1. Introduction
Bamboos are monocarpic in nature, therefore, their seeds are always in short supply. In the absence of seeds, vegetative propagation methods are used for the production of planting stock. Two major types, viz., macro- and micro-propagation methods are used in vegetative propagation of bamboos. In macro-propagation, conventional methods of offset planting, rhizome planting, rooting of cuttings and layering are used while in micro-propagation various tissue culture techniques are being employed. Details of the macro-propagation techniques are given below.

2. Methods of Macro-Propagation

2.1. Macro-Proliferation
Young seedlings are allowed to grow for six months to one year before carrying at macro-proliferation. To promote growth, two doses of NPK fertilizer are given at an interval of one month from the day of planting. In this method, rhizomes are separated from the seedlings using a secateur. The separated rhizomes are planted in fresh polybags of 24 cm x 18 cm size repeating the same fertilizer treatment. By around three months, tillers develop, out of which some are retained in the nursery for future multiplication and remaining saplings are used for field planting (Fig. 2.1.1.). This cycle can be repeated every year for the production of planting stocks for raising large scale plantations (Adarsh Kumar, 1991).

The advantages of this method are that a large number of planting stock can be produced from limited quantity of seeds and the planting stock can be maintained in the nursery, so that, every year it can be used without going for repeated nursery establishment.
2.2. Offset Planting

An offset is the basal portion of a single culm with the rhizome axis and roots attached to it. For offset planting, preferably one- to two-year-old culms from the peripheral portion of a clump are selected. The identified culms are cut in a slanting manner in such a way that two to three nodes are left at the base. Cutting can also be done right above the node without damaging the basal portion of the branches. The rhizome to which the culm is attached is dug and cut at about 30 to 45 cm from the ground. While collecting the offsets, the rhizome and attached roots should not be damaged and the buds should remain intact. If transportation to the planting site is required, the underground parts of the offset should be wrapped with moist substratum like banana stem, coir or gunny bag to avoid drying (Fig. 2.2.1.). These offsets can either be planted in the field in 45 cm x 45 cm x 45 cm pits or potted in a medium sized gunny bag. Offsets can be planted along with the pre-monsoon showers or just before the
beginning of the rainy season. Watering has to be done during the dry period as and when needed. Offsets can be collected during the summer season, just two or three months before planting. If collected later, the buds are liable to be damaged, as new sprouts are produced during this season. The major limitation of this method is that the offsets are bulky and extraction and transportation is labour intensive. Also, the number of offsets available per clump is limited to one or two and hence the method is not feasible for raising large-scale plantations. However, initial mother plant collections of suitable species can be established using this method (Banik, 1995).

2.3. Rhizome Cuttings
Rhizome cuttings are sections of fresh living rhizomes with at least a bud of the preceding year along with a portion of the culm (about 15-30 cm long). This technique is mainly suitable for monopodial bamboos with runner type of rhizome. Rhizome with roots, rhizome with culm and roots or rhizome with culm-stock and roots are being used for propagation in this method. Rhizomes should not be more than two-to three-year-old, not physically damaged and have roots attached to them for successful rooting and sprouting. If transportation is involved, the rhizomes should be protected from drying as in offsets (Fig. 2.3.1.). Most of the plantations of monopodial bamboos like *Phyllostachys pubescens* are established by this method.

2.4. Rooting of Cuttings
This method is suitable for clump forming species. Of the different macro-propagation techniques, it was found to be the best. Rooting can be induced in culm, branch and
nodal cuttings. In addition to the effect of growth regulating substances (GRS), method of treatment, time of collection of cuttings and part of the culm (like base, middle and top) from where the cutting is taken have got critical roles in root formation. The methods for root induction in cuttings are given below in detail:

2.4.1. Culm cuttings

Extract two- or three-year old healthy culms from a clump by cutting just above the first node. Trim the leaves and side branches without damaging the axillary buds. After shifting the culms to the nursery site, two-noded culm cuttings are prepared using a sharp knife or saw. While preparing the cuttings of thin walled bamboo species like *Ochlandra travancorica*, splitting of the culm at the cut surface should be avoided. It is necessary to leave about 5 cm part of culm on either side of the nodes to protect the axillary buds from drying (Fig. 2.4.1.1.).

Treatment with GRS like naphthyl acetic acid (NAA) and indole butyric acid (IBA) enhances rooting response in bamboos. Since NAA is cheaper than IBA, generally, NAA is preferred. For bamboos with hollow internode (e.g. *Bambusa bambos*), GRS solution is poured into the cavity and for solid bamboos (e.g. *Dendrocalamus strictus*), dip method of treatment (the basal part is dipped in GRS solution overnight) is given. For cavity method of treatment in two-noded culm cutting, an opening (2 cm long and 1 cm wide) is made on the internode using a small sharp chisel or two holes of 0.2-0.3 cm is made using a drill. For most of the bamboo species, 100 ppm solution of GRS is used. Volume of the solution required will depend on the size of the cavity. Generally, 50-100 ml is used for bamboos like *B. balcooa, B. bambos, D. brandisii*, etc. For large diameter bamboos like *D. giganteus*, about 250 to 500 ml of the solution will be required (Fig. 2.4.1.1.). The solution is poured into the internodal cavity and the hole is closed by wrapping and tying with a polythene strip; if it is a drill hole it can be easily sealed with plaster adhesive tape.
Macro-Propagation Methods for Vegetative Multiplication of Sympodial Bamboos

2.4.1.1. Preparation of solution of growth regulating substances

The GRS solution is prepared by dissolving 10 g naphthyl acetic acid (NAA) powder in 100 ml of 90 per cent ethyl alcohol very slowly so as to avoid any coagulation. The solution is then made up to 100 l while adding the concentrated solution to water. The solution should be stirred while adding to water to avoid precipitation.

2.4.1.1. Planting of culm cuttings in nursery

The treated cuttings can be planted horizontally in nursery beds. One week prior to planting, the nursery beds are drenched with insecticides and fungicides to prevent the attack of termites and fungi. Culm cuttings are placed horizontally (the opening facing...
upwards) in nursery bed, 15-30 cm apart. About 50-60 cuttings can be planted in a nursery bed of size 10 m x 1 m. Sprouting from the nodes takes place within a week. Initially, a cluster of sprouts develops and completes its growth within one month. Natural thinning occurs retaining two to five dominant sprouts. Slender roots develop within one month and rhizome development takes place within three to six months. At this stage, the rooted cuttings can be transferred to polybags for macro-proliferation or planted in the field directly. If rooting occurs in two nodes they can be separated into two plants by cutting in the middle. The method was very successful with thick walled species (60-95% rooting) but not much encouraging in thin walled species (0-40%).

2.4.2. Branch cuttings

It is simple and easy method of propagation but the success of rooting is not as high as in culm cuttings. Considering the availability in large number and ease in handling, even 50 per cent rooting is good if this method of propagation is successful. It is promising for bamboo species having prominent primary branches arising from the base of the culm like *B. balcooa, B. vulgaris*, but very difficult in species like *D. giganteus* and *Thyrsostachys oliveri*. Propagation through branch cuttings is one of the easiest methods due to the ease in handling (Fig. 2.4.2.1.).

Treatment with GRS enhances rooting response in branch cuttings and dip method of treatment can be used. The time taken for rooting is about four to eight
months and rhizome formation takes still longer periods of about a year. Preparing pre-rooted and pre-rhizomed branch cuttings can reduce the time taken for rooting and rhizome development in branch cuttings. In some species natural aerial rooting and rhizome formation is seen and planting material can be collected from this region. Chopping off the top part of the culm and covering the nodal buds with moist medium like moss or coir can also induce pre-rooting. For preparation of branch cuttings the branches are excised using sharp knife or saw. The cuttings are made by trimming the leaves and small branches. Cuttings with four to eight nodes are made and the basal part is dipped in GRS solution for 24 hr. Planting and aftercare is similar to culm cuttings. Sprouting and rooting time depends on the season and varies from 30 to 70 days. When rooting occurs the cuttings should be removed from nursery beds and poly-potted.

2.4.3. Layering
Layering is done by bringing a culm or branch in contact with a moist rooting medium while attached to the mother plant. There are four types of layering: ground or simple layering, stump layering, air layering or marcotting and seedling layering. For ground layering, young culms less than two years are selected and the top part is cut off to stimulate bud growth. Side branches are trimmed four to five nodes. Either a whole culm or a branch bearing part of the culm is bent down into a shallow trench, pegged down and covered with soil. The size of the trench depends of the size of the culm. If it is difficult to bend the culm, a partial cut can be made at the base. The rooting medium is used to cover five to nine cm deep. It will be good to mulch with moist straw or coir mat. Water logging should be avoided. Rooting and sprouting occurs in the nodes and when the rhizome formation is observed separate the nodes by cutting in the internodal regions using a sharp knife or saw.

Stump layering is not common. In this method, the culm is cut leaving two to three basal nodes and the stump is covered with rooting medium. Use of GRS like IBA (200 ppm) is found to enhance sprouting and rooting. Marcotting, which is a form of air layering, is by bending the culm to a slanting position, supported by a prop. The nodes are covered with suitable rooting medium after pruning off the branches. It is held in position by tying. The medium should always be kept moist; hence rainy season is best for marcotting. Seedling layering helps to produce more planting stock from limited number of seedlings. For this, polybag with seedlings is placed in horizontal positions, so that, the nodes of seedlings touch the ground. Nodes are covered with rooting media leaving the branches to stand above. Rooted nodes are separated by cutting in between and transplanted to poly bags. The process can be used repeatedly to produce more number of seedlings.
3. Advantages and Disadvantages of Various Vegetative Propagation Methods

The advantages and disadvantages of various vegetative propagation methods are given in the Table 3.1.

Table 3.1. Advantages and disadvantages of different vegetative propagation methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
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<tbody>
<tr>
<td>Offset planting, rhizome cutting</td>
<td>Good survival percentage, traditionally well known method and suitable for both thin walled and thick walled bamboo species</td>
<td>Limited in number, labour intensive for extraction, heavy and difficult to transport, synchronous flowering of vegetatively propagated plant with that of parent clumps</td>
</tr>
<tr>
<td>Culm cutting</td>
<td>Comparatively better than offset planting, culm cutting are available in more numbers, method of rooting is simple</td>
<td>Low rooting percentage for thin walled species, requires larger nursery, area than seedling, rooting is season bound synchronous flowering of vegetatively propagated plant with that of parent clumps</td>
</tr>
<tr>
<td>Branch cutting</td>
<td>Branches are available in larger numbers than culm cuttings</td>
<td>Rooting percentage is low, technique has not been standardized for many species, availability of branches is limited in species which branch only from top one-third of the culm, synchronous flowering</td>
</tr>
<tr>
<td>Layering methods</td>
<td>Good for propagating isolated clumps and seedlings</td>
<td>Rooting response is poor and season bound, labour intensive, synchronous flowering</td>
</tr>
<tr>
<td>Macro-proliferation</td>
<td>Cost effective and simple</td>
<td>Requires mother stock produced by other methods</td>
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References
