TRAINING MANUAL ON NURSERY RAISING, COMMERCIAL PLANTATION, PRESERVATION AND PRIMARY PROCESSING OF BAMBOO

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CONTENTS

• Acknowledgement 4
• Wood Industry in India 5
• National Bamboo Mission (NBM) 7
• Bamboo Propagation through Nursery Raisings 9
• Commercial Plantation of Bamboo 18
• Clump Management 21
• Shoot Harvesting and Handling 23
• Insect Pest and Disease of Bamboo and their Control 25
• Durability of Bamboo and Its Rural Preservation Techniques 27
• Primary Processing of Bamboo at the Village Level 30
• Cost /Benefit of Hand Operated Machines 31
• Bamboo Cluster Development Model 32
• Preparation of Hormones Solutions 34
ACKNOWLEDGEMENT

The object of this manual is to disseminate the knowledge and current trend in propagation of bamboo through vegetative means, commercial plantation of bamboo, pest and disease management, village level preservation and primary processing of bamboo. Publication of this manual is a sequel to the already launched National Bamboo Mission (NBM) by the Ministry of Agriculture, Government of India. The NBM with focus in the NER envisages to plant bamboo in an area of 1,76,000 hectares. As a backward integration to this, sufficient nurseries are also proposed to supply quality planting materials. A manual of this nature was found to be missing covering the important aspects right from bamboo nursery to primary processing at the village level.

The Cane and Bamboo Technology Center (CBTC) designated as the Bamboo Technical Support Group (BTSG) under NBM for the North Eastern States of and those of Orissa, Jharkhand, and West Bengal was entrusted to the task of preparing this manual by NBM. While preparing and compiling this manual, a number of stake holder has been consulted and their ideas and suggestion are corroborated into the manual.

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Introduction

Bamboos are a unique group of giant arborescent grasses in which the woody culms arise from underground rhizomes. They are shrubs and have tree-like habit; their culms are erect and sometimes climbing. It is the fastest growing plant on this planet. Bamboos are characterized by woody, mostly hollow culms with internodes and branches at the culms nodes. India is the second richest country in terms of Bamboo genetic diversity with a total of 136 species under 75 genera. It encompasses about 8.96 million hectares of forest area, which is equivalent to 12.8 per cent of the total forest cover of the country. Within the forest area, it suffers from poor management, low productivity and over-exploitation. However, there has been a growing awareness in recent years about bamboo being an important component of development and an effective means to improve the livelihood of the rural poor. This plant, which has over 1500 recorded uses (from cradle to coffin), offers excellent opportunities for employment and income generation and improving the nutritional status of the rural poor. There are three types of Bamboo-1) Sympodial (Fig. A), Sympodial with long neck (Fig. B, e.g. Mecolanna baccifera) 3) Monopodial (Fig. C) and 4) Amphodial (Fig. D). The ten major species identified by the National Bamboo Mission (NBM) for commercial purposes are Bambusa bambos, B. balcooa, B. nutans, B. tulda, Dendrocalamus strictus, D. hamiltonii, D. asper, D. giganteus, Melocanna baccifera, and Ochlandra. Travancorica. The major user of bamboo in India is the paper industry, which consumes nearly 45% of the total annual recorded production from government forests. In addition, bamboo supports a number of traditional cottage industries, including production of handicrafts, incense sticks, and related articles. At the same time, the practices adopted in India as regards bamboo are unscientific, unsustainable, unrewarding and unintegrated.

Wood Industry in India

The wood industry in India developed rapidly after the Second World War. Most of the Plywood industries in the country were located in the North eastern region. There were about 70 nos. of plywood mills producing about 2/3rd of the country’s total plywood production valued at several thousands of crores of rupees. However, these mills were using the logs cut down from trees found abundantly in the forests but much attention was not given on the plantation aspect as a backward integration. This resulted in haphazard felling of trees and deforestation. Ultimately, the Hon’ble Supreme Court of India had to intervene and banned felling of trees in 1996. This has resulted in closure of most of the mills or many have shifted to other parts of the country. Now, the availability of logs in the country is also deteriorating which has resulted import of logs and other wood products. The import bill is increasing and will be touching to about Rs. 10,000 crore shortly as the demand is increasing at about 10% per annum.
Wood Replacement Bamboo Products

But engineered bamboo products manufactured through using modern technology are well suited to use in applications as that of wood products and especially those of hard woods. Hard wood species like *Teak*, *Sal*, *oak*, *maple*, *Michela dipterocarps*, etc. takes about more than 80 years to mature whereas bamboo takes four years. So, when we use bamboo products it means we are replacing wood to the extent possible and thereby saving our forests which will make our planet greener and cleaner for our next generations.

Some Engineered Bamboo Products
National Bamboo Mission (NBM)

To motivate Communities, NGOs, SHGs, Farmers and Entrepreneurs, and to provide an interactive coupling between technology, economy, environment and society for speedy development of Bamboo sector. Initially to plant bamboo on commercial basis to supply quality raw material and to build up a substantial base for production of value added processed bamboo products for domestic and export markets with a strong emphasis on cleaner and user friendly technology and quality. This will enable the production, supply and consumption chain, especially to realize environment friendly products and marketing network and to ensure adequate availability of quality bamboo products for the consumers at economic prices and to promote sustainable development, employment generation and poverty alleviation, launching of a Mission on Bamboo was of utmost importance, especially with emphasize on commercial plantation. This is how the
National Bamboo Mission was born. The National Bamboo Mission is a Centrally Sponsored Scheme in which the contribution of the Central Government will be 100%. The Scheme is being implemented by the Division of Horticulture under the Department of Agriculture and Cooperation in the Ministry of Agriculture, New Delhi.

**Mission Objectives**

The main objectives of the National Bamboo Mission are:

- To promote holistic growth of the bamboo sector through areas based regionally differentiated strategies;
- To increase the coverage of areas under bamboo both in forest and non-forest areas; with appropriate varieties to enhance yields;
- To promote marketing of bamboo-based handicrafts.
- To establish convergence and synergy among stake-holders for development of bamboo.
- To promote, develop and disseminate technologies through a seamless brand of traditional wisdom and modern scientific knowledge.
- To generate employment opportunities for skilled and unskilled persons, especially unemployed youths.

**Strategy**

To achieve the above objectives, the Mission would adopt the following strategies:

- Adopt a specific approach covering production and marketing to assure appropriate returns to growers/producers;
- Promotion of Research and Development (R&D) of technologies for production.
- Enhanced acreage (in forest and non-forest areas) and productivity;
- Adopt a coordinated approach and promote partnership, convergence and synergy among R&D marketing agencies in public as well as private sectors, at all levels;
- Promote cooperatives and self-help groups to ensure support and adequate returns to farmers;
- Facilitation of capacity-building and Human Resource Development;
- Setting up of National, State and sub-State level structures, keeping in view the need for getting adequate returns for the produce of the farmers and eliminating middlemen to the extent possible

**Key Elements of the National Bamboo Mission**

1. Research and Development for Bamboo Development
2. Establishment of new Nurseries to raise bamboo seedlings
3. Raising high yielding bamboo plantations on commercial basis in Forest and Non-Forest areas
4. Improvement of senile bamboo plantations, Pest and Disease Management of bamboo.
5. Handicrafts, bamboo marketing and exports
6. Capacity building and Human Resource Development of farmers and personnel
7. Establishment of Bamboo Markets and new Marketing Strategy for Bamboo
8. Meticulous monitoring, evaluation and reporting, Database generation, compilation and analysis
**The proposed Fiscal Benefits in a Nutshell are**

1. **For Nursery raising:** Rs. 2.73 lakh for Centralised Nursery by Govt./Public sector and Rs. 0.68 lakh by Private sector, Kisan/Mahila Nursery Rs. 0.065 Lakh by Private sector
2. **Commercial Plantation:** Rs. 25000/hectare by Govt./Public sector and Rs. 8000 by Private sector
3. Apart from the above, there is 100% assistance on Plantation related R & D, Certification of Plantation etc. and limited grants for imparting training to farmers, PRIs/Block level functionaries, etc. Also funds have been earmarked for conducting State level/District level seminars for awareness generation/technology dissemination and the like.

The State Activities related to the NBM will be implemented through the respective Bamboo Development Agencies/Forest Development Agencies or any other Agency approved by the respective State Governments. The proposals will have to come through the State Level Steering Committee already formed for the purpose. The funds for the year 2006-07, as approved by the National Level Steering Committee have already been released to the respective States.

**Bamboo Propagation through Nursery Raisings**

There are various methods of propagating bamboo, especially at the Nursery level. Bamboo Nursery business is a viable proposition and banks are also willing to help financially. The following are the methods by which bamboo can be propagated in a nursery for onward plantation on commercial basis:

**PROPAGATION OF BAMBOO**

1. **Sexual Reproduction (By Seeds)**
2. **Asexual Reproduction (By Vegetative)**
   - 1) Rhizomes / Offset
   - 2) Cuttings
   - 3) Macro - Proliferation
   - 4) Layering
   - 5) Tissue Culture

   a) Culm
   b) Branch

**Bamboo can be propagated by conventional and non-conventional methods:**

**Conventional methods**

A. Propagation through seeds.
B. Propagation through rhizome/off-set planting.

Conventional methods of propagation of bamboo are based on seeds and vegetative methods. Availability of seed is limited to certain specific periods only as bamboos flower once in life time only. Most of the bamboos flower in long cycles ranging from 10 years to over 60 years depending upon species. Usually, the cyclic flowering is gregarious and after flowering, the entire flowered
population of bamboo dies. The huge quantity of seeds produced are either washed away in hill slopes during rains, or eaten by rodents (rats). The remaining seeds fallen in ideal conditions germinate to seedlings for regeneration.

**Non conventional methods**

A. Propagation through root cutting.
B. Propagation through culm cutting.
C. Propagation through branch cutting.
D. Propagation through macro-proliferation.
E. Propagation through layering and macro-rotting.
F. Tissue culture

**Nursery**

**Site selection**

The site to be selected for raising a bamboo nursery should have good accessibility, a nearby water source and also the source of the planting material should be nearby to avoid expenses and other technical related matters. Then the site so chosen should be planned properly depending upon the shape and size. The planning should be done keeping into confidence the way of propagation, the estimated yearly production capacity, macro-proliferation, beds required, irrigation facilities, overhead tanks and the like. The transportation & logistics and marketing aspects also needs careful consideration.

**Nursery raising season**

The season for Nursery raising also effects the viability of the business. Though, the best season for nursery raising as far as growth and mortality rate is concerned is March in this part of the country, especially through any of the vegetative propagation methods like culm cutting, branch cutting, layering etc., However, it still can be done throughout the year but with higher mortality rate.

**Preferred soil characteristics for Bamboo nursery**

The preferred soil for vegetative propagation is sandy loam with pH value of about 6.5 to 7.5. The land should be a bit high land without any water stagnation or should be well drained. Like any other nursery, a few shade trees make the place better.
Types of Nursery Under the National Bamboo Mission

1. **Centralised Nursery**: This kind of nursery will have an annual production capacity of at least 50,000 planting materials. (Fig : 1)

2. **Kisan / Mahila Nursery**: Should have a minimum annual production capacity of 10,000 nos. and 5,000 nos. of planting materials (Fig : 2 & 3 respectively)

**A. Propagation through seeds:**

Seeds formed after sporadic/gregarious flowering can be collected and cleaned. The cleaned seeds can be stored for 6 months or even more than a year through special storage techniques like controlled moisture, low temperature etc. But, the germination capacity of bamboo seeds (Fig : 4 & 5) loosens gradually after two months if it is not stored with proper ventilation for seed respiration, controlled temperature, etc. Otherwise, the seed should be sown soon after the collection. The collected seeds are cleaned properly, dried it in the sun for 1-2 hours and it is soaked in clean ordinary water for 6-12 hours to break the dormancy and water is drained out properly 10-20 minutes before sowing. Prepare a raised nursery bed of 10x1.5 m by deep ploughing or digging and fill it with a mixture of soil, sand and fully decomposed FYM¹ in 3:1:1 ratio. One week before sowing, drench the nursery bed with insecticide like aldrin and fungicide like bevistin to prevent termite and fungal attack. For each bed use 40 litres of 0.015% (a.i) aldrin prepared by adding 0.5 ml of aldrex 30 EC per litre of water and 30 litres of 0.05% (a.i) prepared by adding

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¹FYM-Farm Yard Manure is the material resulting from the decomposition of mixture of animal dung and urine soaked leaves litter by micro organisms. This is prepared in pit or trench on 1mtr. depth and dumped with cow dung, urine and leaves litter everyday until the height reaches 30 cm above ground. After this, the bed is plastered with mud and left to itself for about 4-6 months where the material inside gets decomposed and becomes ready to use.
1 gram of Bevistin 50 WP per litre of water. During non availability of aldrin other insecticides like chloropyriphos @2ml per litre of water or Endosulphan-35EC @ 2ml per litre of water can be applied by spraying 40 litres of solution on each bed. The sowing (Fig : 6) should be done in overhead shade protected preferably by leaves or bamboo split. A line sowing with furrow up to 1cm depth is advised and should be covered with thin layer of soil and watered lightly once in a day. Seed starts germinating after 3-7 days and continue up to 15-25 days. When seedlings are of 3 – 4 months old (Fig : 7), it is transferred to the poly pot (Fig : 8) and irrigate once in a day preferably in the evening time continuously for 1-2 weeks. The poly pot should be filled with well rotten FYM, soil and sand mixture at the ratio of 2:3:1 (Fig. 5).

**Propagation through Off-set planting**

Vegetative propagation by rhizome or off-set is an age old method and has been used extensively in the region. Though it is traditional and perhaps the most commonly used method of propagation of bamboos, it is practicable only in cultivating a few clumps particularly in small and accessible area. Availability of propagules in large number by this method is somewhat limited. It is best if offsets are planted just before the rainy season. In general, success of off-set planting in thin walled bamboo species is relatively poor and varies greatly from species to species. Bamboo species with large diameter culms requires larger rhizomes for planting.

Off-sets from 1-2 year old culms are cut at about 1.0 - 1.5 m height (3 to 5 nodes bearing viable branch buds) and is excavated along with a portion of rhizome with its root system (Fig : 9). The rhizome must be separated by cuttings from its neck carefully causing minimal damage to rhizome during excavation. Such offsets are best taken and planted in season of rest prior to rainy season, so that they are capable of establishing roots easily and growth during favourable season. Off-sets taken in the late rainy season after the new growth has started, usually fail to establish. Off-sets should be transplanted immediately after the extraction from mother clump and kept in moist gunny bag during transport. In field, preferably the top of culm should be covered with polythene bag and cavity filled with water to prevent drying. Alternatively people also practice covering the cut end using soil cow dung mix. In case of prolonged dry weather daily watering may be required in new plantations.

**Propagation through culm cutting**

Vegetative propagation using culm or stem segments is a viable alternative and has several advantages over other methods. The success and survival are higher (40 to 80%) than offset method. The method involves treatment of culm cuttings with growth regulating chemicals for inducing root formation. The method has been tested for most species of economically important bamboo and has been reported successful. Large scale multiplication of superior varieties is possible through this method. When out planted, plants raised from cuttings develop to culms much faster than seedlings. The practical steps involved in propagation of bamboo through culm cuttings are as follows:-

**Preparation of Nursery beds**

1. Prepare raised nursery beds of 10m x 1.2m by deep ploughing/digging and fill with a mixture of soil, sand and fully decomposed FYM in 2:1:1 ratio (Fig : 10).
2. One week prior to planting, drench the nursery beds separately with the insecticide, Aldrin and the fungicide, Bevistin to prevent termite and fungal attack. For each bed, use 40 liters of 0.015% (a.i). Aldrin prepared by adding 0.5 ml of Aldrex 30EC per liter of water and 30 liter of 0.05% (a.i) prepared by adding 1g of Bevistin 50 WP per liter of water. During non-availability of Aldrin other insecticides like Chloropyrophos (Dursban) @ 2 ml per liter or Endosulphan - 35 EC @ 2 ml per liter can be applied by spraying 40 liter solution on each bed.

Collection of bamboos and preparation of cuttings

1. Extract 1.6 to 2 years old culms (Fig: 11) from healthy clumps by cuttings them at the ground level or just above the first node. The propagation should be done before shoot initiation preferably during the month of April-May.

2. Remove the tender top thin part of culm bearing leaves and trim the side branches. Take care not to injure the auxiliary buds on nodes while removing leaves and side branches.

3. Transport the culms to the nursery site as quickly as possible. Maximum care should be taken to prevent drying. This can be done either by wrapping the cut end with moist gunny bags or embedding in boxes containing moist saw dust.

4. Prepare one or two nodded cuttings (cutting with 1-2 nodes leaving 5-cm on either side of nodes) using preferably a hacksaw or a sharp knife (dao) (Fig: 12, 13 & 14). For thin walled bamboos use of hacksaw is advised to avoid splitting of the cut ends.

5. Make an opening (about 2 cm in length and 1 cm in width) or drill two holes (about 7 mm diameter) in the centre of internodes. Care should be taken while making hole that auxiliary buds or branches on both the nodes must lie in lateral plane to the ground.

Treatment of cuttings for root induction

1. Dissolve 20 g NAA or Boric Acid in half-liter water. Pour this solution to a clean container and add water to make up 100 liters. Mix the solution thoroughly by stirring. The final concentration of boric acid will be 200 mg/
liters of water or equivalent to 200 ppm (part per million). This solution is sufficient to treat 1000 cuttings.

2. Pour about 100 ml of the solution to the culm cavity (Fig: 15). To avoid spillage, use wash bottle or funnel to pour the solution through the drilled holes.

3. Close the hole by melted wax or by wrapping and tying with a polythene strip (6cm width x 60 cm length) or by cello-tape (Fig: 16). Ensure that the polythene wrapping is tight so that solution does not leak out. Keep the cuttings horizontally with the opening facing upwards.

4. After extraction, culm cuttings should be treated with NAA/Boric acid as quickly as possible (preferably the same day). If the planting site is far away and there is unavoidable delay for planting, the treated cuttings can be preserved up to three days by keeping in moist saw.

**Planting of cuttings**

1. Make 10 to 16 cm deep furrows at a distance of 40 to 50 cm apart across the nursery beds. Depth and distance of furrows can be decreased or increased depending on the diameter of culm cuttings.

2. Place the cuttings in furrows horizontally across the nursery beds in such a way that the hole/opening facing upward or buds placed laterally. About 50-60 cuttings may be conveniently planted on a raised nursery bed of 10 m X 1.0 m size. Cover the cuttings with a 2-3 cm layer of soil. Frequent irrigation should be given till proper root development. Rooted culms are taken out after flooding the field or during rainy days when bed is loosened. The well rooted plants (Fig: 17) are detached from culm with roots and poly-potted. The saplings are de-topped with secateur or sharp knife to avoid excess respiration.

**Propagation through branch cutting**

In thick-walled bamboo species having prominent primary branches, branch cutting is the ideal planting material. Its small size and the fact that many branches can be extracted without damaging the mother clump makes it the propagating material of future. Branch age should be 0.5-1 year to guarantee survival rate. Discard the top portion leaving two nodes and the basal swell (Fig. 18 & 19). Then dip the cuttings in growth regulators like IBA/NAA. @
200 ppm (20g/ltr. Add up to 200 ltr.) equivalent to 200 mg/ltr. of water or rootex-3 powder for 24 hours (Fig. 20). Seal the cut ends with wax to prevent desiccation. Dip the cuttings in Bavistin (0.1%) solution just before planting. Plant the cuttings vertically either in polybags or raised beds in such a way that the rhizomatous swelling and one node remain below the soil surface (Fig.: 22). The polybags were kept under partial shade (75% shade provided by agro shade nets) and irrigated daily (Fig. 5). The sprouting and rooting take 1-4 months after planting (Fig. 6).

The successfully rooted and rhizomed cuttings were out-planted in the next rainy season.

**Propagation through layering the whole culm**

This process is not suitable for all the species and is practical in sparse bamboo stands located at plain terrains. However, in this process a suitable culm of about 1-2 year old is selected from a clump. Then the culm is undercut at the base and is bent down and then keep about 20 nodes and remove the top of the culm. The branches are pruned except a few branches at the base (Fig. 23). Care should be taken so that the dormant buds are not injured. Then the culm is buried under the well prepared soil and the branches and leaves are exposed to the outside atmosphere. The depth of the prepared soil; should be about 15 to 20 cm and the culm is buried to about 5 to 8 cm and then covered by soil and press the soil. Then cover the soil with straw and water regularly. The buried culm should be often checked so that a (rebound) culm should be pressed immediately under the ground again. New roots and shoots develop at the buried nodes after a few weeks. The internodes are then separated after about 6-8 months for plantation at the prepared field.

**Propagation through whole culm cutting (with or without stump)**

Select a healthy culm of about 2 years age and remove it from the ground with the stump or cut the culm at the base. Retain one or two main branches from the base and remove all other branches and also retain about 20 nodes from the base and remove the other portions. Prepare the bed where the depth is 15 to 20 cm and place
the culm horizontally. If the stump is there, then the position of the stump head should be upside down. It is advisable to saw a section on each inter-node with a depth of about 1/2 to 1/3 rd of the culm diameter (the section near the stump are deeper) for better results (Fig : 24). Then cover it with a layer of soil of 5 to 10 cm thick and press tightly. Then cover it with straw and start watering. The shoots and roots develop after few weeks.

**Macro-proliferation (Seedling Multiplication)**

This method is generally practiced in small seedlings. A bamboo propagule, for successful establishment and growth must possess a well established root system, rhizome and shoots. The multiplication of bamboo seedling by rhizome separation leading to smaller sized planting materials is known as macro-proliferation. In order to increase planting stock before transfer to the field, macro-proliferation is practiced. A bamboo seedling, at the age of 30-40 days, produces new culms and start developing rhizome. At four to five months period, these plantlets develop five to six culms (tillers) (as shown in Fig : 25). These tillers may be separated into as many units with a small piece of shoot, rhizome and roots. In order to avoid/minimise casualties the seedlings, after separation, should be kept in shade, watered regularly few days and then brought to the nursery beds. These propagules attain the size of field plantable saplings within four months, or they can be further multiplied through macro-proliferation (Fig : 26 & 27). Banik (1985) reported that five to nine months old seedlings of B. tulda can be multiplied 3-5 times in number through this technique. The survival rate of these multiplied seedlings is within 90-100%. By this technology a large number of identified planting stocks can be made available.

Advantages of this method are that once seedlings of a bamboo species are available the process can be continued at least for a number of years. It is easy to handle and transport the proliferated seedlings (Banik, 1985; Tewari, 1992) as they are small in size due to continuous rhizome separation. Banik (1985), however, suggested that such a seedling multiplication should not be continued for a very long time. The advantages of this method are that once seedlings of a bamboo are available, the process can be continued at least for a number of years.
**Brick and Sand Nursery**

Nurseries made out of brick and sand are Permanent in nature but investment is more. The rooting is faster. Prepare the bed with concrete cement like turtle shaped (Fig : 28). Collect coarse sand which should be free from earth. Sieve it properly and thoroughly. Collect bricks of required numbers for preparation of the beds over the concrete base. The length of the bed may be restricted to 6 meters and height equivalent to three bricks put over one another as per Fig : 29. The breadth may be about 1.2 meters from inside. No mortar should be used. The beds should then be filled with the sieved sand and no efforts should be made to close the gaps between the bricks.

Sheds as required may be arranged for any bamboo nursery. Proper irrigation should be maintained.
Commercial Plantation of Bamboo

Commercial plantation of bamboo is defined as bamboo plantation with intensive management like cultivation of any other cash crops to enhance the yield per annum to a predetermined level. Once the bamboo plantation achieves the optimum level i.e. generally by the seventh year of plantation for sympodial bamboo under the prevailing geo-climatic condition of the NER, the income becomes very stable and goes on providing till the stands attains an age of around 20 to 25 years. After this, it may be required to uproot the entire plantation in a phased manner for raising new plantations. Moreover, Commercial bamboo plantation may be done for three purposes- 1) For high yield of shoot alone 2) for high yield of poles alone and 3) for high yield of both shoot and poles. For such different purposes, the management is different and especially relates to the harvesting techniques of either shoot or poles or both. But, here as per the NBM, this guideline gives emphasis more on both high yield of shoots and poles at the same time.

Proposed Planting Scheme

The planting scheme has to take into consideration the size and growth habit of the species. In the proposed planting scheme (below), it should be noted that spacing of plants between lines is greater than the spacing of plants in line. This is because a wide space between lines allows greater ease of movement for maintenance and harvesting activities.

<table>
<thead>
<tr>
<th>Selected Species</th>
<th>Plant Spacing (m)</th>
<th>Total plants/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In line</td>
<td>Between lines</td>
</tr>
<tr>
<td>Bambusa tcula</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Bambusa balcooa</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Dendrocalamus hamiltonii</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Melocanna baccifera</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Dendrocalamus giganteus</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Dendrocalamus asper</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

Following a few rules can greatly aid the establishment of a productive plantation.

1. In selecting the plantation site check the quality of the soil. Bamboo can grow well on most soil, but deep porous fertile soil with high moisture content and a pH of 5.5 is preferable.
2. Good soil drainage is very important. Verify that the land is not prone to flooding. Bamboo does not perform well on waterlogged soils. It is, therefore, preferable for the plantation to be situated on moderate slopes.
3. Clear the land of all weeds and unwanted vegetation. Burning may be necessary during the dry season.
4. Carefully plan the layout of plantation so that the planting holes are placed at the specified distances and intervals (Fig : 31).
5. Plan the activities so that the plantation layout is completed at least 2 weeks before planting.
6. The planting holes should be positioned along North-South lanes. This will provide an optimal distribution of sunlight to all the plants.

7. Planting holes with a diameter of 30cm and a depth of 30cm should be evenly spaced out according to the recommended spacing of each species.

Planting should coincide with the start of the first rains in April or May. Upon planting, around 1.5 kg of cow dung should be placed into each hole and mixed with topsoil.

8. A week or two after planting, a small amount of inorganic fertilizers (NPK) may be applied over the planting hole. The prescribed dosage of fertilizers is indicated in the following table:

<table>
<thead>
<tr>
<th>Inorganic Fertilizer NPK 2:1:1</th>
<th>Substance per Plant (g)</th>
<th>Mixture per Plant * Proportion</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea (N : 46%)</td>
<td>33</td>
<td>35%</td>
<td>0.07</td>
</tr>
<tr>
<td>Super Phosphate (P:16%)</td>
<td>16</td>
<td>51%</td>
<td>0.10</td>
</tr>
<tr>
<td>Potash (K20:60%)</td>
<td>16</td>
<td>14%</td>
<td>0.03</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>0.20</td>
</tr>
</tbody>
</table>

The NPK mixture should be prepared according to the proportions indicated above. Only 200 grams of the mixture should be applied around each plant in the first year.

**Note on Intercropping**

During the first two years of the plantation, intercropping of cash crops and vegetables may be done in between the lines of bamboo. Intercropping serves several purposes. It provides greater stability to the soil, it provides a source of income to farmers, and it is an incentive for farmers to maintain and protect both their vegetable crops as well as the newly planted bamboo. Generally, intercropping is done for a limited duration of 2 years. When the bamboo canopy has developed, sunlight will be fully absorbed by the bamboo and the cultivation of vegetables will no longer be viable. During the third year after planting, leguminous species may be planted to serve as ground cover in between the lines of bamboo.

**Maintenance Activities**

Maintenance activities during the first 2 years after planting are centered on protecting the young plants from competing vegetation and pests. After the second year, maintenance activities are concentrated on clump management.
**Weeding**

The growth of any young plant can be hampered by weeds and competing vegetation. It is very important to control and arrest the growth of weeds around each bamboo clump. Failure to do so will invariably result in poor root and stem development in the young bamboos. The area with a radius of 50 cm around each plant should be cleared of all weeds and vegetation.

**Control of grazing animals**

The presence of pests and grazing animals should be thoroughly controlled. Every available means should be taken to prevent grazing. In small homesteads, fencing is a solution, but for a large plantation it is costly. Careful supervision in this regard is therefore crucial. The plantation supervisor should make daily rounds and check for damage, seek the cause, and find suitable means to eliminate the problem.

**Fertilizers**

Dosages of NPK will increase in the second and third year as indicated in the tables below. In the second year it is estimated that 307 kg of NPK mixture is needed per ha. From the third year onward about one ton of NPK is required. The dosage should be distributed evenly around each clump. Fertilizers should be applied in advance of a normal rainy period in order to avoid leaching and to maximize the growth of the plants.

<table>
<thead>
<tr>
<th>Inorganic Fertilizer Application in Year 2</th>
<th>Mixture Kg/ha</th>
<th>NPK Kg/ha</th>
<th>Bags per ha (50 Kg/ Bag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK 2:2:1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea (N: 46%)</td>
<td>109</td>
<td>50</td>
<td>2.2</td>
</tr>
<tr>
<td>Super Phosphate (P:16%)</td>
<td>156</td>
<td>25</td>
<td>3.1</td>
</tr>
<tr>
<td>Potash (K20: 60%)</td>
<td>42</td>
<td>25</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>307</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inorganic Fertilizer Application from Year 3 onwards</th>
<th>Mixture Kg/ha</th>
<th>NPK Kg/ha</th>
<th>Bags per ha (50 Kg/ Bag)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPK 2:1:1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea (N: 46%)</td>
<td>217</td>
<td>100</td>
<td>4.3</td>
</tr>
<tr>
<td>Super Phosphate (P:16%)</td>
<td>313</td>
<td>50</td>
<td>6.3</td>
</tr>
<tr>
<td>Potash (K20: 60%)</td>
<td>530</td>
<td>150</td>
<td>1.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1060</strong></td>
<td><strong>300</strong></td>
<td></td>
</tr>
</tbody>
</table>
**Mulching**

Mulching is a proven way of improving the growth of bamboo. Mulching is achieved by uniformly spreading a layer of soil, leaf litter, and other organic material on the surface of the soil around the bamboo clump (Fig : 34). Mulching is an effective way of preventing weed growth, conserving soil moisture, and increasing the organic matter of the soil.

Mulching is absolutely necessary for the production of good quality bamboo shoots. The mulch protects young shoots from direct sunlight and keeps them moist, thus allowing them to grow to an optimal size without hardening and losing their quality.

**Rhizome Exposure**

It has been reported from some of the ASEAN countries that during the summer, the soil covering the rhizome of clumps may be removed in such a way that no rhizome or buds are injured and exposed to the sun for about a week or so (Fig : 35) and than covered with soil mixed with some fertilizer. This ensures activation of the buds and the rate of burgeoning of shoots increases.

**Clump Management**

The proper maintenance of the clump not only improves productivity but also eases the job of the plantation worker.

Clump management is partly a maintenance task and partly a result of harvesting. As a maintenance activity it involves removing unwanted culms to prevent clump congestion. This is particularly necessary with densely tufted species. It is sometimes necessary to sacrifice a few culms in order to allow for better shoot production in the clump. Fig. 36 shows unmanaged clump whereas Fig. 37 shows well managed clump.

Ideally a clump should be managed such that there are no more than 9 to 12 culms per clump. The culms should be distributed evenly by age i.e., 3-4 culms of one, two, and three years in age. For sympodial bamboos, all culms of four years and older should be removed from the clump at the time of harvesting. In the case of Melocanna baccifera, culms are mature after two years, and therefore all culms two years and older should be removed from the clump.

Controlling the clump for rotting is necessary to promote the healthy growth of shoots and new culms. Attention should be placed on rotting in the stubs of culms that have been harvested. If rotting is apparent it is advisable to dig around the stub and completely remove it. Likewise rotting culms should be removed. Symptoms of disease or fungal infections should be noted and a plant pathologist should be advised for possible remedies and control measures.

**Harvesting and Handling**

Harvesting operations in a bamboo plantation are divided into the collection of shoots in the rainy season and cutting of poles during the dry season. Harvesting is a labor intensive operation and it is necessary to make good arrangements with plantation workers so that harvesting operations are not delayed. This is especially important for shoot harvesting which has to be completed within a short period of time during the rainy season months.
**Culm Harvesting and Handling**

The following rules apply for harvesting culms of sympodial bamboos.

1. Harvesting of mature culms may begin in the fourth year after planting.
2. Approach clumps with caution. It is necessary to make a lot of noise to frighten snakes which may be nesting inside the bamboo clump.
3. Only harvest culms during the dry winter season. The starch content of bamboo is lower during period of dryness. Lower starch content in the culms will make them less susceptible to attack by borers, etc.
4. Harvesting should be selective: only mature culms should be harvested.
5. Plan the cutting operation to avoid harming young culms.
6. Use very sharp tools. It is highly advisable to disinfect harvesting tools using bleach. This lowers the risk of infecting the plants.
7. Do not cut young culms unless congestion in the clump prevents the cutting of mature culms.
8. Cut each culm right above the first node from the ground level. This is necessary so that water is not allowed to accumulate in the protruding internode. The accumulation of water may result in rotting and invites insects to lay their eggs.
9. Never clear-cut an entire clump unless it has been verified to be seriously infected by a disease.
10. Never harvest culms during the rainy season!
11. Mulch each clump after harvesting.

After they are cut, the branches and leaves of the culm should be stripped off. These should be neatly piled around the clump to provide organic material for mulching. As a thumb rule and depending upon the species, the number of culm (average) harvested should follow the following:

- **3 Culms per Clump after 4,5 years**
- **4 Culms per Clump after 5,6 years**
- **5 Culms per Clump after 7 years**

**Or Average 1500 -2000 Culms per hectare after 7th year of Plantation**

If the plantation is situated near a river, the culms may be allowed to soak in water for a few weeks to aid in the removal of starch and protect them from beetle attack. Otherwise the stripped culms should be hauled to an area where they are sorted and air-dried.

Good practices to enable drying will help minimize losses due to biodegradation of the culms. The large culms should be stacked horizontally on parapets where there is good air circulation. Smaller culms (e.g. Melocanna baccifera) may be piled horizontally at a 60° angle to form a “tepee shape” allowing air to circulate around them to aid the drying process. After drying, the whole culms or culm segments are sold in local markets. If preservative treatments are necessary, proper methods have to be applied depending upon the requirements as mentioned in this manual.
Shoot Harvesting and Handling

The emergence of new shoots begins during the rainy season of the year after planting. These new shoots should not be harvested. They should be allowed to grow to a full height in order to promote the healthy establishment of the clump. The number of shoots produced per clump will always vary. Only one or two shoots may appear in some clumps. Other clumps may produce many more.

A small amount of edible young shoots may be harvested in the third year of the plantation, i.e. two rainy seasons after planting. Shooting for some species may start earlier than for others. Awareness of the pattern of growth which differs from species to species and from place to place is therefore vital. Harvesting of shoots should only be done on well established clumps. A few rules apply to the harvesting of shoots.

1. At the start of the first rains check for bumps or swellings on the ground around the clump and beside the culms. These bumps are signs of the imminent emergence of new shoots.

2. Become familiar with the shooting season of each species. Some species may shoot as early as April or May, while others may shoot several months later.

3. Keep in mind that shooting usually occurs for a certain period. It is therefore necessary to inspect the clumps for new shoots.

4. See to it that there is a good heap of mulch around the clump. The mulch will keep the new shoots moist and retain their quality.

5. Timing is very important: shoots should be harvested within one to two weeks after they appear from the ground. Shoots harvested too late will be tough and of poor quality as food. Still, there are some species of bamboo (D. Oldhamii) whose shoots can be eaten raw but once they are out of the soil, they taste bitter. So, they are always covered by the soil with intensive management and harvested by removing the soil at the right time.

6. A new shoot will be 10 to 20 cm tall depending on the species.

7. The young shoot should be cut using a sharp harvesting blade (resembling a large chisel). The cut should be made about 10 cm to 15 cm below the soil at the soft section where the shoot emerges from hard rhizome.

8. Do not cut shoots that have grown beyond the average edible shoot size. These will be fibrous, tough, and inedible and should be allowed to grow into culms.

9. After harvesting the shoots, periodically check the clump for the presence of new shoots. It is not unusual for a second round of shoots to appear, especially during period of high rainfall and intensive growth.

10. Never harvest all the shoots of a clump. Always see to it that several shoots are allowed to grow into culms.
Harvested shoots should be handled with care. After harvesting, the shoots of each species should be sorted according to size and bundled using the means traditionally used for vegetables. The harvested shoots should be stored in a cool place, away from direct light and humidity. This will prolong the life of the product. If a large mixed species of bamboo plantation is there, then the norms for harvesting shoots are as below:

### Shoot

<table>
<thead>
<tr>
<th>Estimated yield (Tonne/year)</th>
<th>B. Tulda</th>
<th>B. Balcooa</th>
<th>D. Asper</th>
<th>D. Hamiltoni</th>
<th>M. Baccifera</th>
<th>D. Giganteus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Wt(Kg) shoot</td>
<td>1.5</td>
<td>2</td>
<td>3.5</td>
<td>1.8</td>
<td>0.53</td>
<td>3.5</td>
</tr>
<tr>
<td>Average no. harvested/clump</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Average kg/clump</td>
<td>6</td>
<td>8</td>
<td>14</td>
<td>7.2</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Projected maximum Yield (Tons per hectare)</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Average Yield per Hectare per year</td>
<td></td>
<td></td>
<td></td>
<td>2.67</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Estimated harvest

<table>
<thead>
<tr>
<th>Annual Yield to estimated maximum yield</th>
<th>Shoots</th>
<th>Tonnes/Hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 3</td>
<td>10%</td>
<td>0.27</td>
</tr>
<tr>
<td>Year 4</td>
<td>25%</td>
<td>0.67</td>
</tr>
<tr>
<td>Year 5</td>
<td>50%</td>
<td>1.34</td>
</tr>
<tr>
<td>Year 6</td>
<td>75%</td>
<td>2.00</td>
</tr>
<tr>
<td>Year 7 onwards</td>
<td>100%</td>
<td>2.67</td>
</tr>
</tbody>
</table>
Insect Pest and Disease of Bamboo and their Control

Insect Pest of Bamboo

Bamboos are subject to injury by various kinds of herbivorous insects. Attack by these insects reduces plant vigour and the productivity of bamboo stands. A large number of insects, which have highly modified mouthparts, feed on sap of leaves, branches, culms, shoots, roots and rhizomes. These insects can damage bamboo in four ways:

1. Removing the plant fluid.
2. Causing mechanical injuries from egg laying.
3. Injecting toxic compounds into the plants.
4. Transmitting disease

The results of these are defoliation, wilting of young shoots and branches, and even death of culm.

Main Pest of Bamboo

Smoot moth (Artionia fumerlis)

Distribution: China, India, Korea, Japan

Control: Burying cocoon by ploughing soil; spraying chemical insecticides before population going to epidemics and protecting its natural enemy.

Notodontid defoliators / Green bamboo caterpillar (Loudonta dispar)

Control: Burying over wintering insect by digging and other cultivation; protection of parasitoids, spider and birds.

Green slug Worm (Parasa bicolor)

Distribution: India, China, Burma, Indonesia.

Control: Burying and destroying cocoon with cultivation, Release of parasitoid; spraying chemical insecticides when necessary.

Bamboo powdering beetle (Dinoderus minutus)

Control: Selection of resistant bamboo, e.g. bitter bamboo. Choosing cut period of bamboo during autumn to winter when there is low content of starch and sugar; immersing bamboo in water to remove sugar and starch and treatment of bamboo with pesticides.

Disease of Bamboo

A total of 440 fungi, two viruses, one phytoplasma and one bacterium like organism have been reported to be associated with this disease and disorders. Only a few diseases identified as serious ones, affecting culm production as well as stand productivity.

Among the diseases that affect bamboo in stands, foliage disease is most common, and about 220 fungi are known to be associated with such infections. Diseases which are recognized as potentially serious include: culm blight cause by Sarocladium oryzae rot of emerging and growing culms caused by Fusarium spp.; witches’ broom caused by Balansia species, little leaf disease caused by phytoplasma in the dry tracts, culm mosaic caused by bamboo mosaic virus and culm rust caused by Stereotatum corticioides and top blight.

Apart from the infectious diseases, non-infectious diseases caused by abiotic factors—also play a major role in limiting culm production.
**Main Diseases of Bamboo**

**Damping-off disease**

Causal organism: *Rhizoctonia solani*, *Fusarium moniliforme* and *F. oxysporum*.

**Distribution and hosts**: India, China. Damping-off has been recorded in *Bambusa bambos*, *Dendrocalamus brandisii*, *Throstachys siamensis* and *Phyllostachys pubescens*.

**Symptoms**: Damping-off is common in bamboo nurseries, causing considerable loss to seedlings. The disease occurs in patches in the seedbeds 7 to 12 days after sowing. The pre-emergence damping-off are characterized by the rotting of well viable seeds and post-emergence damping-off by soaked grayish brown lesion on the emerging premule near the soil level. The lesion spread and become necrotic, resulting in the collapse of the premule.

**Control**: The best means to control damping-off is by preventing fungi from entering into the seedbed. Damping-off can be avoided by adopting proper nursery technique. Excessive watering and shading should be avoided. Seedbed solarization and seed dressing with fungicides such as Bevistin are other measures suggested to minimize the disease incidence.

**Smut**

Causal organism: *Ustilago shiraiana* and *Tilletia bambusae*

**Distribution and host**: India, China and Japan. Smut has been reported on Bambusa Spacies.

**Symptoms**: The fungal attack young developing tillers and often completely replaces the seeds with black fungal spores, causing smut. Only seed that are not infected attain maturity but they may also contain fungal spores. Infected seeds on germination do not produce healthy seedlings.

**Controls**: Control of smut is possible by planting resistant species and seed treatment. Carboxin, thiabendazole, etaconazole and other systemic fungicides are effective in controlling smut fungi.

**Black mildew**

Causal organism: *Melioia species*, *Haraea japonica*, and *Sterinella hiugensis*

**Distribution**: India, China, Japan, and Thailand

**Symptoms**: Powdery black patches appear on the upper surface of matured leaves. As the infection developed, the upper surfaces become densely coated with a black powdery growth of fungal hyphae. Infection also occurs on leaf sheaths and minor branches. Severe infection reduces effective photosynthetic area of the leaves.

**Control**: Opening the canopy will reduce the infection.

**Sooty Mould**

Causal organism: *Capnodium sp.* and *Spiropes scopiformis*

**Distribution**: India, China, Japan

**Symptoms**: Infection usually appears on the upper leaf surface as a sparse, black network of hyphae or a thin, effuse, black powdery fungal coating. The disease also occurs on branches. Usually bamboo aphids associate sooty moulds.

**Control**: To control aphids is key treatment. Protection of natural enemy such as ladybug beetles, parasites.
Durability of Bamboo and Its Rural Preservation Techniques

The durability of bamboo compared to timber, etc is short. If bamboo is untreated and exposed to the atmosphere is prone to fast biodegradation. This is because of presence of large amount of hemi-cellulose, starches and abundance of moisture which acts as nutrients, etc. for the bio-degrading agents. All these components together with bio-degrading agents like white-rot, brown-rot, group of stain fungi and insects like borer and termites make bamboo prone to attack and thus fast decay (Fig : 39 & 40). It is estimated that more than 40% of bamboo is being destroyed due to these biological agents during use and storing in untreated conditions.

The durability of bamboo can be enhanced by adopting preservation methods with or without chemicals. However, from scientific point of view and field experience, it has proved that application of chemicals in the preservation methods enhances the life of bamboo many times than without chemicals.

The precautionary measures for increasing the life of harvested bamboo poles by adopting preservation methods can be applied right from the time of harvest.

Storage of Harvested culms: Proper storage of harvested culms is an important aspect as negligence on this part can cause great losses. Whenever bamboo is stored, it should be ensured that the culms do not up-take any additional moisture either by rain on by ground contact. Culms left on the ground open to rain are prone to infestation by fungi, beetles etc. Further, to avoid cracking by sun exposure, the culm should be preferably placed under cover for a period of 6 to 12 weeks depending on the season.

Preservation measures: There are many preservation techniques both as Traditional Methods as well as Chemical Methods.

Traditional Methods

There are various Traditional preservation methods followed in the rural areas in all the bamboo growing countries. Without the use of chemical these methods are easily to be followed and can be carried out by in experienced villagers without any technical equipments and at a low cost.

1. Self-culm curing: In this process the selected culm is cut at the base and left for a few days within the clump which provide leaning support (Fig : 41). The bottom of the harvested culm, should preferably, not touch the ground and may be placed over a stone, etc. When the leaves, branches etc turn yellowish brown, the culms
are removed and transported to the storage site. It may be noted that the culm weight while removing from the clump is reduced because of loss of water due to continuous transpiration by the leaves and also the starch content is reduced.

2. **Water curing**: This is a common practice. The freshly cut culms are put either into running water or stagnant water like pond for 1 to 3 months (Fig : 41). The affect of this treatment is better if the nodal walls are ruptured. However, if the storage under water is prolonged, the culm gives bad odour and may lead to staining. This treatment improves resistant to borers and some stain fungi. Culms or slivers to be used for handicraft products may also be boiled in fresh water for 30 to 60 minutes which gives good results.

3. **Smoke curing**: Smoke curing is also a traditional process in some of the Asian bamboo growing villages whereby bamboo culms are stored inside the house above a fire place. In doing so, for few days the moisture content of the culm is reduced considerably and is therefore, insufficient for biological degradation. However, the colour of the culm becomes brown or dark brown depending upon time and temperature which prevent fungal spores as well as beetles.

**Chemical treatment methods**

**Temporary protection for short life**

There are different kinds of chemical treatment methods. Some methods needs costly equipments including power and also some chemicals like CCA are very toxic and require careful handling. Considering all these factors, only a few methods that requires a little investment and uses chemical which are not very toxic are being discussed here.

1. **Spraying Chemicals**: In this method, chemicals/insecticides are mixed and dissolved in water and sprayed on the stacked bamboos or the bamboos are put into the solution for about 30 minutes. The solutions can be made from various chemicals. But, considering the rural environment and expertise in handling such chemicals, a dose of Borax with 6-8% concentration or Borax and Boric acid (1.5:1) with 5% concentration is recommended. The stacked bamboo should not be kept in touch with the ground directly and not exposed to rain.

2. **Dipping**: In this process, the poles or slivers to be used for making handicraft products or furniture, mats, etc are recommended as this process is more effective than the previous one. If slivers/strips are to be used, they may be bundled together before dipping. The solution may be made from Borax : Boric acid in proportion to 1.5:1 with concentration of about 5%. The time of dipping depends upon requirement and end use. However, as a thumb rule, 30 minutes dipping will give some protection.

**Permanent protection or for Longer service**

1. **Steeping or But-End Treatment**: In this process, freshly cut bamboo culms of desired length are immersed with their butt ends in a solution of Boric acid: Borax (50:50) of about 10% concentration. The immersion ends should be done up to a length of about 30 cm of the butt-end. The treatment may last for 8 to 12 days. In this process, stirring of the solution is demanded.
on every day to avoid sedimentation and also add small amount of the boric acid: Borax mixture to make up the uptake loss. This treatment is suitable for using as fencing/support to horticultural plants like banana, etc. as the end comes in constant contact with the ground (Fig : 42).

2. **Diffusion/Soaking Process:** In the diffusion process, freshly cut culms having M.C.* >50% are kept submerged in preservative solution for 1-2 days (Fig : 43) followed by stacking under shade for 10 - 15 days. To treat dry bamboo culms, they are wetted by keeping under water till M.C. about 50%. In this process, bamboo splits can also be treated. For effective penetration, two opposite holes may be drilled in each internodes before immersion of the culms. In order to fasten the simple dipping in cold solution of preservatives, the solution can also be heated (Fig : 44). In such case, the total duration for completion of the process is about 3 hours.

3. **Hot and Cold process:** This process is to be used especially for the culms to be used as poles with end cuts are to be put underground or for fencing in the form of both as poles and strips. Bamboo culms are placed in a drum vertically. The drum to be filled with creosote oil and diesel oil mixture (1:1). Heat the drum directly for 2-3 hours followed by cooling the solution overnight (Fig : 45). This will provide some enhanced penetration.

4. **Internodal Injection:** Also for dry bamboo poles, creosote and diesel fuel mixture of (1:1) proportion can be injected by drilling holes at the internodes. The oil covers the inner walls throughout the cross structural area. The holes after injection can sealed and the poles are rolled for better distribution once in two days for a week before use (Fig : 46).

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* M. C. - Moisture Content
Primary Processing of Bamboo at the Village Level

Primary Processing essentially means converting Bamboo after harvesting to some other form involving cross cutting, splitting, knot removal, etc either to make Handicraft products, furniture and the like or to feed large bamboo processing units. Primary processing can either be done using locally available tools like Dao or using machines either with power or hand operated. In order to increase the yield, productivity and maintaining size uniformities, use of machines are advisable.

This primary processing of bamboo can be set up at the village level near the source of raw material i.e. bamboo. Such units can be set up by either rural entrepreneurs, SHGs, NGOs, PRIs or by the community preferably based on cluster approach. Setting up of such primary processing units not only lead to income and employment generation but also makes a beginning towards Rural Industrialization thereby facilitating Rural populace to direct their own development by..

- Placing control of the resources they create by their own hands.
- Attaining self reliance by team work and have a financial stack.
- Enjoying the autonomy and accept accountability for building and managing their own Institution.
- Developing a strong relationship with the Industry /Consumers.
- Encouraging a co-operation movement, something similar to “Operation Flood”* which is a successful model under Indian condition. Such models can probably be replicated in these parts of the country with bamboo as community here seems to have more affinity towards bamboo than milk.

The various activities under primary processing that maybe categorized as –

1. **Cross-Cutting**: cross cutting means sizing the whole bamboo culm upto the desired length longitudinally. This may either be done using electric power cross-cutting machine or manually by Hacksaw, Dao etc.

2. **Splitting**: In this cross cut poles are splitted vertically in the form of strips of required width. This operation may also be carried out using either power operated splitting machine or hand operated splitting.

3. **Internal Knot removing**: The unwanted internal knots are removed either by using an internal knot removing machine or in a two site planer or manually.

4. **Slicing**: The bamboo strips after splitting and internal knot removing can further be made thinner upto the require size (with limitation on thinness) by using a slicing machine of either power operated or manually operated. After slicing the strips with thickness of about 0.6 mm to 1.5 mm, these are generally called slivers. These slivers have various uses e.g. mat making, sticks making, handicraft and furniture making etc.
5. **Stick Making Machine**: Round Bamboo Sticks of different diameters and square bamboo sticks of different dimensions have various uses like Agarbatti Sticks, Flower Sticks, tooth picks, match sticks, blind weaving etc. These sticks can either be made by power operated or hand operated machines. But because of technical reasons, hand operated machines can only make square sticks and that too without knots.

### Village Level Primary Processing Units

- **Cross Cutting**
- **Knot rendering**
- **Splitting**
- **Square Stick making**
- **Slicing / Slivering**

### Cost / Benefit of Hand Operated Machines

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holding Device</td>
<td>Rs. 600/-</td>
</tr>
<tr>
<td>Slivering Machine (for Stick)</td>
<td>Rs. 4000/-</td>
</tr>
<tr>
<td>Stick Making Machine</td>
<td>Rs. 7500/-</td>
</tr>
<tr>
<td>Slivering Machine (for Mats)</td>
<td>Rs. 4000/-</td>
</tr>
<tr>
<td>Manual Splitter</td>
<td>Rs. 1000/-</td>
</tr>
<tr>
<td>Hand Tools &amp; Accessories</td>
<td>Rs. 1500/-</td>
</tr>
<tr>
<td>Bamboo Stick</td>
<td>Rs. 35/- each</td>
</tr>
<tr>
<td>Production of mat</td>
<td>Rs. 35/- each</td>
</tr>
<tr>
<td>Bamboo Sliver</td>
<td>Rs. 35/- each</td>
</tr>
<tr>
<td>Selling Price</td>
<td>Rs. 12/- kg</td>
</tr>
<tr>
<td>Mat</td>
<td>Rs. 45/- each</td>
</tr>
<tr>
<td>Gross Family income</td>
<td>Rs. 120-130/- per day</td>
</tr>
</tbody>
</table>

These costs are tentative and may vary from place to place of implementation depending upon various factors. However, one family with the above machines in a village may not do good as total output per month or in 2-3 months time will be too less unless there is a very good existing collection system. Alternatively, a Cluster approach may be followed. A model Cluster Model is discussed in the next page:
As per the above diagram, each Cluster may consist of 10 families or more or less and there should be enough such clusters within a comfortable radius with logistical advantages so that the collection Centre gathers enough product to sell in a truck load, say on weekly basis. The main collection centre may be run and operated by a lead NGO of the area.

With the approach of such models, the villagers in a teamwork spirit can operate an economic scale unit with competitive edge contributing marginally at the individual family level. Such models working in other sectors like Textiles, Automobile spares are doing very good in the country.

Apart from the above, a Lead NGO or the Community themselves can adopt a Common Facility Centre (CFC) approach. Under this model, the Lead NGO or the Community implementing a CFC will invest in setting up a shed of required area and in procuring the machines. The artisans/villagers can bring their bamboo poles for conversion to different semi-finished products by paying a nominal conversion fees or the investors can purchase bamboo from the villagers/forest department and convert them to required semi-finished products like slivers, etc. and distribute to the artisans/villagers for weaving into mats/baskets, etc. and collect them at regular intervals by paying them for the work and store them in the storage depot for ultimate selling.

There are so many bamboo based products being made by our local artisans that have, in fact, tremendous local demands like baskets for vegetable and fruit carrying, tea leaves, chicks, etc. to name a few. But, all these are made by the artisans single-handedly right from harvesting of poles to carrying to his house to cross cutting to splitting to internal knot removing to slicing and then
weaving. If there are sources around whereby slivers can be delivered to the artisan, he can concentrate more on the weaving sector and thus produce more there by increasing the yield. Further, if two three families are involved in producing the same basket with different jobs on the same i.e. one family engaged in polishing the slivers, other two families are engaged in weaving the main basket, another family is engaged in finishing the open edges of the basket then this will work like an assembly line in a modern factory and enhance the yield by many times and thus the product becomes cost competitive in the market and the artisans income will mainly come from the volume of sell and quality of the product though at a lesser price.
Preparation of Hormones Solutions

IBA (Indole Butyric Acid) = Roots inducing hormone.
NAA (Naphtyl Acetic Acid) = Shoots inducing hormone.
Bavistin = Fungicides
Boric Acid = A Chemical that activates rooting

PPM (Parts per million)
1 million = 10 lakhs

Preparation of 200 ppm IBA or NAA or Boric acid solution

1. Take 20 gm of IBA/NAA/Boric acid with the help of measuring scale and put into a clean mug, add ½ liter of distilled water (can be bought from Retail outlets, Battery recharge shops, etc).

2. Stirred it well until it dissolved completely into the water; add the distilled water up to 200 liter.

3. This prepared is ready to use for 1000 cuttings @ 200 ml per two nodded cuttings. However, while using Boric acid, the amount will be more as the internodes are to be entirely filled with the solution.

Preparation of 1% Bavistin solution

1. Take 10 gm of Bavistin with the help of measuring scale or two tea spoons and mixed with 1 liter of clean water.
# Identified species under NBM - Fact Sheet

<table>
<thead>
<tr>
<th>Species</th>
<th>Bambusa tulda</th>
<th>Bambusa balcooa</th>
<th>Dendrocalamus asper</th>
<th>Dendrocalamus hamiltonii</th>
<th>Melocanna baccifera</th>
<th>Dendrocalamus giganteus</th>
<th>Bambusa nutans</th>
<th>Bambusa bambos</th>
<th>Osthagnandra travancarica</th>
<th>Dendrocalamus strictus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Height Range (m)</strong></td>
<td>9 to 20</td>
<td>9 to 20</td>
<td>10 to 20</td>
<td>9 to 20</td>
<td>10 to 15</td>
<td>10 to 15</td>
<td>10 to 15</td>
<td>10 to 15</td>
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<tr>
<td><strong>Average Height (m)</strong></td>
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<tr>
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<td>8 to 19</td>
<td>10 to 20</td>
<td>10 to 20</td>
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<tr>
<td><strong>Average Diameter (cm)</strong></td>
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<td><strong>Wall Thickness Range (mm)</strong></td>
<td>8 to 12</td>
<td>14 to 22</td>
<td>11 to 26</td>
<td>10 to 24</td>
<td>6 to 12</td>
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<td>6 to 12</td>
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<tr>
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<tr>
<td><strong>Cold Tolerance (°C)</strong></td>
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</tbody>
</table>

## Description

- **Bambusa tulda**: Tufted bamboo with large, thick walls and culms. Multi-purpose bamboo, useful for construction, shelter, and ornamental purposes.
- **Bambusa balcooa**: Densely tufted, symmetrical bamboo with thick walls and strong culms. Useful for construction and crafts.
- **Dendrocalamus asper**: Giant bamboo of Southeast Asia, mostly introduced in Northeast India. Excellent species for timber and edible shoots.
- **Dendrocalamus hamiltonii**: Native to the Northeast Hills, this species produces excellent shoots and strong poles for construction and industrial purposes.
- **Melocanna baccifera**: shoots are used for construction and crafts.
- **Dendrocalamus giganteus**: One of the great bamboo species in Northeast India. Culms are very strong and are used for construction and industrial purposes.
- **Bambusa nutans**: Culms are often curved, shoots are up to 30 cm long.
- **Bambusa bambos**: One of the most useful bamboo species in the Northeast Hills. Culms are strong and shoots are up to 50 cm long.
- **Osthagnandra travancarica**: Culms are long, straight, and useful for construction and industrial purposes.
- **Dendrocalamus strictus**: Culms are long, straight, and useful for construction and industrial purposes.

## Growth Habit

- **Symppodial (Clumping) bamboo**: Shoots are tufted and shoots are closer together.
- **End of Pre-Monsoon Start of Monsoon**: Culms are slender and shoots are used for construction and industrial purposes.
- **Symppodial (Clumping) bamboo**: Shoots are tufted and shoots are used for construction and industrial purposes.
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## Bamboo Culm Management

- **Thinning / Mulching**: Culms are thinned and shoots are mulched to promote better growth.
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## Flowering Cycle

- **30 to 60 yrs**: Culms flower after 30 to 60 years.
- **33 to 45 yrs**: Culms flower after 33 to 45 years.
- **30 to 45 yrs**: Culms flower after 30 to 45 years.
- **40 to 45 yrs**: Culms flower after 40 to 45 years.
- **35 yrs**: Culms flower after 35 years.
- **25 to 45 yrs**: Culms flower after 25 to 45 years.

## Period for Harvesting Culms

- **Post Monsoon – Winter (Nov–March)**: Culms are harvested after the post-monsoon period.
- **Post Monsoon – Winter (Nov–March)**: Culms are harvested after the post-monsoon period.
- **Post Monsoon – Winter (Nov–March)**: Culms are harvested after the post-monsoon period.
- **Post Monsoon – Winter (Nov–March)**: Culms are harvested after the post-monsoon period.
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- **Post Monsoon – Winter (Nov–March)**: Culms are harvested after the post-monsoon period.
- **Post Monsoon – Winter (Nov–March)**: Culms are harvested after the post-monsoon period.

## Period for Harvesting Shoots

- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.
- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.
- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.
- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.
- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.
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- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.
- **Pre-Monsoon to Monsoon (April–Sept)**: Shoots are harvested during the pre-monsoon period.

## Yield (Air dried tons/ha), Culms

- **15**: Yield of culms is 15 tons per hectare.
- **20**: Yield of culms is 20 tons per hectare.
- **25**: Yield of culms is 25 tons per hectare.
- **30**: Yield of culms is 30 tons per hectare.
- **35**: Yield of culms is 35 tons per hectare.
- **40**: Yield of culms is 40 tons per hectare.
- **45**: Yield of culms is 45 tons per hectare.
- **50**: Yield of culms is 50 tons per hectare.

## Average culm weight (Air dried Kg), Culms

- **15**: Average weight of a culm is 15 kg.
- **20**: Average weight of a culm is 20 kg.
- **25**: Average weight of a culm is 25 kg.
- **30**: Average weight of a culm is 30 kg.
- **35**: Average weight of a culm is 35 kg.
- **40**: Average weight of a culm is 40 kg.
- **45**: Average weight of a culm is 45 kg.
- **50**: Average weight of a culm is 50 kg.
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<th>Planting Time Options</th>
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