KFRI HANDBOOK NO. 16

PRESERVATIVE TREATMENT OF BAMBOO AND BAMBOO PRODUCTS

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Kerala Forest Research Institute
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Peechi – 680653 Thrissur, Kerala

Development Commissioner(Handicrafts)
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The Kerala Forest Research Institute (KFRI) is an autonomous institute established in 1975 by the Government of Kerala, India. KFRI conducts research on all aspects of forestry to facilitate scientific management and utilization of forest resources. It is financed by the State and receives project specific grants from other agencies. A Governing Body comprising scientists, forestry professionals, government officials and a representative from forest industries appointed by the Government guides its policies. KFRI is multidisciplinary and currently organized in 15 Divisions covering Silviculture, Soil Science, Ecology, Agro forestry, Forest Economics, Botany, Genetics, Physiology, Pathology, Entomology, Wildlife Biology, Non-wood Forest Products, Statistics, Wood Science, and Extension. It has one Sub-centre and a Field Research Centre.

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Trade names *of preservative* chemicals are used to *identify* the chemicals and this does not constitute endorsement *of or* discrimination against any product by the Organization

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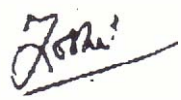
FOREWORD

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. In India, recognition of the suitability of bamboo for paper pulp in the beginning of twentieth century changed the fate of bamboo which otherwise was considered as weed. Since then there has been a steady decline in the bamboo resources due to over-exploitation, lack of scientific management after gregarious flowering, and lack of efforts for establishment of bamboo plantations.

Canes are spiny trailing and climbing palms of tropical rain forests with about 600 species predominently found in South East Asia. Until very recently canes were one of the neglected natural resources, even though it is an important employment source for the hibals and locals. In India canes are distributed in three major regions, the Western Ghats of Peninsular India, Eastern and North east India and The Andaman Nicobar Islands.

Cane and bamboo handicrafts in India current account for Rs. 360 crores and most of it is general household items, furniture and package materials. There is tremendous scope for value addition and innovation and has untapped potential for export market. As per study conducted by the International Network for Bamboo and Rattan, it is likely to be a Rs. 3000 crores market provided adequate investment is made in skill upgradation, creation of infrastructure and availability of quality rawmaterial in abundant quantities. It is in this context, a joint initiative of office of The Development Commissioner (Handicrafts) and United Nations promoted The Kerala Forest Research Institute alongwith the two other institutions from North east i.e. Rain Forest Research Institute, Jorhat and State Forest Research Institute, Itanagar, to standardise nursery practices and to make available sufficient planting stock for organised cultivation of bamboo and cane in the country.

I congratulate KFRI for bringing out a series of publications regarding bamboo and cane to transfer the technology to the stakeholders to take up cultivation in plantation scale and adopt better processing techniques for longer life of raw material and value addition. The institute has organized several training programmes, workshops and interaction meetings to invite the attention of all stakeholders, especially the farmers and artisans and ensure their involvement for the bamboo and cane sector development.



New Delhi
1 November 2002

Mrs. Tinoo Joshi, IAS
Development Commissioner (Handicrafts)
Ministry of Textiles, Government of India

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PREFACE

Bamboo has been used by the mankind from time immemorial. Over the years, more than 1500 traditional uses of bamboo have been documented. In the handicraft sector, bamboo is used in round or split form or as slats. Woven products like mats, baskets or intricate curio items are made with bamboo slivers. The major disadvantage of bamboo or bamboo products is that these are prone to deterioration caused by non-biological as well as biological agents during storage and in service. For increasing the service life of bamboo, the Institute has standardized the preservative treatment methods for bamboo used in construction sector. The need for such a document for the handicraft sector in a user-friendly language was felt. This Handbook on preservative treatment of bamboo and bamboo products meets the requirement. I am sure it will be useful to the bamboo artisans, entrepreneurs and others interested in the utilization of bamboo.

Dr. Jyoti K. **Sharma**
Director
Kerala Forest Research Institute

Peechi
01 November 2002

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1.0 INTRODUCTION

Bamboo grows longitudinally without any radial growth and hence the culm is anatomically different from wood. Bamboo culm is normally hollow with nodes and possesses good mechanical properties and a high strength-to-weight ratio. Bamboo has been used in multifarious and imaginative ways dating back to early human civilization. There are more than 1500 documented traditional uses for bamboo.

Some of the important uses are:

- Agriculture - baskets, farm implements, irrigation pipes, stakes, props, fencing.
- Construction- houses, mat board, parquet, posts, reinforcements, roofing, scaffolding, screens.
- Household implements, furniture, etc.
- Handicrafts.

Although bamboo has a number of advantages, its wide acceptance is limited due to the problem of insect and fungal attack on the raw material as well as the finished products. Losses are incurred due to discolouration caused by fungi or due to damage caused by powder-post beetles that produce bore holes on the culm. Termites attack bamboo culm that are in direct contact with the ground. Therefore, there is a need to treat bamboo to obtain clean, blemish-free and high quality bamboo culm and bamboo products.

This Handbook provides information on the available treatment methods and preservative chemicals to improve the quality as well as service life of bamboo and bamboo products.

2.0 NEED FOR PRESERVATIVE TREATMENT

The natural durability of bamboo is very low and the expected service life is less than two years which depends on the species and end use. Under cover, the untreated bamboo may last for 4 to 7 years; under favourable circumstances, bamboo busses and rafters may last 10 to 15 years. This low durability is a major reason for widespread non-acceptance of bamboo as building material. It is considered by many as short-life material suitable for temporary shelters only. Preservative treatments can remedy this problem to a large extent by increasing its service life by 3 to 5 times.

Bamboo is composed of 60 to 70% holocellulose, 16 to 20% pentosans and 20 to 30% lignin. It is rich in silica content, up to 4%, which is located in the epidermal layers. Bamboo has also minor amounts of resins, waxes, and tannins. None of these constituents has toxicity to impart natural durability. On the other hand, the presence of high contents of starch makes it more susceptible to attack by staining fungi and powder-post beetles. Thus it becomes imperative that bamboo should be treated prior to its use in order to enhance its service life.

3.0 AGENTS OF DETERIORATION

Bamboo succumbs to deterioration caused by non-biological as well as biological agents during storage or in service. Split bamboo is more rapidly destroyed than round bamboo. The inner part of the culm is severely and easily attacked than the outer one due to its difference in anatomical characteristics, chemical composition, and nutrient status. The waxy siliceous coating on the outer surface provides some protection to the outer part. The intensity of deterioration also depends much on the bamboo species, duration of storage, mode of use and prevailing environmental and storage conditions. Damage in bamboo can be caused by any or a combination of the following agents of deterioration.

3.1 Non-biological agents

- *Physical agents:* The ultraviolet rays of the sun will degrade and change the colour of the bamboo surface. Likewise, heat also will affect the integrity of the tissues.
- *Chemical agents:* Strong acids or alkalies will cause hydrolysis of cell components.
- *Mechanical wear:* This is due to forces applied on the surface of the material. For example, friction caused by a rope or wire tied around a pole results in wearing out of the bamboo surface.

3.2 Biological agents

3.2.1 Fungi

There are three major groups of fungi that cause biological deterioration.

Surface moulds: Fungi under this group are normally found on the surface of the affected material and derive their food from simple sugars which occur in freshly cut bamboo. These attack bamboo culms exposed to high humid conditions. Moulds reduce the aesthetic quality of freshly cut bamboo and finished products, while these are in storage, transit or in service (Figure 1). Materials that are damaged show a change in colour which may be black, grayish black (affected by *Aspergillus niger*), blue (affected by *Penicillium* sp.), yellow, green or pink (affected by *Trichoderma* spp.).

Figure 1: Surface moulds on bamboo culm.

Staining fungi: Many fungi cause stains on bamboo culms, particularly when the culms are exposed to excessive humidity and lack of sunshine (Figure 2). Fungi of this group also derive their food from simple sugars but they penetrate deep inside the bamboo tissues. The affected materials appear brown, grayish to black in colour (affected by *Botyodiplodia theobromae, Apiospora* sp., *Ceratocystis* sp.) because of the pigmented fungal hyphae that occur in the tissues. Since the infection is deep-seated, these are not easily planed off.

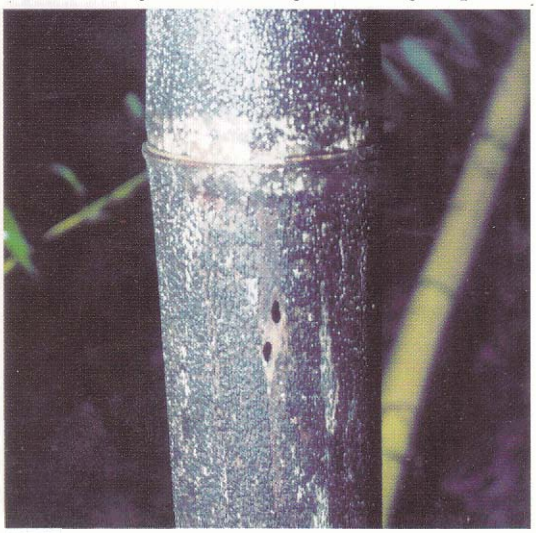

Figure 2: Fugal staining on bamboo culm.

Soft rot fungi: This group of fungi utilizes lignin and cellulose in the secondary cell walls and produces cavities which are conical or spindle shaped. Affected bamboo becomes soft when wet and shows charred appearance when it is dry (Figures 3-5).

Figure 3: Soft rot of bamboo culms

Figure 4: Soft rot of bamboo culms caused by *Daedalia* sp.

32.2. *Insects*

The powder-post beetles like *Dinoderus* spp., Lyctus sp., *Minthea* sp., etc. cause major damage to the bamboo culm. Damage can be readily sew as bore holes of pin-hole size to about 1 mm in diameter. The powdery mass that is often observed is a sign of powder-post beetle attack.

Figure 5: Soft rot of bamboo culms - advanced stage.

4.0 PRESERVATIVE TREATMENTS

Even though, keeping the bamboo culms dry during storage or in service will make it free from fungal attack, protection against borers and termite cannot be ensured. Bamboo, thus requires chemical treatment. Attention has to be focused on the proper care and maintenance of bamboo or bamboo products to assure high quality materials that can compete in the international market.

The following is a guide on how to prevent and control fungal and insect attack on bamboo and bamboo products.

4.1. Short-term protection (prophylactic treatment)

4.1.1 Storage

Improper handling or storage of bamboo can cause immense loss due to physical as well as biological degradation. A quick moisture loss should be avoided to prevent cracking or splitting. Ground contact during storage is highly hazardous as it

promotes immediate fungal decay and possibility of termite attack. The following points should be kept in mind while storing.

- For poles or culms that shall be stacked horizontally, place about 3 sleepers (made of a durable wood) at about 3 m apart.
- Place the culms on top of the sleepers to allow uniform drying.
- Properly stacked bamboo under a shed will ensure uniform drying and prevent any moisture increase due to rain or water splashes.

Smce most bamboo species are prone to borer and termite attack during storage, chemical protection becomes necessary, if the material has to be stored over long periods exceeding 3 months in cold weather conditions. Under tropical conditions when the day temperatures are above 25 ^{0}C, prophylactic treatment should be immediately given to prevent biodegradation.

4.1.2 Chemical treatment

Prophylactic treatment is only superficial and is effective only for a limited period and may have to be repeated if the storage conditions demand so. Any of the following methods can be adopted depending on the nature of material (bamboo in round or split form, or slats or slivers).

Spraying: The kind of sprayer to be used shall depend on the volume of stacked material to be sprayed. Use a knapsack sprayer for small stacks or a power sprayer for large stacks.

- Prepare the preservative as suggested in *6.0.*
- Place all materials in such a way that there shall be maximum coverage of the materials when treated.
- Spray the preservative thoroughly on the surfaces and cut ends of the materials.

Brushing: The process is good for very small quantity of materials to be used in the handicraft or cottageindustry (Figure 6).

- Use 50 or 75 mm brush depending on the size of material to be treated.
- Prepare the preservative (see *6.0*).
- Apply by running 2-3 strokes on the surface.
- Air dry the treated material.

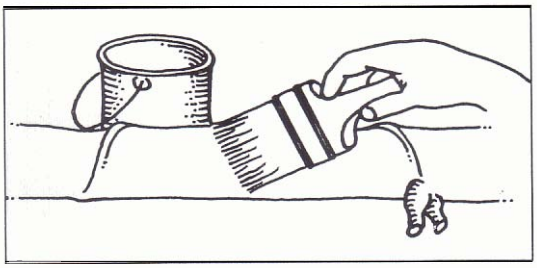

Figure 6: Brush- on application of preservative **chemical.**

Dipping: This gives better results than brushing (Figure 7).

- Prepare sufficient amount of preservative to be used (see *6.0*)
- Dip materials for 30 seconds to 1 minute.
- Retrieve the materials and drip dry.
- Dry under the sun or under shade.

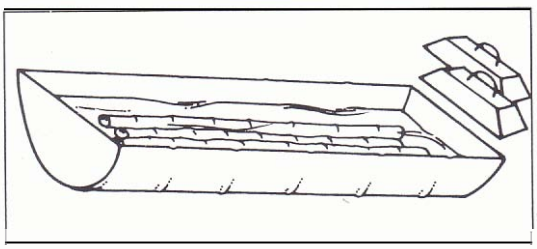

Figure 7: Dipping of clums in preservative solution

4.2 Long-term protection

4 . 2 Green bamboo

Steeping: This is the simplest method with less technical skill required.

- Cut bamboo poles into desired sizes.
- Place bamboo horizontally into the dipping vat. To improve treatment, bore holes on opposite sides near the nodes of the culm.
- Put weights on top to prevent the bamboo from floating.
- Soak for 10-15 minutes in the appropriate preservative (*see 5.2*) for indoor use and 14-17 days for outdoor use.
- Retrieve and drain excess preservative.
- Air dry by letting the culms stand

Dip-diffusion: This is an economical method and can be used for treating large quantity of material with adequate retention of 12 kg/m^3.

- Prepare a solution of higher concentration of diffusible chemicals (e.g. Boric acid – borax) in a dipping vat (see *6.0*).
- Dip the bamboo culms in the solution.
- Stack the materials closely under non-drying conditions to allow diffusion of chemicals.

Double diffusion: The process results in over 40% penetration across the wall thickness with loading of preservatives of around 12 kg/m^3.

- Soak bamboo for a week in copper sulphate (20%).
- Retrieve and soak in sodium dichromate (20%) for 4 days.
- Dry for 2 days.

Steam quenching: This method results in complete penetration of preservative across the wall thickness of bamboo. However, it is more expensive as it requires a boiler and a steaming chamber, but the quality of treatment is better with a retention of more than 15 kg/m^3.

- Steam green bamboo at 100 ^{0}C for about 2 hours.
- Immerse in 10% solution of water-borne preservative for 2 days (see *5.2*).
- Retrieve the material and stack closely for 15 to 30 days.

Sap displacement methods: It is suited to treat green bamboo, as freshly felled material has a very high longitudinal permeability because of sap flow activity in the living bamboo. There are several variations working on natural osmotic pressure, hydrostatic pressure or low pneumatic pressure created by a simple cycle pump. The sap is slowly replaced by the preservative solution in the vessels, which offer a continuous channel for flow. Subsequently the preservative diffuses longitudinally in the fibres and parenchymatous tissues.

Butt treatment: Bamboo culms in round or split form can be treated by this method which involves allowing the culms in the treatment solution in the upright position.

- Prepare 10% solution of boric-acid-borax, CCA or CCB in a container.
- Place round or half or quarter or 1/8 split freshly cut bamboo vertically up to 25 cm into the container.

  Allow to stand for a week and make up the preservative each day.
- Save left-over preservative solution.

Modified Boucherie process: The conventional Bouchcrie process was modified to treat bamboo quickly and in large numbers (Figure 8).

- The equipment consists of a simple preservative solution reservoir capable of withstanding pressures of 3-4 kg/cm^2.
- The outlet of the reservoir is attached to bamboo with the help of a pressure rubber hose.
- Apressure of 1-1.5 kg/cm^2 is applied on the top of the preservative with the use of a cycle pump and sap drips from the other end of the bamboo culm.

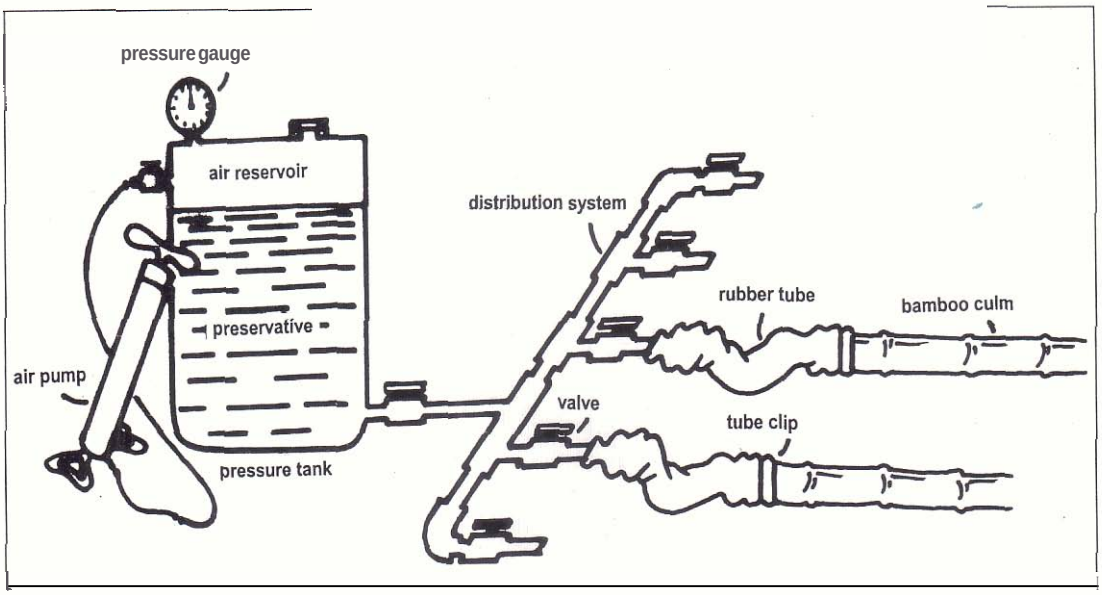

Figure 8: Treatment of culms by modified Boucherie process

4.2.2 Dry bamboo

Steeping: This is the simplest method with less technical skill required.

- Prepare bamboo, either split or round
- See procedure given under treatment of green bamboo (see *4.2.1*).

Hot and cold process: This method operates on the principle that while heating, not only moisture in the culm moves out but also the entrapped air in the cells expands, and while cooling, there is a partial vacuum created which allows the preservatives to be sucked into the culm.

- Place the bamboo in a tank provided with heater.
- Fill with creosote oil or its mixture with furnace oil.
- Raise the temperature to 90°C for 2 to 3 hours.
- Allow the preservative to cool and drain.

For boron formulations heating is permitted to 50 °C.

For dichromate solution, bamboo is heated in water first and then immersed in cold preservative solution in another tank.

Pressure treatment: For effective treatment, especially for outdoor/ground contact use, this method is suggested. Under the full-cell process, dried bamboo can be impregnated with preservative chemicals to the desired dry salt retention.

- Bore holes (3mm) near the nodes on opposite sides.
- Load bamboo in the treatment cylinder.
- Fill with preservative.
- Apply vacuum at about 600 mm for 30 minutes.
- Increase the pressure to 3.5 to 10 kg/cm^2 for 15 to 30 minutes.
- Drain the solution.
- Apply vacuum to clean the surface of the treated materials.

4.3 Protection of finished bamboo products (untreatedor treated materialswhichshow signs of damage)

4.3.1. Initial attack caused by surfacemoulds and staining fungi

- Scrape off infected portion.
- Spray or brush with chemicals (see *5.4)*

4.32. Mild attack ofpowder-postbeetle

- If damage is slight, use a syringe and apply sufficient quantity of Deltamethrin(see 611) in the bore holes (Figure 9). Be sure that all the holes are treated.
- If a powdery mass is still present the following day, repeat the injection treatment.

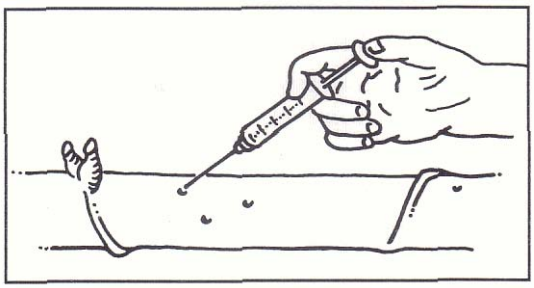

Figure 9: Injecting preservative into the bore holes.

4.3.3 Fumigation:

Finished products in bulk quantity, especiallyfor export, may be fumigated to ensure these are free from the presence of borers.

- Place all materials in a fumigation chamber.
- Expose the material to the fumigant as prescribed by fumigation authority.

5.0 PRESERVATIVE CHEMICALS

5.1 Short-term protection

a. Boron compounds (Boric acid, Borax).
b. Thiocyanomethylthio-benzothioazole (TCMTB) + methylene bisthiocyanate (MBT).
c. Deltamethrin
d. Cu-8-quinolinolate

5.2 Long-term protection

52.1 Indoor
a. TCMTB
b. Boric acid-borax

52.2.Outdoor
a. Oil-borne preservatives
   Creosote
b. Water-borne chemicals
   i. Copper chrome arsenate (CCA)
   ii. Copper chrome borate (CCB)

5.3 Food contact
a. Borax
b. Cu-8-quinolinolate

5.4 Remedial treatment
a. TCMTB
b. Deltamethrin

6.0 PREPARATION OF PRESERVATIVES

Preservatives are group of chemicals which may be in the form of wettable powder, granule, paste, or liquid.

Follow the example givenbelow for determining the preservative required:

To prepare one litre of 5% CCA solution, what will be the quantity of CCA (72% concentration and specific gravity of 1.2) required?

Use the formula: $W = DV/A$
where: W = weight of chemical required
D = recommended dosage
V = volume of solution to be prepared
A = active ingredient of chemical*

$$W = \frac{0.05 \times 1}{0.72 \times 1.2^{*}}$$

$$= 0.057\,kg = 57\,g$$

(*in case of chemicals of specific gravity other than 1.0, it should be taken into consideration)

Computation of the desired amount of the following preservatives can also be done in the same manner.

a. Boric acid and borax – white powders which dissolve easily in water used at 20% concentration. For 20% boric acid equivalent solution, use 10 kg of boric acid and 15 kg of borax in 100 litres of water.

b. TCMTB (2-thiocyanomethylthiobenzo-thioazole) – it is an emulsifiable concentrate used at 1:50 dilution during wet season and 1:100 dilution during dry season.

c. Deltamethrin – 50 ml of 20 EC formulation should be mixed in 100 litre of water.

7.0 GENERAL PROCEDURE IN THE PREPARATION AND USE OF PRESERVATIVES

- Read the instructions on the label of the bottle. This will give information on the right dosage or concentration to be used.
- Compute for the amount of chemical that shall be used.
- Keep a dipping tank, sprayer, brush ready
- Use gloves, masks, boots and long sleeve shirt.

8.0 HEALTH AND SAFETY

In order to prevent or minimize the harmful effects of preservatives or chemicals on the person using the chemical and the environment as well, a knowledge on proper handling, preparation and application of chemicals is important.

8.1 Safety precautions in the preparation, handling and application of chemical treatment

- Wear appropriate clothing, gloves, safety boots and helmet. An eye protection is needed in mixing preservative solutions.
- Do not drink, eat or smoke, during or immediately after the application of the treatment.
- Spray along the wind direction.
- Wash *hands*, feet or take a shower after work. Change work clothes.
- Place containers out of reach of children. Empty containers can be disposed by burying them underground.
- Dispose treating solutions properly. Allow water to evaporate and bury the precipitate underground.

9.0 FURTHER READING

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Resource Enhancement and Processing
of Cane and Bamboo Species Suitable for
Handicrafts

List of Publications

Handbooks

Commercial Bamboos of Kerala
Commercial Canes of Kerala
Nursery and Silvicultural Techniques of Bamboos
Nursery and Silvicultural Techniques of Rattans
Oil Curing Technology for Value-added Rattan (Cane) Products
Manual on Preservation of Bamboo
Protection of Rattan Against Fungal Staining and Bio-deterioration.

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Directory of Bamboos and Canes in Kerala

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