# MANUAL FOR ESTABLISHMENT AND MANAGEMENT OF **BAMBOO PLANTATIONS** B.122-KEKI National Bamboo Mission March 2015

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#### 1. INTRODUCTION

The unique features of bamboo- the group of fast growing woody perennial grasses, has in recent times attracted world-wide attention as a source of quickly renewable biomass and a viable alternative to trees for planted forests. The diversity of bamboo species available within the Indian subcontinent and the capacity for this group of woody grasses to adaptation make it suitable for cultivating in different regions throughout the country. Natural distribution of bamboo is mainly dependent on rainfall, altitude, temperature and soil type but different species of bamboos can be grown in areas which receive an annual rainfall of 1200 to 4000 mm and where mean annual temperature ranges from as low as 8°C to 36°C. Bamboo grows in different types of soils ranging from rich alluvium to hard lateritic soils and coastal sandy saline soils but under good inputs and ideal management regimes is known to grow well. The multiple uses, resilience of the plant, its extraordinary fast growth rates and possibility of multiple harvests are great advantages that bamboo has over other forestry species. The diversity of uses that it has been traditionally used and the new uses as an industrial raw material that it has found in recent times has lead to an interest in promoting the plant as an ideal candidate for planted forests. Bamboo is thus an ideal crop for commercial cultivation in a country as vast as India. The farming community will do well to take up bamboo planting as there is scope for regular income from well managed plantations besides providing for a multitude of other small produce like leaf for fodder, poles for agricultural use, thorns for fencing and dead rhizomes for fuel.

This Manual is designed to provide guidelines for farmers and forest managers to establish and manage scientifically bamboo plantations. The manual does not address the subject of the marketing of bamboo produce or the huge potential for utilization of bamboo and the reader is advised to refer to the National Bamboo Mission website for more information.

#### 2. SPECIES SUITABLE FOR CULTIVATION

Although about 18 genera and 134 species of bamboos are reported from India, only less than 20 species have been identified as commercially important. This includes native species as well as exotic ones from the South east Asian region which have been in cultivation for a long time in parts of the country and other that are expected to be suitable in the different agroclimatic zones.

Several species do play an important role in the ecological services they render in the native forest as part of the ecosystem and as food for the wildlife. Other species which are rare or restricted in occurrence are only of academic value for the present. These are outside the purview of this Manual. Only the clump forming bamboo species are included in this manual since they are more widely grown in India than the running bamboo species. Information on selected species that can be cultivated on a large-scale is given in Appendix -1

#### 3. SELECTION OF SITES

Most of the bamboo species can be grown in a wide range of agro-climatic zones in the country but a suitable matching of the species with the site is crucial to maximize the benefits. Based on the natural range of the species and past experience with the exotics, some species have been identified that perform better under specific conditions. Appendix 1 gives the details of the NBM priority species and indicates the kind of sites they are known to be suited to. Many other species have not yet been tested for their suitability in a different climate and therefore the potential is not yet ascertained. In Bambuseta maintained in different parts of the country good more than 30 species can be observed. Under intensive management the growth of performance of many of the species could be much better than under the typical unmanaged plantations in forest areas or homesteads. Thus Bambusa vulgaris var. striata and B. vulgaris are tolerant of salinity in coastal soils. Dendrocalamus strictus is hardy and withstands arid climate well but productivity is improved under good management. B. balcooa has gained popularity many parts of the country since it is easy to propagate through vegetative means as well as tissue culture, carries no risk of gregarious flower and responds well to inputs. exotic species Guadua angustifolia introduced recently from South America is found to grow well in the early years of planting in areas with good rainfall and therefore might be a good candidate for plantations. The bamboo reed ( Ochlandra species) has performed quite well in introductions to the North Eastern States and Melocanna baccifera which is native to the area has performed well in Karnataka and Kerala.

Bamboo comes up in a variety of soils, however productivity will be the best if the soils are of alluvial type of soil which is well drained. Care should be taken to see that a minimum soil depth

of 45cm is available. This is mainly because bamboo is a surface feeder with a shallow but

sturdy root system. At times bamboo can be invasive and can compete with adjacent crops for

Ideal locations for establishing bamboo plantations

Level land with good drainage or slopes of upto 10%

Availability of water

Availability of labour for plantation management and harvesting

Accessibility to road and transport

Availability of market for bamboo

moisture and nutrition hence care should be taken to see that site selection is done meticulously

keeping in mind the active spreading habit of the plant. Bamboo requires open sunshine and

hence planting bamboo under other trees may lead to failures in plantation establishment.

Optimum temperature range is between 20 to 38°C and rain fall between 900 to 4000 mm for

luxuriant growth of bamboo. The altitudinal range in which bamboo can be grown economically

is 500 to 4000 MSL. Water logged areas are to be avoided for planting bamboo as the rhizome

growth will be affected due to poor air circulation in the soil. However if the objective is only to

stabilize the water logged area, soil can be made in to mounts and clumps planted above the

mount. It is not advisable to plant bamboo in very steep slopes due to the possibility of the

clumps toppling down due to heavy wind or rain is high.

It should be borne in mind that the bamboo shoots and leaves are a favorite food for wild

animals like elephants and wild boar and therefore when plantations are considered in the areas

where wild life could be attracted to the young crop adequate precautions should be taken

Ideal climatic conditions for Bamboo plantations

Temperature: 20 -38°C

Rainfall: 900-4000 mm

Altitude: 500 - 4000 msl

### **Types of Bamboo Plantations**

Large Commercial Plantations (for timber /pulp/edible shoots/ bio-energy)

Agroforestry plantations on farmland (with intercropping)

Plantations on marginal lands for eco-restoration+ timber production (river bank, ravines, wastelands)

#### 4. PREPARATION OF PLANTING SITE

It is ideal if the area to be planted is first leveled with the help of earth movers if needed, so that it is clear of obstructions or depressions or tree stumps that could interfere with proper establishment and facilitate easy access to the entire site for men and machinery, particularly for harvesting of culms in later years. This step also ensures that weeds are also removed and delays their reestablishment compared to an unprepared site. It is preferred that no large trees are present except those that come outside the planting area. If trees are to be retained then it would be a good idea to leave an area adjacent to the canopy around it free of bamboo.

Once the land is prepared for plantation after leveling and weeding, the next step is to align and place stakes to mark spots for taking the pits. Depending on the spacing chosen and modifications made to avoid large trees and earth formations if any, wooden or bamboo stakes are driven into the ground to mark the centre of the square or round pits (in case augers are used). This will help avoid misalignment of pits when unskilled labour or machinery is used for pitting, particularly when planting is to be done along contours on undulating sites in hilly areas. A North –South orientation is ideal for aligning the rows to get the best benefit of sunlight.

Bamboo is normally planted in 45 cm x 45 cm x 45 cm pits. Other options are subject to availability of financial resources and logistical support. Larger pits of 60 X 60 X 60 cm or even larger (1 X 1 X 1 m.) can be considered if the soil is of poor quality or if the area is rocky or hard laterite so that the filled soil permits easy establishment of plantations. Bigger pits will also benefit the lager bamboo species in establishing well. In low lying areas a system of bunds can be considered. A trench is dug and the soil used to make a bund of about 1 m in width and 0.5 m in height along the length of the plot. The spacing between the trenches depends on the species (see below).

In smaller plantations and in homesteads pits can be dug manually. For larger areas this activity can be efficiently done with hand operated or tractor mounted powered augers or small earth movers, if found economical in the locality. Large trenches is an option which facilitates the use of large earthmovers and does away with the need for individual pits. The excavated soil from poorer sites is best discarded when pits are filled during planting but otherwise can be mixed with nutrient rich soil and fertilizers/manure. Addition of 10kg of dried and powdered

#### Local factors to be considered before raising bamboo plantations

Since the purpose of planting, site conditions and the social and economic factors vary widely across the country, providing a common protocol and breakup of cost is not very meaningful. However the following major aspects are to be considered when planning for a bamboo plantation .

- 1. Preparation of planting site (Leveling, Weeding, Pitting) Manual or mechanical
- 2. Cost of planting material (Seedling, vegetative propagation, tissue culture)
- 3. Mortality replacement (3-30 %)
- 4. Fertilizer and mulching (Chemical fertilizer /Manure/compost)
- 5. Protection (Perimeter Fencing, individual guard (net), Watch and ward)
- 6. Irrigation (Rain fed, drip irrigation, piped, fertigation)
- 7. Plantation Management (Soil mounting, harvesting)
- 8. Labour costs

farm yard manure and 5kg of vermicompost/mixed weed compost in the pit prior to planting is recommended to ensure better survival and initial growth. Application of chemical fertilizers in bamboo plantations is not a general practice but is deemed useful if soil testing shows deficiencies. The application of anti-termite insecticides in the pit is found essential in termite prone areas to prevent mortality in the first few months after planting. Termites hardly ever cause problems in established bamboo plantations that are well managed and having healthy culms. They probably play an important role in removing the dead rhizome and stumps of harvested culms if present in the soil.

#### 5. PLANTING MATERIAL

The natural mode of propagation in bamboo is through seeds although flowering cycles are long and unpredictable. Many species do not set seeds at all. Therefore for cultivation other methods of propagation has to be often resorted to. Vegetative propagation of bamboo is in fact very commonly done in different parts of the world to meet the demand for planting material. The characteristics and pros and cons of the different methods are as follows. The reader is advised to consult the guidelines issued by the NBM on "Certification of High Quality Bamboo Planting Stock" and also on "Establishment and Management of High-Tech Bamboo Nurseries" (The guidelines are available on the NBM web site: http://www.nbm.nic.in).

#### Seeds:

In species that set seeds usually after gregarious flowering at long intervals of 30 -60 years, huge quantities of seeds are produced. Seeds have short viability of few months unless stored under reduced humidity and temperature. Even under the best conditions seed viability declines after 1-2 years and production of seedlings no longer becomes practical.

#### Macroproliferation:

This is a common method of producing bamboo planting material in the seedling nursery long after seed viability is lost. After a year of growth in the nursery bamboo seedlings have several tillers (culms) each with a rhizome formed below the soil. It is feasible to produce planting

stock by dividing (splitting) the seedling into tillers each with a rhizome. The process can be repeated in the same manner every year and if proper nutrients, water and maintenance is provided in the nursery this method can ensure continuous production of planting material. The other advantage of the method is that the size of the plant produced remains the same as the seedling and thus facilitates transport from nursery to field.

#### Vegetative propagation through rhizome transplants:

When seeds or seedlings are not available, bamboo can be propagated vegetatively by extracting and transplanting the rhizome along with a small portion of the previous years culm or sometimes the entire culm and the rhizome. Since the rhizome has a store of food and is capable of growing into the culm and establishing itself, this method has a good rate of success although the removal and transport if the bulky material is a limitation. The number of propagules that can be extracted is also a limitation for large scale propagation.

#### Vegetative propagation thorough culm cuttings:

This method is perhaps the most practical of large scale vegetative propagation methods. The method involves preparing culm cuttings (each with a single node or more effectively with two nodes each), and if found necessary, use of rooting hormones. Either the cuttings are dipped in a hormone solution or in the case of the species with large and hollow internodes the hormone solution is poured into the cavity and place in the propagation beds in the nursery or propagation chamber. Each node produces shoots and roots and can be transplanted into bags and hardened in the nurser.. The propagule that results is often bulky for transport. The advantage is that a single culm can produce several plants.

#### Micropropagation (Tissue culture)

This is the method that can produce plants on a very large scale using small plant parts. The tissue culture method requires trained personnel and specialized facilities for maintaining sterile and controlled environment. Propagation protocols including specific nutrient media are also required to be standardized through research. High multiplication rates and sterile conditions

ensure that uniform, small and disease and pest free propagules can be produced throughout the year. Contrary to the general perception, the tissue culture procedure does not impart any special benefit on the performance of the plants and the quality of the tissue cultured plants eventually is dependent on the mother plant used for propagation. The higher cost of tissue culture plants is therefore justifiable only when superior genetic stock is used for propagation.

Guidelines issued by the NBM aims at ensuring that plantations of bamboo in the country is raised only through certified superior planting stock produced through a network of certified high-tech bamboo nurseries. The superior clones of different bamboo species have been identified and rhizome banks are being established as source of mother plant for mass production of quality planting stock. In the interests of improving productivity bamboo growers are advised to ensure that plantations in future be established as far as possible with superior planting stock.

#### 6. PLANTING

Best time for planting is during the pre-monsoon showers so that establishment during the monsoon is successful and requires less watering. The seedling/cutting is placed in the pit and the polybag is removed with a sharp blade taking care not to disturb the roots and rhizome of the plant. Soil around the plants should be consolidated tightly by pressing with feet. The surface of the pit, after filling should be slightly sloped to one side so as to promote moisture retention. Generally, three weedings in the first year, two in the second and one in the third year has to be carried out.

According to the clump size, species can be classified to small (5-15 m tall with a clump diameter of 1-3 m), medium (15-20 m tall with a clump diameter of 3-5 m) and large (20-30 m tall with a clump diameter of 5-8 m) clumps. Higher densities (closer spacing) are appropriate for small-sized bamboos, and lower densities (more spaced) are appropriate for larger bamboos. Depending on the parent clump size, 3-4 m, 5-6 m and 8-10 m. spacing can be provided in the range of 4 X 4m, 5 X 5m (e.g. *Thyrsostachys oliverii*), 7 m X 7m (e.g. *Dendrocalamus hamiltonii*) or even 10 X10 m (e.g. *Dendrocalamus giganteus*).

#### 7. PLANTATION MANAGEMENT

Bamboo plantations do not require much care except sufficient moisture to prevent drying up in summer. Mortality of plants can be expected in extremely difficult sites and replacements should be considered in the next planting season in rain fed areas or as an when noticed in sites where drip irrigation is provided. Once established planted bamboo is not very demanding in terms of additional care compared with many other plantation species. However the following activities are recommended for improving the performance of plantations and ensuring profits for the farmers.

#### Weeding:

Regular weeding in the initial two to three years is very important for quicker establishment and faster growth of bamboo clumps. Soon after the rainy season clear knife weeding will have to be carried out depending on the site condition and amount of weed present in the plot. At least an area of 60 cm around the bamboo should be kept clear of weeds particularly the climbers which can smother the young plants. By the third/fourth year when usually the clump gets established, bamboo starts shedding its own leaf thus preventing the growth of other weeds under the clump.

#### Soil working and moisture conservation methods:

The soil around the plant should be loosened twice every year for better rhizome growth and shoot production. Soil working also improves the water retention capacity and fertility of the soil; adjusts temperature and air permeability, improves soil physical and chemical composition and decreases weed competition for water and nutrients. The soil at the base of the clumps should be worked with care to avoid damage to the new emerging rhizomes underneath.. Spreading rice husk and other mulching materials like leaf litter in plantations will help in increasing the moisture retention. The use of mechanical devices should be explored for soil working in the larger plantations.

#### **Mulching:**

Mulching is providing for a cover over the soil around the bamboo plant which reduces loss of

moisture through evaporation and checks weed growth around the clumps. Degradation of the mulch by the natural decay process eventually releases nutrients in to the soil and improves the texture through addition of organic carbon. The branches, tips of harvested culms and particularly the leaves and sheath accumulated below the clump will serve as a mulch. The requirement of silica for the growing clumps can be met through the addition of the mulch. It is recommended that in larger plantations, the litter be shredded or chipped mechanically to improve the mulch quality. In plantations maintained for edible shoots, the mulch helps keep the emerging shoot in a healthy good condition by retaining the moisture and protecting it against sunlight.

#### **Mounding:**

The network of rhizomes and the root system is what anchors the tall and heavy culms to the soil. The tendency of rhizomes in sympodial bamboo is to grow horizontally under the soil and only the newly emerging culms grows upwards. Roots emerging from below the new culms need soil to establish. However as the clump gets older the rhizome system tends to gets exposed above the ground. This usually happens when the soil is eroded and the mulch is minimal. In such a clump, rhizomes are likely to be retarded in growth if it gets exposed to the sun and the overall availability of nutrients and moisture tends to be reduced. Exposed rhizomes are also likely to lead to clumps that are top heavy and when lacking sufficient anchorage, leading to toppling in wind or rain. When the rhizomes are seen exposed in a clump, usually after several years of establishment, soil mounding may be considered. Loosening of the soil around the clump and mounding so as to cover the base of clump, just prior to the culm emergence. Soil mounting is usually done to a height of 30 -60 cms.



Soil mounding in bamboo plantation

#### **Trenching**

The gregarious root system of bamboo, although a very useful feature for the bamboo clump in absorbing the nutrients from the top layers of the soil and from the point of view of soil stabilization since it binds the soil against erosion, can be disadvantageous at times. The extensive root system can interfere with the cultivation of other agricultural crops in the vicinity. Furthermore, the rhizome system, which in an older clump can form an underground network of old and dead rhizomes, together with the stumps of the harvested or dead culms, is slow to decay and can be difficult to remove using simple tools. This can not only reduce the quantity and quality of the new culms formed every year as well as difficulty in harvesting the mature culms. There are however several means available to overcome the problem or bring it under control. Digging of trenches around the clumps upto a depth of 60 cm will prevent the spread of roots/rhizomes into the adjacent areas. An alternative is to have a vertical barrier made of thick plastic sheet or ferro-cement slabs inserted upto a depth of about 60 cm. No gaps should be left in between the barrier slabs, through which roots/rhizomes may penetrate later.

#### Protection from fire, pests and grazing:

For initial two years, the planted area should be protected from fire and grazing. Fencing of the plantation with protection against rodents, wild boar and grazing animals may therefore be needed in some areas. When the seedlings are established, especially with proper rhizome formation, fire mainly affects only the above ground portion of the plant. However, new sprouts will be produced during the forthcoming monsoon. Burning due to fire affects the growth of bamboo but with an intact rhizome and root system the plant survives. Similarly severe grazing is deleterious for the proper establishment of bamboo clumps. In many parts of the country elephants could turn out to be a menace since bamboo is a favoured food. Electric fencing or trenches are the common mean adopted for protection but besides being costly to install also require regular maintenance to be effective. Use of razor wire fencing suspended on wires that creates a flexible barrier that is difficult to breach and this type of fencing can be considered for larger plantations.

Damage to newly emerging shoots from wild boar and deer is often a problem in some regions adjoining forest areas. A simple and cheap means of protection is obtained by providing a barrier made of plastic net around each clump. Fishing nets, even those which are partly damaged and can be obtained cheaply, have been found to be suitable material. A net barrier of 3 ft width or more held in place loosely by stakes are adequate in keeping the animals away due to the fear of getting entangled. Stretching of the net will be less effective since in the event of being damaged it will leave openings through which animals can enter.

#### **Irrigation:**

During the first year of planting watering helps obtain higher survival rates especially in areas where the dry period is longer than two months. Irrigation generally helps to increase the productivity at least by three times. Natural water conservation methods like ditches or crescent shaped trenches and use of mulch help in moisture conservation. Reports from Karnataka show that yield was increased to three fold when plantations of *Dendrocalamus strictus* were irrigated. However the requirement of irrigation will vary with the local climatic conditions and microenvironment. In water scarce areas drip irrigation has been found cost-effective, but that requires

technology and investment during site preparation. Considerable savings in water will be achieved when drip irrigation is used and should be preferred where water resources are scarce. Another advantage of the drip irrigation system is that fertigation can be considered



Drip irrigation provided for ensuring survival and quick establishment of plants

#### **Pruning:**

Some of the bamboo species like *Bambusa bambos*, *B. balcooa*, *B. nutans* and *Dendrocalamus hamiltonii* has a tendency to produce large number of branches at the base of the clump thus producing a congestion. This indirectly can affect the development of new sprouts. In order to prevent the congestion it is advisable to prune these branches when the clump is two to three years old and continue every year preferably during the months of November to February. The thorns provide supplementary income for the farmer since it can be used for fencing. Cleaning of the clump is done by removing the dead and dying culms from the clump and thinning the clump by removal of weaker culms and this will facilitate proper growth of new shoots. Removal of the upper part of the culm is also recommended in areas prone to heavy wind and frost.



A well managed clump of *Bambusa bambos*. Note the absence of congestion due to removal of thorny branches and the "horseshoe pattern" of clump management.

#### **Cleaning:**

The clump takes about one year for establishment and by the third year production of new culms starts regularly. Pruning and clump management should start from the third year onwards, otherwise congestion will set in. Usually new sprouts- the younger ones, are produced towards the outer side and those seen towards the inner portion are the older ones. The older culms will have to be cut and removed when the clump is around five years of age. All the dead and malformed culms seen towards the inner side will have to be removed and the clump should be left clean all the time.

#### Fertilizer application:

Intensively managed plantations require application of fertilizers as bamboo is a heavy feeder and respond well to fertilizers. Fertilizer application will also ensure higher yield and overall profitability from plantations. In general bamboo responds well to phosphorous, potassium and especially nitrogen. It is a good idea, however to carry out soil analysis prior to establishment of the plantation, and at annual intervals thereafter to fix and confirm the fertilizer dosages. While planting one-year-old seedlings, ammonium phosphate (300 g), potash (150 g) and FYM/ cow-

dung/vermicompost (5-10 kg) per plant can be added in the pits. One and half times of the above doses can be added during the second year. Then there is no need to add any fertilizers till harvesting. After first harvest, 1.5 kg of ammonium phosphate and 750 g of potash and 45 kg of cow dung can be added annually. The fertilizer is added in the trench made (about 15 cm deep) around the clump.

Fertilizers should be applied in ditches around the clump when the soil has enough moisture, and then covered with soil. If the stands are situated in steep slopes, it is better that the fertilizer is directly applied at the base of the clump but taking care that rhizomes do not come in direct contact. Organic fertilizers are best applied during the onset of monsoon. Organic manure and compost are established sources of nutrients, and simple to prepare and use. There are many other sources of organic and naturally occurring fertilizers. Organic fertilizers can provide a range of nutrients to the soil. They encourage microbial activity, which allows the fertilizer to provide nutrients over a longer period of time. Unlike chemical fertilizers, the nutrients in organic fertilizers are less likely to leach away in rainwater.

#### **Intercropping:**

Since in bamboo plantation the planting is done at a spacing that leaves a gap in canopy for several years, farmers can benefit by using the space for short rotation crops and add to the profitability of the plantation. The option depends on the bamboo species and the spacing chosen and the crop. The grower can also adopt the spacing of 7 X 7 or 10 X 10 deliberately with the purpose of obtaining multiple benefits from a diversity of crops on the farm. Various agricultural crops have been found successful like tomato, watermelon, sweet potato, ginger and turmeric. The last two are relatively shade tolerant and can be taken up even after the canopy closes partially because the leaf fall in summer months is conducive. Some of the shrubby medicinal plants can also be introduced as an under crop in bamboo plantations. In the north eastern states some of the crops being cultivated include soya bean and maize. The use of nitrogen fixing leguminous plants is particularly suggested to improve the availability of nitrogen. Use of living mulch or cover crops will also serve to conserve moisture due to their spreading and leafy nature. The presence of such intercrops also helps recycle and retain the

nutrients in the soil and prevent the growth of weeds. The duration of intercropping depends on the spacing provided in bamboo plantations. As soon as the canopy closes, the shade prevents many crops from coming up well. Trimming of the culms beyond the marketable pole length could be considered as a means of improving the light availability and thereby permit intercrops to be cultivated for a longer duration and improve the profitability of the farmer.



Intercropping of vegetables and pulses in the early stage bamboo plantation

(photographs courtesy of Mr Raveendran)

#### 8. DISEASES AND THEIR MANAGEMENT

Bamboo is a robust species and no serious disease problems are observed in plantations. Of the various diseases that affect bamboo plantations, rot of emerging and growing culms, bamboo blight and thread blight are the economically important ones.

#### **Rot of culms**

Rot of emerging culms occurs in Bambusa bambos, B. balcooa, B. polymorpha B. vulgaris, D.

longispathus, D. strictus and Thyrsostachys oliveri. The infection causes rot of the tender, succulent emerging shoot, which becomes discoloured, and gives off a strong smell of molasses. Severe infection and culm mortality were reported in plantations situated in high rainfall areas. The disease affects further development of the culm and causes total decay. Heavy rainfall during and after the emergence of culm, water logging around the clump, mining insect activity and poor stand management are the factors favouring the infection.

Cultural control measures such as removal of debris around the clumps before the onset of monsoon, light burning of the debris over the ground, loosening the soil around the clump before culm emergence, and pruning and removal of branches from the basal part of the older culms during March-April are suggested to minimize the disease incidence.

Rot of growing culms of various species of bamboos has been recorded and *B. bambos*, *B. polymorpha* and *D.strictus* are the severely affected ones. The disease appears as water-soaked brown lesions at the base of culm sheaths. The disease control can be achieved by taking preventive measures (spraying insecticide, Monocrotophos 0.05 % a.i.) against build-up of *Purohita cervina* population during the culm elongation phase and by application of fungicide Carbendazim (Bavistin) or Mancozeb (Dithane M 45) at 0.2 % a.i. on the infected culms.

#### Bamboo blight

Bamboo blight affects *Bambusa nutans*, *B. vulgaris*, *B. tulda*, *B. balcooa*, and *B. bambos*. The disease results in a sequential die-back of culms in their first season of growth. Symptoms appear when culms are nearing full growth or shortly. The initial symptoms of blight are premature death of culm sheaths and partial collapse of the fragile apical region, later necrotic patches develop on the internodes, which spreads quickly resulting in die-back. Silvicultural measures recommended for controlling the disease includes: cutting and removing blighted culms, burning the debris of clumps *in situ* and addition of new soil around clumps. Light surface fire (control burning) before the onset of monsoon is suggested for reducing the disease incidence.

Application of Carbendazim (Bavistin) combined with Mancozeb (Carbendazim. 0.15% a.i. + Mancozeb 0.3% a.i.) or Fytolan combined with Carbendazim (Carbendazim 0.25 % a.i. + Fytolan 3%

a. i.) is suggested for controlling the disease. Drenching the soil around the bamboo clumps with Copper oxychloride (0.2% a. i.) is also desirable to check the disease.

#### Thread blight

Thread blight affecting culms, branches and foliage of different bamboo species has been reported. Most bamboo species are affected and disease appears during monsoons, subsides and almost disappears during the dry period. Large water-soaked grayish lesions occur on leaves, which advance towards the leaf tip. Pruning the diseased branches from the affected clumps and cleaning and burning the debris from the ground around the clumps can minimize the disease incidence.

#### 9. HARVESTING

A systematic harvesting of culms every year will encourage the emergence of straight and healthy new shoots. This is particularly true of the species which have congested clumps like *B. bambos* and *D. strictus* which under natural conditions are generally difficult to harvest and consequently have poor productivity. Generally in plantations, depending on the species, harvesting starts between fourth and eight years. In natural forest areas, where regular or shorter cycles are impractical harvesting need to be based on the knowledge of culm age distribution, so that the harvest can be restricted to culms of the appropriate age. If the clumps are scientifically managed by pruning and fertilizer applications, harvesting can be done annually on a culm selection system. For easy harvesting, the culms in a clump should be thinned from the early stages and culms spaced in a manner to facilitate harvesting of selected culms. Some important general rules to be followed while managing (while working in) bamboo stands are given below.

Harvesting of mature bamboo culm (usually culms above three years of age) should be carried out on a 70 % felling intensity i.e., a certain proportion of the older culms are to be retained to protect the new culms in order to ensure their proper growth. The mature culms are usually found in the middle of the clump and they are to be harvested during the initial years. Harvesting should not be carried out during the season, generally during the monsoon, when the delicate new shoot emerge since it will reduce the productivity of the plantation.

Culms should be cut at a height as low as possible leaving only one internode above the ground. If they are cut leaving more than one internode, this will result in production of more bushy branches from the nodes, ultimately affecting the growth and extraction of culms during the subsequent years.

Clearfelling of clumps will lead to their degeneration in to a bushy form, resulting in a gap of 5 – 6 years before new extractable culms are produced. Hence it should be avoided as far as possible.

Harvesting of culms in areas where growth is good is often a labour intensive work and requires a high level of skills. Harvesting methods and levels or skill and tools used vary with location. Use of heavy knives and thick ropes will be required in locations where culms are large and heavy and use of power tools and devices are not feasible. It is to be noted that cutting of the heavy culms is fraught with risk since the flexible culms are under tension and safe removal requires careful planning to avoid splitting or jolting out of control or getting entangled within the congested mass of culms and thorns. This is especially so in plantations that are managed under longer harvest cycles like in forest plantation. Adopting one of the management regimes given below will overcome some the problems by creating easy access to the culms and enough space for their safe removal.

#### 10. MATURITY MARKING

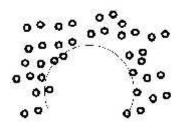
In order to facilitate the identification of mature culms for harvest when unskilled labour is employed or when the age is not easily evident from the colour or appearance, marking of culms with colour codes at the time of emergence is adopted. A set of three colours (e.g. bright yellow, red and blue) are chosen and as soon as the new culms have emerged and the culm internode is exposed, enamel paint of one of the colours is used to make a distinct mark at a particular level. All new culms of that year therefore carry the mark in that colour. The next year the procedure is repeated with a different color and so on for the third year. Since by the third year the first years culms will be harvested the colours can be repeated in the fourth year culms.

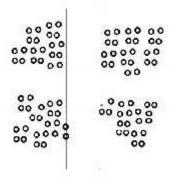
#### 11. TREATMENT OF CONGESTED CLUMPS

If the clumps are not managed from the beginning (first three to five years) it is likely that congestion of the clump will occur as in thorny bamboos (*Bambusa bambos*). Two methods for the initial cutting and extraction of selected clumps from a congested clump are suggested. In the first method, two tunnels are made through the centre of the clump dividing the clump into four sections. Now culms are to be removed selectively from all the four sections in such a way that there is enough space between the two retained culms.

In the second method, the clump is worked in a horse-shoe pattern or inverted "V" shape to facilitate easy working. For this, an opening of the clump is made opposite to where the maximum production of new culms is noticed. All old culms including dry and rotten stumps from the interior of the clump are removed leaving only one-year old straight and vigorously growing culms along with an equal number of straight and evenly spaced older culms. The culms towards the periphery are thinned retaining all one-year old culms unless they are crooked – and the old culms subject to a maximum of five and spacing them evenly. Although these methods will incur high cost initially and removal of some immature culms, it will prevent congestion, provide space for future easy working of the clumps and will allow proper growth of new shoots without deformation.

Another approach to harvesting of bamboo is applicable to high density plantations where clear felling of biomass through mechanized extraction is done and the next rotation or cycle is either through fresh planting or through coppicing i.e. permitting new shoots to emerge from the rhizomes left underground. There are some claims that this is feasible but required confirmation and experimentation in the different species since the ability of the clear-cut clump to regenerate is dependent on the health and vigour of the rhizomes retained underground and the ability of the new culms to support itself. Extraction of the underground rhizome and root system requires considerable effort and expense.





Horse shoe pattern of harvesting culms

Cross tunnel pattern of harvesting

#### 12. MANAGEMENT OF GREGARIOUS FLOWERING

Gregarious flowering of bamboo, a phenomenon which is very common in species like *Bambusa bambos* and *Dendrocalamus strictus* requires special attention. In many of the exotic species or those for which the taxonomic identity has not been ascertained, flowering gives an opportunity to confirm the identity of the species. Flowering should be reported to the concerned State Bamboo Mission Directors or research institutions under the ICFRE/state forest research institutes so that proper scientific records and documentation is enabled. A database and reporting format has been given in the Bamboo Information Centre India web site(<a href="http://www.bicindia.org">http://www.bicindia.org</a>). Such documentation can help determine the precise flowering cycle of different species and forecast the year of gregarious flowering well in advance so that appropriate management measures can be taken by growers and forest departments.

Unexpected gregarious flowering in bamboo plantations is the result of using planting material of uncertain origin. Usually most gregarious flowering events occur over a period of three or more years with the peak in the second or third year. When several clumps in the plantations show widespread signs of flowering and emergence of new culms ceases or reduces drastically, it is safe to assume that flowering is gregarious and will continue into the coming years with death of the clumps. To minimize the loss it would be desirable to begin harvesting of the bulk of the remaining clumps at the earliest.

Culms that have already undergone flowering are poor in their mechanical properties and pulping quality and therefore cannot be used for any of the typical applications and are best left to decompose and return the nutrients back into the soil. From the conservation and ecological point of view leaving the bamboo forest without any intervention is ideal since the dead clumps eventually decay and nutrients are recycled. Gregarious flowering followed by massive death of clumps carries as risk of forest fires when the dried culms accumulate in huge quantities. Therefore precautions against occurrence of fire should be taken once the culms start drying. It is desirable that once unambiguous indications of gregarious flowering are seen or when gregarious flowering is anticipated (as in cases where the flowering cycle is known with certainty), bamboo clumps be harvested on a large scale for utilization but leaving at least 1/3<sup>rd</sup> of the clumps undisturbed to serve as source of seeds for repopulating the area in the next few years.

Once gregarious flowering has occurred in an area, measures should be taken for collection of sufficient seeds since there is always a surplus of seedling population of which only a proportion survive when left to nature. The seedlings form a source of propagules of known age and carries an assurance of the number of years left to the next flowering. The seeded clumps may be clear felled and removed only after the seeds have been collected for nursery use. Collection is facilitated by spreading plastic sheets or nets beneath the clumps or by clearing the area of weeds and litter and sweeping up the seeds. After seed set the dead bamboo culms should be removed as quickly as possible. If seed set has occurred, a carpet of green seedlings can be seen in flowered areas after the onset of rains. The area should be protected from fire and grazing to ensure proper survival and growth. Thinning of excess seedlings and removal of weeds is necessary; otherwise weeds suppress the growth of young seedlings. Sometimes physical barriers such as trenches and mounds will have to be created around groups of bamboo seedlings to facilitate rehabilitation of the forest.

#### 13. BAMBOO PLANTATION FOR SPECIAL PURPOSES

# i. Establishment and management of high-density/intensively managed plantations for biomass/fiber production.

High density plantations are those where the bamboo clumps are much closely spaced than in the normal plantations thus accommodating more number of clumps per unit area. Such plantations are intended for the rapid production of bio-mass for industrial raw material. Plantations of this kind can play an important role in environment protection as the bamboo is capable of absorbing carbondioxide - the gas mainly responsible for global warming. The high density plantations are also considered as energy plantations because of the availability of large quantity of biomass for multiple purposes.

The most common species found suitable for high density plantations are *Bambusa balcooa* and *Thyrsostachys oliveri*. Other species that are suggested are *B. tulda*, *B.vulgaris*, *B longispathus*, *B. polymorpha*, *B. hamiltonii*, *D. asper* and *D. stocksii*.

#### Climatic/edaphic conditions.

Tropical to moderately temperate climates are best suited for raising high density plantations. The selected area should have well distributed rainfall but not in any way water logged. Deep well drained fertile soils which are neutral to slightly acidic are the best type of soils in which the plantations can be raised successfully. Areas with red loamy soils are also ideal for the plantation. Artificial irrigation improves the establishment and growth of the bamboo. In case proper drainage is not available in the area, it has to be provided artificially.

#### Site preparation.

Demarcation and fencing are the first step to be followed for raising the plantation. It is better to complete the work at least 4 months ahead of planting. Total weeding and through ploughing has to follow and it may be best done at least two months in advance. Aligning and staking are to be

taken up prior to planting in June in case the monsoon starts in June. The spacing to be followed is 3m between the rows and 1.5 m between the plants thus accommodating 2222 clumps per ha. The ideal pit size is  $60\text{cm}^3$ . The pits are to be closed partially with the top soil and then with a mixture of good soil, sand and dried and powdered farm yard manure mixed in a 3:2:1 proportion.

#### Planting.

Once all the pre planting operations mentioned above are over, planting has to be initiated during the pre monsoon showers in May and completed prior to the onset of the monsoon in June so as to ensure 100% clump establishment. In case artificial irrigation is the main source of watering, planting can be taken up at any time of the year, but it is always better to plant the one year propagule along with the monsoon as described above so as to take advantage of the microclimate prevalent during the monsoon season.

#### Post planting operations.

Periodic weeding preferably once in two months, at least during the first year followed by weeding as and when required later. Bamboo respond very well to fertilization, however the appropriate dosage should be fixed on after a through soil testing and as per the advice of a soil scientist/testing officer.

## Cultivation practices for high density plantations promoted by Tripura Bamboo Mission for adoption of farmers under MGNREGA

B. balcooa, B. tulda, B.vulgaris, B longispathus, B. polymorpha, B. hamiltonii, D. asper and T.oliveri

#### a. Planting density:

1250 plants /ha. ( *T.oliveri* -4000 plants/ha.)

#### b. Spacing:

- i. Between plants: 1.5 2 m (*T.oliveri* 1 m.)
- ii. Line to line spacing: 3-4 meters (*T.oliveri*-2.5 m.) Planting in straight lines in plain land and contour lines on hilly or sloping land.

iii. Pit size: 60 X 60 X 60 am (*T.oliverii*- approx 40 cm X 40 cm X 40 cm)

#### c. Management operations

Fencing against cattle; one weeding and earth mounding operation annually

## ii. Planting and managing bamboo stand along river banks, tanks and other areas frequently inundated with water/flood prone areas.

The extensive root system that characterizes most bamboo species is of great relevance when bamboo is planted for soil stabilization and erosion control particularly along rivers, steams and water bodies. The presence of bamboo increases the interception of rain and prevents runoff and soil erosion. Silting up of tanks, lakes and reservoirs can be controlled by bamboo planting along the streams flowing into them. River bank stabilization can be successfully done through planting suitable small clump forming species like *Ochlandra scriptoria* and *Bambusa multiplex*. The clumps may be planted as the lower most rows and this should be just above the maximum water level attained during the peak of the monsoon. Since the selected species are small sized, either 3 X 3 or 4 X 4 m spacing will be ideal. On small streams one row would suffice and on bigger rivers with a sloping bank a second row of plants 3 m above the first row in a staggered pattern is suggested. Species like *Ochlandra travancorica*, *Melocanna baccifera*, *Bambusa vulgaris* etc. are suitable for the planting in the second row. The staggered planting of these species will check the soil erosion from the entire portion of the river bank.

It will be desirable to combine other soil stabilizing methods with planting of bamboo. Gully plugging can be done with loose rubble or with temporary check dams (made of pieces of bamboo culms) across the gullies and planting of bamboo on either side.

#### Waterlogged or flood prone areas:

Bamboo in general does not tolerate submergence in water well and growth will be sub optimal in water logged areas where the submergence of the rhizome continues for more than 2 weeks. Water logging leads to root decay and eventually the death of the culms. However better performance is expected in bamboo planted on mounts which are kept 30 to 45 cm above the maximum water level. The mounting will have to be stabilized as and when required so that the rhizome growth and proliferation is not prevented due to the absence of good loose soil. In areas

cronically prone to flooding and waterlogging, it best to make arrangements for preventing flooding through bunds wherever possible or encourage drainage of part of the land by cutting channels sloping away to a low lying area set apart for the purpose so that the remaining area can be rehabilitated.

Species recommended: Ochlandra scriptoria, O. travancorica, Bambusa bambos, B. multiplex, B. vulgaris

## iii. Cultivation of bamboo on slopes of hills, ravines and drought-prone/water-stressed areas

#### a. Hills and slopes:

On hilly terrain and slopes, bamboo are commonly seen growing naturally especially in the North Eastern States of India, sub-Himalayan hills and the Western Ghats. Plantations of selected species of bamboo can therefore be taken up on such land. Depending on the region it will be feasible to grow species like *Bambusa bambos*, *B.tulda*, *D. hamiltonii*, *D. strictus*, *D. stocksii*, *Melocanna baccifera*, *Ochlandra travancorica*. Areas prone to heavy wind has to avoided as there is a danger of clumps toppling especially in the rains when they become top heavy. In areas with good rainfall it is sufficient to plant bamboo in simple pits along the contour. In other areas where water conservation is essential, platforms of about 1 X 1 m square or longer (if other intercrops are being considered) is made and the loosened soil is usually kept at the rim of the platform in a semi circular pattern. Small to medium sized bamboos are ideal for planting in such areas. To avoid soil erosion it is desirable that strips are left untouched between the rows and between the platforms. On gentle slopes trenches of 1 m X 0.5 m X 0.6 m can be dug to encourage water infiltration into the soil and reduce runoff.



Bamboo planted on platforms along the contour of a hill

#### b. Ravines and Gulleys:

Ravines which consists of small, medium and deep and narrow gulleys, constitute about 4 million ha in the North Western states of India. Ravines are prone to degradation though erosion and loss of vegetative cover. This has serious impact on the productivity of the adjacent land and therefore are in dire need of rehabilitation and productive utilization. Rehabilitation through engineering measures are capital intensive and therefore establishing a vegetation cover is a better option that benefits the stakeholders. More than 80 % of rainfall is reported to be absorbed in bamboo plantation based interventions in ravines and nutrient losses reduced by 50-67%. In the context of climate change mitigation and conservation of the soil and water resources too, rapid establishment of vegetative cover is a pressing need. Bamboo is in many ways very suited for such an application and will additionally bring in benefits for the farming community in the region. The National Bamboo Mission encourages bamboo plantations in the ravine landscapes of the country.

In the ravines planting of *D. strictus* has been found to be suitable. A spacing of 4 X 4 m and 400 plants /ha is ideal and trenching and water conservation measures are to be adopted. Three types of bamboo based interventions in reclaiming degraded gully beds in ravine recommended by the CSWCRTI, Dehra Dun

- i) Bamboo plantation with staggered contour trenches
- ii) Bamboo plantation supported by earthen check dams (bori bunds)
- iii) Close spaced bamboo plantation as live check dams

Before the start of rains, staggered contour trenches of 0.5 m x 0.5 m x 2 m (length) with a spacing of 4 m x 4 m is made across the slope in the ravine beds. Excavated soil is placed as a bund towards the downstream side of the trench as a water conservation measure. Bamboo is planted in the middle of the trench in pits filled with soil mixed with FYM.

Another method that has been found to be successful is to have earthen check dams (bori bunds) constructed along with bamboo planting. Woven plastic bags filled with soil is place in rows ( 3 bags wide at bottom, 2 bags wide above it and one row at the top) and the top and sides filled

with soil. For each such check dam, two lines of bamboo is planted on either side at a spacing of 2 m. In between the check dams bamboo plantation is done with 4 m x 4 m spacing in staggered manner. Reduced runoff, soil loss and nutrient loss and the maximum of silt deposition was observed in such bamboo plantation with small earthen check dams.



Bamboo plantation on either side of check dam (photographs courtesy of CSWCRTI, Dehra Dun)

Bamboo based interventions are recommended for preventing gully head extension and for stabilization and preventing erosion on the banks. Bamboo is planted on bunds on periphery and near the gully head (at a close spacing of 2 X 2 m). Upto 50% reduction in gully head extension can be obtained.

Before planting weeding and deep ploughing (about 20 to 30 cm) with tractor or country plough, to loosen soil is advised. Pits are of 35 cm X 35 cm depth with filling of the excavated soil mixed with 1-3 kg FYM

Planting is done with the beginning of the rains with one year old bamboo seedlings of 30 - 40 cm in height. Treatment of roots with termiticide solution is recommended when the incidence is high. Plants along with the ball of earth is planted 4 to 6 cm below the ground level. After rains irrigation is done 8-13 times with 10-12 litres per plant for the initial 2 years. Frequent weedings are also done.

Fertilizers are applied at the time of planting and manuring is done 5-6 months later at the end of monsoons or at the time of soot bud initiation. Soil working before emergence of new culms helps in improving the emergence of new culms. Organic fertilizers should be applied during winter or dry period.



Bamboo in gully bed planting (photographs courtesy of CSWCRTI, Dehra Dun)

#### c. Areas with scarcity of water:

In water stressed areas measures to conserve water will have to be given priority besides selection of species. *D. strictus* is the most promising species in rain-fed conditions. *D. asper, D. hamiltonii* and *D. stocksii* will be the species of choice when minimal irrigation is feasible. Under rain-fed conditions planting can be done in pits where a saucer like depression at the base of the plant will retain water available during the rainy days. Mulching with organic matter or plastic mulch will serve to further conserve moisture. Other than these silvicultural interventions all other procedures are to be followed as is done in routine bamboo plantations.

Whenever feasible, setting up a drip irrigation system will be the best solution to optimize water use. Alternatively the use of a clay pot buried upto the neck in the root zone of the bamboo can be considered if the situation permits regular refilling of the water as it gets used up. Variations to this option include use of an inverted plastic bottle with a wick inserted in the neck to permit slow outflow of water. The use of hydrogels (e.g. Jalashakti) that absorb several times its weight of water to be mixed with soil around the plant is a measure that hold promise but has not been tested specifically for bamboo in the field.

#### iv. Cultivation of bamboo in acidic/alkaline soils and other waste lands.

Sodic and saline soils:

Over 10 % of cultivable land in India is affected by sodic and saline soils that make it unfit for agriculture. Such lands are termed as wastelands due to high levels of alkalinity and salinity even to the point that salt encrustation is seen. Reclamation of such land through regeneration of vegetation together with other scientific methods is thus of great importance to the country. One of the plants that shows promise in the situation is bamboo.

Alkalinity in soils can be remedied through addition of gypsum, sulphur dust, urea or sulphate fertilizers. If there is a hard pan formation then measures to break the pan and encourage infilteration of water is to be taken up. Methods of leaching the salts out of the soil and improvement of the drainage of the soil needs to be adopted. As recommended earlier for poor soils, it is advisable here to uses mechanical pitting or trenching and replacement of soil so that bamboo is established in the site and the soil quality is improved due to green cover and the presence of leaf litter and organic matter being added to the soil.

Addition of rice straw compost and other types of compost, organic fertilizers and manure is also recommended in such soils. Planting of bamboo in raised mounds which have been prepared years in advance to facilitate washing out of alkalinity is advised wherever feasible.

D. strictus is the most preferred of the species for such soils. B. multiplex, B. maligensis, D. hamiltonii and D. asper are other species that are recommended. B. vulgaris is a species that has been seen to tolerate salinity especially of coastal areas.

#### Acidic soils:

Bamboo which generally prefers slightly acidic soils which is usually found in areas with high rainfall, is however retarded in areas with very acidic soils. Managing the acidity is possible by adding lime, ash and manure. *D. stocksii* and *B. vulgaris* are recommended for acidic soils.

#### APPENDIX - 1

#### BAMBOO SPECIES SUITABLE FOR CULTIVATION IN DIFFERENT STATES OF INDIA

The list of end uses to which bamboo is put to is a long one. Besides the numerous uses that bamboo poles find in the traditional rural building construction, it is also used as fencing, as props for agricultural crops and numerous household articles. It is now widely used in furniture making. The species suitable for such uses are mainly decided based on the culm diameter, wall thickness, straightness and durability. There is fortunately sufficient diversity of bamboo species that can be grown in different parts of India that for almost any end use there is a suitable species that can be grown in plantations. Most of the species have multiple end uses. The NBM has prioritized the species taking in to consideration their potential to be grown as plantations. The species also offers possibility for production of planting stock through one of the three propagation methods viz. seeds or vegetative methods and tissue culture. The species listed below have been in cultivation in various parts of the country and some information of the suitability has been available, but it should be borne in mind that under good management practices the bamboo species will perform differently from those that are grown in forest plantations or untended clumps in homesteads. Estimates of culm numbers and productivity are for that reason not given in this manual. When results of coordinated multi-locational field trials of different species that are under way become available in a few years time, it will be clear which species perform well in specific situations and how they can be integrated in to traditional or modern agricultural practices so as to give the farmer maximum returns through a good mixture of bamboo and intercropping.

#### Bambusa balcooa

#### Local names:

Baruwa (Manipur); Bhaluka (Arunachal Pradesh, Assam, Bengal); Beru (Meghalaya); Bhalu bans (Nagaland); Barak (Tripura)

#### Uses:

Scaffolding, construction, ladders, Agarbatti sticks, edible shoots, paper

#### **Dimensions:**

Culm length: Upto 30 m Culm diameter: 8-15 cm Internode length: 20-40 cm

Wall thickness:



A clump of Bambusa balcooa



Culms and branches

1. Distribution: Indigenous to North eastern India but naturalized in many states of India.

#### 2. Recommended for cultivation in following site conditions:

Altitude- Sea level up to 600m

Soil type- Grows in a wide range of soil types but maximum productivity is seen when grown in heavy textured soil with good drainage.

*Climatic conditions*- Growth is profuse in tropical and tropical to sub tropical conditions.

#### 3. Planting material:

This species does not set seed although flowering is occasionally seen, Vegetative propagation techniques are however quite successful and propagules can be easily produced in a span of one year. Planting material produced in NBM High Tech Nurseries or accredited Tissue culture labs is

recommended. This species is one of the most commonly available tissue cultured planting material in India.

Availability of planting stock:

Vegetative propagation: KFRI, Peechi, Thrissur, Kerala; SFRI, Chessa, Arunachal Pradesh; DFO, Arunachal FD; FRI, Dehra Dun; State Silviculturist, Assam; DFO, Kokrajhar, Assam; BCKV, West Bengal, BEEDS, Tamil Nadu, GBPUA&T, Uttrakhand, NBDA, Nagaland, TBM, Tripura.

Tissue culture: Growmore Biotech, Husur, Tamil Nadu; Hindustan Newsprint Limited, Jagi Road, Assam; KFRI, Peechi, Thrissur; Rain Forest Research Institute, Jorhat, Assam.

### 4. Planting procedure:

*Season of planting-*. During the pre monsoon showers planting should be initiated and completed. In areas were artificial irrigation is feasible planting can be delayed upto December.

*Pre planting operations-* The area to be demarcated is fenced and weeded at least 15 days prior to planting.

*Pit size* & *treatment*- 45 X 45 X 45 cm cubical pits are to be dug, half filled and kept exposed to sun for top soil sterilization. Trenches are an option if heavy earth movers are used for preparation of the site.

*Planting*- Simultaneous with the pre monsoon showers, the pit to be filled with one year old plantable seedling/propagule, taken out of the container and kept in position in the pit. The filled up soil is to be compacted around the plant.

Spacing- The species to be planted at closer spacing of 5 X 5m if managed for the production of edible shoots and 7 m<sub>X</sub>7 m for timber production. High density plantation intensive management have been suggested for biomass for bioenergy production but the sustainability of this practice is not clear in all situations . The recommendation is for planting at a spacing 1.21 m (4 ft) X 3,04 (10 ft) so as go have access to machinery for management operations and harvesting.

## 5. Soil/water conservation measures:

Productivity can be increased multi fold if water harvesting trenches (60cm X 45cm X 30cm) are dug in interspaces if square planting is done. Care should be taken to see that the trenches will not interfere with the harvesting and transportation of shoots/culms from the plantation.

## 6. Management of established clumps:

Fertilization: Depending on the soil testing carried out just prior to planting and after clump establishment, fertilizer doses are to be fixed up by an expert. Bamboo responds well with NPK and dry farm yard manure or vermicompost

*Irrigation:* Essential in the first two years just to ensure healthy establishment and culm production. Moisture retention through trenches also helps.

## Plant protection measures:

If managed properly with routine pruning, thinning and cleaning (cultural practices) bamboo usually escapes pest infestations. Bamboo blight caused due to *Sarocladium oryzae* can be controlled by application of Indofil M-45 as a soil drench, physically removing the blighted culm, burning debris *in situ* and adding contamination free new soil around the clumps.

Clumps managed for edible shoots needs protection from porcupines and wild pigs in particular. This can cheaply be provided by encircling the clump with fishing net as barrier. The method can be adopted in clumps managed for culm production also.

Thinning- Regular pruning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to provide sufficient space in the clump for new sprouts. Branch pruning also provides sufficient space for the emerging culms to grow upwards quickly without any hindrance. As a regular practice these operations are to be carried out every year probably soon after winter months.

## 7. Harvesting

For edible shoots- Culms can be harvested in non rainy months when usually copious culm production occurs. For edible shoots tender sprouts are to be harvested within 3 weeks of emergence when they are about 30 to 40 cm in length. Ensure that not more than 60% of the sprouts are removed in one season. Soon after extraction the tender sprouts are to be taken for processing as drying of the sprout is detrimental for further processing.

For poles- Harvesting of culms is done following the colour coding system to avoid removal of immature culms or miss the mature ones.

**8. Flowering cycle**: 35-40 years but no seed set or death of clumps have been ever reported and therefore the species is ideal for plantations in that respect.

## Bambusa bambos

Local names:

Kotoha (Assam)

Behor bans (West Bengal)

Mula (Malayalam)

Kanta bans (Orissa)

Nal bans (Punjab)

Saneibo (Manipur)

Mungil (Tamil Nadu)

Mulla veduru (Andhra Pradesh)



Construction, scaffolding, ladders, Furniture, Paper/pulp, edible shoots, leaf as fodder

## **Dimensions**:

Culm length: Upto 30 m Culm diameter: 15-18 cm Internode length: 15-30 cm

Wall thickness:



Clump of B. bambos



New culms



Culms of B. bambos



Seeds of *B.bambos* 

- **1. Distribution:** Most common indigenous species of the Indian subcontinent growing throughout the country in the plains. It covers about 28% of the total bamboo area in the country.
- 2. Recommended for cultivation in the following site conditions:

Altitude- All along the plains up to 1200m above sea level.

Soil type- All most all types of soil with good drainage, however better growth is seen in slightly acidic soils, sandy loams and alluvial soils.

Climatic conditions- Growth is profuse in tropical and tropical to sub tropical conditions but comes up in dry areas as well.

**3. Planting material:** One year old seedlings and vegetatively propagated planting stock will have to be procured from NBM high tech nurseries.

Seeds are available for a few years after gregarious flowering if stored under right conditions. Seeds have no dormancy and help to utilize the favorable condition after seed fall.

Seeds can be sown directly on nursery beds during March-May in patches and cover lightly with soil. If fresh seeds are sown 90 to 100 percent germination can be achieved. Partial shade is necessary for initial establishment of seedlings. The seedlings can be poly-potted after 45 days. Large scale production can be achieved through macro proliferation.

Offset planting can be done during the onset of monsoon but this method is expensive for transportation and rhizome extraction as it is difficult. This species is also propagated through culm cutting and branch cuttings after treated with growth regulating hormone.

Seedlings are available with the Forest Department nurseries in many states.

Vegetatively propagated planting stock is available at: KFRI, Kerala; BEEDS, Tamil Nadu, TBGRI, Kerala, Tripura Bamboo Mission; Forest Departments of Kerala, Karnataka, Tamil Nadu

Micropropagation technology has been standardized for the species and commercial scale production was done by NCL, Pune and TERI, New Delhi.

#### 4. Planting procedure:

Season of planting- Planting during the pre monsoon showers or just prior to active monsoon ensures better survival and quicker field establishment. If irrigation of the plants is feasible planting may be delayed by a few months even up to December.

*Pre planting operations-* Demarcation and fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

Pit size & treatment- 45 X 45 X 45 cm cubical pits to be half filled with soil and kept exposed to sun for sterilization for about a month.

*Planting*- Along with the pre monsoon showers when the soil is sufficiently moist, the pits are to be completely filled and planted with one year old planting stock. The filled up soil to be compacted around the clump.

Spacing- Spacing of 5 X 5m to be maintained when grown for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) dug along the interspaces in alternate rows of planting ensures higher culm production.

## 6. Management of established clumps:

Cultural practices- All dead and dying culms to be cut from the base leaving one/two nodes from the bottom and removed from the third year of establishment. Thorns to be pruned from the base of the clump every year preferably during the months of November –December. Thorns can be used for strengthening the fencing around the plantation.

Fertilisation- To be carried out as per the advice of an expert after testing the soil soon after clump establishment. Bamboo responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Small doses of nitrogenous fertilizers (2000g of ammonium sulphate or calcium ammonium nitrate) are applied in a furrow during first year of planting. 200g of super phosphate are applied per plant at the time of planting which promote better development of roots. A dose of fertilizers in second year is also recommended.

*Irrigation* -Responds well to irrigation however essential only during the first one or two years so as to ensure better establishment and quicker culm production. Moisture retention through trenches to be practiced.

Plant protection measures- If managed properly with routine pruning, thinning and cleaning, and by adopting proper sanitation measures, (cultural practices) Bamboo usually escapes pest/fungal infestations. Protection with appropriate fencing material will help the tender sprouts (new culms) from wild animals.

Thinning - Regular pruning of the thorns, cleaning of clumps from the fourth year of clump establishment ensures higher culm production. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for the new sprouts to grow up straight. Branch/thorn pruning also creates sufficient space for the emerging culms to grow upwards quickly without hindrance. These operations should form regular practices carried out every year probably during November to February.

- 7. Harvesting- Culms should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps. However it is always better to retain a few older culms in the clump to give support to the younger culms and newly emerging cullms. However if the stand is managed for the production of edible shoots, they are to be cut either in the early morning or late evening when they attain about 25 to 35 cm in height to avoid desiccation. While harvesting the tender shoots care should be taken to see that only 70% of the sprouts that too distributedfrom all portions of the clump are removed while 30 % is retained in the clump.
- **8. Flowering cycle:** 35-45 years. Gregarious flowering spread over 2-3 years, Harvesting can be resorted to when signs of flowering are seen: flowering in a few shoots and lack of new shoots during the season.

## Bambusa nutans

#### Local names:

Bidhuli (Assam)

Malla (UP)

Mahi bans (Sikkim)

Badia bans (Orissa)

Makala (Tripura)

Utang (Manipur)

Rungazumi (Nagaland)

#### Uses

Construction, furniture, scaffolding

## Dimensions:

Culm length: 6- 20 m Culm diameter: 5-15 cm Internode length: 20-45

cm

Wall thickness:Hollow with very thick walls sometimes totally solid



Clump of B. nutans



Culms of *B. nutans* 

- 1. **Distribution:** Mostly confined to Himachal and other North Eastern states. Also grows well in Orissa, Sikkim, Uttar Pradesh, West Bengal. Can also be grown in South Indian states of Kerala, and parts of Karnataka.
- 2. Recommended for cultivation in the following site conditions.

Altitude-The species prefers colder habitats and comes up well in areas with 600 to 1500 m

Soil type- Prefers well drained sandy to clay loams for better growth. Well drained residual soils also supports good growth

Climatic condition- Though prefers sub tropical climate, can be grown in wet tropics also. Growth is

profuse in tropical and tropical to sub tropical conditions.

### 3. Planting material:

Vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries.

Tissue culture: IFGTB, Coimbatore, RFRI, Jorhat

## 4. Planting procedure:

Season of planting- Planting during the pre monsoon showers ensures better survival and quicker field establishment

Pre planting operations- Demarcation and fencing to be completed at least three months prior to planting. Weeding to be completed at least 15 days prior to planting.

Pit size & treatment- 45 X 45 X 45 cm cubical pits to be half filled and kept exposed to sun for top soil sterilization for about a month.

Planting- Along with the pre monsoon showers, the pits are to be completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

Spacing Closer spacing of 6 X 6 m Is ideal.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 5 X 5m spacing.

#### 6. Management of established clumps:

Cultural practices- All dead and dying culms to be cut and removed from the third year of establishment. Thorns to be pruned from the base of the clump every year preferably in the months of November – December.

Fertilisation- To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermin-compost and dried farm yard manure.

*Irrigation*- Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. Moisture retention through trenches should also be practiced.

Plant protection measures - If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections. Proper protection with appropriate fencing material also helps to save the tender sprouts from wild animals.

Thinning- Regular thinning of the older culms and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to

provide sufficient space in the clump for new sprouts. Branch pruning also provides sufficient space for the emerging culms to grow upwards quickly without any hindrance. As a regular practice these operations are to be carried out every year probably prior to the winter months.

- **7.** *Harvesting* Culms should be harvested only during non rainy months. No current year culms are to be cut. However it is always better to retain a few older culms in the clump to give support to the younger culms and newly emerging culms.
- **8. Flowering cycle**: 35 years

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# Bambusa pallida

#### Local names:

Bijuli, Bakhal, Burwal (Assam)

Bijli (Arunachal Pradesh)

Pashipo, Pushee (Lapcha-Sikkim)

Tenang (Meghalaya)

Makkal (Tripura)

Tesero, Watoi (Nagaland)



Clump of *B.pallida* 



Culms of B. pallida

## Uses

Construction, baskets, mats, handicrafts

## **Dimensions:**

Culm length: 13- 20 m Culm diameter: 5-8 cm Internode length: 40-70 cm

Wall thickness: Hollow with thick

walls especially at base



Seeds

- 1. **Distribution:** Confined to Himachal and other North Eastern states. Can also be grown in higher reaches of West Bengal, Orissa, parts of UP and in south Indian states of Kerala, and parts of Karnataka.
- 2. Recommended for cultivation in the following site conditions:

Altitude: The species prefers high altitudes in the range of 700 to 2000 m with cold climate

Soil type: Grows well in well drained sandy to clay loam soils.

Climatic condition: Tropical hilly to mild temperate conditions.

3. Planting material: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

### 4. Planting procedure:

Season of planting- Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations*- Demarcation / fencing to be completed at least three months prior planting. Weeding, at least 15 days prior to planting.

Pit size & treatment- 45 X 45 X 45 cm cubical pits to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting*- Along with the pre monsoon showers/prior to active monsoon. The pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing-* Closer spacing of 4 X 4 m for edible shoot production and 6 X 6 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

### 6. Management of established clumps:

Cultural practices: All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation: To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation:* Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

**7. Plant protection measures**: If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning- Regular thinning and cleaning should be carried out from the 4th year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create

sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

**8. Harvesting**: Culms (for timber) should be harvested only during non- rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support to the younger culms and newly emerging culms.

In stands managed for the production of edible shoots, the new culms are to be cut when they attain about 25 to 35 cm in height and only in the early morning or late evening to avoid desiccation. Care should also be taken to see that only 70% of the sprouts are removed ensuring that the extraction is from all parts of the clump

**9. Flowering cycle**: Sporadic flowering reported in the species

# Bambusa polymorpha

#### **Local Names**

Betwa (Assam, West Bengal )
Narangi bans (Madhya Pradesh)
Bari (Tripura)

#### Uses:

Poles, construction, matmaking, edible shoots,, Paper, composites

#### **Dimensions:**

Culm length: 16- 25 m Culm diameter: 8-15 cm Internode length: 40-60 cm



Clump of *B. polymorpha* 



Culms of B. polymorpha

- 1. **Distribution:** North Eastern states of Assam, Arunachal Pradesh, Madhya Pradesh, Meghalaya, Tripura and West Bengal. Can also be grown in south Indian states of Kerala, parts of Andhra Pradesh and Karnataka.
- 2. Recommended for cultivation in the following site conditions:

Altitude- The species prefers high altitudes with cold climate. It also grows well in low hill slopes along the valleys.

*Soil type-* Grows well in well drained sandy to clay loam soils. Deep fertile ,well drained loam and riverine alluvial soil is the best for growing the species.

Climatic conditions- Tropical hilly to mild temperate conditions.

**3. Planting material**: Seedlings and vegetatively propagated planting stock will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

### 4. Planting procedure:

Season of planting- Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations*- Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment-* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting*-Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil is to be compacted around the plant.

Spacing- Closer spacing of 4 X 4 m for edible shoot production and 6 X 6 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

## 6. Management of established clumps:

*Cultural practices*- All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation- To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried FYM. Organic fertilizers recommended if grown for edible shoots.

*Irrigation*- Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenching should also be practiced.

Plant protection measures- If managed properly with routine pruning, thinning and cleaning, (cultural practices) the species usually escapes pest and diseases. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning- The species forms dense clusters and therefore regular thinning and removal of dead culms should be carried out from the 4<sup>th</sup> year of clump establishment to permit emergence of new culms and their proper growth . All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year prior to the winter months.

7. Harvesting. Culms (for timber) should be harvested only during non rainy months. No current year culms are to be cut. For vegetative propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps . About 60% of the 3 year old culms and almost all of the 4th

year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms. If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8.** Flowering cycle: 55-60 years

## Bambusa tulda

#### **Local Names**

Jati (Assam, Arunachal Pradesh, Nagaland, West Bengal)

Wati, Owati (Meghalaya)

Mirtinga (Tripura)

Rawthing (Mizoram)

Paoshiding (Sikkim)

Deobans (Behar)

Longmeii (Nagaland)

Koraincho bans (Sikkim)



Clump of B.tulda



Culms of B. tulda

#### Uses

Construction, flutes handicrafts, edible shoots, Paper /pulp, Bamboo boards composites and laminates

#### **Dimensions:**

Culm length: Upto 20 m Culm diameter: 5-15 cm Internode length: 20-45 cm



Seeds of *B. tulda* 

1. **Distribution:** Found in the states of Assam, Behar, Meghalaya, Mizoram, Nagaland and Tripura. It is being cultivated in Arunachal Pradesh, Uttrakand. Can also be grown in south Indian states of Kerala, and parts of Andhra Pradesh, and Karnataka.

## 2. Recommended for cultivation in the following site conditions:

Altitude- Though the species prefers altitudes around 1500 m it can be easily grown in the plains

*Soil type*- Prefers moist alluvial soil to fine textured soils also in well drained sandy and clayey soils.

Climatic condition-Tropical and sub tropical conditions.

**3. Planting material**: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

Availability: KFRI, Kerala; State Silviculturist, Assam; SFRI, Chessa, Arunachal Pradesh; DFO, Kokrajhar, Assam;, BDA, Nagaland, TBM, Tripura

Tissue culture: KFRI, Peechi; RFRI, Jorhat, TERI, New Delhi

## 4. Planting procedure:

Season of planting: Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations:* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment:* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting:* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing:* Closer spacing of 4 X 4 m for edible shoot production and 7 X 7 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

## 6. Management of established clumps:

*Cultural practices:* All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation: To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation:* Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures: If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

*Thinning:* Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

7. Harvesting: Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8. Flowering cycle:** 30-60 years

# Bambusa vulgaris

#### **Local Names**

Barak (Assam)

Bakal (West Bengal)

Lam Sameibi (Manipur)

Mirtinga (Tripura)

Vairua(Mizoram)

Sunderkania bansa(Odisha)

Pachamula (Malayalam)



A clump of *B. vulgaris* 



Culms of B. vulgaris

#### **Uses:**

Construction, scaffoldings, pulp and paper, fencing, ornamental

## **Dimensions:**

Culm length: 8-20 m Culm diameter: 5-10 cm Internode length: 45 cm



New shoot

- 1. **Distribution:** Found in states of Arunachal Pradesh, Assam, Bihar, Madhya Pradesh, Manipur, Mizoram, Odisha, Tripura, West Bengal. Can also be grown in south Indian states of Kerala, and parts of Andhra Pradesh, Tamil Nadu and Karnataka.
- 2. Recommended for cultivation in the following site conditions:

Altitude- Grows well in plains and up to altitudes of 1500 m. it can be easily grown in the plains

Soil type- Prefers moist alluvial soil, also grows well in well drained sandy and clayey soils. Tolerant to salinity and water logging

*Climatic conditions-* It prefers a tropical climate.

3. Planting material: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting. Vegetative propagation is very easy in this species and culm or branch cuttings root easily and even without use of rooting hormones throughout the year.

Availability: KFRI, Kerala; BEEDs, Tanjavur, SFRI, Chessa, Arunachal Pradesh; TBGRI, Kerala.

### 4. Planting procedure:

*Season of planting-* During the pre monsoon showers planting should be initiated and completed. In areas were artificial irrigation is feasible planting can be delayed upto December.

*Pre planting operation-* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment-* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting-* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

Spacing- Closer spacing of 4 X 4 m for edible shoot production and 7 X 7 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

#### 6. Management of established clumps:

*Cultural practices*- All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation- To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation*- Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures- If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning- Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

- 7. Harvesting: Culms (for timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms. If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.
- 8. Flowering cycle: Rarely flowers but does not set seed and the clumps usually survive.

# Dendrocalamus asper

#### **Local Names**

Sweet Bamboo, Rough bamboo

Thaitama Bans (Sikkim)

## **Uses:**

Mainly grown for the high quality edible shoots. Poles are strong and useful in construction



A clump of D. asper



Culms of D. asper

## Dimensions;

Culm length: upto 30 m Culm diameter: 20 cm Internode length: 30 cm Wall thickness: Hollow culms with thick wall especially

towards base



Emerging shoot of *D.asper* 

- **1. Distribution:** It is an exotic species cultivated in the North Eastern states as the shoots are very popular item of food. Can also be grown in south Indian states of Kerala, and parts of Tamil Nadu and Karnataka.
- 2. Recommended for cultivation in the following site conditions:

Altitude- Grows well in plains and in hilly tracts up to 1000m altitude.

*Soil type-* Prefers well drained black soils, Sandy clay loam or shallow lateritic soil mixed with fine sandy clay. Good drainage is essential.

Climatic condition- It prefers a sub tropical climate to tropical climate. Suitable for drier tracts

**3. Planting material**: Vegetatively propagated and micropropagated planting stock will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

Availability: Vegetatively propagated- KFRI, Peechi, TFRI, Jabalpur, RFRI, Assam; SFRI, Arunachal Pradesh. Tissue culture- Century Laminates, Hapur, UP; TERI, New Delhi; Growmore Biotech, Hosur, TN

## 4. Planting procedure:

Season of planting- Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations-* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment-* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting*- Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing*- Closer spacing of 4 X 4 m for edible shoot production, 5 X 5m when planted as a species in ornamental/shelter belt plantations and 7 X 7 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

## 6. Management of established clumps:

*Cultural practices*- All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation- To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation-* Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures- If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning- Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

- 7. Harvesting. Culms (for timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.
  - *D. asper* is a preferred species for edible shoot since the shoots are sweet. In stands managed for edible shoots, extraction is done when the sprouts attain 35 to 45 cm in height. Care should be taken to see that only 60% of the sprouts extracted from all portions of the clump are removed while 40 % are retained in the clump. Shoots are collected either early in the morning or late in evening.
- **8. Flowering cycle:** More than 100 years. Most planting material available in India are tissue culture plantlets derived from seeds of a flowering event about 25 years back and therefore for the next 75 years plantations are not expected to flower. Other accessions appear to have introduced subsequently and one such population flowered in November 2014- March 2015 in the KFRI Bambusetum at Velupadam, Thrissur.

## Dendrocalamus brandisii

Local names

Bulka (West Bengal)

Wanan (Manipur)

Bilathimula (Malayalam)

#### Uses

Construction, handicrafts, edible shoots



A clump of *D. brandisii* 



Culms of D. brandisii

## **Dimensions**

Culm length: 19-33 m Culm diameter: 13-20 cm Internode length:30-38 cm



**New Shoot** 



Seeds of D. brandisii

- **1. Distribution:** Found mainly in the states of Manipur and Andamans. Can also be grown in south Indian states of Kerala, and parts of Andhra Pradesh, Tamil Nadu and Karnataka.
- 2. Recommended for cultivation in the following site conditions:

Altitude: Grows well in plains and in hilly tracts and upto 1300 m

Soil type: Prefers well drained sandy and clayey soils.

Climatic condition: It prefers a tropical climate and responds well to water availability.

**3. Planting material**: Seeds are available from the flowering in 2013 in Coorg, Karnataka and Wyanad, Kerala. Vegetatively propagated planting stock is also available of selected clones at IWST, Bangalore. One year old planting stock should be preferred and procured from NBM recognized

nurseries or NBM high tech nurseries for out planting. Tissue culture technology has also been standardized.

Availability: IWST Bangalore; UAS, Dharwad; KFRI, Peechi; Uravu, Wyanad.

### 4. Planting procedure:

Season of planting: Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations:* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment:* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting:* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing:* Closer spacing of 4 X 4 m for edible shoot production, 5 X 5m when planted as a species in ornamental/shelter belt plantations and 7 X 7 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

## 6. Management of established clumps:

Cultural practices: All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation: To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermi compost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation:* Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures Enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures: If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning: Very large clumps consisting of around a hundred culms or more can be expected in very fertile areas with good watering. Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

7. Harvesting: Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8. Flowering cycle:** 45-50 years.

## Dendrocalamus giganteus

#### **Local Names**

Worra (Assam)

Maipo (Arunachal Pradesh)

Bhalo Bans (Sikkim)

Maribol (Manipur)

Warok (Nagaland)

Rawnal (Mizorram)



A clump of *D. giganteus* 



Culms of of D. giganteus

#### **Uses:**

Handicrafts, containers construction, edible shoots, paper

## **Dimensions:**

Culm length: 24-30 m Culm diameter: 20-30 cm Internode length: 35-40 cm



New shoot



Seeds of *D. giganteus* 

- 1. **Distribution:** Found mainly in the states of Sikkim,Uttranchal,West Bengal. Its being cultivated in the North Eastern states for handicrafts and shoots. Can also be grown in south Indian states of Kerala, parts of Tamil Nadu and Karnataka.
- 2. Recommended for cultivation in the following site conditions:

Altitude-. Grows well in plains and in hilly tracts up to 1200m.

Soil type- Prefers well drained loamy soils.

Climatic condition- It prefers a sub tropical to tropical climate.

3. Planting material: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

Availability: SFRI, Arunachal Pradesh; FRI Dehra Dun; KFRI, Peechi;

Tissue culture Plants: Sunglow Biotech,

## 4. Planting procedure:

Season of planting: Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations:* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment*.45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting:* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

Spacing. Closer spacing of 5 X 5 m for edible shoot production, 9 X 9 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

## 6. Management of established clumps:

*Cultural practices:* All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation: To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation:* Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures: If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning: Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to

create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

**7. Harvesting**. Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8. Flowering cycle:** 40 years

# Dendrocalamus hamiltonii

## Local names:

Kako/Hate (Arunachal Pradesh)

Kako banh (Assam)

Unap (Manipur)

Aotsü (Nagaland)

Choya Bans/Ban Bans/ Dhungray bans (Sikkim)

Phulrua (Mizoram)

Pecha(Tripura)

**Uses:** 



Poles, mats and baskets, edible shoots, Leaves for fodder

## **Dimensions:**

Culm length: 12-20 m Culm diameter: 10-18 cm Internode length:40 -70 cm



Clump of D.hamiltonii



New shoot



Culms and branches



Seeds of D.hamiltonii

- 1. **Distribution:** Central Himalayas to Northeast India up to 1800 m, Sikkim, West Bengal.
- 2. Recommended for cultivation in the following site conditions:

Altitude- 870-1800 m

Soil type- Well drained loams

Climatic conditions- .Sub tropical to warm temperate

3. Planting material: Seedlings and vegetatively propagated propagules (the planting stock) will

be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting. Micropropagation methods have been standardized by IHBT, Palampur

## 4. Planting procedure:

Season of planting- Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operation-* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment-* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting*- Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

Spacing-Spacing of 5 X 5 m for shoot production and 6 X 6 m for timber.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

#### 6. Management of established clumps:

*Cultural practices*- All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation- To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation*- Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures- If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning- Regular thinning and cleaning should be carried out from the 4th year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

7. Harvesting. Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8. Flowering cycle**: 45-55 years

## Dendrocalamus stocksii

#### **Local Names**

Chivari, Mes (Maharashtra),

Konda (Karnataka)

Oyi (Kerala)

## **Uses:**

Furntiture, Handicrafts, construction, edible shoots,



A clump of *D. stocksii* 



Culms of of D. stocksii

## **Dimensions:**

Culm length:9 m Culm diameter:2.5-4 cm Internode length: 15-30cm Wall thickness: Solid culms except at the tops internodes



New shoot of D. stocksii

- 1. Distribution: Coastal areas of Maharastra, Goa, Karnataka and Northern Kerala
- 2. Recommended for cultivation in the following site conditions:

Altitude-. Grows well in plains and in hilly tracts up to 1200m.

Soil type- Lateritic soils.

*Climatic condition-* It prefers atropical humid climate.

**3.** Planting material: Vegetatively propagated planting stock will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

Availability: KFRI, Peechi; IWST, Bangalore, Uravu, Wyanad, Kerala Tissue culture Plants: IWST, Bangalore; Grow more Biotech, Hosur

## 4. Planting procedure:

Season of planting: Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations:* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment*.45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting:* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing.* Closer spacing of 5 X 5 m for edible shoot production, 9 X 9 m for timber production.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

## 6. Management of established clumps:

*Cultural practices:* All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation: To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation:* Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures: If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning: Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to

- create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.
- 7. Harvesting. Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.
- **8. Flowering cycle:** Flowering and death of the species is seen rarely. The species does not set seed.

## **Dendrocalamus strictus**

#### Local names:

Lathi bans (throughout North and North East India)
Sandapa Veduru (Andhra Pradesh)
Karal (Bengal)Nakur bans (Gujarat)
Kallanmula (Kerala)
Narvel (Maharashtra)
Salia (Odisha)
Kalmungil (Tamil Nadu)
Tursing (Mizorram)



A clump of *D.strictus* 



Culms and branches

### **Uses:**

Furniture, poles for construction, ladders, Paper Edible shoots

## **Dimensions**

Culm length: 8-16 m Culm diameter: 2-5 – 8 cm Internode length: 30-45 cm

Wall thickness: Culms are almost solid in the lower internodes especially in drier areas



New Shoot



Seeds of D.strictus

- **1. Distribution:** Found throughout India especially in the drier tracts. Grows well in the plains and in the foot hills.
- 2. Recommended for cultivation in the following site conditions:

Altitude- Grows well in plains and in the foot hills up to 1000m.

Soil type- Grows well in well drained coarse grained/stony/degraded/dry soils.

*Climatic conditions-* It prefers tropical climate.

**3.** Planting material: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

### 4. Planting procedure:

Season of planting: Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operation:* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size & treatment:* 45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting:* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

Spacing: Spacing of 5 X 5 m for shoot production and 6 X 6M for timber.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

### 6. Management of established clumps:

*Cultural practices:* All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation: To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers are recommended if grown for edible shoots.

*Irrigation*: Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

*Plant protection measures:* If managed properly with routine pruning, thinning and cleaning, bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning- Regular thinning and cleaning should be carried out from the 4th year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these

operations are to be carried out every year probably prior to the winter months.

7. Harvesting. Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8. Flowering cycle**: 45-55 years

# Melocanna baccifera

#### Local names:

Muli bans (Arunachal Pradesh, Tripura, Bengal)

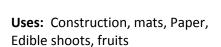
Moubiwa (Manipur)

Turiah (Nagaland)

Tarai (Assam)

Watrai (Meghalaya)

Mautak (Mizoram



### **Dimensions**

Culm length: 10-20 m Culm diameter: 3-7 cm Internode length: 20-25 cm Wall thickness: Culms are hollow

and thin walled



Clumps of *M. baccifera* 



**New Shoot** 



Culms and branches



Seeds of M.baccifera

- 1. Distribution: A species very common in the plains and foot hills of North Eastern states.
- 2. Recommended for cultivation in the following site conditions:

Altitude. Grows well in plains and in the foot hills up to 1000m.

*Soil type.* Grows well in well watered sandy clay loam, alluvial soil and on well drained residual soil or almost pure sand.

Climatic condition- It prefers tropical to sub tropical climates.

3. Planting material: Seedlings and vegetatively propagated propagules (the planting stock) will

be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

## 4. Planting procedure:

Season of planting. Planting during the pre monsoon showers or prior to active monsoon.

Pre planting operations. Demarcation / fencing to be completed at least three months prior

to planting. Weeding, at least 15 days prior to planting.

Pit size & treatment.45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting.* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing.* Being an amphipodial species the culm production is very diffuse. A wider spacing of 10 X 10 m will be ideal both for shoot production and timber. Trenches of 60 cm depth can be dug to prevent spreading of clump to adjoining land.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

### 6. Management of established clumps:

*Cultural practices.* All dead and dying culms to be cut and removed from the third year of preferably in the months of November – February.

Fertilisation. To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried farm yard manure. Organic fertilizers recommended if grown for edible shoots.

*Irrigation*. Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures- If managed properly with routine pruning, thinning and cleaning, (cultural practices) bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

*Thinning.* Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment although congestion of clump is not a serious problem in the species. As a regular practice removal of dead culms may be done every year probably prior to the winter months.

7. Harvesting. Culms can be harvested in 5-6 years after planting. Harvesting during rains is practiced. No current year or one year old culms are to be cut. Culms mature in two years. About 60% of the 2 year old culms and almost all of the 3rd year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

If the stand is managed for edible shoots, they are to be cut either in the early morning or late evening when the sprouts attain 35 to 45 cm in height. While harvesting the tender shoots care should be taken to see that only 60% of the sprouts that too from all portions of the clump are removed while 40 % are retained in the clump.

**8. Flowering cycle**: 48 years

## Ochlandra travancorica

#### **Local Names**

Karretta (Kerala)

Eeral (Tamil Nadu)

Konda (Karnataka)

#### Uses:

Mats, baskets, flutes, paper



Clumps of O. travancorica



Culms of O.travancorica

#### **Dimensions:**

Culm length: 2-6 m
Culm diameter: 2.5-5 cm
Internode length: 45-60 cm
Wall thickness: Thin walled,
thicker at lower part of culms



Fruits of O. travancorica

- 1. Distribution: Species seen widely in Kerala and parts of Tamil Nadu
- 2. Recommended for cultivation in the following site conditions:

Altitude: In the plains and foot hills.

*Soil type:* Dark brown, acidic, sandy loam with granular structure. The species thrives well in soils with high porosity, good aggregate stability and high water holding capacity.

Climatic conditions: It prefers tropical climates.

**3. Planting material**: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

Availability: KFRI, Peechi, JNTBGRI, Palode, Trivandrum

### 4. Planting procedure:

Season of planting. Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations.* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

*Pit size* & *treatment*.45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting.* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

*Spacing.* Spacing of 6 X 6 m is ideal if grown for timber. The species is a very strong soil binder when planted in closer spacing of 3 X 3 m along canal/stream/river banks for soil stabilization.

**5. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

### 6. Management of established clumps:

*Cultural practices.* All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation. To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried FYM.

Irrigation. Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures— If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning. Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

**7. Harvesting**. Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from

all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

**8.** Flowering cycle: 7-12 years

# Thrysostachys oliveri

#### **Local Names**

Kanak kainch(Tripura)

Lathi mula (Kerala)

#### Uses:

Construction, Furniture, baskets, umbrella, fishing rods, Sport goods, Edible shoots



Clumps of T.oliveri



Culms of T.oliveri

#### **Dimensions:**

Culm length: 15-25 m
Culm diameter: 5 cm
Internode length: 40-60 cm
Wall thickness: Hollow but with
thick walls to almost solid in the

lower part of culm



## 1. Distribution: Recommended for cultivation in the following site conditions:

Altitude: From plains to upto 1500 m

Soil type: Well drained loamy soils.

Climatic condition: It prefers tropical climates.

**2. Planting material**: Seedlings and vegetatively propagated propagules (the planting stock) will be available and one year old planting stock should be preferred and procured from NBM recognized nurseries or NBM high tech nurseries for out planting.

Availability: SFRI, Itanagar, KFRI, Peechi, Uravu, Wyanad: Tripura Bamboo Mission, Agartala,

RFRI, Jorhat

### 3. Planting procedure:

Season of planting: Planting during the pre monsoon showers or prior to active monsoon.

*Pre planting operations.* Demarcation / fencing to be completed at least three months prior to planting. Weeding, at least 15 days prior to planting.

Pit size & treatment.45 X 45 X 45 cm cubical pits, to be half filled and kept exposed to sun for top soil sterilization for about a month.

*Planting.* Along with the pre monsoon showers/prior to active monsoon the pits are completely filled and planted with one year old planting stock. The filled up soil to be compacted around the plant.

Spacing. Spacing of 6 X 6 m is ideal if grown for timber. High density plantations at a spacing of 1 X 2.5 (line to line) are also recommended. The species is a very strong soil binder when planted in closer spacing of 3 X 3 m along canal/stream/river banks for soil stabilization.

**4. Soil/water conservation measures**: Moisture/water harvesting trenches (60cm X 45cm X 30cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 X 6 m spacing.

#### 5. Management of established clumps:

*Cultural practices.* All dead and dying culms to be cut and removed from the third year of establishment preferably in the months of November – February.

Fertilisation. To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermicompost and dried FYM.

Irrigation. Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced.

Plant protection measures— If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

Thinning. Regular thinning and cleaning should be carried out from the 4<sup>th</sup> year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the winter months.

**6. Harvesting**. Culms (timber) should be harvested only during non rainy months. No current year culms are to be cut. For propagation about 20 % of two year old culms can be selectively cut from all portions of the clumps which can be made use of for vegetative propagation through rooting of culm cuttings. About 60% of the 3 year old culms and almost all of the 4th year culms can be cut and removed. However it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

**7.** Flowering cycle: 48-50 years