Brochure

Farmers Friendly

Bamboo Propagation Technologies

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Introduction

Bamboo is woody grass belonging to the sub-family *Bambusoideae* of the family *Poacae*. There are more than 1,250 species under 75 genera of bamboo worldwide which are unevenly distributed in the various parts of the humid tropical, sub-tropical and temperate regions of the earth (Subramaniam, 1998). This natural resource plays a major role in the livelihood of rural people and industry. This green gold is sufficiently cheap and plentiful to meet the vast needs of human populace from the 'child's cradle to the dead man's bier'. That is why, sometimes, it is known as '*poor man's timber'*. Bamboo has versatile uses as building material, paper and pulp resource, scaffolding, food, medicine, agriculture implements, fishing rods, weaving and plywood, particle board material, and substitute for rattan. Pickled or stewed bamboo shoots are regarded as delicacies in many parts of the country. The major user of bamboo in India is paper industry, which consumes sizeable proportion (20%) of the total annual bamboo production. Bamboos are good soil binders owing to their peculiar clump formation and fibrous root system and therefore, play an important role in soil and water conservation.

Its supports a number of traditional cottage industries in India. The origin of this craft is traced from the beginning of the civilization when man started cultivation of food crops thousand of year ago. Bamboo is emerging as a major source of raw material for several industries, viz; bamboo mat boards, bamboo mat veneer composites, bamboo mat corrugated sheets, etc. It has kindled new interest in bamboo development across the world.

The shrinkage in extent and alarming decrease in density have led to great reduction in the supply of industrial wood from forests and there is an urgent need to look for alternative source to meet the growing demands. In this search, bamboo emerges to be a very ideal, naturally renewable, alternative source. With the trend of decrease in production and rise in population, the gap between supply and demand is going to be larger. The situation demands increase in bamboo production. Adequate attention on raising bamboo plantation under various programmes has not been given so far. Now, we need to involve farmers and villagers in bamboo production. Besides protecting natural stands of bamboo, the propagation has to be brought outside the conventional forestry and forestry land. It is the high time when cultivation of bamboo must be intensified through small and marginal farmers.

Bamboo is used in the rural housing sector in the hills and remote areas. Its potential in industry and commerce is much more. Bamboo as furniture and its other value and laminated products, flooring, wood substitute, etc are quite popular today.

Clump forming bamboo constitute over 67% of the total growing stock, of which *Dendrocalamus strictus* is 45%, *Bambusa bambos* 13%, *D. hamiltonii* 7%, *B. tulda* 5% and *B. pallida* 4%. All other species put together are 6%. *Melocanna baccifera*, a non-clump forming bamboo, accounts for 20% of the growing stock and is found in the north-eastern states.

As bamboo is a fast growing and quick harvested crop, the output of plantations will be apparent 4 to 5 years after afforestation and reforestation activities. The main beneficiaries will be the rural poor because of the increase in employment and boost to cottage industries.

Bamboo Propagation

Propagation through seeds

Being a member of grass family, bamboo flower once in its life time and subsequently, the clump die. The flowering interval is also very long ranges between 15 to 120 years. In between, there is no seed available for nursery for producing planting stock production. The seed viability is also less generally between three to six months, hence the seed can not be stored for long time to meet the seed requirement for growing planting stock. Therefore, it is important to use the whole lot of seed of bamboo for growing planting stock whenever there is gregarious flowering and seeding.

Seed collection and processing

Seeds can be collected both from the clumps and ground. Generally, seeds produced in the early part (mid-February to May) of the season are healthy and more viable.

Except for *M. baccifera*, glumed seeds of all other species can be separated from debris and empty seeds by floating in water. As the seeds of *M. baccifera* are big and not covered with glumes, they can be separated easily from debris and unwanted materials.

Seed germination, longevity and storage

Bamboo seeds should be sown in polythene bags under shade just after collections as it facilitate higher seeds germination than in direct sunlight. The germination media (soil and cow dung 3:1) should be wet, but not waterlogged. Normally seeds of all bamboo species start germinating within 3-7 days of sowing and continue up to 15-25 days (Banik 1987b).

Seedling nursing and management

Initially, seedlings do best in partial shade compared to direct sunlight. Complete shading over seedlings should be discouraged. The emergence of shoots is successive. The new shoots are bigger and taller than older ones. The germinating plumules are very thin in *B. tulda* (1-2 mm diameter) and thick in *M. baccifera* (4-6 mm). Within 1-4 weeks, plumules elongate rapidly into stems bearing single leaves arising alternately. The stems of *B. tulda*, *B. longispathus*, and *B. polymorpha* are more or less woody in nature, but *M. baccifera* has a soft and succulent stem with vigorous growth. *M. baccifera* seedlings become most elongated (175 cm) and thick (0.8 cm, dia.) at 3 months of age (Banik, 1991).

Seedlings of *D. strictus*

A rhizome system starts to develop in the seedling 1-2 months after germination, and at a young stage, the rhizome movement is strongly geotropic and horizontal

creating a mass of trusted and intertwined roots and rhizomes with neighbouring polythene bags (Fig: 1). As a result, the roots and rhizomes are damaged at the time of transportation. Frequent shifting of seedlings from one bed to another helps in minimizing the root rhizome intermingling. Seedlings need regular weeding and daily watering in the nursery.

Wild seedlings

Wild seedlings of bamboo look like rice or wheat seedlings and are often seen on the ground just below the flowering mother clumps. The numbers of seedlings can be very high and they often form a thick mat on the ground. These dense seedlings compete strongly for survival. Such seedlings should be thinned out to minimize the competition. Wild seedlings so collected should be brought to the nursery and transplanted in polythene bags containing soil mixed with cow dung (3:1). At the beginning, seedlings have to be kept under shade for 3-5 days for hardening, then, placed under partial shade. Two-to four-leaved stage of wild seedlings of *B. tulda* and *D. longispathus* are best for collection, while in *M. baccifera* germinating seedlings are best. For better survival (about 80-90%) in the field, less than one-year old seedlings should not be transplanted. While uprooting the seedling from the wild or from nursery bed, removal of the aerial part helps to minimize water loss through transpiration which ultimately leads to batter survival. The rainy season is the best time for planting of seedlings in the field.

Collection of wild seedlings.

Bunch of wild seedlings ready of transportation.

Vegetative Propagation

The bamboo plant consists of three morphological parts - the aerial part (the culm) and two underground parts (the rhizome and root). A bamboo propagule must develop all three structures. Failure in development of any of these structures leads to failure of a propagule (Banik, 1980). Due to the scarcity of seeds, bamboo is generally propagated by vegetative methods. These methods have been studied in different countries and each country has methods suitable for their own species. These include:

Clump divisions

This is the traditional, and perhaps the most prevalent method of vegetative propagation (McClure, 1966). Clump divisions are generally done in two ways - offset planting and rhizome planting.

(a) Offset planting

The term 'offset' was designated by Deogun (1937) for bamboo propagules, each composed of the lower part of a single culm with the rhizome axis basal to it. According to Deogun, 1-or 2-year old offsets of *D. strictus* gave best results, while propagules consisting of material 3 years or more in age gave progressively poorer results. Over a century ago, Peal (1882) reported that propagation of bamboos by offset planting was common in the villages of Assam and Bengal. The offset planting is common in most bamboo growing countries.

Both, age of the offsets and their collection time have significant effect on their survival and growth in plantations (Banik, 1991). Offsets of *Bambusa balcooa*, *B. longispiculata*, *B. tulda*, *B. vulgaris*, *D. longispa thus*, *M. baccifera*, *Neohouzeaua dullooa* and *0. nigrociliata* were planted both in April and June. Success was higher when collected and planted in April (44-76%) than in June (3-38%). The younger (one year old) offsets showed higher percentage of survival than older ones (2-3 year old). Thin walled species like *M. baccifera*, *N. dullooa* and *0. nigrociliata* showed poor success in offset planting. In these species, 30-40% success was obtained by planting rhizome assemblies (part-clumps) with 2-3 offsets at a time .

(a)

(b)

(c)

(d)

(e)

(f)

(g)

(h)

(i)

Propagation of bamboo by offset planting - (a) Bamboo clump, (b) collection of clum, (c) offset, (d) offset with new shoot emergance, (e) rooted brunch cutting, (f) plantation material in gunny bags ,(g) transport of plantation stock ,(h) field plantating and (i) development of rhizome and new culms.

(b) Rhizome planting

Reports on the propagation of bamboos by rhizome planting are meagre (McClure, 1966). Dabral (1950) described it as 'the best method', but he did not mention the species or details of the method. The use of rhizomes for propagating bamboo has been limited to non-clump forming species like *Phyllostachys* species *Sinarundinaria junsaresis*. Uses of these propagules are practicable only in cultivating a few clumps, particularly within a small accessible area.

Farmers carrying rooted offset for field planting.

Whole culm cutting

Kurz (1876) described this method as 'by taking whole halms (culms) with their roots and burying them length-wise in the ground'. Pathak (1899) tried propagation of *D. strictus* using 3-5 year old culm cuttings. Although sprouting was good in the initial stages, the cuttings failed to establish during summer. McClure and Kennard (1955) did some experiments with *D. strictus* and *B. tulda* and reported that 2-year old culms produced more propagules than 1-year-old culms. The success was reasonable, but the procedure was cumbersome.

Culm- or stem- cutting

Propagation of bamboos through culm or stem segments is known as the culm-cutting or stem-cutting technique (McClure, 1966; Troup, 1921). Generally, culm segments of bamboos of 1, or usually 2-3 node bearing healthy buds or branches, have been used for propagation. The branches on each culm segments are generally pruned to a length of less than 25cm and no foliage is retained. Such cuttings are usually set upright or at an angle, with at least one node well covered.

Propagation studies in Sri Lanka showed that 2-node-culm-cuttings of some major bamboo species are more satisfactory than split culm-cuttings and the technology is being gradually transferred to the planters (Vivekanandan, 1987).

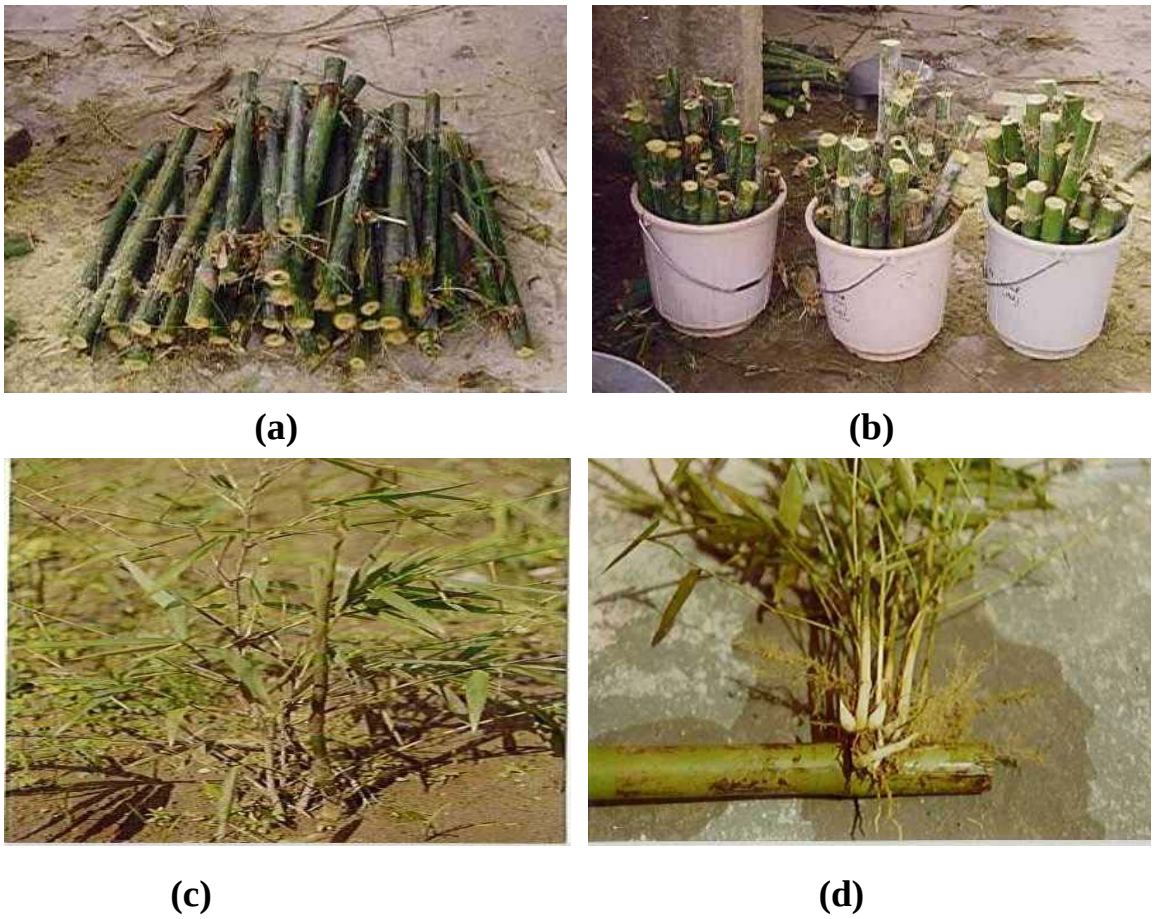


Fig. 7 Propagation of Bamboo by Culm Cutting (a) Binodal cuttings ready for planting, (b) antifungal treatment of cuttings (c) horizontal planting of culm cutting and (d) Rooting and sprouting of culm cutting

Branch cutting

A large number of experiments were laid out at Forest Research Institute and its sister institutes working under ICFRE on rooting response of branch cuttings of different bamboo species. It was reports that horizontal planting of cuttings give better results than vertical planting. The another important finding is that the cuttings collected from the base of branch of the standing culms during April to June give batter rooting response.

(a) (b)

(c) (d)

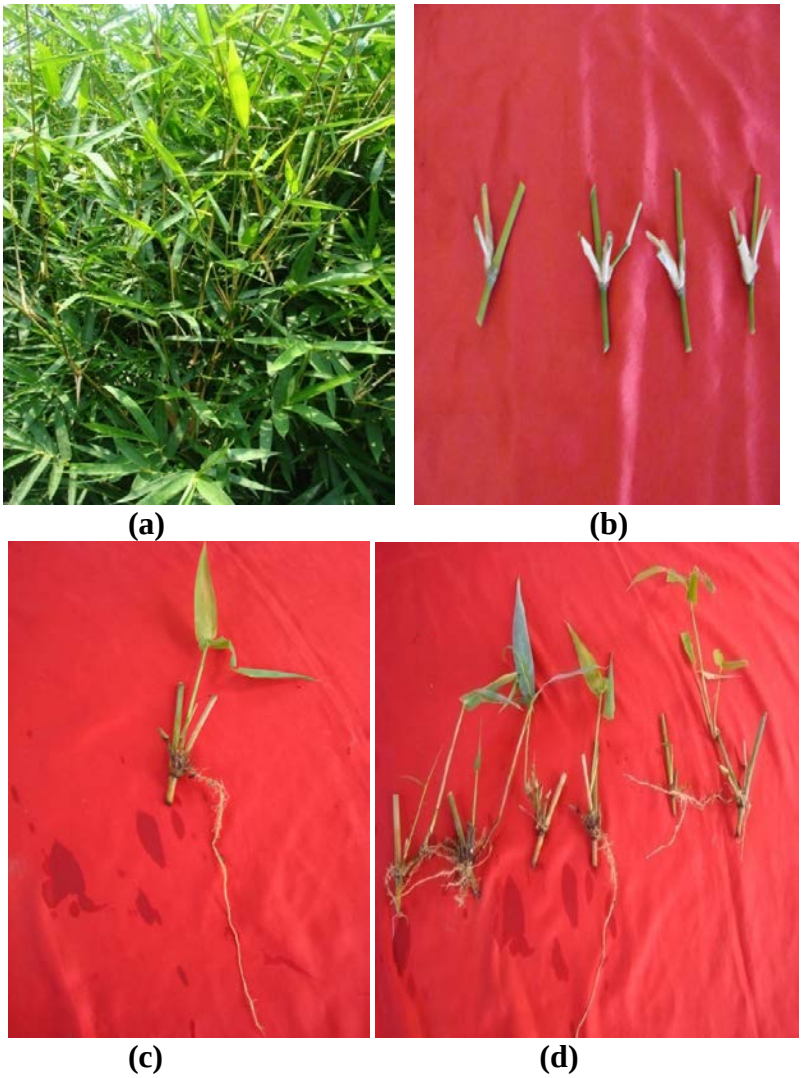
(e) (f)

Propagation of Bamboo by Branch Cutting - (a) Bamboo culm with branches (b) Branch cuttings (c) Rooted and sprouted cuttings (d) Rooted cuttings with rhizome development (e) Rooted cutting of *B.vulgaris var striata* (f) Rooted cutting with rhizome development.

Propagation by Juvenile single nodal cuttings

The major breakthrough in bamboo propagation is the success in rooting of thin juvenile shoot cuttings. The initial experiments were done in *B. vulgaris (*Green*)* to find out easy and cost effective method of propagation of this species. Single nodal juvenile cuttings were prepared and surface sterilized with 0.1% $HgCl_2$ solution prepared in water. Lower portion of the cuttings was treated with different auxins (IAA, IBA and NAA) in 500ppm concentration for 24 hours. The control was treated

with water only. After hormonal treatment the cuttings were planted in wet vermiculite rooting media filled in plastic trays and shifted to the mist chamber. After 45 days, these cuttings were uprooted and observations on rooting of cuttings were recorded. Up to 60% rooting was observed in the cuttings which are considered a good result. This method is being tested in other bamboo species as well.



Rooting response of single nodal juvenile branch cuttings of *Bambusa vulgaris* (green) (a) Juvenile shoots produced after pollarding the main culm ,(b) juvenile cuttings for rooting, (c) and (d) juvenile rooted and sprouted cuttings ready for transplanting.

It is interesting to note that the cuttings treated with water (control) showed maximum rooting response indicating that *B. vulgaris* does not require any rooting hormone treatment as also reported by Nautiyal *et al.* (2007) in case of rooting response of branch cuttings of *D. giganteus*.

Macroproliferation of bamboo seedlings

Like many other grasses, bamboo has the inherent proliferating capacity to reproduce itself probably due to its long interseeding period. By utilizing this habit, an interesting technique has been developed by Plant Physiology discipline of Botany Division, Forest research Institute Dehradun for multiplication of a seedling through the rhizome separation method. The technique was termed as macroproliferation of seedlings. It is reported that 5-9 month old seedlings of *B. tulda* can be multiplied 3-5 times in number through this technique. Every year the seedling can be multiplied at the same rate and a big portion of them may be planted while keeping a stock for future macroproliferation. The survival rate of these multiplied seedlings is 90-100%. It has also been observed that seedlings of *B. arundinacea, B. tulda*, and *D. strictus* raised in big-sized polythene bags (15x23cm) produced a higher number of shoots (6-8 number) within one year than in small sized bags (10x15cm). Therefore, seedlings raised in big polythene bags produced a higher number of multiplied seedlings (5-7 times), whereas seedlings in a small-sized bag could produce only 2-3 number of multiplied seedlings. Later, Adarsh Kumar *et al*. (1988) also used this method successfully for multiplication of the seedlings of *B. arundinacea, D. strictus,* and *D. hamiltonii*. Recently, in India a detailed plan has been developed by Adarsh Kumar (1991, 1992) for continuous production of field plantable saplings in massive numbers

Till date, ten major bamboo species *Arudinaria falcate, Bambusa bambos, B. tulda, B. nutance , B. vulgaris, B. multiplex, Dendrocalamus strictus, D. hamiltonii, D. asper and D. membranaceous* have been propagated through this technology at Plant Physiology Discipline of Forest Research Institute, Dehradun in mass .

The main advantage of this method is that once the seed or seedlings of a bamboo are available, the process can be continued for a number of years. Proliferated seedlings remain small in size due to continuous rhizome separation$_1$ thereby making it easy to handle and transport them. However, it is suggested that seedling multiplication in this way should not be continued more than 10 year since the time gap between the last multiplication and subsequent flowering gets shorter. As a result, the last multiplied seedlings might start flowering due to their physiological maturity before attaining the commercial culm size.

Fig. 10 (a) Bamboo seedlings, (b) individual seedling with tillers, (c) tillers after removal of the soil, (d) separation of individual tillers with a part of root and rhizome, (e) and (f) each tiller planted in separate polybags.

Layering

The layered stem when rooted is detached to become a new plant. Three layering procedures for bamboos have been described (McClure, 1966). These are:

Ground or Simple layering: Either a whole culm or only the branch bearing part of it is bent down to the ground and into a shallow trench, fastened in place by means of hooked or crossed stakes, and covering it with suitable propagating medium.

Stump layering: The 1-2- node stumps of severed culms are covered with a suitable propagating medium.

Air-layering or marcotting: A culm is kept erect, and the base of each branch complement in the mid-culm range is surrounded with a suitable propagating medium, held in place by a suitable receptacle (Fig. 11).

McClure (1966) found that 1-year -old culms of *B. textilis* and *Guadua angustifolia,* when bent down and covered with earth while still attached to the mother clump, satisfactorily produced little plants. According to him, this method was too cumbersome except in dwarf cultivars of *B. mutiplex* var. *riviereorum.* Cabandy (1957) obtained a survival of 28% for *B. blumeana* by ground-layering 1-year- old culms pruned off branches.

While studying the stump layering methods in *B. longispiculata,* McClure (1966) obtained only 25% rooted branches, but it increased up to 54% when the stumps were treated with 200 ppm IBA. He also tried the same method with 4 other species: *B. textilis, B. tulda, B. tuldoides* and *D. strictus,* and reported that either the plants died or did not produce any rooted propagules.

In exploratory studies, McClure (1966) tried air layering of matured branch components of 1-year old culms of *B. tuldoides* and current year (developing) branch complements of *Semiarundinaria fastuosa* without achieving any success with either species. Cabandy (1957) obtained success (70%) in marcotting only with *B. blumeana.*

(a)

(b)

(c) **(d)**

Air Layering- (a) Iniciation of small branchs at nodal portion after remove the top of the culm. Root iniciation by raping the moss, (b) root inication in the bottam of thin barnchs and (c) & (d) the development of root and rhizome and tillers after removal the branchs from the parant culm and planted in a poly bag.

Raising Nursery from Vegetative Propagules

Vegetatively, bamboos are propagated through clump divisions, rhizomes, offsets, layering, marcotting, culm cutting, branch cutting and macro-proliferation. In general, it has been observed that there is increasing difficulty in producing bamboo propagules as one goes from the rhizome to the culm and to the branch. At the same time, the number of cuttings or potential propagules increases. For raising large quantity of seedlings within a short span of time, 'macro-proliferation technique' is probably the best method. The technique has been described by Adarsh Kumar (1991, 1992) and Nautiyal *et al* (2008).

The other practical method of mass multiplication is through culm cutting technique. Depending on species, single- noded or two- noded cuttings taken from 2 – year- old culms, suitably treated with root inducing hormones, when planted in the month of February-May give reasonably good result. The limitations include (i) large space requirement (ii) fear of flowering and death of plantation in case source materials are taken from old clumps. Hence, vegetative propagation of the same stocks should not be continued for a long period of time and adequate care should be taken while selecting mother clumps.

Weaknesses and Gaps in Conventional Propagation Methods

The traditional rhizome/offset methods are applicable only in cultivating few clumps, particularly within a small accessible area. The limitations of traditional methods are:

- The method is expensive due to high cost of the propagules and labour for excavation and transportation.
- Offsets and rhizomes are bulky and heavy (4-30 kg per propagule) and as a result, difficult to handle and transport.
- In most species, the survival success is only 5-50%.
- Availability of propagules per clump is limited, as only young (1-2 year old) culms can be used as propagules. Not more than 30-50% young culms should be collected from a clump; otherwise, it would lose regeneration capability.

The culm or stem-cutting method is comparatively well studied. This method is also expensive and the propagules are difficult to transport. The disadvantages of the method are:

(i) Such cuttings are generally of 1-to 2-node culm segments and, therefore, the length of the segment may vary from 0.1 to 1.5m, and obviously need big-sized pots for planting in the nursery.

(ii) Handling, carrying and transportation of these big-sized pots are difficult and expensive due to their heavy weight. Split culm cuttings can be used to overcome such problem, but applicable only to a few species.

(iii) There is limitation of using 1-2-year-old culms, which can otherwise be put to other uses.

Abeels (1962) mentioned that there are indications that the stem layering in bamboos may be successful if it is carried out *in situ* and the layered stem is not transported. However, while studying the air-layering in bamboos, Abeels (1962) also mentioned that cutting out of rooted parts is not easy and on planting time in the nursery, their survival is not definite.

Prerooted and prerhizomed branch cuttings are comparatively more dependable as propagules than are normal branch cuttings. This method has been found suitable mostly for thick-walled and stout branching bamboo species.

As far as is known, most of the thick-walled bamboo species are amenable to vegetative propagation techniques. Thin-walled species like *Melocanna baccifera, Oxytenanthera nigrociliata,* and *Neohouzeaua dullooa* are difficult to propagate by any of the known conventional vegetative propagation methods. However, in general, no one method of vegetative propagation of bamboos is universal and effective for all the species. From the published literature and practical experience, it is evident that there is an optimum age for rooting in each type of propagating material (rhizome, offset, culm segment, branch cuttings, etc.).

Considering bamboo as a source of livelihood, the farmers friendly bamboo propagation technologies given in this brochure will help in producing bamboo planting stack at village level to promote large and small plantations of bamboo to meet the local and industrial demand of bamboo. The farmers can also earn money by establishing bamboo propagation nursery at village level and produce bamboo planting material for sale. Using these methods large and small plantations of bamboo in our country can be promoted.

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