
38	*Gauda angustifolia*	Bangalore, Karnataka	Offset 2002	1
39	*Giantochloa atter* (Hassk.) Kurz	Bhuvaneswar, Orissa	Offsets 2001	1
40	*Gigantochloa atroviolacea* Widjaja	Wayanad Kerala	Offsets 2001	1
41	*Gigantochloa macrostachya* Kurz	Chessa, Arunachal Pradesh	Offsets 2002	2
42	*Gigantochloa mangong* Widjaja	Thiruvananthapuram, Kerala	Offsets	8
43	*Ochlandra ebracteata*Raizada and Chatterji	Thiruvananthapuram Kerala	Offsets 1993 @	11
44	*Ochlandra scriptoria* (Dennst.) Fisch.	Vazhachal, Kerala	Offsets 1993 @	9
45	*Ochlandra talbotii* Brandis	Veerajpet, Kerala	Offsets 2001	3
46	*Ochlandra travancorica* Benth.	Thiruvananthapuram, Kerala	Offsets 1993 @	6
47	*Ochlandra wightii* (Munro) Fisch.	Agasthyamala, Kerala	Offsets 2001	2
48	*Oxytenanathera abyssinica* (A. Rich.) Munro	Chessa, Arunachal Pradesh	Offsets 2002	2
49	*Oxytenanthera albociliata* Munro	Chessa, Arunachal Pradesh	Offsets 2002	3
50	*Oxytenanthera species*	Bhuvaneswar, Orissa	Offsets 2001	1
		Chessa, Arunachal Pradesh	Offsets 2002 *	0
51	*Peudosasa japonica* (Sieb. And Zucc. Ex Steud.) Makino ex Nakai	Chessa, Arunachal Pradesh	Offsets 2002	1
	P. japonica (Sieb. And Zucc. Ex Steud.) Makino ex Nakai	Wayanad, Kearala	Offsets 2001	4
52	*Psedoxytenanthera bourdillonii* (Gamble) Naithani	Nelliyampathy, Kerala	Offsets 2002	1
53	*Pseudoxytenanthera ritcheyi* (Munro) Naithani	Vyppin, Kerala	Offsets 2001 *	0
		Nilambur, Kerala	Offsets 1993 @	7
54	*Pseudoxytenanthera stocksii* (Munro) Naithani	Thiruvananthapuram, Kerala	Offsets 1993 @	8
X	*Pseudoxytenanthera species*	Vyppin, Kerala	Offsets 2001 *	0
X	*Sasa fortunei* (Van Houtte)	Bangalore, Karnataka	Rhizome 2001*	0

	Nakai			
X	*Sasa* species*	Japan	Rhizome 2001	0
55	*Schizostachyum pergracile* Munro	Kozhikod Kerala	Offsets 1993 @	3
		Bhubaneswar, Orissa	Offsets 2002*	0
		Chessa, Arunachal Pradesh	Offsets 2002*	0
56	*Thyrsostachys oliveri* Gamble	West Bengal	Offsets 1992 @	16
57	*Thyrsostachys siamensis* Gamble	Thailand	Seedlings 1993 @	9
58	*Tienostachyum dulloa* Gamble	Chessa, Arunachal Pradesh	Offsets 2002	2
59	*Tienostachyum species*	Jorhat, Assam	Offsets 2002	1
Total				291
Bamboo species in the KFRI Bambusetum (Devikolam, Munnar)				
1	*Melocanna baccifera* (Roxb.) Kurz	Chessa, Arunachal Pradesh	Rhizome 2002	5
2	*Phyllostachys assamica* Gamble ex Brandis	Hong village Appathani, Arunachal Pradesh	Rhizome2002	4
3	*Phyllostachys bambusoides* Sieb. and Zucc.	Arunachal pradesh	Rhizome 2002	2
4	*Phyllostachys edulis* (Carriere) Houzeau De Lehaie	Yactually, Arunachal Padesh	Rhizome 2002	3
X	*Phyllostachys recticulata sensu* Koch.	SFRI, Ittanagar	Rhizome 2002 *	0
X	*Phyllostachys species*	Shillong Meghalaya	Rhizome 2002 *	0
X	*Phyllostachys species*	Shillong Meghalaya	Rhizome 2002 *	0
5	*Phyllostchys sulphurea* Robert Young McClure	Wayanad, Kerala	Rhizome 2002	1
			Total	15

*species collected and planted in the Bambusetum but not survived
@ species that existed in the Bambusetum prior to this project.

Growth of different bamboo species at Veluppadam

Species planted during project period

Additional propagules of seven genera of bamboo planted during 2000 established well. Of the 15 species belonging to 5 genera established, maximum number of culms were produced in clumps of *Bambusa textilis* (18 culms) followed by *B. albostriata* (10 culms). Both *B. oldhami* and *B. albociliata* produced 7 culms per clump in a short span of two years. Culms with maximum height (5 m) were produced in *Bambusa dissimilator* followed by *B. textilis* (4.6 cm). Maximum girth of 8cms (at the 6th internode) were observed in *Bambusa oldhamii* followed by *B. dissimilator* (7.8 cm). Maximum inter nodal lengths were seen in *B. textilis* (42 cm) and *B. blumeana* (32.2 cm). Establishment of other species viz., *Davidsea attenuata*, *Dinochloa machlandii*, *Gauda angustifolia* and *Pseudoxytenanthera bourdilonii* was also promising. *Gigantochloa mangong* - a species from North-Eastern India established well and produced about 9 culms per clump, followed by *G. atroviolacea* (4 culms). *Ochlandra talbotii* with very long internodal lengths (37.5 cm) grew and established in the Bambusetum. The details on growth of various species

newly established in the Bambusetum are given below. A proforma for collection of information from bambusetum is given in Appendix – 9.

Table 9. Field performance of bamboo species for initial two years

Sl. No.	Name of the Species	No.of shoots	Height (m)		Girth (cm)		Inter nodal length (cm)	
			Max.	Min.	Max	Min	Max	Min
1	*Bambusa albociliata*	7	4.35	3.10	7.2	4.5	17	15
2	*B. albostriata*	10	3.30	2.15	4.6	2.6	19.5	16.8
3	*B. blumeana*	4	4.00	2.55	4.5	2	32.2	16
4	*B. dissimilator*	4	5.00	1.90	7.8	4.2	26.5	22
5	*B. textilis*	18	4.60	2.85	6.4	2.8	42	25.8
6	*B. oldhami*	7	4.25	2.90	8	4	22	20
7	*Davidsea attenuata*	4	0.70	0.50	1.5	1	15.5	12
8	*Dinochloa machlandii*	4	0.65	0.38	1.5	1	11.3	11
9	*Gauda angustifolia*	4	1. 28	0. 5	1.7	1	12	6. 2
10	*Gigantochloa atroviolacea*	4	5.00	1.60	9.5	1	26	16
11	*G. attar*	1	1.58	-	1.5	-	13	-
12	*G. mangong*	9	3.85	2.60	8.4	3.7	36	33
13	*Ochlandra talboti*	17	3.25	2.18	3.5	2.3	37.5	25
14	*O. wightii*	12	1.00	0.70	2	1	26.5	24
15	*Psedoxytenanthera bourdilonii*	4	1.83	1.30	1.3	1	20	15

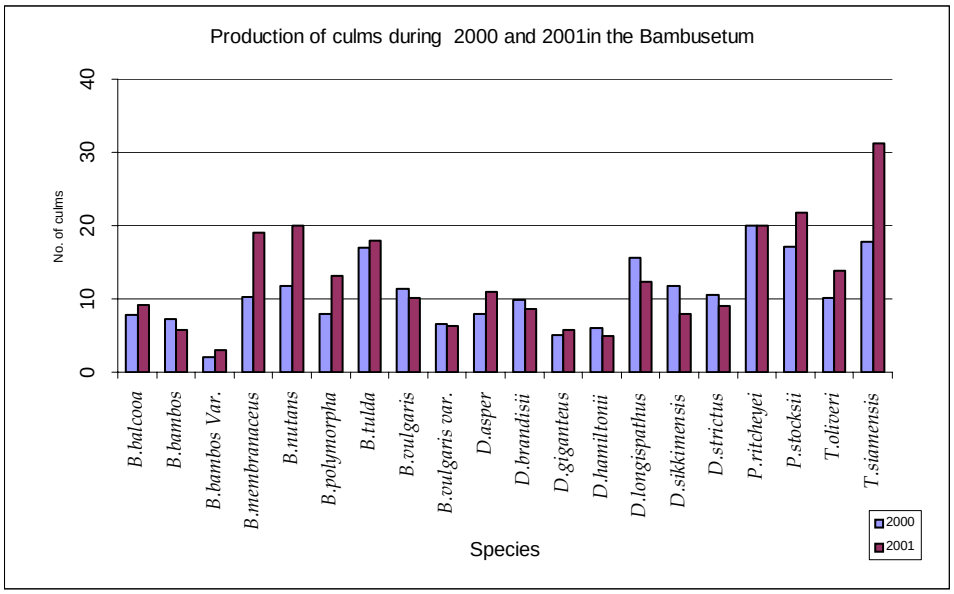
Performance of existing species in Bambusetum

Culm production varied in different species in different years and a general trend was the production of more number of culms/clump as the clumps mature. This was evident in species like *Thrysostachys siamensis* (18 culms/clump in 2000 and 32 culms/clump in 2001) followed by *Pseudoxytenanthera stocksii* (18/2000 and 22/2001) and *Pseudoxytenanthera ritchei* (20/2000 and 20/2001). Similar trend was observed in *Bambusa membranaceus*, *Bambusa nutans*, *Bambusa polymorpha* and *Thyrsostachys oliveri*. Of these, *P. ritchii* and *P. stocksii* are naturally occurring in Kerala and others are introduced. From the observations taken for two years from the Bambusetum it is evident that all the species mentioned above can be introduced in Kerala

Growth performance of bamboos vary from species to species (Banik, 1988) Usually, bamboo culms complete their physical growth in about 2 to 3 months soon after the emergence of the young sprouts from the ground, and thereafter, there is no apparent increment in their diameter and height growth (McClure, 1967; Banik, 1980; Ueda, 1981). Growth of some of the bamboo species such as *Bambusa balcooa, B. blumeana, B. logispiculata B. vulgaris,* and *B. tulda,* increased up to 4 to 7 years and then gradually declined (Kondas, 1981; Banik, 1988, Gonzales,1999). Such a trend is expected in *Bambusa bambos*, *B.*

hamiltonii, D. longispathus, D. sikkimensis and *D. strictus* from the observations made for two years during the present study. The details of culms produced by 20 species in the Bambusetum are given in Fig 1.

Fig 1. Details of number of culms produced by 20 existing species in the Bambusetum



The height and girth of culms produced during 8th and 9th year showed only negligible difference (Fig 2 and 3). However in species like *Dendrocalamus giganteus*, *Dendrocalamus brandisii*, *Dendrocalamus strictus*, *Dendrocalamus hamiltonii*, *Dendrocalamus asper*, *Bambusa vulgaris*, *Bambusa striata*, *Bambusa membranaceus*, *Bambusa nutans*, *Bambusa bambos*, *Bambusa balcooa* production of taller culms with total height in the range of 15-24 meters, was observed during the 8th and 9th year of field growth.

Fig. 2 Height of new culms produced during 2000-2001 in the Bambusetum

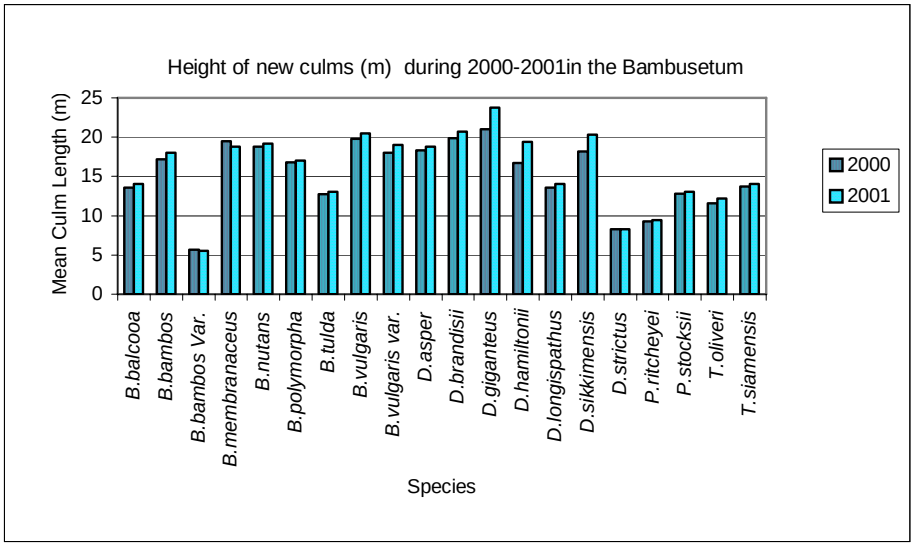
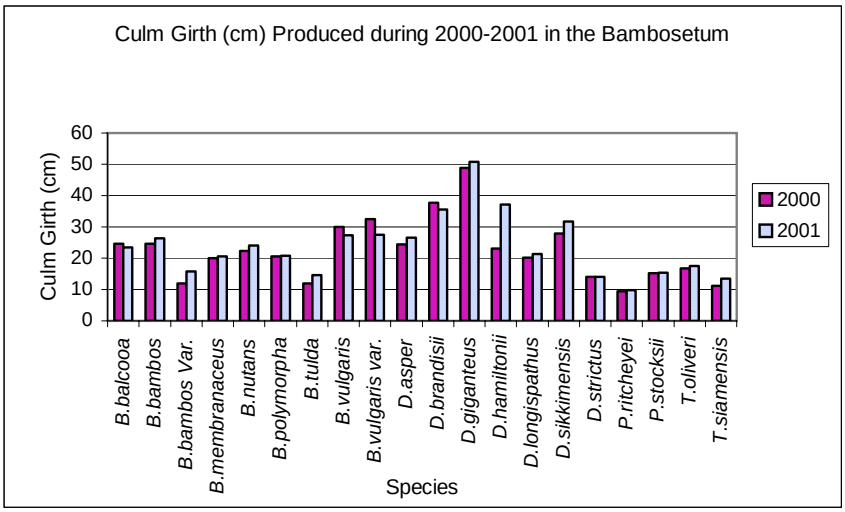
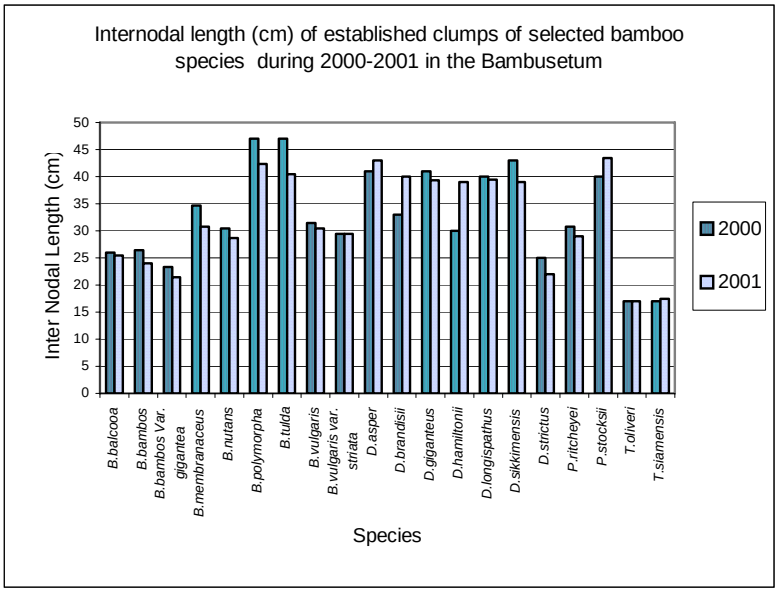


Fig. 3. Girth of the new culms produced in 2000-2001 in the species existing in Bambusetum



Species like *Bambusa polymorpha, Bambusa tulda, Dendrocalamus asper, Dendrocalamus brandisii, Dendrocalamus giganteus, Dendrocalamus hamiltonii, Dendrocalamus longispathus, Dendrocalamus strictus*, and *Pseudoxytenanthera stocksii* were observed to be producing culms with maximum internodal lengths ranging from 35 to 48 cm in the Bambusetum (Fig 4).

Fig. 4. Internodal length of the culms in the Bambusetum during 200-2001



Germplasm of Cane

The seedlings are in rosette stage and observations are being continued.

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TISSUE CULTURE AND MULTIPLICATION NURSERIES

The application of plant tissue culture techniques for mass clonal propagation viz. micropropagation, has in the recent times been widely used for a number of forestry species, some of them successfully on a commercial scale. The technology is available at the laboratory scale for a large number of species, which need to be tested on a bigger scale for field application.

Tissue culture methods for propagation of canes have been developed at KFRI over the past five years using seeds and shoot tips of 1 to 3-year-old seedling. Since conventional vegetative propagation in cane is not practical, tissue culture can be used in situations where seeds are not available or to take advantage of the following benefits such as high multiplication rates (useful when seeds are in short supply), potential for production of propagules with multiple stems for higher production of mature stems at harvest, potential for inducing clustering in single stemmed species for improved yield.

Techniques for micropropagation of bamboo are fairly well standardized for a large number of species although methods using mature culm material have generally produced poor results particularly at the rooting stage. While the cost of production is higher when compared to macropropagation, the advantages offered by micropropagation are very high multiplication rates (starting material not a great limitation), plant production throughout the year, smaller plantlet size, comparable to seedlings (easy to transport without mortality), possibility of inducing rhizome formation in culture (improves survival rates), a propensity for early and more prolific culm formation, which results in early culm formation and improved yield and improved multiplication rates during macroproliferation.

Since micropropagation techniques for production of plating stock from mature ex plants are not perfected to commercial scale, currently the preferred species for which seeds are not available can only be multiplied using conventional vegetative propagations methods such as rooting culm cuttings. The simple technology of rooting culm cutting using growth regulating substances developed by KFRI can be easily transferred through training to interest groups and planting stock production can be taken as a joint venture. When seeds are available seedling populations can be raised.

During this programme the scaling-up of the technology to mass-produce planting material for selected commercial species of cane and bamboo and establishment of joint venture nurseries in collaboration with farmers/NGOs for production of planting stock were undertaken. Also, research was carried out to develop protocols for micropropagation using mature buds as explants.

MICROPROPAGATION OF BAMBOO AND CANE

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Abstract

Micropropagation of selected species of bamboo and canes of importance to the handicraft industry was attempted. Four species of bamboo and nine species of cane (rattan) were selected for micropropagation. Nodes taken from both seedlings as well as mature clumps were used for culture in bamboo whereas immature and mature embryos and shoot tips from 1 to 3-year-old seedlings were used as explants in rattan.

Shoot cultures were established from nodes of one-year-old seedlings of *Bambusa bambos* var *giganteus* on a liquid medium consisting of the Murashige and Skoog's basal medium (MS) supplemented with 3 μM of BAP, 2 μM of Kinetin and 0.5 μM of NAA and 2% sucrose. Stationary liquid medium was found to be sufficient for multiplication of shoots. Rooting was induced *in vitro* on an MS medium supplemented with 2 mg/l of IBA or NAA or ex vitro by treatment with 1000 mg.l of IBA. Hardening was done by transfer to vermiculite in a mist propagation unit. Shoot cultures were established from nodal explants taken from mature clumps of *Thrysostachys oliveri, Dendrocalamus giganteus* and *Bambusa balcooa.* The highest number of sterile explants were obtained when explants were collected during the drier months. A pre-treatment for 30 min. with 0.25 % carbendazim and 200 mg/l gentamycin, followed by sterilization with 0.2% mercuric chloride for 10 min gave best results. Multiple shoot formation was best on a MS basal media supplemented with 4.5 μM BAP and 2.5 μM kinetin.

Multiple shoot formation was obtained through culture of immature and mature zygotic embryos as well as shoot tips taken from 1to 2 year old seedlings in nine rattan species (*C. andamanicus, C. hookerianus, C. nagbettai, C. pseudotenuis, C. prasinus, C. rotang, C. travancoricus , C. thwaitesii* and *C. vatayila).* MS basal medium with 8 μM BAP and 0.5 μM NAA was found to suitable for all the species. Stationary liquid culture was also found to be suitable for shoot cultures. Rooting was obtained in elongated shoots placed on MS with 2 mg/l NAA. Fifty percent of plantlets survived after hardening for 4 weeks in a mist propagation chamber.

A handbook on micro-propagation of bamboo and rattan was prepared to provide ready reference for the beginners in this field.

Introduction

Efficient propagation methods for large-scale production of planting stock play an important role in efforts to improve bamboo and cane resources. Large scale cloning has to be considered when there are limitations in the conventional propagation methods through seeds and vegetative methods. In bamboos due to the unique flowering behavior and the short viability of seeds, the conventional means of propagation cannot be depended upon totally. Careful collection and proper storage of seeds may improve the situation to some extent. Although vegetative propagation through rooting of culm cuttings can be successfully used for large-scale propagation of bamboos, shortage of plant material for multiplication is the major limitation.

In rattans, conventional propagation through seeds and, especially, the standardized nursery techniques works well when there is an assured supply of seeds. Many of the economically important rattan species are over exploited and due to dearth of mature plants, seeds are scarce. Vegetative propagation gives poor results in rattan. Micropropagation methods therefore have great potential to meet the needs of raising plantations for the immediate future.

In general bamboo tissue culture has been successful in several tropical and temperate bamboo species all over the world (Rao *et al*., 1990; Zamora, 1994; El Hassan and Debergh, 1987). Regeneration of bamboo in tissue cultures has been achieved through induction of multiple shoot formation from vegetative buds and through somatic embryogenesis. A vast majority of the published reports of bamboo tissue culture involved the use of juvenile plant material as the explant (Rao *et al*., 1990; Das and Rout, 1994). Since bamboo flowering is unpredictable in most bamboo species and bamboo seeds typically have a short period of viability the methods are not of much practical value. Micropropagation of bamboo from field growing clumps is of great importance particularly since they are of proven performance and superior genotypes can be selected. Reports of successful micropropagation using explants taken from mature clumps include *Dendrocalamus strictus* (Chaturvedi *et al*., 1993, Nadgir *et al*., 1984), *Bambusa arundinacea* and *B. vulgaris* (Nadgir *et al*.,1984) and *B. vulgaris* (Hirimburegama and Gamage, 1995). Somatic embryogenesis and regeneration of plantlets has been reported in several species of bamboo (Zamora *et al.,* 1988).

Studies on micropropagation of canes are much more restricted when compared to bamboo (Rao *et al*., 1990; Patena *et al*., 1984; Umali-Garcia, (1985), Yusoff *et al*., 1985). On Indian rattans, the first report by Padmanaban and Illangovan (1989) was followed by Muralidharan (1992, 1994) and Valsala and Muralidharan (1998). Somatic embryogenesis from callus derived from root tips of in *vitro* plantlets was reported in *C. manan* (Goh *et al*., 1999).

Objective

Setting up of a tissue culture facility for production of planting material of commercially important cane and bamboo species.

Materials and Methods

Plant material

Bamboo: One- and two-year-old seedlings collected from the forest floor near the clumps of *Bambusa bambos* var *gigantea*, in Chitoor, Attapadi, Kerala, planted in polythene bags and maintained in the nursery were used as the source of nodal explants. In one-year-old seedlings the entire plants were used for culture after removing the roots. Stem explants (2 cm) excised from the two-year-old seedlings were also used to initiate cultures.

Mature clumps of *Bambusa balcooa, Dendrocalamus giganteus, D. brandisii* and *Thyrsostachys oliverii* from the germplasm collection at the KFRI Field Research Station, Veluppadam were used as source of explants. Explants of 2-3 cm containing an unopened axillary bud were taken from the secondary branches of the current year's culms. Young inflorescences collected from a flowering clump of *D. giganteus* located in a homestead at Kottayam District, Kerala were also used for culture.

Rattan: Immature or mature fruits of nine species viz. *C. andamanicus, C. hookerianus, C. pseudotenuis, C. nagbettai, C. prasinus, C. rotang, C. thwaitesii, C. travancoricus* and *C. vattayila* were collected from forests in Andaman and Nicobar Islands, Kerala and the Coorg District of Karnataka. Immature fruits were used for culture as soon as possible whereas mature fruits were processed by soaking in water for 24 h. and removing the sarcotesta by abrasion. Seeds were then stored in moist sawdust until used for culture.

Seedlings obtained from seeds germinated and maintained in moist sawdust up to one year or two-year-old seedlings grown in soil in polythene bags were used as the source of shoot tips for culture.

Surface sterilization

Explants were first cleaned in running tap water to remove soil and dead tissues, trimmed to size and washed in a dilute solution of Extran Neutral – a detergent, followed by three rinses with distilled water.

Mercuric chloride at different concentrations was used for surface sterilization of all the explants used in this study. The nodal explants of bamboo were treated with a 0.1 % solution for 5, 7 or 10 minutes. Explants of bamboo taken from mature culms were pre treated for 1 hr in a solution consisting of

Carbendazim (Bavistin®) 0.25 % w/v along with Gentamycin (200 mg/l) before surface sterilization. This was used as a pretreatment for all the mature culm explants regardless of the subsequent treatment.

Immature or mature fruits of rattan were sterilized with 0.2 % solution for 10 minutes and the seeds excised from mature fruits treated with 0.2 % solution for 15 minutes.

Nutrient media

The minerals salts and organic compounds according to Murashige and Skoog (1962) were used as the basal medium (MS). Supplements of plant growth regulators, sucrose and agar were added at different concentrations to formulate the different media required for the different stages of culture. The pH of the medium was adjusted to 5.7 and agar was added to the media at a concentration of 0.52% w/v if solidification was required. The media was autoclaved in a pressure cooker or a horizontal steam sterilizer for 15 minutes.

Since a large percentage of cultures were lost due to contamination, an initial media consisting of a hormone free basal media was used as an initial screening stage. In bamboo nodal explants and rattan shoot tip explants, Bavistin (0.2% w/v) was also tested alone and together with Gentamycin (200 mg/l) as an additive to the initial culture media along with controls consisting of media without antibiotics. To induce shoot multiplication or organogenesis in bamboo and rattan, the basal media was supplemented with auxins and cytokinins at different concentrations.

Culture containers

Several types of glass and plastic containers were used in this study depending on the species and stage of culture and included test tubes, glass bottles and , polypropylene containers. As a cost reduction measure Polypropylene bags (pp) (of the type used commonly for packing grocery) were used as culture containers by modifying them into `pouches' of required size and shape using a heat sealer. To permit improved venting of some of the containers, modifications were made in the lids by cutting an hole and closing it with cotton wool plugs or two layers of soft paper surgical tape (3M Micropore®).

Culture Conditions

Cultures were transferred to shelves in a culture room maintained at 25 $\pm$ 3 ^{o} C with a photoperiod of 8 hrs lights and 16 hrs darkness. Lights were provided by fluorescent tubes that gave a PAR of 25 $\mu E\ m^{-1}\ s^{-1}$. Some of the explants were placed in the initial media in the dark for the first 4-6 days after which they were shifted to light. Observations were taken at regular intervals

and subcultures to fresh media carried out with division or trimming of the tissues as and when required.

Shoot cultures of both bamboo and rattan at the multiplication stage were normally transferred every 4-6 weeks to fresh media after splitting into smaller clusters. Elongated shoots were also separated from smaller shoots and shifted to rooting media during such subcultures. Shoots were trimmed to appropriate size in bamboo and it was ensured that at least two visible nodes with expanded leaves were present. The cut was made a few millimetres below the lowest node.

A liquid medium with a filter paper bridge was to support the micro shoots of bamboo in the test tube. A basal medium supplemented with different concentrations (1, 2, 5 mg/l) of NAA, IBA and IAA, singly and in combinations was used to induce rooting. The effect of coumarin was tested by adding it to the media containing IBA (2 mg/l) or NAA 2 mg/l). *Ex vitro* rooting was also attempted by treatment with a solution of IBA and NAA (5 mg/l, 100 mg/l and 5000 mg/l) in ethanol. The lowest node of the microshoots prepared as above was dipped in the solution for a few seconds and air dried before planting in sterile moist vermiculite in trays. The cuttings were then placed under intermittent mist in a propagation unit.

Elongated rattan shoots were separated from the cluster by pulling them apart as far as possible and without cutting with a scalpel. A solid rooting media consisting of the basal medium supplemented with various auxins (NAA and IBA at 1, 2, 5 mg/l) for inducing rooting.

Hardening

Rooted shoots of bamboo and rattan were washed in running tap water to remove traces of media. After a treatment with 0.25 % solution of Bavistin for 30 min. the plantlets were shifted to vermiculite in disposable plastic cups and placed in a mist propagation unit for periods up to 4 weeks. When new leaves had unfurled the plantlets were shifted to the nursery area under shade for about a weeks after which they were transferred to soil in polythene bags for maintenance in the nursery until planting.

Results and Discussion

Bamboo

Surface sterilization

In the preliminary experiments mercuric chloride solutions in the range of concentrations from 0.1 to 0.2 % were ineffective in sterilizing the explants taken from mature culms except in the dry season. A seasonal difference in percentage of sterile cultures obtained from nodal explants of mature culms, was observed. During the months with no rainfall a maximum of 60 % of the explants remained sterile. Ramanayake and Yakandawala (1997) found a similar correlation between contamination rates and the seasonal rainfall patterns in cultures of *D. giganteus*. They succeeded in obtaining sterile cultures in a medium supplemented with benomyl (1 g/l) and cytokinins. Zamora *et al.(*1988b) found contamination to be a major problem in three species of bamboo and that different methods were required for each species to obtain sterile cultures. The appearance of contamination on the cut ends of the explants as well as in the vicinity of the buds, which had begun to sprout, is explained as proof of contamination derived from deep seated flora or endophytes.

The effect of pretreatment with antibiotic compounds was tested by pretreatment of explants by a solution of a systemic antifungal compound (carbendazim) and a broad-spectrum antibiotic (gentamycin) before the surface sterilization with mercuric chloride

Establishment of cultures

Sprouting of nodes: The nodes inoculated on the initiation media show signs of swelling in two days after culture and the axillary buds sprout and emerge in one week (Fig. 5). Sprouting of axillary buds occurred in the nodal explants regardless of contamination. Quite often shoots that do not show signs of contamination at the early stages develop it later, pointing to the possibility of deep seated presence of the organisms that proliferated as the tissues expanded during culture. In explants of seedlings the nodes produced one shoot each. Chaturvedi *et al.,* 1993 obtained sprouting of buds from nodal explants of *D. strictus* and 2-4 axillary shoots on MS medium supplemented with 0.5 mg/l of IAA and 15 mg/l of adenine sulfate.

Multiplication stage

The number of shoots constituting the cluster that emerges from a single node ranges from 1 to 10. The shoot emerging from the middle of the cluster is the thickest and most vigorous. The shoots continue to elongate and develop in length up to 5-8 cm in two weeks of culture. Leaves then start to

turn brown at the tips and the shoots begin to show signs of dying if left on the same medium.

When the explant is transferred to the multiplication medium consisting of MS+ BAP (4.5 μM) + Kin (2.5 μM) and 2 % sucrose multiple shoot are formed. Multiplication was found to be better in a liquid medium (Fig. 6) when compared to the solid medium of the same composition. Stationary liquid cultures in *B. bambos var. giganteus* gave better results over longer subculture periods but multiplication was more rapid when cultures were agitated and subcultures carried out at weekly intervals. Preetha *et al*., (1992) have obtained high multiplication rates in *D. strictus* shoot cultures. Ramanayake and Yakandawala (1997) obtained shoot multiplication in a liquid MS medium with 6 mg/litre BAP, 0.1 mg/litre kinetin and 8% (v/v) coconut. water. Shoot proliferation was however only 1.8-fold and there was a lag phase of 65 days before multiplication occurred.

Among the liquid media those that were kept stationery showed better growth and appearance when compared with the cultures maintained on a shaker. This is different from the results obtained by others in different species of bamboo. However unless subcultures were carried out at 2-week intervals the shoots turned brown and eventually turn senescent while those on solid medium last longer.

In shoot cultures of *B. bambos* var. *giganteus*, which were derived form seedling nodes, the best multiplication was obtained on a MS+ BAP (3 μM) + Kin (2 μM) + NAA (0.5 μM). Occasional rooting was also obtained in shoots growing on this medium.

Rooting

When shoot multiplication had progressed sufficiently in bamboo cultures rooting was attempted by shifting the microshoots to a rooting medium or *ex vitro* rooting treatment. While more than 70 % of the shoots derived from seedling explants of *B. bambos* var. *giganteus* readily rooted in all the treatments with IBA *in vitro* as well as *ex vitro*, those of *T. oliverii* and *D. giganteus* failed to root. *B. balcooa* shoots gave rooting on MS + IBA (3 mg/l) in just one batch of shoots. NAA (2.7 to 5.4 mM) was used by Prutpongse and Gavinlertvatana (1992) in rooting 54 species of bamboo belonging 15 genera. Hirimburegama and Gamage (1995) used MS basal medium at 50% macroelements and IBA (0.25 μM)for rooting of shoots of *B. vulgaris.* Nadgir *et al*. (1984) obtained rooting of the shoots of *D. strictus* on half-strength MS with activated charcoal after treatment with IBA for 96 h in the dark. Ramanayake and Yakandawala (1997) obtained rooting in *D. giganteus* shoots on MS modified to half strength major salts with 3 mg/l IBA and 10 mg/l coumarin.

The recalcitrance of bamboo shoots to rooting is not surprising considering that a similar response is obtained in culm cuttings taken from mature clumps. Chaturvedi *et al.*, (1993) failed to get rooting in shoots derived from mature nodes of *D. strictus* in spite of a large number of treatments with auxins and phenolic compounds. Rooting was obtained in 30 % of the shoots when the nodes were cultured in an inverted position. This points to the influence of the endogenous levels of plant growth regulators and its polar transport within the explants. The use of adjuvants in the rooting media like phenolic compounds and preculture of shoots in a priming medium before the rooting treatment needs to be studied. The effect of age of the culm and the position of the buds on the culms, response in culture including rooting could not be examined in this study due to the problem of contamination.

Callus cultures

Immature unopened spikelets of *D. giganteus* inculated on 2,4-D containing media produced a translucent yellowish white callus after 2 weeks of culture. The origin of the callus was not clear but the outer bracts of the spikelets were free of callusing. When subcultured on fresh medium a friable and nodular callus developed which is typical of embryogenic callus of grasses. The callus was maintained on the same medium by subcultures every 4 weeks. Regeneration of callus was not obtained when the callus was shifted

Huang and Murashige (1983) induced callus cultures from shoot tip explants in species of *Bambusa, Phyllostachys* and *Sasa* on MS media supplemented with 2,4-D. Zamora *et al*.(1988) obtained callus induction and plant regeneration from internode tissues of *Dendrocalamus latiflorus*. Huang, *et al. (*1989) also report organogenesis in callus cultures derived from shoot apices of these species leading to plantlets. Yeh and Chang (1986) obtained somatic embryogenesis in callus cultures derived from inflorescences of *B. oldhamii*. Plantlet regeneration was obtained through prolonged culture on the induction medium or through transfer to hormone free medium. They suggest that the method could be useful for induction and selection of useful variants. The increased risk of somaclonal variation in callus cultures make the method less attractive for clonal propagation bamboos. But the advantages of somatic embryogenesis are in its potential for making micropropagation quick and cost effective. The potential for mechanized plantlet production through suspension cultures and artificial seed production is also tremendous. Therefore it is still of interest to ascertain the risk of genetic variability, through large-scale field trials of somatic embryo derived bamboo plantlets. Because of the nature of bamboo flowering and the limited scope of hybridization and generation of useful variability the potential for somaclonal variation is also to be tapped.

Hardening of plantlets

Rooted shoots of *B. bambos* var. *giganteus* when shifted to vermiculite and kept under intermittent mist showed above 80 % survival. Plantlets established well in soil when they were transferred to polybags after 4 weeks of hardening (Fig. 7 & 8).

Rattan

Embryo culture

Embryos excised from immature and mature fruits of the different species became swollen and greenish white within two weeks of culture on the initiation media free of hormones. Embryos that were free of contamination were transferred to a solid establishment media consisting of MS + BAP (8 μM) + NAA (0.5 μM) and MS+ BAP (18 μM) + 2,4 D (2 μM) supplemented with 2 % sucrose. All species showed development of shoot intials at the base of the plumule in 4 weeks of culture on the BAP + NAA media while in *C. andamanicus, C. travancoricus* and *C. vatayila,* the BAP + 2,4-D media also showed good results. Upto 4-7 shoot initials were formed per explant in the early stages of cultures.

Shoot multiplication

Shoot multiplication continues through formation of new initials at the base of the embryo and thus the shoot cultures had asynchronous development. Only when cultures were maintained without subculture for longer periods (beyond 5 weeks) does shoot appear to be uniform and leaves expand and attain the typical morphology of the lamina. *C. travancoricus, C. hookerianus, C. pseudotenuis* showed the highest multiplication rates.

Rooting

Elongated shoots separated from the shoot clusters rooted in about 2 weeks on MS + NAA (2 mg/l). IBA did not give consistent rooting in all the species. Rooting of above 70 % of the shoots were obtained in *C. hookerianus C. pseudotenuis* and *C. travancoricus. In C. vatayila, C. andamanicus* and *C. thwaitesii* only 50 % of the shoots rooted when shoots of assorted size were used. Shoots with well developed leaves gave upto 80 % rooting in all the species.

Hardening

Plantlets of rattan of all the species were transferred to sterile vermiculite and hardened in the mist propagation unit (Fig. 9). Mortality of upto 30 % of the plantlets due to fungal rot at the collar region was observed. Plantlets that survived after 4 weeks in the hardening unit were transferred to soil in polythene bags and maintained under shade net (75%) in the nursery (Fig. 10 & 11). Upto 95 % of the plantlets survived and established well in the nursery.

Gunawan (1991) reported a survival percentage of 60 –65% in plantlets of *C. manan* transferred to soil. Mortality of micropropagated *C. manan* plantlets due to *Fusarium* rot and improved survival on inoculation with vesicular-arbuscular mycorhizae was reported by Maziah (1986, 1991).

Handbook on micropropagation

The handbook contains an introduction on micropropagation, state of art review on the technique for bamboo and rattan, the facilities required and references. Composition of media and a glossary of technical terms are appended (Appendix–10).

Conclusions

Micropropagation of the selected bamboo species selected for this study was successful when juvenile explants were used. Endogenous contamination is a serious hurdle in the establishment of sterile cultures in bamboo when material is collected form field growing clumps. Control of contamination can be achieved initiating cultures during the summer and through use of antimicrobial compounds in the medium. .

High rates of multiplication of shoots in bamboo and rattan were achieved in the study in media containing a mixture of cytokinins with or without auxins. Multiplication could be sustained for a few subcultures in bamboo by use of liquid media without agitation.

Rooting in bamboo was relatively easy in cultures derived from seedlings. *Ex-vitro* rooting by short dip in IBA was sufficient. In the microshoots derived from mature clumps rooting was not possible except in B. *balcooa* where the percentage was low. To increase the chances of rooting ability several options needs to be tested. A pre-culture in cytokinin free nutrient media before shifting to rooting media, selection of shoots for vigour and quality before induction of rooting are some of the aspects to be tested. The influence of season and phase of growth of culms on the response *in vitro* including rootability is to be examined in all the species.

Micropropagation of all the rattan species was carried out successfully using explant taken immature or mature seeds and 1-2 year old seedlings. High rates of multiplication, rooting and survival percentages were obtained in all the species.

Considerable cost reduction can be achieved through use of polypropylene pouches as culture containers and liquid stationary cultures as compared with conventional culture vessels and agar solidified media or agitated liquid cultures.

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ESTABLISHMENT OF MULTIPLICATION NURSERIES FOR COMMERCIAL BAMBOO SPECIES

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Abstract

Bamboo plantations are found profitable since farm management is easier compared to other plantation crops. The major bottleneck for organized cultivation of bamboo is non-availability of planting stock of preferred species. Due to inherent limitations of long flowering cycles, lack of seed setting and low viability of seeds, seedling production on a regular basis is difficult in bamboos. Vegetative propagation methods have limitations in meeting the large-scale requirement due to difficulty in rooting of cuttings and non-availability of parent material in sufficient quantity. Large-scale production of planting stock of preferred species to promote organized cultivation of bamboo was taken up during this programme. Totally, 11 bamboo nurseries were established of which three were in KFRI and eight under joint-venture nursery programmes in collaboration with interest groups like other institutions, NGOs, SHGs and planters themselves. A total of 1,77,240 seedlings belonging to six bamboo species (*Bamboo bambos, D. tulda, B. giganteus*, *D. strictus, Ochlandra ebracteata* and *O. travancorica*) and 5,375 rooted cuttings of 13 species (*B. balcooa, B. pallida, B. polymorpha, B. striata, B. tulda, B. vulgaris* (green), *D. brandisii, D. giganteus, D. longispathus, D. membranaceus*, *Pseuodoxytenanthera ritcheyi, P. stocksii* and *Thyrsostachys oliveri)* were produced in different nurseries. One species viz. *T. siamensis* did not root. Species like *Bambusa balcooa, B. striata* and *D. brandisii* were multiplied easily through joint-venture nurseries since they are easy to root. But for species like *T. oliveri* and some of the thin walled bamboos like *D. longispathus* that are difficult to root, initial rooting trials will have to done in the mother nurseries of KFRI and planting stock transferred to joint-venture nurseries at the macro-proliferation stage. To obviate the problem of shortage of parent material inherent to clonal propagation technology, an area of 5 ha for a mother plant collection of 15 selected species was established in KFRI-FRC, Veluppadam.

Introduction

In the context of the integrated development envisaged in the bamboo sector, the requirement of suitable raw material is expected to shoot up in the forthcoming years. Bamboo is still considered as a forest produce. Popularisation of bamboo cultivation in the non-forest areas, especially in homesteads will provide additional source bamboo raw material to what is available in forest areas. Bamboo plantations are bye and large profitable since they are easy to manage and require less labour compared to other plantation crops (Wagh and Rajput, 1994; Marawar *et al.*, 1998). Homesteads can be taken as a viable alternative for cultivation of bamboo. KFRI, through some of the extension programmes implemented earlier, had found that farmers and NGO groups in Kerala are interested in taking up bamboo cultivation. The demand for planting stock of preferred bamboo species by farmers such as *Thyrsostachys oliveri*, *Dendrocalamus giganteus*, *D. brandisii* etc. is very high. Setting up of joint venture nurseries with farmers/NGOs and transfer of technology for planting stock production will be of great advantage to cater to the requirement. Through this activity KFRI has taken initiative to implement the idea and analyse its feasibility.

For most of the species preferred by farmers, seeds are not available and the clumps are distributed in restricted locations, mainly in non-forest areas. While vegetative propagation (macro-propagation methods) of these species was attempted, lack of sufficient quantity of parent material for root induction and need for long distance transport from mother clump to nursery site were the two main constraints experienced. To address these issues, a study was undertaken with the following objectives.

Objectives

1. To establish a mother plant collection (MPC) of selected bamboo species.

2. To establish plant multiplication nurseries using conventional propagation techniques for commercial bamboo species suitable for cultivation in Kerala.

Methodology

Mother plant collection

An area of 5 ha adjacent to existing bambusetum was demarcated in the KFRI Field Research Centre, Veluppadam. Fifteen species were selected for

planting in the MPC site (Table 10). Twenty propagules each of 15 species were planted in four blocks in the MPC and planting was done in July 2000. Different spacing was given based on the clump size of different species. Large clump forming bamboos such as *D. brandisii*, *D. giganteus*, *D. membranaceus* and *D. hamiltonii* were given a spacing of 10 m x10 m, medium size bamboos such as *B. nutans*, *B. balcooa*, *B. tulda* and *B. longispiculata* were given a spacing of 8 m x 8 m and small size bamboos like *B. polymorpha*, *B. wamin*, *D. longispathus*, *D. strictus* and *T. olivei* were given a spacing of 5 m x 5 m.

Table 10. List of bamboo species planted in the MPC at Veluppadam

Sl. No.	Name of species		Sl. No	Name of species
1	*Bambusa balcooa*		2	*B. nutans*
3	*B. longispiculata*		4	*B. polymorpha*
5	*B. tulda*		6	*B. vulgaris*
7	*B. wamin*		8	*Dendrocalamus brandisii*
9	*D. hamiltonii*		10	*D. longispathus*
11	*D. membranaceus*		12	*D. giganteus*
13	*D. strictus*		14	*Pseudoxytenanthera stocksii*
15	*Thyrsostachys oliveri*			

Establishment of multiplication nurseries

Totally, 11 bamboo nurseries were established during the project period, of which four during the first year and seven during the second year. Selection of participating farmer/NGO was made from the people who had expressed interest in establishment of collaborative nurseries during the farmers' training programme. KFRI experts, visited the area for selection of the site and an agreement was executed with the implementing agency (Appendix-11).

Details of nurseries

The location, address of responsible institute/person and information to contact are given below (Table 11).

Bamboo species and production of planting stock

Planting materials of the following 18 species (Table 12) were produced in the above nurseries. Of these propagules of *Bambusa bambos*, *Dendrocalamus strictus*, *Ochlandra ebracteata* and *O. travancorica* were produced through seeds and others by vegetative methods. In addition, seedling stock of *B. tulda* and *D. giganteus* was also produced through limited quantity of seeds procured by a planter. The methodology for production of planting stock through seed

and vegetative propagation is given in detail in the Handbook on Nursery and Silvicultural techniques for Bamboos (Appendix-7).

Table 11. Details of KFRI and joint venture nurseries established

Sl No.	Location and address	Category,contact Person & phone No
A. KFRI Nurseries (from the project funds)		
1	**KFRI Campus, Peechi, Thrissur** Kerala Forest Research Institute, Peechi - 680 653 Thrissur, Kerala	**Institution** Director, KFRI, Peechi O487-2699062 jksharma@kfri.org
2	**KFRI Sub centre Campus, Nilambur** Kerala Forest Research Institute, Sub centre, Chandakunnu - 679 342 Nilambur, Malappuram Dt Kerala	**Institution** Scientist-in-Charge KFRI Sub centre, Nilambur 04931 – 222846 forest@sancharnet.in
3	**KFRI Field Research Centre, Veluppadam** Kerala Forest Research Institute, Field Research Centre, Veluppadam – 680 303 Varantarapally,Thrissur Dt.	**Institution** Officer-in-Charge KFRI Field Research Centre, Veluppadam 0480 –2762205
B. Joint Venture Nurseries (with technical help from KFRI and financial support from the project)		
4	**FCRI Campus, Kanjikode, Palakkad** Fluid Control Research Institute Kanjikode West Palakkad 678 623 Kerala	**Institution** Director, FCRI 0491–2566206, 256119 fcri@vsnl.com
5	**Uravu** (Centre for Indigenous Science and Technology) Thrikkaipetta 673 577 Meppadi, Kalpetta Wyanad Dt.	**NGO** Mr. K. Sivarajan, President 0493–6683244 9447341584 (mobile) uravu_india@yahoo.com.uk
6	**Kondotty Agri Horticultural Development Society (KAHDS)** Kondotty – 673 638 Malappuram Dt.	**NGO** Mr. M. C. Veerankutty Secretary 0483 – 2715573
7	**Aiswarya Swashraya Sangam** Register No. 52 Thekkekulam North Peechi 680 653 Thrissur	**SHG (women)** Ms. Pusphakumari Secretary 0487 –2699041
8	**Janahshram** Vyasagiri – 680 623 Vadakkanchery, Trichur Dt.	**Interest Group** Mr. Rajasekharan Secretary 0488 – 432286
9	**Mr. T. Shahabudeen** Cherry's Kuniyamoochi Estate Vetillappara – 673 639 Malappuram Dt	**Planter** O493-2759132
C. With technical help from KFRI		
10	**Mr. C A Abraham** Chittazathu House Chilavanoor Rd Kochi -682 020 Ernakulam Dt.	**Planter** 0484 - 2307356 9847030911 (mobile)
11	**Adv. K.E John** Valloore House Nedumanni 686 542 Kottayam Dt.	**Planter** O481 –2415442

Table 12. List of bamboo species for which planting stock was produced

Sl No.	Name of species	Sl. No.	Name of species
1	*Bambusa balcooa*	10	*D. longispathus*
2	*Bambusa bambos*	11	*D. membranaceus*
3	*B. pallida*	12	*D. strictus*
4	*B. polymorpha*	13	*Pseudoxytenanthera ritcheyi*
5	*B. tulda*	14	*P. stocksii*
6	*B. striata*	15	*Ochlandra ebracteata*
7	*B. vulgaris* (green)	16	*O. travancorica*
8	*Dendrocalamus brandisii*	17	*Thyrsostachys oliveri*
9	*D. giganteus*	18	*T. siamensis*

Evaluation

The survival percentage of 15 species planted in the MPC was collected after one year.

The number of plants produced by each nursery and their functioning was evaluated by visiting the nurseries in the second year. Also the details of the utilization of the planting stock produced by them were taken into account.

Results

Mother Plant Collection, FRC Veluppadam

The details on number of propagules planted, type of propagules and source and percentage of survival are given in Table 13. Observation, one year after planting, showed survival rate of more than 50% for seven species.

Table 13. Details of MPC at Veluppadam

Sl No.	Species	Type of propagule	Source of mother stock	Survival(%)
1	*Bambusa balcooa*	Rooted cuttings	Nilambur	77.5
2	*B. longispiculata*	Seedlings	Itanagar,1992 flowering	60.0
3	*B. nutans*	Rooted cuttings	FRC, Veluppadam	50.0
4	*B. polymorpha*	Rooted cuttings	FRC, Veluppadam	15.0
5	*B. tulda*	"	SC, Nilambur	75.0
6	*B. striata*	"	FRC, Veluppadam	66.3
7	*B. wamin*	"	FRC, Veluppadam	0
8	*Dendrocalamus brandisii*	"	FRC, Veluppadam	60.0
9	*D. hamiltonii*	"	FRC, Veluppadam	20.0
10	*D. longispathus*	"	SC, Nilambur	46.3
11	*D. membranaceus*	"	FRC, Veluppadam	48.0
12	*D. giganteus*	"	FRC, Veluppadam	20.0
13	*D. strictus*	Seedlings	Coimbatore	47.5
14	*Pseudoxytenanthera stocksii*	Rooted cuttings	Monacha, Kasaragode	10.0
15	*Thyrsostachys oliveri*	"	KFRI, Peechi	57.5

Planting stock production in KFRI Nurseries

1. KFRI, Peechi (KFRI)

A total of 64,220 propagules were produced in KFRI nursery located in the main campus at Peechi. Of these, 62500 (4 species) were through seeds and 1720 (7 species) were through rooted cuttings. The number of propagules produced for each species is given separately in Table 14 with source of material. The year of seed collection is given in parenthesis for seedlings which will enable to predict the flowering year of this planting stock.

Table 14. Details of planting stock produced in KFRI, Peechi

Sl No.	Name of species	Number of plants	Source /year of flowering
Through seeds			
1	*Bambusa bambos*	50000	Shimoga, Karnataka -2000
2	*Ochlandra travancorica.*	4000	Nanattupara, Ranni, Kerala - 2000
3	*Dendrocalamus strictus*	8000	Coimbatore, TN - 2000
4	*Ochlandra ebracteata*	500	FRC, Veluppadam - 2001
Total		62500	
Through rooted cuttings			
1	*Bambusa balcooa*	651	Culm cuttings from KFRI campus
2	*B. striata*	506	"
3	*Dendrocalamus giganteus*	25	Maniangode, Wyanad
4	*D. longispathus*	30	FRC, Veluppadam
5	*D. membranaceus*	74	"
6	*Pseudoxytenanthera stocksii*	50	Monacha, Kasaragode
7	*Thyrsostachys oliveri*	384	KFRI Campus, Peechi
	Total	1720	
	Grand total	64220	

2. KFRI Sub centre, Nilambur (SCN)

Planting stock of 14 species belonging to five genera (*Bambusa*, *Dendrocalamus*, *Ochlandra*, *Pesudoxytenanthera*, and *Thyrsostachys*) were produced in this nursery. A total of 45,410 propagules were prepared of which 44,000 were from seeds and 1410 from rooted cuttings (Table 15).

Table 15. Details of planting stock produced in Sub centre, Nilambur

Sl No.	Name of Species	Number of plants	Source/ flowering year
Through seeds			
1	*Bambusa bambos*	40000	Nilambur (2000)
2	*Ochlandra travancorica.*	4000	Nanatupara (2000)
Total		44000	
Through rooted cuttings			
1	*Bambusa balcooa*	110	Bambusetum , Nilambur
2	*B. pallida*	65	"
3	*B. polymorpha*	75	"
4	*B. tulda*	150	"
5	*B. striata*	250	"
6	*B. vulgaris* (green)	150	"
7	*Dendrocalamus brandisii*	75	"
8	*D. giganteus*	275	Maniankode, Wyanad
9	*D. longispathus*	64	Bambusetum, Nilambur
10	*D. membranaceus*	38	"
11	*Pseudoxytenanthera ritcheyi*	150	Proliferated seedlings (Nilambur, 1987)
12	*Thyrsostachys oliveri*	8	Bambusetum, Nilambur
Total		1410	
Total			45410

3. KFRI FRC, Veluppadam (FRC)

Four species were multiplied in FRC. Of these, three species were from seeds and two species from rooted cuttings. Totally, 12,795 propagules were produced of which 12,700 were from seeds and 95 from cuttings. Details are furnished below (Table 16).

Table 16. Details of planting stock produced in FRC, Veluppadam

Sl No.	Species	Number of plants	Source/flowering year
Through seeds			
1	*Bambusa bambos*	5000	Seeds, Chinnar 2000
2	*Ochlandra ebracteata*	2200	Seeds -FRC, Veluppadam 2000
3	*Ochlandra travancorica*	5500	Seeds – Kuthumannu, Ranni 2000
Through rooted cuttings		12700	
1	*B. balcooa*	65	KFRI campus, Peechi
2	*D. membranaceus*	30	FRC , Veluppadam
Total		95	
Grand Total		12795	

Planting stock production in Joint Venture Nurseries

1. FCRI, Kanjikode (FCRI)

The Director, Fluid Control Research Institute expressed his interest in establishing a demonstration plot in this campus. Considering the planting stock requirement, a multiplication nursery was established. No financial help was provided to this nursery. Six species were multiplied in this nursery through rooting of cutting (Table 17). Of these, cuttings of *Thyrsostachys oliveri* were taken from the clump available at FCRI campus, *B. balcooa* from KFRI campus, Peechi and the rest four were extracted from FRC, Veluppadam and transported to the nursery site at FCRI, 120 km away.

Table 17. Details of planting stock produced in FCRI nursery

Sl. No.	Species	No. of cuttings planted	No. of propagules	Rooting Response (%)
1	*B. balcooa*	55	35	63.6
2	*B. vulgaris* (green)	88	61	69.31
3	*D. brandisii*	125	68	54.4
4	*D. longispathus*	55	15	27.27
5	*D. membranaceus*	97	24	24.74
6	*T. oliveri*	300	18	6.0
	Total	720	221	

The propagules were planted in the FCRI campus at Kanjikode, Palakkad.

2. URAVU, Wyanad (URAVU)

URAVU is an NGO involved in bamboo planting and handicrafts. This nursery was established to cater to the planting stock requirement in Wyanad. Eight species were multiplied in this nursery of which three were produced from seeds and five were multiplied by rooted cuttings. The details are given below (Table 18). The nursery is being maintained by URAVU now and it is strengthened by the collections made by the organizers. Actual labour cost and materials for thatching were given by KFRI for the first year from the project funds.

Table 18. Details of planting stock produced in URAVU nursery

Sl No.	Species	No. of cuttings planted	No. of propagules	Rooting/ germn (%)
Through seeds				
1	*B. bambos*	35000*	20000	57.14
2	*D. strictus*	1200*	500	41.67
3	*O . travancorica*	7000*	5600	80.0
Total		43200	26100	
Through rooted cuttings				
1	*B. balcooa*	80	50	62.5
2	*B. striata*	60	75#	100
3	*B. vulgaris* (Green)	40	50#	100
4	*D. brandisii*	75	50	66.67
5	*D. giganteus*	80	50	63
9	*T. oliveri*	50	30	60
Total		340	305	
Grand Total			26405	

* Number of seeds sawn. # More than one plant due to rooting of both nodes

3. Kondotty Agri Horticultural Development Society (KAHDS)

KAHDS is an NGO involved in rural development. This nursery was established to facilitate distributing planting material in Malappuram District. Eight species were multiplied in this nursery. The planting stock was supplied from KFRI bambusetum at Veluppadam and a financial help of Rs. 2,500/- was provided from the project funds. Four hundred and eighty propagules were produced through rooted cuttings (Table 19). The planting material was distributed to farmers in the locality and part of it was purchased by KFRI for establishment of bamboo multiplication areas.

Table 19. Details of Planting stock produced in KADHS Nursery

Sl. No	Species	No. of cuttings planted	No. of propagules	Rooting Response (%)
1	*B. balcooa*	90	60	66.67
2	*B. polymorpha*	35	10	28.57
3	*B. striata*	105	125*	100
4	*B. vulgaris* (Green)	105	125*	100
5	*D. brandisii*	100	100	100
6	*D. longispathus*	70	10	14.28
7	*D. membranaceus*	105	30	28.57
8	*T. oliveri*	135	25	18.51
	Total	780	485	

* Some of the cuttings gave two plants/cuttings due to rooting in both the nodes

4. Aiswarya Swashraya Sangam , Peechi (ASS)

This is a SHG of women. The nursery was allotted to it to provide additional income for the members and improve their livelihood. Seven species were multiplied in the nursery. A financial help of Rs. 10,000 was provided. About 535 propagules were produced during the first year (Table 20). The nursery is well maintained and macro-proliferation of the propagules is done regularly.

Table 20. Details of planting stock produced in ASS nursery

Sl No.	Species	No. of cuttings planted	No. of propagules	Rooting response (%)
1	*B. balcooa*	215	70	56
2	*B. polymorpha*	55	20	36.37
3	*B. striata*	100	143*	100
4	*D. brandisii*	200	185	92.5
5	*D. longispathus*	75	37	49.33
6	*D. membranaceus*	75	20	26.67
7	*T. oliveri*	310	60	19.35
	Total	1030	535	

5. Janashram, Thrissur (JNM)

To plant the boundary of the Ashram campus with bamboos, a nursery was initiated in this campus with selected species. Of the seven species tried, only five produced propagules (Table 21). Totally, 175 plants were produced and all of them were planted in the boundary of the campus. A financial assistance of Rs. 5,000/- was given to this nursery.

Table 21. Details of the planting stock produced in Janashram

Sl No.	Species	No. of cuttings planted	No. of propagules	Rooting response (%)
1	*B. balcooa*	80	25	31.25
2	*B. polymorpha*	40	20	50
3	*B. striata*	175	65	37.14
4	*B. vulgaris* (Green)	40	25	62.5
5	*D. brandisii*	80	40	50
6	*T. oliveri*	200	0	0
7	*T. siamensis*	300	0	0
	Total	915	175	

6. Mr. Shahabudheen, Malappuram (TSM)

This nursery was established to supply planting stock in Malappuram district. Totally, 329 propagules belonging to eight species were produced at this site (Table 22). Financial assistance of Rs. 2,500/- was provided. The number of plants obtained fom *B. balcooa* and *B. polymorpha* cuttings was very less since grazing was an impediment.

Table 22. Details of planting stock produced in the nursery

Sl. No.	Species	No. of cuttings planted	No. of propagules	rooting response (%)
1	*B. balcooa*	128	10	7*
2	*B. polymorpha*	110	10	9*
3	*B. striata*	85	70	82.35
4	*B. vulgaris* (Green)	86	75	87.20
5	*D. brandisii*	200	60	30
6	*D. longispathus*	97	49	50.51
7	*D. membranaceus*	75	45	60
8	*T. oliveri*	278	10	3.5
	Total	1059	329	

* Plants were grazed by cattle soon after sprouting and hence rooting was very poor.

7. Mr. Abraham, Ernakulam (CAA)

Technical help for establishment of a nursery was provided to an interested planter. He had procured seeds from different locations. The details of seeds, seedlings produced and percentage of germination are given below (Table 23). This is retained as a commercial nursery. Seed germination was very low in *Dendrocalamus giganteus* (0.2%).

Table 23. Details of seedlings produced in the nursery of Abraham

Sl No	Species	No of seeds sown	seedlings produced	Germn. (%)
1	*B. bambos*	85000	12000	14.11
2	*B. tulda*	15000	7500	50
3	*D. giganteus*	20000	40	0.2
4	*D. strictus*	35000	12000	34.28
	Total	155000	31540	

8. Adv. John, Kottayam (KEJ)

The owner multiplied four species in this nursery to meet the planting stock requirement. Of these, *Dendrocalamus strictus* was produced from seeds and the other three species were multiplied using culm cuttings (Table 24). Totally, 500 plants were produced.

Table 24. Details of planting stock produced in the nursery of Adv. John

Sl No.	Species	No of cuttings/seeds planted	No. of propagules	Germination/ rooting (%)
Through seeds				
1.	*D. strictus*	17500	400	22
Through rooted cuttings				
1	*B. balcooa*	110	40	36.36
2	*B. polymorpha*	125	15	12
3	*D. membranaceus*	120	45	37.5
	Total	355	100	

Totally, 1, 77, 240 seedlings belonging to six species *(B. bambos, B. tulda, D. giganteus, D. strictus, O. ebracteata and O. travancorica)* and 5375 rooted cuttings of 13 species *(B. balcooa, B. pallida, B. polymorpha, B. striata, B. tulda, B. vulgaris* (green), *D. brandisii, D. giganteus, D. longispathus, D. membranaceus, P. ritcheyi, P. stocksii* and *T. oliveri*) were produced by different nurseries. The summary is given in Table 25.

Initial one-year observations from the joint venture nurseries indicate that species like *Bambusa balcooa, B. striata, D. brandisii* were easy to root and it is possible to multiply these easily through joint-venture nurseries. Rooting response of species like *T. oliveri* and some of the thin walled bamboos like *D. longispathus* was very poor. Easy to root species can be directly multiplied through these nurseries. For difficult to roots species, rooting has to be done in the mother nurseries of KFRI and planting stock can be transferred to joint-venture nurseries at the macro-proliferation stage. Farmers could easily produce seedlings from seeds with technical help from KFRI.

Table 25. Summary of the planting stock production by various nurseries

Particulars	1 KFRI	2 SCN	3 FRC	4 FCRI	5 URA	6 KAH	7 ASS	8 JNM	9 TSM	10 CAA	11 KEJ	Total
Through seeds												
B. bambos	50000	40000	5000	0	20000	0	0	0	0	12000		127000
B. tulda										7500		7500
D. giganteus										40	0	40
D. strictus	8000	0	0	0	500	0	0	0	0	12000	400	20900
O. ebracteata	500	0	2200	0	0	0	0	0	0	0	0	2700
O. travancorica	4000	4000	5500	0	5600	0	0	0	0	0	0	19100
Total	62500	44000	12700	0	26100	0	0	0	0	31540	400	177240
Through rooted cuttings												
B. balcooa	651	110	65	35	50	60	70	25	10	0	40	1116
B. pallida	0	65	0	0	0	0	0	0	0	0	0	65
B. polymorpha	0	75	0	0	0	10	20	20	10	0	15	150
B. striata	506	250	0	0	75	125	143	65	70	0	0	1234
B. tulda	0	150	0	0	0	0	0	0	0	0	0	150
B. vulgaris (green)	0	150	0	61	50	125	0	25	75	0	0	486
D. brandisii	0	75	0	68	50	100	185	40	60	0	0	578
D. giganteus	25	275	0	0	50	0	0	0	0	0	0	350
D. longispathus	30	64	0	15	0	10	37	0	49	0	0	205
D. membranaceus	74	38	30	24	0	30	20	0	45	0	45	306
P. ritcheyi	0	150	0	0	0	0	0		0	0	0	150
P. stocksii	50	0	0	0	0	0	0	0	0	0	0	50
T. oliveri	384	8	0	18	30	25	60	0	10	0	0	535
Total	**1720**	**1410**	**95**	**221**	**305**	**485**	**535**	**175**	**329**	**0**	**100**	**5375**

The details of utilization of the planting stock are given under "Setting up of demonstration plots".

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ESTABLISHMENT OF FARMS WITH NGOS AND LOCAL FARMERS

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Abstract

Interest groups, prepared to take up bamboo cultivation, required details regarding various species available for cultivation, the nature and appearance of the species, growth and productivity and annual expected income. The information available on these aspects is either restricted mainly to two species *Bambusa bambos* and *Dendrocalamus strictus* or based on the case studies undertaken in other states, which differ in agro-climatic conditions. Demonstration plots were established to generate the above data. For familiarization with different bamboo species, field visit was organized to the bambusetum and cane nurseries at KFRI-FRC, Veluppadam. Demand for planting stock by participants was ascertained and the species preferred by farmers in Kerala for cultivation in homesteads was arrived at. There were high demand for species such as *Dendrocalamus giganteus*, *Thyrsostachys oliveri*, *Bambusa nutans*, *Dendrocalamus brandisii* and *Bambusa bambos*.

Many participants expressed their interest for taking up bamboo cultivation in homesteads. KFRI, in collaboration with them, established 14 plots in their land. On the long run, these plots will serve to generate site specific performance of various species. In addition, planting stock raised in multiplication nurseries was distributed to participating farmers as per their demand.

Formation of an organized group such as Bamboo and Cane Club was felt necessary to streamline different activities, to facilitate exchange of ideas and also to undertake group planting and marketing of harvested bamboo. Meetings were held for facilitating formation of such a group. Similarly, setting up at least 0.5 hectare plantation was felt necessary to understand commercial viability. For initiating this, an interaction meeting of potential large-scale farmers was organized at KFRI.

Publication of a newsletter in Malayalam *(Muladhwani)* for creating awareness on the potential of bamboo and cane cultivation and value addition along with other relevant information in this sector was initiated.

Introduction

It became clear from the training programmes organized as a part of the current project, and also from earlier case study and extension project undertaken by KFRI (Chandrashekara *et al*., 1997, Seethalakshmi, 2001), that farmers and other interest groups in Kerala are ready to take up bamboo cultivation. Information on suitable species, source of planting stock, productivity of different species, duration required for first harvesting, cost of cultivation and expected annual income was necessary to promote this endeavour. Since majority of the work on silviculture of bamboos are restricted to *B. bambos* and *D. strictus,* the required information on the species farmers preferred was either not available or scanty in literature. During this programme, establishment of demonstration plots in collaboration with farmers/organizations who were willing to spare their land was envisaged to generate first hand information on the above aspects. In addition to the plots in which there was direct involvement of KFRI, plots in different locations in Kerala were also planned. Organizing the interest groups involved in bamboo and cane resource enhancement and utilization is essential to facilitate exchange of ideas, implementation of the planting programmes and organizing of marketing of harvested bamboos. Hence, guidelines for formation of a Bamboo and Cane Club were prepared. Also, the potential farmers need to be familiarised with the different species of bamboos and rattans available for cultivation for which they were given an opportunity to visit KFRI bambusetum and cane nursery at FRC Veluppadam.

Objectives

1. To set up demonstration plots in farmers land for the cultivation of different bamboo and cane species

2. To provide technical inputs needed for cultivation, management and utilisation of bamboo and cane.

3. To organise field day and farmers visit to familiarise with bamboo and cane.

Methodology

Selection of interest groups for establishment of demonstration plots

In order to identify interest groups (farmers, NGOs, youth clubs, farmers' clubs, etc.) advertisements were placed in Malayalam newspapers (All Kerala editions), All India Radio and Asianet Television channel. The applicants

were classified into marginal farmers (land holding less than 1 ha), medium farmers (land holding between 1 and 5 ha) and large farmers (land holding between 5-50 ha). Training was given to interested persons and details of the training are provided elsewhere in the report.

Field visit to KFRI-FRC bambusetum, Veluppadam and selection of species

Farmers were given opportunity to get familiarised with various potential bamboo species for cultivation by arranging a field day to KFRI bambusetum at FRC, Veluppadam. The species preferred by farmers were identified from their demand for planting stock.

Supply of planting stock

The planting stock produced through multiplication nurseries was supplied to the farmers in all 14 districts by the project team. Also, planting stock was provided for Kerala Forest Development Corporation and River Bank Stabilization programme organised by youth clubs at Nilambur.

Establishment of demonstration plots jointly with farmers

From the list of farmers/institutions who were interested in making their land available for bamboo cultivation, were chosen and plots were established jointly. The list of farmers/institution having demonstration plots is given below (Table 30).

Table 30. List of farmers/institution having demonstration plots

Adv. K.E John Valloore House Nedumanni 686 542 Kottayam Dt. Ph. 0481 215442	Fluid Control Research Institute Campus Kanjikode West Palakkad 678 623 Kerala. Ph. 0491 2566120	Mr. C. D. Manual Chirayathu House East Fort, Trichur. Ph. 0487 2337766
Mr. V. R. Bharathan Easwara Nilayam Nellikkad Perukkunnam Palakkad Ph. 04922 272178	Mr. V. S. Subramanian Saraswathi Vilayannur Perukunnam Palakkad Ph. 04922 284456	Mr. V. R. Subramanian Siva Nilayam Vilayannur Perukunnam Palakkad Ph. 04922 284249
Mr. V. K. Balakrishnan Vadakkethil Paruthipully 678 573 Palakkad Ph. 04922 285286	Mr. V. C. Velayudhan Vadakkethil Paruthipully Palakkad Ph. 04922 285749	Mr. Thomas Jacob Maliyekkal House Payyanam, Kannara Thrissur Ph. 0487 2699252
Dr. Hydrose, Mulakkunnathukave Thrissur Ph. 0487 287718	The Manager Malankara Estate Thodupuzha Ph. 0486 2255433	VS Moosakutty Valiaveetil House Cheranellur 682 034 Ph. 0484 2431532
Rajagiri College of Engineering	Kerala Chemicals & Proteins Ltd.	

Kakkanad Cochin 683 104	Kathikudam Koratty 680 308	

Bamboo and Cane Club formation and publication of newsletter

A proforma was sent to the trainees and also the proposal to from a club was disseminated through media. About 165 persons expressed their interest in the formation of a club. Two meetings were conducted at KFRI, Peechi on 10th October and 29th November 2001. Eight agenda items (Appendix-12) were discussed in the meeting and different views were recorded. Guidelines for formation of the club were prepared.

To popularise prospects of bamboo and cane cultivation and exchange of information, a Malayalam newsletter on these aspects was planned.

Interaction meeting of Potential large-scale bamboo planters

A meeting of the potential large-scale bamboo planters (ready to plant more than 0.5 ha) was organized on 7th January 2003. For this, invitations were sent by KFRI to selected farmers. The theme of the meeting was, Potential of bamboo for large-scale planting and development of an action plan.

Results

Selection of interest groups

Selection of farmers clubs, NGOs, Youth clubs, Government agencies, schools and colleges was done from the responses received to the advertisements in various media. A total of 876 participants were selected for creating awareness about potential of bamboo cultivation and capacity building for bamboo and rattan cultivation. Programme schedule and Resource Persons who participated in the Training programme are given in Appendix 14. The details of the participants are given under Activity 8: Training. Trained farmers having land expressed their interest to cultivate bamboo and booking for planting stock was done. Farmers also showed interest to establish their own nurseries (Appendix–13) and undertake responsibility of distribution of seedlings in their respective localities.

Table 31. Categories of participants trained for taking up bamboo cultivation

Particulars	2000	2001	2002	Total
Members of NGO	56	50	175	281
Farmers	59	104	216	379
Others*	6	8	202	216
Total	121	162	593	876

* Includes officials like Krishi Vijnan Kendra, Yuvajana Kendra, Agricultural officers, Vegetable and Fruit Promotion Council of Kerala technical officers, Members of SHGs, etc.

Selection of species for cultivation in homesteads by interest groups

During the training programmes on 'Nursery and plantation techniques' under this project (Activity 8), participants were taken to the bambusetum at FRC, Veluppadam. After getting familiarized with the species available in the bambusetum, farmers gave their requirement for planting stock. The demand for planting stock is given in the order of preference (Table 32). Species that are in most demand are *Dendrocalamus giganteus, Thyrsostachys oliveri, Bambusa nutans, Dendrocalamus brandisii* and *Bambusa bambos.*

Table 32. Demand for planting stock of bamboo by interest groups

Sl. No.	Name of Bamboo Species	No. of planting stock required
1	*Dendrocalamus giganteus*	30233
2	*Thyrsostachys oliveri*	28875
3	*Bambusa nutans*	27535
4	*Dendrocalamus brandisii*	26432
5	*Bambusa bamboos*	16870
6	*Ochlandra travancorica*	4730
7	*Dendrocalamus membranaceus*	2936
8	*Bambusa balcooa*	1910
9	*Bambusa polymorpha*	1350
10	*Ochlandra travancorica* var. *hirsuta*	500
11	*Thyrsostachys siamensis*	480
12	*Dendrocalamus hamiltonii*	375
13	*Dendrocalamus strictus*	360
14	*Dendrocalamus longispathus*	337
15	*Pseudoxytenanthera ritcheyi*	322
16	*Pseudoxytenanthera stocksii*	240
17	*Bambusa vulgaris*	235
18	*Bambusa multiplex*	132
19	*Bambusa wamin*	40
20	*Ochlandra scriptoria*	27
Total		143919

Establishment of demonstration plots jointly with farmers

Eleven plots were established in collaboration with farmers/institutions who were ready to spare their land. The details of the species planted in each plot along with spacing, approximate area in hectare and type of planting are

given in Table 33. Only establishment of plots was completed during this phase. More number of plots with other species is required. Monitoring of survival and growth of propagules of different species in the demonstration plots needs to be taken up as a long-term activity. However, limited observations indicated good survival of the propagules especially one-year old seedlings planted during the onset monsoon. Age of the planting stock and planting season are two factors which affected establishment in the field.

In addition to the above demonstration plots, a programme for bamboo planting to stabilize riverbanks in Malappuram District (Kerala) was undertaken with people's participation. About 100 km length was planted with 35000 seedlings of *Bambusa bambos* and 5000 seedlings of *Ochlandra travancorica*. The performance of the seedlings needs to be evaluated during the next phase.

Table 33. Details of the species and type of planting in demonstration plots

Sl. No.	Name of species	No. of propag	Spacing (m)	Type of planting
Plot 1. Adv. K. E John. Nedumanni. Kottayam (0.46ha)				
1	*D. strictus* (seedlings)	250	3	Plot
2	*B. balcooa*	40	2	Border
3	*B. polymorpha*	15	4	River bank
4	*B. vulgaris*	500	4	River bank
5	*D. membranaceus*	45	4	Border
Plot 2. FCRI Kanjikode, Palakkad (1.19ha)				
1	*B. bambos*	500	3	Border
2	*T. oliveri*	25	In gaps	Mixed planting
3	*B. vulgaris* (green)	100	6	Border
4	*D. brandisii*	100	6	Border
Plot 3. C.D. Mannual, Palakkad (0. 27 ha)				
1	*D. strictus*	65	3	Border
2	*B. balcooa*	9	6 x 6	Plot
3	*D. membranaceus*	9	6 x 6	Plot
4	*D. brandisii*	9	6 x 6	Plot
5	*D. giganteus*	6	6 x 12	Plot
6	*T. oliveri*	9	3 x 3	Plot
7	*B. polymorpha*	9	3 x 3	Plot
8	*D. longispathus*	9	3 x 3	Plot
Plot 4. V. R. Bharathan, Nellikkad (0. 25 ha)				
1	*B. bambos*	100	5	Border
Plot 5. V.S. Subramanian, Vilayannur, Palakkad (0. 18 ha)				
1	*B. bambos*	70	5	Border
Plot 6. V.R. Subramanian, Vilayannur, Perumkunnam Palakkad (0. 20 ha)				
1	*B. bambos*	80	5	Border
Plot 7. V.K.Balakrishnan, Paruthipally Palakkad (0. 45 ha)				
1	*B. bambos*	125	5	Border
2	*D. strictus*	125	3	Border
Plot 8. V.C. Velayudhan Master, Paruthipully Palakkad (0. 45 ha)				
	B. bambos	125	5	Border
	D. strictus	125	3	Border

Plot 9. Thomas Jacob. Payyanam, Thrissur (0.09 ha)				
	B. balcooa	80	5	Border
Plot 10. Dr. Hydrose, Mulakkunnathukavu, Thrissur (0.826ha)				
1	*B. balcooa*	30	8 x 8	Plot
2	*D. brandisii*	30	8 x 8	Plot
3	*D. giganteus*	30	8 x 8	Plot
4	*D. strictus*	250	3	Border
Plot 11. Malankara Estate, Thodupuzha				
1	*Ochlandra travancorica*	200	4 x 4	River bank
Plot 12. Mr. Moosakutty, Cheranellur (0.84 ha)				
1	*D. giganteus*	30	10 x 10	Plot
2	*B. balcooa*	40	8 x 8	Plot
3	*D. strictus*	125	3	Border
4	*D. brandisii*	20	8 x 8	Plot
5	*D. longispathus*	5	5	Border
6	*O. travancorica*	30	3	River bank
Plot 13. Kerala Proteins and Chemicals Ltd. Cochin (0.49 ha)				
1	*B. balcooa*	30	5	Border
2	*B. striata*	20	5	Border
3	*B. vulgaris* (green)	60	5	Border
4	*D. strictus*	25	5	Plot
5	*D. brandisii*	20	5	Border
6	*D. longispathus*	20	5	Border
7	*O. ebracteata*	50	3 x 3	Plot
Plot 14. Rajagiri college of Engineering, Kakkanad, Cochin (0.19 ha)				
1	*B. balcooa*	20	5 x 5	River bank
2	*D. giganteus*	5	10 x 10	River bank
3	*D. brandisii*	10	5 x 5	River bank
4	*O. travancorica*	25	5 x 5	River bank

In addition to the above mentioned demonstration plots, planting stock of both bamboo and cane was provided to farmers/NGOs, institutions and local bodies (Table 34). Species-wise list and address of farmers provided with more than 20 propagules is given in Appendix–15.

Table 34. Number of farmers supplied with planting stock of bamboo and cane (District-wise)

Sl. No.	District	No. of Farmers	No. of Propagules		
			Bamboo	Reed	Cane
1	Thiruvananthapuram	1	37	35	33
2	Kollam	5	573	325	149
3	Alappuzha	4	181	113	213
4	Pathanamthitta	2	15	15	15
5	Idukki	23	601	135	443
6	Kottayam	32	669	57	347
7	Eranakulam	49	876	391	657
8	Thrissur	57	1686	482	663
9	Palakkad	15	3145	10	318
10	Malappuram	11	876	293	130

Total	304	8659	1721	2968

Planting stock supplied for river bank stabilization, demonstration plots and bulk planting by KFDC not included.

Bamboo and Cane Club formation

From the discussions held in the meeting convened, a three level structure was proposed for the bamboo and cane club. It consists of an Apex Club at KFRI, Peechi, District Clubs at District HQ or any suitable location and Village Clubs in villages associated with cane and bamboo. The guidelines for formation of club were drafted. Since the formalities and registration were not over during this phase due to technical problems, the programme has to be continued during the next phase. However, as per the decision made in the meetings a newsletter in vernacular language (*Malayalam*) viz., "*Muladwani*" [voice of bamboo] about cane and bamboo was brought out (Appendix – 16). The first issue was released in a simple function on 31st December 2001 at KFRI. The Director, KFRI distributed the first copy to Smt. Pushpakumari, Secretary, Aiswarya Swashraya Sangam, Peechi who is an active partner in nursery programmes.

Interaction meeting of potential large-scale planters

Following decisions were taken in the interaction meeting of 30 potential large-scale farmers. (The minutes of the meeting are given in Appendix–17.)

1. To prepare a Bamboo plantation project with the help of KFRI and make it bankable.

2. To establish an Association of Bamboo Growers. (The nature and character of the same of be fixed by a subcommittee.)

3. To entrust Sri. C.A. Abraham to coordinate the activities.

Of the 30 participants, 22 expressed their readiness to take up bamboo cultivation (Table 34). About 25 hectares of land was offered which will be sufficient to plant about 10000 seedlings at a spacing of 5 m x 5 m.

Table 34. Details of planters, area offered and number of propagules

Sl. No.	Name	Area proposed to plant (ha)	No. of propagules*
1	Dr. P.H. Hydrose	1.2	480
2	Mr. Mohammed Saheer	1.2	480
3	Mr. O. Sharif	0.5	200
4	Mr. Kurien Francis	0.5	200
5	Mr. John Maliakal	0.5	200
6	Mr. A.G. Rammohan	0.5	200
7	Mr. Chandrasekharan	2.2	880

8	Mr. Sebastian J. M	0.5	200
9	Mr. George Kurien	4	1600
10	Mr. K.C. Francis	1	400
11	Mr. K.J. George	0.5	200
12	Mr. V.C. Krishnankutty	2.2	880
13	Mr. G. Anandakuttan	1.2	480
14	Mr. S. Pushkaran	1.2	480
15	Mr. P.Chamukkan	1	400
16	Mr. K.J. Thomas	0.5	200
17	K.V. Kuriakose	0.5	200
18	Mr. Philip Joseph	2.2	880
19	Mr. Syed Muhammed	1	400
20	Mr. K.C. Paul	1	400
21	Mr. Jose P. Joseph	1.2	480
22	Mr. P. Balachandran	0.5	200
Total		25.1	10040

* Calculated @ 400 propagules/ha (spacing 5 m x 5 m) and will vary according to species selected

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OIL CURING OF CANES: TRASFER OF TECHNOLOGY IN KERALA AND NORTH-EAST

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Abstract

Oil curing is a post-harvest processing technique that has to be applied immediately after harvesting the canes for improving the colour and for reducing the susceptibility of the green canes to fungal attack in the field conditions. Curing in a 9:1 mixture of hot diesel and coconut oil or kerosene alone will impart an ivory white colour, which enhances the value of rattan products in domestic as well as export market. The immediate reduction in moisture content of the freshly harvested rattans due to curing in the hot oil will help in reducing the chances of fungal attack.

Recently, the Kerala Forest Research Institute (KFRI) has standardised the curing system and conditions. It was intended to transfer the technology to the user communities in Kerala as well as the cane rich North-East India through extension activities of the present project. The cane curing system was modified to incorporate fire-safety measures and newly designed equipments were fabricated to install one unit at Nilambur, Kerala and another at Tipi, Arunachal Pradesh, where proximity to cane harvesting areas exists. A handbook entitled, "Oil curing technology for value-added rattan (cane) products," was published (Appendix - 18) and Workshops and Field Demonstrations were conducted in both the places and the technology was successfully transferred to cane harvesters, processors, traders, product manufacturers, co-operative and charitable societies, NGOs, entrepreneurs and the Government Departments concerned and Agencies. Live demonstration of the curing process convinced the potential of the technology for adding value to the raw material to be able to compete in international rattan trade.

For the follow-up action in Kerala, a charitable society, "CANEFED", was established to increase the awareness, to pursue the goal of implementing cane curing process and to introduce low cost mechanization in downstream processing. For popularisation of the technology in the North-East, State Forest Research Institute (SFRI), Arunachal Pradesh was identified as the nodal agency. Follow-up extension activities such as multiplying the cane curing units in other rattan harvesting regions were initiated by SFRI. As the North-Eastern Handicrafts and Handlooms Development Corporation (NEHDC), Shillong could be another end-user agency to organise curing of canes for the entire North-Eastern region, interactions were held.

Introduction

One major problem in rattan trade is that the quality of Indian rattan products is poor compared to that of South–East Asian products. This is not due to the poor quality of the raw material, but due to the poor processing practices followed. However, there is already an awareness that with appropriate preliminary processing techniques and with the application of simple processing tools, devices and equipments, the quality of Indian rattan products could be improved in order to compete in the domestic as well as export market (Bhat, 1996).

One processing technique for improving the appearance and finishing of rattan products is curing freshly cut green canes in hot oil/oil mixtures. The advantages of oil curing are recognized as: (a) obtaining an ivory white colour (which is more desirable for export market) due to the conversion of chlorophyll into pheophytins in the stem skin, (b) rapid reduction of the moisture content in rattans (which will help to reduce the chances of immediate fungal infestation after harvesting) and (c) removal of waxy or gummy/mucilaginous substances for better appearance and for better finishing qualities. The canes need to be oil cured within 2–4 days after harvesting.

In the year 1989, Kerala Forest Research Institute, in collaboration with Karnataka Forest Department, standardized the oil curing technology for quality improvement of the raw material in the manufacture of handicraft and furniture of high aesthetic value (Yekantappa *et al*., 1990; Dhamodaran and Bhat, 1995a&b). Field demonstrations of oil curing of canes, conducted by the Kerala Forest Research Institute (KFRI) in 1992, for quality improvement of cane furniture/handicraft products received tremendous response from the small-scale/cottage type and larger industries alike. While many major cane traders from Kolkata and the Andaman regions now choose to supply oil-cured canes for manufacture of quality products, several units in the country have planned to modernise the processing factories with the technical advice from KFRI and with the financial support of rural institutions like Khadi and Village Industries (Bhat, 1994). One of the beneficiaries of cane research and training programme of KFRI currently manufactures high quality furniture and cane craft for the house-boats and holiday resorts which aim to preserve the aesthetic cultural value and indigenous resources to promote eco-tourism in Kerala (Fig. 1).

In addition, many State Forest Departments have acknowledged the improvement of cane quality by oil-curing at the extraction sites. While Karnataka Forest Department has already made a significant headway in

adopting curing technology near the extraction site, Kerala Forest Department has agreed in principle to take over the direct control of rattan extraction from the current practice of leasing to tribal societies for the following reasons:

- More judicious and scientific extraction followed by oil-curing for rational supply of quality raw material to various manufacturing units.

- Rural communities who are socially and economically weaker sections of the society can derive greater benefits of full collection charges without the involvement of middlemen.

Objectives

The specific objectives of this component of the project were:

- To set up cane curing facilities (units) and impart training in Kerala and North-East India

- To provide training to entrepreneurs and artisans in oil curing of canes

Methodology and Results

Consultations with the cluster groups in Kerala revealed that Nilambur (Malappuram District) could be the right place to install the first model cane curing unit in Kerala and for effective control over the processing practices, the first model cane curing unit for Kerala was installed in the KFRI Sub-Centre campus at Nilambur. The main consideration for the selection of site was the proximity/access to rattan harvesting sites in the region.

After consultation with the scientists of North-East India, State Forest Research Institute (SFRI), Itanagar, Arunachal Pradesh was identified as the nodal agency for extending the cane curing technology to the North-Eastern region. Accordingly, Tipi, Arunachal Pradesh was selected as the site for establishing the cane curing unit, as this place is in close proximity to rattan harvesting areas with a working unit of the Arunachal Pradesh Cane and Bamboo Federation. This Society was identified by SFRI as the first beneficiary of transferring the technology through installing a unit at Tipi.

Installation of Cane Curing facility in Kerala

For the application of the cane curing technique the basic infrastructural requirement is a curing tub of appropriate length (8–12 or 16 ft length, 2.5 ft width, 2.5 ft height, 2–4 mm thickness, made in mild steel).

The first design of the curing system was of a mud-hearth type using firewood as the heat source (Fig. 2). This had the disadvantage of least fire-

safety measures in view of possibility of exposure of the extremely volatile hot oil vapour to the open flame/burning sparks from the firewood and the consequent fire hazards. Later, the design of curing tub has been modified keeping the fire safety uppermost in mind. The new curing tub was designed in such a way that kerosene can be used as the source of heat. Three kerosene burners are placed at equidistance below the tub for heating and are concealed within a bracket to avoid the contact of direct flame with oil mixture (Fig. 3). The dimensions of the curing tub are illustrated in Fig. 4.

A nomad type cane curing unit using kerosene pressure stove as the heat source was established in the KFRI Sub-Centre at Nilambur, in view of proximity to the cane extraction areas (Fig. 3). A mixture of 9:1 by volume diesel and coconut oil was used as the curing medium. A curing temperature below boiling conditions was maintained to avoid drying defects in the cured canes. Optimum curing periods of 20 minutes for the small, 30 minutes for medium and 45 minutes for the large diameter rattans, as suggested by Dhamodaran and Bhat (1995b), were followed for ensuring that the processing practices are not affecting the utilization value adversely. The cured canes were cleaned by rubbing with gunny cloth before sun-drying for a week to impart excellent ivory white colour (Fig. 5). The oil-cured canes were sized by end trimming, before bundling for storage and transportation.


Fig. 1.Oil-curing adds value to the furniture, handicrafts and traditional houseboats in eco-tourism industry in Kerala


Figure 2. The mud-hearth type design of the cane curing system, using firewood as the heat source



Fig. 3. Nomad type Cane Curing Unit for field demonstration at KFRI Sub-Centre, Nilambur, Kerala

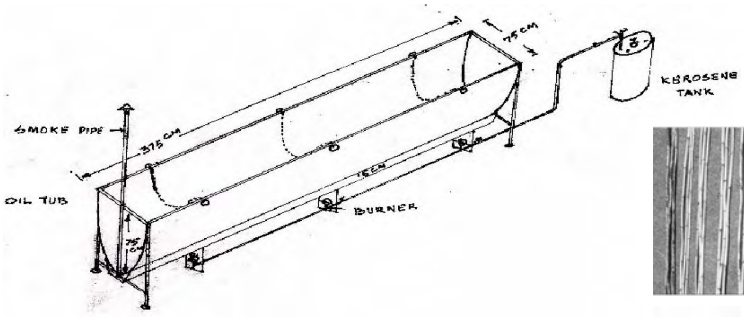

Fig. 4. Illustration of the newly designed curing tub

Fig. 5. Comparison of colour of cured canes with control samples (**extreme left)**

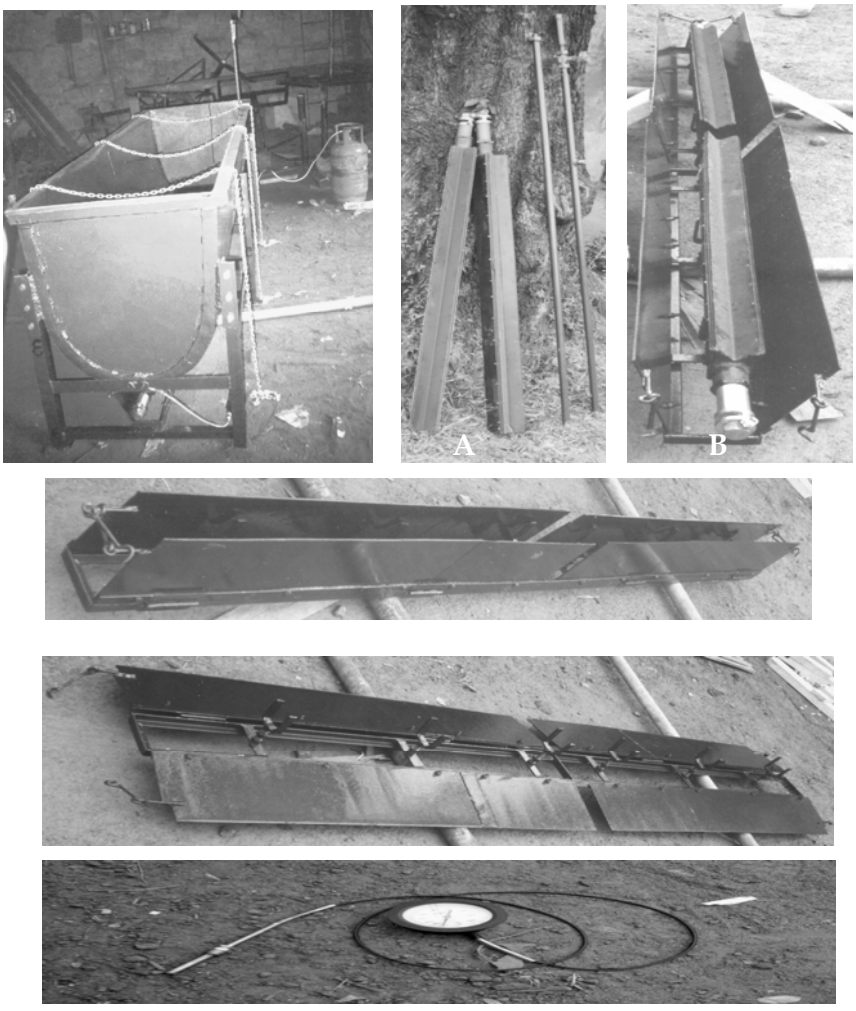

Fig. 6. Improved version of the cane curing unit (installed at Arunachal Pradesh) using LPG as the heat source. A – Curing Tub; B – Longitudinal burners and gas pipes; C – Longitudinal gas burner fitted inside the fire- bracket; D & E – Fire-bracket in the closed and open positions respectively; F - Dial type thermometer probe.

Cost structure of cane curing

The cost estimates indicate the economic viability of the cane-processing programme before the supply to manufacturers (Table 1).

Table 1. Cost Structure of Extraction and Cane Curing (Nilambur, Kerala) during March 2001

Item No.	Items	Quantity	Cost (Rs)
	Non-recurring cost for (2,75,000 canes)		
1	Curing tub (366cm x 76.2 cm top width x 30.5 cm bottom width x 76.2 cm height)	1	19,500
2	Accessories (pressure /drainage pumps)	1	670
3	Miscellaneous (barrels, knives, gunny cloths, temporary installation cost including labour, etc.)		5000
4	**Total**		25,170
	(a) Recurring Cost (1000 canes)		
5	Diesel	180 litters	3420
6	Coconut oil	20 litters	700
7	Kerosene oil	30 litters	540
8	Labour charges (cutting, bundling, transportation to road side, etc.)	36 man days	3600
9	Transportation to curing site + labour (boiling, drying, watch & ward, etc.)		2000
10	Price of Large canes (Extraction site)	1000 @Rs.20	20000
11	Total		30260
12	Cost of oil curing process (Total cost –item no 8 and 10)		**6660**
13	Depreciation Allowance (Non-recurring) 91.5 (25,170/275,000x1000) (92.00)		
14	Total (item 12+ 13)	6660+92=6752	
15	Additional Cost for 1000 canes (Item 14 - the cost of Rs. 1000 for clearing & drying in traditional processing method)	6752-1000 **5752(29%)**	

The additional cost estimated in cane curing within the limits of Rs. 5.75/- for a large diameter cane (29% of the original value) which is well justified in the context of improved quality and ready acceptance by the manufacturers.

Training in the Modified Nomad type Cane curing Unit

A One-Day Field Demonstration-cum-Training Programme was conducted on 16th March 2001 at the KFRI-Sub Centre, Nilambur, Kerala (Fig. 7 and 8) for the benefit of traders, rural artisans and cane entrepreneurs, to introduce oil-cured high quality cane raw material which is free from fungal discolouration, in the manufacture of bright/ivory-white coloured cane

furniture and handicraft products of better aesthetic value. Twenty trainees from Kerala participated. A special beneficiary from the Institute of Rain and Moist-Deciduous Forests (IRMDF), Jorhat, Assam also participated and trained in this programme to absorb and adopt the simple rural technology for the North-East India, the main source of cane supply in the Country, besides the Andamans.

Outcome of Field Demonstration/ Training Programme

A special session was held to receive feedback from the trainees. Trainees felt that oil-curing of canes would enhance the value of raw material and contribute to value-addition. A strong recommendation was that oil curing of canes be made mandatory near the cane extraction sites before the supply to manufacturers and immediate action should be initiated to adopt this simple technology through cooperative institutional support.

To facilitate the implementation of cane curing process, it was resolved that:

1. State Forest Departments of cane growing States be urged to make an agreement with the Federation of SC/ST cane extracting Societies for adoption of cane curing technology before permitting the extraction.
2. A charitable society by name "Canefed" be established with the participation of traders and manufacturers with the technical advice from KFRI scientists in order to establish a tie up and trading relationship with the local Federations of cane extraction Societies in North-Eastern states and the Andamans who engage themselves in cane extraction.
3. Institutional support should be sought for establishing Common Facility Centres for the small-scale manufacturers to have access to simple machineries in the conversion process of oil-cured canes and manufacture of quality craft products for export purposes.

Follow-up Action

1. As a follow up action, a charitable society, "CANEFED", was established to increase the awareness and pursue the goal of implementing cane curing process and introduction of low cost mechanisation in down-stream processing with the involvement of KFRI scientists and cane traders/entrepreneurs (Fig. 8).
2. As an extension activity of the project, technical advice was rendered to North-Eastern Handicraft and Handlooms Development Corporation Limited (NEHDC), Shillong, Meghalaya for establishing cane curing facilities and training in curing techniques.

Figure 7. Training imparted at KFRI Sub-Centre, Nilambur

Fig. 8. Field Demonstration of Oil curing of Canes

Fig. 9. Core-committee of CANEFED constituted during the Training Programme with cane traders, entrepreneurs and the scientists of KFRI and IRMDF

Installation of Cane Curing Unit in Arunachal Pradesh

Even though the North-eastern states in general and Arunachal Pradesh in particular, are rich in rattan resources of the country, oil curing technology for value-addition of the raw material was not known in the region. In this context, it was decided to install an upgraded cane curing unit in Arunachal Pradesh as a model for transfer of technology and for demonstration and training to the entire North-eastern region.

The pressure-kerosene stove and tub system (installed at Nilambur, Kerala) has the limitation that it can use only round burners. This can lead to excessive local heating, which again can cause hazardous situations. In the latest version of the cane curing tub, it was possible to overcome the above limitation by the use of longitudinal gas burners which can use LPG (Fig. 6). Here again, the entire burners are concealed within fire-brackets which will prevent the exposure of open flame to volatile oil fumes from the curing tub. Further, in case of emergency, the entire supply of LPG can be cut off by the use of a single control valve. A dial-type thermometer was also attached with the tub in this model. This can further help to indicate the use of appropriate hot oil mixtures to avoid the wrinkling of rattan stems thereby reducing the drying defects. The processing schedules developed by Dhamodaran and Bhat (1992; 1995a) mentioned earlier can be employed for the treatment of rattans. The use of kerosene alone as the cooking medium was suggested (Dhamodaran and Bhat 1992) for the unit installed at Arunachal Pradesh, since local availability of coconut oil would be a problem.

Popularisation of the Technology and Training in the North-East

To transfer the oil-curing technology to the rattan rich North-eastern states, a Training Workshop on "Oil curing of Rattans" was conducted at Tipi, Arunachal Pradesh on 29th September 2001 in collaboration with State Forest Research Institute, Itanagar, Arunachal Pradesh. The cane curing equipment designed and fabricated at KFRI, was transported and installed at Tipi, Arunachal Pradesh. The cane curing equipment was handed over to the 'Cane and Bamboo Federation of Baleukpong, Arunachal Pradesh', the traditional cane processors of the region.

The Cane Curing Unit as well as the Workshop was inaugurated by the Minister of Forests, Arunachal Pradesh (Fig. 10). Live demonstration of oil curing of canes was organised for training the Arunachal Pradesh Cane and Bamboo Federations' (APCBF) personnel to show the benefits of the process. A total of about 200 persons participated in the Workshop. Participants included rattan furniture and other handicraft products manufacturers, traders, representatives of industries and industrial co-operative societies, artisans, NGOs, Officers of the Forest as well as Industries Departments of the State and entrepreneurs.

Feed back and Follow-up Action from the North-East

Based on the evaluation of benefits of cane curing, strong political and public will for wider implementation of cane curing process near the extraction sites in Arunachal Pradesh was evident from the attendance of the Chief Minister with the Forest Minister and the Minister of State for Agriculture and large number of local leaders and Government officers on the following day after inauguration of the Unit (30th September 01). The Government of Arunachal Pradesh is understood to plan for establishing more such units in the State.

The successful extension of the technology in Arunachal Pradesh will popularise the system in the entire North-Eastern region. The North-Eastern Handicrafts and Handlooms Development Corporation Ltd. (NEHDC), Shillong, Meghalaya as well as the State Forest Research Institute, Itanagar, Arunachal Pradesh have shown keen interest in adopting the technology in other parts of the North-Eastern region.

Conclusions

Setting up of the cane curing units in Kerala and Arunachal Pradesh and the Workshops and Field Demonstrations of the cane curing technique convinced cane entrepreneurs to change the public opinion about the poor quality of Indian rattan products, provided the curing technique is applied at the right instance (immediately after harvesting the rattans).

The modified design of the curing tub has been effective to improve fire-safety measures in working with petroleum oils in hot condition, used for curing.

The charitable society, "CANEFED", established for increasing the awareness and pursuing the goal of implementing the curing process and introduction of low cost mechanization in the downstream processing, needs to be strengthened. Similar to other Government motivated agencies such as the Rubber Board, Coffee Board, Spices Board, Coconut Development Board, Bamboo Board, Coirfed, Consumerfed, etc., there is a need for a Board/Federation for promoting/encouraging the attempts for improved product quality. The newly formulated 'CANEFED can serve the purpose, provided the institutional support is forthcoming from Government programmes in the right channel.

Common Facility Centres (CFC) need to be established for extending/ transferring the processing technologies and for sharing the machinery facilities for improved product quality.

Follow-up actions in the rattan rich North-eastern region should be undertaken by agencies like SFRI, Arunachal Pradesh and NEHDC, Shillong.

Fig. 10. Inauguration of the Cane Curing Unit and the Workshop on 'Oil– curing of Rattans', at Tipi, Arunachal Pradesh on 29th September 2001, by Sri. Nabam Tuki, Hon'ble Minister of Forests, Arunachal Pradesh.

More cane curing units need to be installed in all the NE States following Field Demonstration and Training in this region. As the curing process needs to be done immediately after harvesting, awareness needs to be generated among the rattan harvesting agencies by means of conducting more Workshops, Field Demonstrations and Training.

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PUBLICITY AND AWARENESS

Sankarapillai K[1], Sarojam N [1], Hussain KH [1], George KF [1],
Gnanaharan R [2], Mohanan C [3], Bhat KM [4], Damodharan TK[4],
Pandalai RC [5], Renuka C [6] and Seethalakshmi KK [7]

[1]- Library, [2]- Research Monitoring and Evaluation, Divisions of [3] - Plant Pathology, [4] - Wood Science, [5] - Silviculture, [6] - Botany and [7] - Plant Physiology

Abstract

Research Institutions, Forest and Agricultural Departments and Universities have generated a wealth of information on bamboo and cane. This needs to be compiled and made user friendly to promote cultivation and utilization. During this programme experts in relevant fields were identified and handbooks, directory and bibliographies were prepared. Handbooks on species used in handicrafts, Nursery and Silvicultural techniques, Micro-propagation, Oil curing of rattans for value addition, Preservative treatments and Information resources for bamboo and cane development have been published. Part of the information was the outcome of some of the activities of this project and the rest is compiled from literature and from the field experience of experts involved. Two annotated bibliographies covering the world literature on bamboo and rattan were also prepared which serve as a ready reference to get an overview of the growth of literature, species specific and regions specific publications. Also this will serve as a ready reference to avoid duplication in research and find out the information gaps for future researchers. The extensive work KFRI had undertaken on bamboo and rattan has been made available to user groups all over the world through a website launched specially for bamboo and rattan which is linked to KFRI website.

Introduction

Information on various aspects of bamboo and cane has to be made user friendly and easily accessible to promote cultivation and utilization. Research organizations, Forest and Agricultural Departments and Universities have generated a wealth of information on these species. But they are scattered in several scientific papers, technical reports and books and most of them are not available to the stakeholders directly involved in the field of cultivation and processing. Lack of awareness about the potential of these plant groups is one of the reasons for slow progress in enhancing resources through organized cultivation and value added utilization. This programme was undertaken to compile published information and field experience of technical experts to prepare handbooks in selected topics required by the user groups, to provide information on bamboo and cane in Kerala and annotated bibliographies on both cane and bamboo covering world literature. In addition, a website exclusively on bamboo and cane research at KFRI was also envisaged for sharing the information generated through multidisciplinary research.

Objective

To prepare information bulletins and handbooks on cultivation, management and utilisation of canes and bamboo species used in handicrafts

Methodology

Preparation of handbooks
Scientists from KFRI having experience on various fields of bamboo and cane were identified and responsibilities were assigned to prepare eight handbooks on the following topics.

- Commercial Rattans of Kerala
- Commercial Bamboos of Kerala
- Nursery and Silvicultural Techniques for Rattans
- Nursery and Silvicultural Techniques for Bamboos
- Micropropagation of Bamboo and Rattan
- Oil Curing Technology for Value-added Rattan (Cane) Products
- Preservative Treatment of Bamboo and Bamboo Products.
- Protection of Rattan against Fungal Staining and bio-deterioration.

The material for some of the handbooks like commercial bamboos, rattans etc were based on the information generated during this project while other books were prepared from the information generated during previous projects and from available literature.

Annotated Bibliographies

KFRI Library professionals were assigned with the preparation of annotated bibliographies of bamboo and cane covering world literature. The database developed by BIC-India, KFRI, TREE CD, CAB, AGRIS databases, bibliographies, workshop proceedings, research reports etc. have been referred to collect literature on both bamboo and rattan. Decade-wise analysis of the growth of literature at during 20th century (starting from 1900 to 1999) has been done. The bibliography is arranged alphabetically by authors name under major subject headings.

Results

Handbooks

Following eight handbooks were published during various activities of the project.

1. **Commercial Rattans of Kerala** (2002). KFRI Handbook No. 10. Kerala Forest Research Institute, Peechi; Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 26p (Appendix-2).

2. **Commercial Bamboos of Kerala** (2002). KFRI Handbook No. 12. Kerala Forest Research Institute, Peechi; Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 20p (Appendix-5).

3. **Nursery and Silvicultural Techniques for Bamboos** (2002). KFRI Handbook No. 18. Kerala Forest Research Institute, Peechi; Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 40p (Appendix-7).

4. **Nursery and Silvicultural Techniques for Rattans** (2002). KFRI Handbook No. 14. Kerala Forest Research Institute, Peechi; Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 8p (Appendix-8).

5. **Micropropagation of Bamboo and Rattan** (2002). KFRI Handbook No 15. Kerala Forest Research Institute, Peechi; Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 20p (Appendix-11).

6. **Oil Curing Technology for Value-added Rattan (Cane) Products** (2002). KFRI Handbook No. 11. Kerala Forest Research Institute, Peechi;

Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 8p (Appendix-18).

7. **Preservative treatment of bamboo and bamboo products** (2002). KFRI Handbook No. 16. Kerala Forest Research Institute, Peechi; Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi. 8p (Appendix-26).

8. **Protection of Rattan against fungal staining and bio deterioration** (2002). KFRI Handbook No. 13. Kerala Forest Research Institute, Peechi Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi 9 p (Appendix-27).

Directory

A directory on information resources on bamboo and cane in Kerala containing details on species available, address of farmers, nurseries, demonstration plots, development offices, wholesale dealers, industries, NGOs, shops, researches and artisans in Kerala. Besides, general information like source of seeds, machineries, diseases etc. is also provided with. Selected bibliographies on both bamboo and rattan are included for ready reference.

Information Resources on Bamboo and Cane Development in Kerala (2002). Kerala Forest Research Institute, Peechi Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi (Appendix - 26).

Annotated bibliographies

Annotated Bibliography on bamboos

A total of 2793 references starting from the year 1832 are available on bamboos. Decade wise analysis of the information flow in 20th Century showed that major contributions came from 1970 onwards. Subject-wise analysis showed the dominance of taxonomy, silviculture, vegetative propagation and tissue culture references. Country wise and topic wise analyses are presented in the introduction of the bibliography. The information collected was published as a handbook and details given below.

Annotated bibliography of Bamboos (2003). Kerala Forest Research Institute, Peechi Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi 362p (Appendix-29).

Annotated Bibliography on rattans

Totally 876 references are arranged subject-wise in the rattan bibliography. Earliest paper on rattan appeared in the year 1903. Similar to bamboos increase in number of publications on rattan was on the increase from 1970 onwards. The details have been published as a handbook given below.

Annotated Bibliography on Rattans (2003). Kerala Forest Research Institute, Peechi Development Commissioner (Handicrafts), Ministry of Textiles, Government of India and United Nations Development Programme, New Delhi 155p (Appendix-30).

Web site

A website on bamboo and cane was developed and linked to the existing KFRI website - www.kfri.org. A button is provided in the home page of the KFRI website to go to the page of bamboo and rattan. The web contains information on the major contributions of Kerala Forest Research Institute in the field of bamboo and cane research, significant achievements, ongoing and completed projects, and list of publications (Appendix-31).

APPENDIX - 29

Kerala Forest Research Institute
Bamboo and Rattan Research

Top

Kerala Forest Research Institute realizing the need to protect and enhance the dwindling bamboo and rattan resources, started research work on various aspects of bamboo and rattan in the early eighties with a phased multidisciplinary programme sponsored by International Development Research Centre (IDRC), which continued until 1995. In the mean time several other programmes were taken up with the assistance of various state, national and international organizations and they have been successfully completed. Details of research undertaken so far on bamboo and rattan and the achievements made by KFRI are included here.

For more information, please contact Dr. J.K.Sharma, Director. Email jksharma@kfri.org or scientists concerned.
Please contribute a copy of your publications on bamboo and rattan for documentation and dissemination.

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Bamboo

Achievements

- A resource survey of bamboos occurring in Kerala has been conducted and a distribution map prepared. Bamboo specimens from different phytogeographic regions of India, including the Andaman Islands have been collected.
- Bamboo herbarium with specimens of 75 Indian bamboo species belonging to 20 genera has been established. Cibachrome sheets of Type specimens obtained from various National and International herbaria like CAL, MH, PBL, K, US and P of 50 species are deposited in the herbarium. Seven holotype

specimens are also deposited in the herbarium.

- Taxonomic revision of four genera of Indian bamboo has been completed. Seven new descriptions, three new genera and one rediscovery have been reported. Nomenclatural update of 16 species and six new combinations has been made.
- A database on bamboo taxonomy and utilization has been developed.
- A pictorial field key for identification of native bamboos of India has been prepared.
- Storage techniques have been developed for increasing the shelf-life of bamboo seeds.
- Vegetative propagation methods have been standardised for several species of bamboo.
- Micropropagation methods have been standardised for several species of bamboo.
- A germplasm collection of 64 bamboo species has been established.
- Homesteads have been found to produce more bamboo than the forests in Kerala.
- Nursery technology has been developed for raising seedlings of different species of bamboo.
- Fertilizer dosage for *Bambusa bambos* has been standardised.
- Plantation trials of bamboo to prevent soil erosion in hill slopes, river banks etc. have been conducted.
- Growing stock of bamboo in Kerala has been estimated.
- A model for predicting the bending strength of bamboo from outer diameter and density has been arrived at.

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Projects

Ongoing Research Projects
Completed Research Projects
UNDP Projects
IDRC Projects
Bamboo Information Centre - India

Ph.D Programmes

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Ongoing Research Projects

Taxonomy
Genetic Conservation
Silviculture
Utilization

Taxonomy

Reversionary studies on four genera of Indian bamboos

Objectives :

1. Taxonomic revision of four genera of bamboos
2. Setting up a bamboo herbarium
3. Publication of a taxonomic monograph of the genera studied

Principal Investigator: Muktesh Kumar

Taxonomy of bamboos (Component of an All India Coordinated Project, Coordinated by Dr. V. J. Nair, Emeritus Scientist, Botanical Survey of India (Southern Circle), Coimbatore

Objectives:

1. Survey, collection, identification and preservation
2. Maintain collection and taxonomic data bank
3. Develop identification manual
4. Train college teachers and students and local communities in para taxonomy

Principal Investigator: Muktesh Kumar

Genetic Conservation

Conservation and genetic improvement of reed bamboo (*Ochlandra* species)

Objectives:

5. To establish a live collection of all the species of *Ochlandra* at least in two locations
6. To select phenotypically superiors clump of *Ochlandra travancorica* and *O. scriptoria* from natural stand and multiply by rhizome or culm cutting and establish a germplasm
7. Using molecular markers screen the different species to see whether it is feasible to use this method to supplement information for easy identification of various species. Also to screen the germ-plasm with the same techniques to see the genetic variation between clones

Principal Investigator: Seethalakshmi, K.K.

Establishment of a bamboo stand for conservation and sustainable utilization of Arayambu (*Pseudoxytenanthera bourdilloni* (Gamble) Naithani

Objectives:

8. Establishment of a bamboo stand of this rare endemic bamboo (Arayambu) for commercial exploitation
9. To standardize the vegetative propagation methods for establishing plantations
10. Adopt simple macro-propagation techniques for large-scale multiplication of this species

Investigators: Muktesh Kumar; Seethalakshmi, K.K.

Silviculture

Establishments of a pilot scale bamboo stand for edible shoot production in Kerala

Objectives:

4. Introduction of edible bamboos from different parts of India
5. Establishment of bamboo-shoot stand by planting the seedling in a suitable area
6. Study the feasibility of production of edible bamboo shoot for conservation

Principal Investigator: Muktesh Kumar

Utilization

Introducing mechanical slivering techniques in traditional reed industry – A techno-economic study

Objectives:

3. Technological evaluation of mechanical slivering process and treatment of slivers and their storage
4. Socio-economic evaluation of using mechanically produced slivers *vis-a-vis* manually produced slivers in mat weaving

Investigators: Gnanaharan, R; Mammen, C; Kurian, A.K.

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Completed Research Projects

General

Species utilisation database for bamboo and rattan. Seethalakshmi, K.K; Muktesh Kumar; Renuka, C; Gnanaharan, R; Rajan, A.R., *KFRI Consultancy Report 3, 2002*

Preparation of the state of the art reviews with annotated bibliography on different aspects of bamboo

1. **Bamboo agroforestry and other smallholder plantation techniques.** Chandrashekhara, U.M; Hussain, K.H
2. **Dendrocalamus strictus**. Seethalakshmi, K.K; Sankara Pillai, K.
3. **Pulp, paper and rayon**. Dhamodaran, T.K; Gnanaharan, R; Sankara Pillai, K,
4. **Bambusa bambos (L.)**. Muktesh Kumar; Sarojam, N.
5. **Management of natural sympodial bamboo stands and plantations**. Pandalai, R.C; Sarojam, N.

Intercropping

Ecological studies on *Bambusa arundinacea* (Retz.) Willd. growing in teak plantations of Kerala, India. Chandrashekara, U.M**,** *KFRI Research Report 107, 1996.*

Soil Science

Prospects of reed bamboo (*Ochlandra travancorica*) for soil conservation in degraded sites. Sujatha, M.P; Thomas, T.P; Sankar, S., *KFRI Research Report 226, 2002.*

Taxonomy

Revisionary studies on four genera of Indian bamboos. Muktesh Kumar. (Report under preparation)

Genetic Conservation

Conservation and genetic improvement of reed bamboo *(Ochlandra* species). Seethalakshmi, K.K.

Establishment of a Bamboosetum in the Institute. Surendran, T; Chacko, K.C; Gopalakrishnan Nair, N; Muhammad, E. *KFRI Research Report 84, 1991.*

Establishment of a pilot-scale bamboo stand for edible shoot production in Kerala. Muktesh Kumar.

Germplasm collection and growth studies of selected bamboo species suitable for the region (Western Ghats). Pandalai, R.C; Muktesh Kumar; Bhat, K.V.

Anatomy

Anatomical changes associated with culm maturation in *Bambusa bambos* and *Dendrocalamus strictus*. Bhat, K.V., *KFRI Research Report 216, 2001.*

Flowering

Bamboo flowering. *Seethalakshmi, K.K.*

Silviculture

Investigations on the possibility of vegetative propagation of bamboos and reeds by rooting stem cuttings. Surendran, T; Seethalakshmi, K.K., *KFRI Research Report 31, 1985.*

Mass multiplication of selected bamboos by macro-propagation. Seethalakshmi, K.K.

Propagation of medicinal plants, bamboo and rattan by tissue culture. Muralidharan, E.M., *KFRI Research Report 87, 1995.*

Supply of planting materials of bamboo. Seethalakshmi, K.K.

Harvesting trials on bamboos. Pandalai, R.C.

Post harvest manuring in *Bambusa bambos* plantation. Thomas, T.P., *KFRI Research Report 179, 1999.*

Resource Economics

Rural Institutions for Development of Appropriate Forestry Enterprises: A Case Study of the Traditional Reed Industry in Kerala State, India. Nair, C.T.S; Muraleedharan, P.K., *KFRI Research Report 18, 1983.*

Socio-economic and ecological aspects of developing bamboo resources in homesteads of Kerala. Part 1. Ecological and social aspects. Chandrasekhara, U.M; Sankar, S; Gnanaharan, R., *KFRI Research Report 125(1), 1997.*

Socio-economic and ecological aspects of developing bamboo resources in homesteads of Kerala. Part 2. Economic and management aspects. Krishnankutty, C.N., *KFRI Research Report 125(2), 1998.*

Survey and estimation of bamboo resources of Kerala. Nair, P.V; Menon, A.R.R; Krishnankutty, C.N., *KFRI Research Report 221, 2001.*

Volume-weight relation of stacked bamboo and reed. Krishnankutty, C.N., *KFRI Extension Report 02, 2003.*

Diseases/insects

Disease of bamboos and rattans in Kerala. Mohanan, C., *KFRI Research Report 98, 1994.*

Preliminary investigations on the biology and control of beetles damaging stored reed. Nair, K.S.S; Mathew, G; Varma, R.V; Gnanaharan, R., *KFRI Research Report 19, 1983.*

Utilization

Bamboo shelter: A demonstration of best constuction practice. Assessment of economic feasibiligy and socio-cultural acceptability of bamboo-based architecture: A study in Kerala, Karnataka and Orissa states (Component 1). Anitha, V; Muraleedharan, P.K., *KFRI Research Report 177(1), 2000.*

Bamboo shelter: A demonstration of best construction practice (Component 2) Review of preservative treatement methods for bamboo. Gnanaharan, R., *KFRI Research Report 177(2), 2000.*

Tools/equipments

Local tools, equipment and technologies for processing bamboo and rattan. Gnanaharan, R; Mosteiro, A.P., *INBAR Publication, 1997.*

Development of appropriate tools for harvesting reed bamboos. Pandalai, R.C; Bhat,K.V., *KFRI Research Report 170, 1999.*

UNDP Projects

Resource enhancement and processing of cane and bamboo species suitable for handicrafts

The Ministry of Textiles, Government of India, initiated a scheme for improvement of cane and bamboo sectors under Fibers and Handicraft Development Program with the financial assistance from United Nations Development Program (UNDP) during 2000-2002. The scheme addresses the development of bamboo and cane sector through resource enhancement, product diversification and better marketing. In this multi-institutional project KFRI had the following objectives to fulfill.

Objectives

11. To undertake survey and documentation of bamboo species used in handicrafts
12. To adopt techniques like macro-propagation for large-scale multiplication of bamboo species used in handicraft industry
13. To develop packages for nursery and silviculture techniques for important species
14. To establish germplasm banks for conservation and propagation of species widely used in handicrafts
15. To set up tissue culture unit for scaling up of successful protocols for large scale production
16. To establish mother plant collection and plant multiplication nurseries of selected species used in handicrafts
17. Selection of interest groups (like farmers, NGOs) and set up farms
18. Conduct training in cultivation, harvesting and processing of bamboo species used in handicrafts
19. To produce materials for publicity about bamboo in different forms to create awareness about bamboo cultivation

Project Leader: Director, KFRI
Project Coordinator: Seethalakshmi, K.K.

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1. Set up integrated gene pool banks

1.1 Survey and documentation of bamboo species used in handicrafts

Objectives

20. Inventory of the species of bamboo used in handicraft industry and under cultivation in Kerala
21. Assessment of the requirement of species of bamboo used by the artisans for handicrafts
22. Explore the feasibility of proper utilization of little known species of bamboo distributed in Kerala

Investigator: Muktesh Kumar

1.2 Macro-propagation of selected bamboo species used in handicrafts in Kerala

Objectives

1. To adopt suitable macro-propagation techniques for selected bamboo species used in handicrafts

Investigators: Seethalakshmi, K.K; Raveendran, V.P.

1.1 Package of practices for the nursery and plantation activities for bamboo

Objectives

1. Collection of available information on nursery and plantation practices of different bamboo
2. Supplementing missing data through nursery trials if needed
3. Visit to different bamboo growing areas for gathering information on nursery and cultivation aspects
4. Preparation of booklets on package of practices for the nursery and plantation activities of different bamboo

Investigator: Pandalai, R.C.

1.4 Establish live collection of bamboo species used in handicrafts

Objectives

1 .Establishment of a live collection of important bamboo species used in handicraft industries in North East and Kerala

Investigator: Pandalai, R.C.

2. Tissue culture and plant multiplication nurseries.

1.1 Production and supply of tissue cultured plants through setting up of tissue culture unit.

Objectives

1. Setting up of a tissue culture unit for production of planting material of bamboo species used in handicrafts
2. Production of plantlets of bamboo species suitable for handicrafts

Investigators: Muralidharan, E.M; Pandalai, R.C.

1.2 Macro-propagation and setting up multiplication nurseries for commercial bamboo of Kerala

Objectives

1. To establish plant multiplication nurseries using conventional propagation techniques for bamboo species suitable for handicrafts in Kerala
2. Distribute planting stock to farmers, NGOs and others interested in bamboo cultivation

Investigator: Seethalakshmi, K.K; Raveendran, V.P.

3. Set up farms with NGOs/local farmers

1.1 Promotion of cultivation and sustainable utilisation of bamboo in rural sectors in Kerala

Objectives

1. To set up the demonstration plots in farmers land and forest land for the cultivation of different bamboo species by involving individual farmers, farmers' clubs and NGOs in Kerala
2. To support participant groups from Kerala, with technical inputs needed for cultivation, management and utilisation of bamboo using appropriate communication media and techniques

Project team: Sankar, S; Seethalakshmi, K.K; Chandrashekhara, U.M; Muktesh Kumar; Pandalai, R. C; Chacko, K.C; Muralidharan, E.M.

4. Conduct training

4.1 Specialised training programme on cultivation, harvesting and preservation of bamboo species used in handicrafts

Objectives

1. To organise a series of specialised trainings in cultivation, harvesting and processing of bamboo

Project team: Sankar, S; Chandrashekara, U.M; Seethalakshmi, K.K; Muktesh Kumar; Gnanaharan, R; Chacko, K.C; Pandalai, R.C; Muralidharan, E.M; Mohammed Kunhi, K.V.

5. Publicity and awareness

5.1 Documentation and dissemination of information on cultivation, management and utilisation of bamboo

Objectives

1. To prepare information bulletins and handbooks on cultivation, management and utilisation of bamboo species used in handicrafts

Project team: Sankara Pillai, K; Sarojam, N; Hussain, K.H; George, K.F; Gnanaharan, R; Seethalakshmi, K.K; Pandalai, R.C; Chacko, K.C.

Publications

Proceedings

1. Policy and Legal Issues in Cultivation and Utiliztion of Bamboo, Rattan and Forest Trees in Private and Community Lands: Proceedings of the National Workshop. Edited by C.Mohanan, K.C.Chacko; K.K.Seethalakshmi; S.Sankar; C.Renuka; E.M.Muralidharan; J.K.Sharma, 2002: 221p.
2. Bamboo Resource Development and Utilization in Kerala. Proceedings of the Interaction Workshop, Thiruvananthapuram, 22 July 2002. Edited by K.K.Seethalakshmi; S.Sankar; J.K.Sharma, 2002: 28p.

Handbooks

1. Commercial Rattans of Kerala. C.Renuka; K.M.Bhat. *KFRI Handbook No.10*, 2002: 24p.
2. Oil Curing Technology for value-added Rattan (Cane) Products. T.K.Dhamodaran; K.M.Bhat. *KFRI Handbook.11*, 2002: 10p.
3. Commercial Bamboos of Kerala. Muktesh Kumar. *KFRI Handbook No.12*, 2002: 20p.
4. Protection of Rattan against Fungal Staining and Biodeterioration. C. Mohanan. *KFRI Handbook No. 13*, 2002: 9p.
5. Nursery and Silvicultural Techniques for Rattans. C.Renuka; R.C.Pandalai and C.Mohanan. *KFRI Handbook No. 14*, 2002: 8p.
6. Micropropagation of Bamboo and Rattan. E.M.Muralidharan. *KFRI Handbook No.15*, 2002: 19p.
7. Preservative Treatment of Bamboo and Bamboo Products. R.Gnanaharan and C.Mohanan. *KFRI Handbook No. 16*, 2002: 8p.

8. Nursery and Silvicultural Techniques for Bamboos. R.C.Pandalai; K.K. Seethalakshmi and C.Mohanan. *KFRI Handbook No. 18*, 2003.
9. An Annotated Bibliography on Rattans of the World. K.F.George and K.Sankara Pillai. *KFRI Handbook No. 19*, 2003.
10. An Annotated Bibliography on Bamboos of the World. N.Sarojam. *KFRI Handbook No. 20*, 2003: 311p.
11. Information Resources for Bamboo and Cane Development in Kerala. K. Sankara Pillai. *KFRI Handbook No. 21*, 2003.

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IDRC Projects

KFRI had been engaged in bamboo research largely with the financial support from the International Development Research Centre (IDRC), Canada from 1987 to 1994. Research works were carried out in two phases on the following aspects of bamboo under the main theme

Silviculture, management and utilization of bamboo resources of Kerala

Bamboo Project Phase I (1987-91)

Market study of bamboo and reed
Propagation techniques
Germplasm collection
Distribution and ecology of reed
Plantation raising
Preservative treatment

Project Team

Propagation Techniques: Seethalakshmi, K.K.
Bamboo Plantations: Chacko, K.C; Pandalai, R.C; Thomas P. Thomas
Distribution of Reeds: Muktesh Kumar
Bamboo Utilisation: Gnanaharan, R
Market Study: Krishnankutty, C.N.
Ecology of reeds: Muktesh Kumar; Thomas P. Thomas

Bamboo Project Phase II (1991-94)

Taxonomical study and preparation of distribution maps
Growing stock estimation
Geographic Information System for resource assessment
Germplasm establishment
Ecological studies on *Bambusa bambos* growing in teak plantation
Storage of bamboo seeds and propagation by branch cuttings
Influence of soil properties on the growth of bamboo stands
Diseases of bamboos
Bamboo furniture

Project team

Taxonomical Study: Muktesh Kumar
Estimation of Growing Stock: Menon, A.R.R.
GIS for Bamboo Resources: Nandakumar, U.N; Nair, P.V.
Species/variety trials; Germplasm establishment: Pandalai, R.C.
Seed Storage; Propagation: Seethalakshmi, K.K.
Soil Properties: Thomas P. Thomas
Control of Diseases: Mohanan, C.
Furniture: Gnanaharan, R.

Anatomical Study: Bhat, K.V.

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Bamboo Information Centre – India

For the effective documentation and dissemination of information on bamboo, a Bamboo Information Centre has been set up in 1989 at KFRI with the financial assistance from the IDRC.

Project Leader: Librarian

Achievements:

Collected about 3200 literature on bamboo and photocopies are being provided on request.

A database of the literature is developed and providing search services from the database.

Publications:

BIC-India Bulletin-A semi annual publication Vol. 1-4; 1991-1994.
Bamboos of South and South-East Asia: An Annotated Bibliography.
Directory of Bamboo Researchers and Projects of South and South-East Asia.
Bamboos of India: A Compendium.
Propagation of bamboos by culm cuttings. KFRI Information Bulletin 8.
Storage of bamboo seeds. KFRI Information Bulletin 12.

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Ph. D Programmes

Economic analysis of forest resource management: A study of bamboos in Kerala. 1996. Jayasankar, B.

Soils of bamboo (*Bambusa bambos*) brakes in Kerala forests. 1998. Thomas P. Thomas.

Characterisation of soil under reed (*Ochlandra travancorica*) in Western Ghats. 1999. Sujatha, M.P.

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Pandalai, R.C; Seethalakshmi, K.K; Mohanan, C. 2003. Nursery and Silvicultural Techniques for Bamboos. KFRI Handbook No. 18. KFRI, Peechi; Ministry of Textiles and UNDP, New Delhi.

Sarojam, N. 2003. An Annotated Bibliography on Bamboos of the World. KFRI Handbook No. 20. KFRI, Peechi; Ministry of Textiles and UNDP, New Delhi: 311p.

Gnanaharan, R and Mohanan, C. 2002. Preservative Treatment of Bamboo and Bamboo Products. KFRI Handbook No. 16. KFRI, Peechi; Ministry of Textiles and UNDP, New Delhi: 8p.

Kumar, M. 2002. Commercial Bamboos of Kerala. KFRI Handbook No.12. KFRI, Peechi; Ministry of Textiles and UNDP, New Delhi: 20p.

Kumar, M. 2002. Field Identification Key to Native Bamboos of Kerala. KFRI, Peechi: 38p.

Mohanan, C; Chacko, K.C; Seethalakshmi, K.K; Sankar, S; Renuka, C; Muralidharan, E.M; Sharma, J.K. (Eds). 2002. Policy and Legal Issues in Cultivation and Utilization of Bamboo, Rattan and Forest Trees in Private and Community Lands: Proceedings of the National Workshop. Ministry of Textiles, Government of India, United Nations Development Programme, New Delhi and Kerala Forest Research Institute, Peechi: 221p.

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Seethalakshmi, K.K; Kumar, M. 1998. Bamboos of India: A Compendium. KFRI, Peechi and International Network for Bamboo and Rattan, Beijing: 342p.

Wang Haojie; Varma, R.V; Xu Tiansen. 1998. Insect Pests of Bamboos in Asia. International Network for Bamboo and Rattan, New Delhi: 200p.

Gnanaharan, R; Mosteiro, A.P. 1997. Local Tools, Equipments and Technologies for Processing Bamboo and Rattan. International Network for Bamboo and Rattan, New Delhi: 83p.

Mohanan, C. 1997. Diseases of Bamboos in Asia. International Network for Bamboo and Rattan, New Delhi: 228p.

Sarojam, N; Sankara Pillai, K; Hussain, K.H; Ravindran, K. 1996. Bamboos of South and South-East Asia: An Annotated Bibliography. KFRI, Peechi: 251p.

Gnanaharan, R; Janssen, J.J.A; Oscar Arce. 1994. Bending Strength of Guadua Bamboo: Comparison of Different Testing Procedures. KFRI, Peechi and International Development Research Centre, Canada: 24p.

Sankara Pillai, K; Sarojam, N; Ravindran, K; Hussain, K.H. 1994. Bamboo Researchers and Projects of South and South-East Asia. KFRI, Peechi: 161p.

Rao, I.V.R; Gnanaharan, R; Sastry, C.B (Eds). 1990. Bamboos: Current Research. Proceedings of the International Bamboo Workshop, 14-18 November 1988, Cochin. KFRI, Peechi and International Development Research Centre, Canada: 394p.

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Bhat, K.M. 2001. Anatomical changes associated with culm maturation in *Bambusa bambos* (L.) Voss and *Dendrocalamus strictus* Nees. KFRI Research Report 216: 18p.

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Gnanaharan, R. 2000. Preservative treatment methods for bamboo: A review. Part - II of bamboo shelter: A demonstration of best construction practice. KFRI Research Report 177(2): 19p.

Muraleedharan, P.K; Anitha, V. 2000. Assessment of economic feasibility and socio-cultural acceptability of bamboo based architecture: A study in Kerala, Karnataka and Orissa States. KFRI Research Report 177(1): 55p.

Bhat, K.V; Pandalai, R.C. 1999. Development of appropriate tools for harvesting reed bamboos. KFRI Research Report 170: 10p.

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Krishnankutty, C.N. 1998. Socio-economic and ecological aspects of developing bamboo resources in homesteads of Kerala. Part 2. Economic and management aspects. KFRI Research Report 125(2): 62p.

Chandrashekara, U.M; Sankar, S; Gnanaharan, R. 1997. Socio-economic and ecological aspects of developing bamboo resources in homesteads of Kerala. Part 1. Ecological and social aspects. KFRI Research Report 125(1): 54p.

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Surendran, T; Chacko, K.C; Gopalakrishnan Nair, N; Muhammad, E. 1991. Establishment of a bamboosetum. KFRI Research Report 84: 22p.
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Nair, C.T.S; Muraleedharan, P.K. 1983. Rural Institutions for Development of Appropriate Forestry Enterprises: A Case Study of the Traditional Reed Industry in Kerala State, India. KFRI Research Report: 18: 150p.
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Propagation of bamboos by culm cuttings. KFRI Information Bulletin 8 (BIC Series 1). 1990: 5p.
Storage of bamboo seeds. KFRI Information Bulletin 12 (BIC Series 2). 1992: 5p.
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Video film

Bamboo - A Crop (English). KFRI, Peechi.
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Periodical

BIC-India Bulletin - A Semi annual Publication of Bamboo Information Centre-India supported by IDRC, Canada Vol. 1-4; 1991-1994.
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Working Papers
Technical Reports

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Muraleedharan, P.K. 2001. Economic feasibility, viability and sustainability of bamboo shelter: A study in Kerala and Karnataka statistics. Indian J. Social Devt. 1(2): 300-314.
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Kumar, M; Remesh, M; Stephen Sequiera; Unnikrishnan, N. 2000. A little known bamboo - *Sinarundinaria microphylla* (Munro) Chao & Renv. from Southern Western Ghats, India. J. Econ. Tax. Bot. 24(1): 215-219.
Kumar, M; Stephen Sequiera; Remesh, M. 2000. The position of Indian bamboos in bamboo systematics. Rheedea 10(1): 33-48.
Kumar, M; Seethalakshmi, K.K; Stephen Sequiera. 1999. Two new species of *Ochlandra* Thw. Poaceae - Bambusoideae from Southern India. Rheedea 9(1): 31-35.
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Chandrashekara, U.M. 1996. Ecology of *Bambusa arundinacea* (Retz.) Willd. growing in teak plantations of Kerala, India. Forest Ecology and Management 87: 149-162.
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Jayasankar, B; Muraleedharan, P.K. 1995. Marketing of agroforestry products: A study of marketing of bamboos in Kerala. J. Trop. For. 11(2): 149-158.
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Rattan (Cane)

Achievements
Projects
Publications

Achievements

- Resource survey of rattans in India has been conducted.
- Fourteen new species have been reported.
- Herbarium specimens of all Indian species (22 species from the Western Ghats, 16 species from North East India and 18 species from the Andaman and Nicobar Islands) are deposited at KFRI.
- Distribution and phenological data of all Indian species have been compiled.
- A taxonomic database on rattan has been prepared.
- A pictorial field key has been developed for easy identification of rattans of Kerala in the field.
- Nursery technology has been developed for raising seedlings of different species of rattan.
- Technology for raising rattan plantations has been developed.
- Root morphological studies of two species have been completed.
- Germplasm of 30 species of rattans has been established.
- Seed stands of 10 commercially important species have been established.
- Micropropagation methods have been standardized for species of rattan.
- Forty two species of Indian rattans were characterised as industrial raw material and classified according to properties and end-uses.
- Anatomical identification keys have been developed for forty two Indian rattans.
- Besides standardisation of terminology and nomenclature of commercial rattan species, grading rules have been brought out.
- Technology transfer and training programms has been implemented for oil curing of rattans for enhancing the market value of the products.

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Projects

Ongoing Research Projects
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IDRC Projects

Ph.D Programmes

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Ongoing Research Projects

Taxonomy
Genetic Conservation
Silviculture

Taxonomy

Taxonomy of palms (Component of an All India Coordinated Project)

Objectives

23. To survey and prepare quantitative inventory of palms in Western Ghats, North Eastern Regions and Andaman and Nicobar Islands
24. To study the distribution pattern and to identify the most threatened palms and to develop conservation programmes for their sustainability
25. To prepare handbooks for general public interest
26. Field key for the identification of palms of India
27. A handbook on palms of India
28. To establish a palmatum in three regions namely, Kerala, Arunachal Pradesh and Port Blair (Andamans)
29. To study the reproductive biology of selected palm species
30. To develop a database for palms of India

Principal Coordinator : Renuka, C.

Genetic Conservation

Germplasm establishment of rattans

Objective

Establishment of germplasm as live collections

Principal Investigator: Renuka, C.

Silviculture

Alternative income generation for farmers in the Western Ghats through introduction and promotion of edible shoot producing rattans

Objectives

1. Introduction of edible rattan species from North East India
2. Identification of edible rattan species from Western Ghats
3. Establishment of a rattan shoot stand by planting the seedlings in suitable area
4. Promoting cultivation for shoot tips among farmers
5. Study the feasibility for commercialisation of rattan shoots

Principal Investigator: Renuka, C.

Propagation of rattans in the Western Ghats – A species trial

Objectives:

1. Establishment of species trial plots at different localities with economically important species of rattans
2. To monitor the growth performance of species planted for 5 years
3. To monitor the growth performance of the species raised by Kerala Forest Development Corporation at various places

Principal Investigator: Renuka, C.

Maintenance of seed stands and species trial plots of rattans. Phase II

Objectives

1. To monitor the growth of different species of rattans in the permanent plots
2. To study the flowering and fruiting pattern of different species in the seed stands
3. To maintain and manage the seed stands

Principal Investigator: Renuka, C.

Tissue culture of rattans (canes) for clonal propagation

Principal Investigator: Muralidharan, E.M; Pandalai, R.C.

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UNDP Projects

Resource enhancement and processing of cane and bamboo species suitable for handicrafts

The Ministry of Textiles, Government of India, initiated a scheme for improvement of cane and bamboo sectors under Fibers and Handicraft Development Program with the financial support from United Nations Development Program (UNDP) during 2000-2002. The Scheme addresses the development of bamboo and cane sector through resource enhancement, product diversification and better marketing. KFRI is given the responsibility for resource enhancement of bamboo and cane and undertaken the responsibility with the following objectives.

Objectives

1. To undertake survey and documentation of cane species used in handicrafts
2. To develop packages for nursery and silviculture techniques for important species
3. To establish germplasm banks for conservation of species widely used in handicrafts
4. To set up tissue culture unit for scaling up of successful protocols for large scale production
5. Selection of interest groups (like farmers, NGOs) and set up farms
6. To set up oil-curing units for improving the quality and appearance of harvested canes
7. Conduct training in cultivation, harvesting and processing of cane species used in handicrafts
8. To produce materials for publicity about cane in different forms to create awareness about cane cultivation

***Project Leader*:** Director, KFRI
Project Coordinator: Renuka, C.

1. Set up integrated gene pool banks

1.1 Documentation and selection of potential species of cane for their proper utilization in handicraft industry.

Objectives

1. Inventory of the species of cane used in handicraft industry and under cultivation in North Eastern states and Kerala
2. Assessment of the requirement of species of canes used by the artisans for handicrafts
3. Explore the feasibility of proper utilization of little known species of canes distributed in the North Eastern States and Kerala

***Investigator*:** Renuka, C.

1.2 Package of practices for the nursery and plantation activities for cane

Objectives

1. To develop packages for nursery and silviculture techniques

Investigators: Renuka, C; Pandalai, R.C.

1.3 Establish germplasm banks for canes

Objectives

1. Establishment of a gene bank in Kerala

***Investigator*:** Renuka, C.

2. Tissue culture and plant multiplication nurseries

1.3 Production and supply of tissue cultured plants through setting up of tissue culture unit

Objectives

1. Setting up of a tissue culture unit for production of planting material of cane species used in handicrafts
2. Production of plantlets of cane species suitable for handicrafts

Investigators: Muralidharan, E.M; Pandalai, R.C.

3. Set up farms with NGOs/local farmers

1.2 Promotion of cultivation and sustainable uilitisation of cane in rural sectors in Kerala

Objectives

1. To set up the demonstration plots in farmers land and forest land for the cultivation of different cane species by involving individual farmers, farmers' clubs and NGOs in Kerala
2. To support participant groups from Kerala, with technical inputs needed for cultivation, management and utilisation of cane using appropriate communication media and techniques

Project team: Sankar, S; Renuka, C; Pandalai, R. C; Chacko, K.C; Muralidharan, E.M.

4. Conduct training

4.1 Specialised training programme on cultivation, harvesting and preservation of cane species used in handicrafts

Project team: Sankar, S; Renuka, C; Chacko, K.C; Pandalai, R.C; Muralidharan, E.M; Mohammed Kunhi, K.V.

5. Set up common facilities center

5.1 To set up oil curing facilities in cane extraction/supply sites in Kerala

Investigators: Bhat, K.M; Dhamodaran, T.K.

6. Publicity and awareness

5.1 Documentation and dissemination of information on cultivation, management and utilisation of cane

Project team: Sankara Pillai, K; Sarojam, N; Hussain, K.H; George, K.F; Renuka, C; Pandalai, R.C; Chacko, K.C.

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IDRC Projects

KFRI had been engaged in rattan research largely with the financial support from the International Development Research Centre (IDRC), Canada from 1987 to 1994. Research works were carried out in two phases on the following aspects of rattan under the main theme

Management and utilisation of rattan resources of India

Rattan Project Phase I (1987-1991)

Taxonomic inventory and live collections
Nursery and Propagation techniques
Structure and properties
Harvesting and processing techniques
Socio-economics

Project team

Project Leader: Director
Project Co-ordinator: Bhat, K.V.
Resource Inventory: Jayaraman, K.
Remote Sensing: Menon, A.R.R.
Taxonomy: Renuka, C.
Propagation Techniques: Seethalakshmi, K.K.
Socioeconomic aspects: Muraleedharan, P.K.
Harvesting and Processing Techniques, Anatomy and properties: Bhat, K.M.
Properties and Processing Techniques: Dhamodaran, T.K.
Fungal Degradation: Mohanan, C.

Rattan Project Phase II (1991-1994)

Taxonomic inventory and live collection of rattans of Andaman & Nicobar islands
Live collection
Reproductive biology and seed orchards
Structure, properties and characteristics of Andaman rattans
Harvesting, processing and preservation
Socio-economics

Project team

Project Leader: Director
Project Co-ordinator: Bhat, K.M.
Taxonomy and Reproductive Biology: Renuka, C.
Soil Studies: Sujatha, M.P.
Structure and Properties: Bhat, K.M.
Silviculture: Pandalai, R.C.
Inventory: Nandakumar, U.N.
Seed Storage and Propagation: Seethalakshmi, K.K.
Harvesting, Processing and Preservation techniques: Dhamodaran, T.K., Bhat, K.M.
Fungal Control: Mohanan, C.
Harvesting and Processing Economics: Muraleedharan, P.K.

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Ph.D Programmes

Root morphology and development in selected species of *Calamus* Linn. Arecaceae. Jayasree. V.K.

Reproductive biological studies in selected species of *Calamus* Linn.

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Systematics and phylogeny of the genus *Calamus* Linn. Arecaceae. Sreekumar, V.B.

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Gnanaharan, R; Mosteiro, A.P. 1997. Local Tools, Equipments and Technologies for Processing Bamboo and Rattan. International Network for Bamboo and Rattan, New Delhi: 83p.

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IMPACT OF THE PROJECT

The project in Kerala and North-eastern states, two bamboo and rattan rich areas of the country, helped to create an awareness on the immense potential of bamboo and rattan, especially for handicrafts.

The species used in handicraft industries were scientifically identified and documented with their taxonomic details and properties.

By capacity building through training programmes on nursery and silvicultural techniques and familiarization of bamboo and rattan species by visiting germplasm the user groups were given a clear idea about cultivation and the choice of species available.

The challenge of planting stock production was addressed using all the propagation methods known (including seed, macro- and micro propagation methods). For species, which seeds are not, available more attention is given to other methods of propagation.

Joint venture nurseries and demonstration plots established with user groups manifested that planting stock production and plantation establishment could be taken up by private sector with technical support of experts from KFRI.

The publications brought out as handbooks and annotated bibliographies helped to solve the issue of lack of user-friendly information to stakeholders to a great extend.

The project facilitated interaction between various stakeholders such as farmers, industrialists, policy makers, traders etc., through the organization of workshops on focal themes like policy and legal issues and bamboo resource development and utilization.

The major limitation of the project was the short duration of three years. Many programmes like planting stock production, monitoring of the performance of various species planted by user groups, capacity building for cultivation and management, creating awareness etc., was only initiated during the period. The project has to be implemented in three phases, of three years each, to collect scientific data and to achieve the expected benefit for the stakeholders.