Cultivating Bamboo

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PREFACE

THIS TRAINING MANUAL elaborates the practices associated with the cultivation and management of bamboo, especially of sympodial bamboos, which are commonly found in India. The manual has a special focus on practices related to plantations.

It is hoped that the manual will encourage large scale planting of bamboo, and provide a basis for improved productivity of the country's forest-based resources and homestead cultivation. An enhancement in the quality and assured supply of bamboo of commercially significant species, in turn, is expected to encourage entrepreneurial activity in the manufacture of value-added products.

There is an increasing interest in bamboo – in its cultivation, and in utilizing it for newer products and applications. As a corollary, research efforts have intensified, including in the area of bamboo cultivation. Many institutions, some with support from the NMBA, have embarked upon exploratory projects, to determine more efficient and rewarding methodologies of cultivation. The impact of this will be left in the coming years, as the outcome of the research enters the public domain.

At the same time, markets are becoming more demanding. Many users are indicating their preferences – for particular species, quality and maturigy, and are willing to pay a premium if their requirements are met.

These are encouraging signs, lending credence to the belief that bamboo is indeed the material of the future. This manual is a step forward in establishing a corpus of goods management practices for bamboo cultivation.

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Introduction

INDIA'S BAMBOO RESOURCES are reportedly the second largest in the world. They cover around 10 million hectares of forestland alone. In addition to this, bamboo is grown in private plantations, homesteads and on community land. Indian bamboos grow in a wide range of habitats, and at altitudes ranging from sea level to over 3,000 metres. With 1,500 documented uses for it in the country, it may be said that there is a bamboo for every reason and region.

In recent years there has a growing interest in the cultivation of bamboo, due to several factors. There is an increasing demand for good-quality bamboo culms for industrial and commercial applications, alongside the continuing demand for traditional uses and crafts. Organised cultivation of bamboo shoot has found new markets from processors. Private plantations have demonstrated the viability of growing bamboo for profit, bringing to the sector principles of scientific management and economies of scale. Ecological awareness too has contributed to the recognition of bamboo as an environment-friendly resource and material. Bamboo's easy renewability, versatility of applications and inherent qualities of strength, and the growing scarcity and cost of conventional timber, have spurred commercial interest in the development and manufacture of bamboo-based composite material. Bamboo has vast, and as yet substantially untapped, potential. It is a resource that can generate income and employment, especially in backward areas and amongst disadvantaged communities.

This training manual is a layperson's guide to the cultivation and management of commercially useful species of Indian bamboo. It highlights the economic viability of raising bamboo as an intensively managed plantation crop. It is hoped that the manual will encourage the setting up of commercial bamboo plantations, especially on marginal agricultural land and degraded community land.

Commercially Useful Bamboos in India

Bambusa balcooa

Habitat and distribution: Bihar, Jharkhand, the Northeast, Uttaranchal, West Bengal
Local *names*: *Bhaluka* (Assam); *Balku bans, Boro bans* (West Bengal); *Wamhah, Beru* (Meghalaya: Garo Hills); *Barak* (Tripura); *Leewa* (Manipur)
Flowering behaviour: Gregarious but isolated and rare, dose not set seed
Flowering cycle: 35-45 years

Bambusa bambos
Habitat and distribution: Throughtout the country
Local names: *Kotoh*a (Assam): *Beharbans* (West Bengal); *Illi,Mula, Pattill*(Kerala)*Kanta bans*(Orissa): *Nai bans* (Punjab): *Sancibo*(Manipur): *Mungil*(Tamilnadu): *Bongu Veduru*(Andhrapradesh)
Flowering behaviour: Gregarious, occasionally sporadic
Flowering cycle: 40-60 years

Bambusa nutans
Habitat and distribution; Himachal Pradesh, the Northeast, Orissa, Sikkim, Uttar Pradesh, West Bengal
Local names: *Bidhuli, Mukia* (Assam); *Malla*(Uttar Pradesh): *Mallo, Mahi bans (*Sikkim:Lepcha*) Badiabans*(Orissa); *Kali, Beng, Makia*(Tripura): *Uttang* (Manipur): *Rungazum*i(Orissa):*Kali,Beng, Makia*(Tripura): Uttang(Manipur); Rungazumi(Nagaland)
Flowering behaviour:Sporadic, occasionally gregarious
Flowering cycle: 35 years

Bambusa pallida
Habitat and distribution: The Northeast; Sikkim, West Bengal
Local names; Bijuli(Assam; Karbi-Anglong)*Seskien ,Skhen, Tneng ,Usken* (Meghalaya:Khasi Hills*); Tesero,Watoi*(Nagaland); *Pashipo,Pushee* (Sikkim;Lepcha);Makaal(Tripura)
Flowering behaviour: Sporadic
Flowering cycle: 40 years

Bambusa polymorpha
Habitat and distribution: Assam, Arunachal Pradesh, Madhya Pradesh, Meghalaya, Tripura, West Bengal
Local names: *Jama betwa*, *Betwa* (Assam, West Bengal); *Narangi bans* (Madhya Pradesh); *Bari* (Tripura)
Flowering behaviour: Gregarious/sporadic
Flowering cycle: 55–60 years

Bambusa tulda
Habitat and distribution: Bihar, Jharkhand, Kerala, the Northeast, Orissa, Sikkim, West Bengal
Kiranti (Bengal: Dooars); *Wati* (Meghalaya: Garo Hills); *Makar* (Kerala); *Miritinga* (Tripura); *Rawthing* (Mizoram); *Paoshiding*, *Ying* (Sikkim); *Deobans* (Bihar)
Flowering behaviour: Gregarious, occasionally sporadic
Flowering cycle: 30–60 years

Bambusa vulgaris
Habitat and distribution: Arunchal Pradesh, Assam, Bihar, Madhya Pradesh, Manipur, Mizoram, Orissa, Tripura, West Bengal
Local names: *Baisni bans*, *Bakal* (Bengal); *Lam Sameibi* (Manipur); *Vairua* (Mizoram); *Sundrogai*, *Sunderkania bansa* (Orissa); *Ketuna* (Assam: Barak Valley)
Flowering behaviour: Sporadic and rare, does not set seed
Flowering cycle: more than 80 years

Dendrocalamus brandisii
Habitat and distribution: Karnataka, the Northeast, Sikkim, Uttaranchal, West Bengal
Local names: Maipo (Arunchal Pradesh: Khamti); *Worra* (Assam); *Ketuna* (Assam: Barak Valley); *Bhalo bans* (Sikkim); *Maribol* (Manipur)
Flowering behavior: Sporadic
Flowering cycle: 40, 80 years

Dendrocalamus giganteus
Habitat and Distribution: Karnataka, the Northeast, Sikkim, Uttranchal, West Bengal
Local names: *Maipo* (Arunachal Pradesh: Khamti); *Worra* (Assam); *Ketuna* (Assam: Barak Valley); *Bhalo bans* (Sikkim); *Maribol* (Manipur)
Flowering behaviour: Sporadic
Flowering cycle: 40, 80 years

Dendrocalamus hamiltonii
Distribution: Bihar, Himachal Pradesh, the Northeast, Orissa, Sikkim, Uttranchal, West Bengal
Local names: *Kako* (Assam); *Fonay* (Assam: Karbi-Anglong); *Pecha* (Tripura, West Bengal); *Tama* (West Bengal: Darjeeling); *Unep* (Manipur); *Wanoke* (Meghalaya: Garo Hills); *Pao* (Sikkim: Lepcha); *Phulrua* (Mizoram); *Maggar* (Himachal Pradesh)
Flowering behaviour: Gregarious/sporadic
Flowering cycle: 30–40 years

Dendrocalamus strictus
Habitat and distribution: Commonly found throughout the country; newly introduced in the Northeast
Local news: *Lathi bans* (north and central India); *Kanka kara*, *sandapa veduru* (Andhra Pradesh); *Karal* (Bengal); *Nakur bans*, *Kiri bidiru* (Gujarat); *Kallanmula*, *Kurathimula*, *Korna* (Kerala); *Narvel* (Maharashtra); *Salia* (Orissa); *Kalmungil* (Tamil Nadu)
Flowering behaviour; Gregarious/sporadic
Flowering cycle: 25–45 years

Melocanna baccifera
Habitat and distribution: Assam, Manipur, Mizoram, Meghalaya, Nagaland, Tripura, West Bengal
Local names: *Mautak* (Mizoram); *Tarai* (Assam: Brahmaputra Valley); *Arten* (Assam: Karbi-Anglong); *Muli* (Bengal, Tripura, Assam: Barak Valley); *Watari* (Meghalaya: Garo Hills); *Moubi* (Manipur); *Turiah* (Nagaland)
Flowering behaviour: Overwhelmingly gregarious, rarely sporadic
Flowering cycle: 30–35, 45, 60 years

Ochlandra travancorica
Habitat and distribution: Karnataka (north), Kerala, Tamil Nadu
Local names: *Eera*, *Eatta*, *Earakalli*, *Kreetta*, *Oda* (Kerala); *Odai* (Tamil Nadu)
Flowering behaviour: Gregarious
Flowering cycle: 7–15 years

Oxytenanthera stocksii
Habitat and distribution: Goa, Karnataka (along the Konkan Coast), Kerala (north), Maharashtra
Local Names: *Konda*, *Oor-shema* (Karnataka); *Uyi*, *Mula* (Kerala); *Chivari*, *Mes* (Maharashtra)
Flowering behaviour: Sporadic, does not set seed
Flowering cycle: 40–45 years

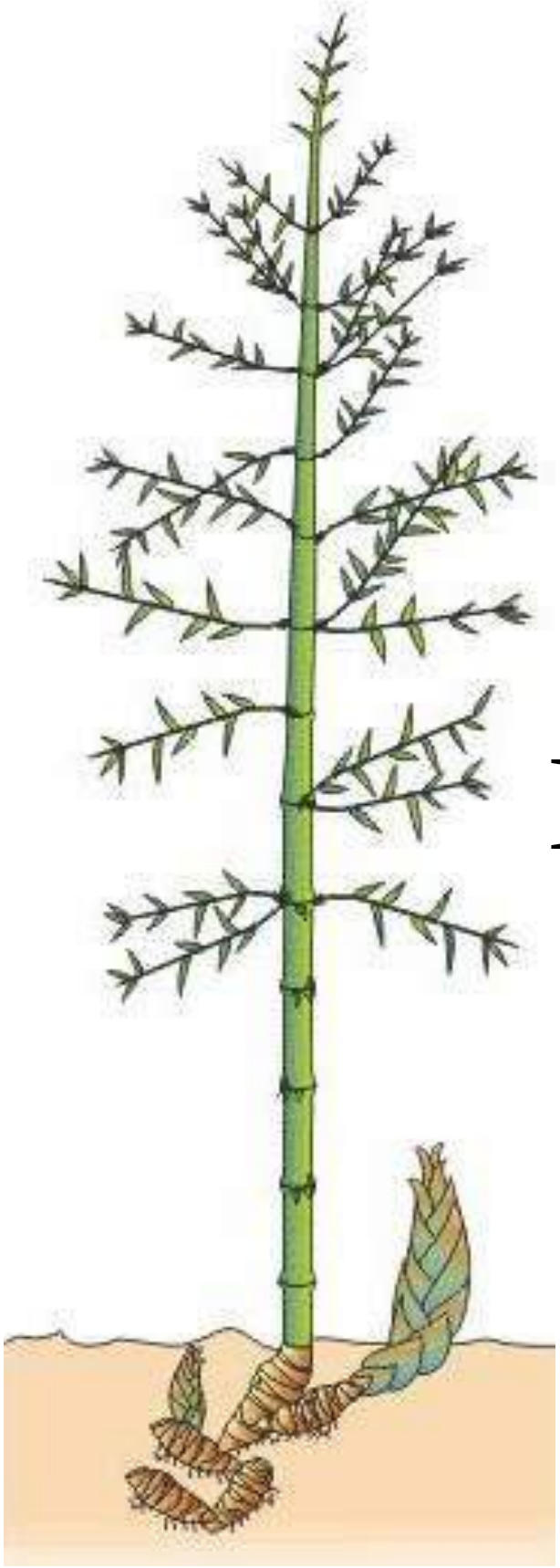
Schizostachyum dullooa
Habitat and distribution: The Northeast
Local names: *Dolo* (Assam, Nagaland, Tripura); *Tolluwa* (Manipur); *Rawthla* (Mizoram)
Flowering behaviour: Sporadic/gregarious
Flowering cycle: 30–35 years

Thyrsostachys oliveri
Habitat and distribution: Manipur, Tripura
Local names: *Kanak kai* (Tripura); *Keirakwa* (Manipur)
Flowering behaviour: Gregarious
Flowering cycle: 48–50 years

Dendrocalamus asper
This bamboo, brought from Thailand in the early 1990s, has been introduced at several locations in Indian as a plantation crop.
It flowers gregariously with a cycle of more that 100 years.

Its shoots are prized and have a ready market in processed form.
Its culm timber is strong and has many uses.

The Bamboo Plant



BAMBOO IS A TALL grass, fast-growing and typically woody. The bamboo plant is a complex system, consisting of two sets of similarly structured vegetative axes: one above the ground and the other below the ground.

- The primary overground axis consists of jointed, tall, cylindrical stems, called culms. Branches, which extend outward from the culms and develop laterally, form secondary overground axes.

- The underground axis is a solid rhizome system with roots and buds.

CLUMP

Bamboos are of two types: clump-forming and non-clump-forming. A ‘clump’ is a cluster or group of bamboo culms. Clump-forming bamboos, or sympodial bamboos, are commonly found in tropical countries like India. Non-clump-forming bamboos, or bamboos that grow at a distance from each other, predominate in temperate regions.

Some bamboos, like Dendrocalamus strictus and Oxytenanthera stocksii, though generally hollow, tend to produce solid culms in dry conditions.

A bamboo clump originates from a seed or plantlet, or as a part of another clump that has been cut away or divided to provide the base material form propagation.

A bamboo clums matures over 4–6 years. Each year it throws up culms of successively larger physical dimensions, i.e. height and girth. Clumps may be tightly packed (as in *Dendrocalamus hamiltonii, Bambusa tulda, Bambusa bambos*) with a large number of closely spaced culms, or they may be loosely spaced (as in *Bambusa vulgaris, Oxytenanthera stoksii*) and yet identifiable as clusters.

CULM

The bamboo culm typically like a hollow cylinder that tapers and narrows towards the top, is the most visible and easily recognizable part of the plant. It is also the most widely used part. It has a wide range of uses that find ready markets.

The culm emerges from the ground as a shoot. It then grows fast and turns woody, reaching its full height and girth within 80–110 days. The culm matures in its forth year, by which time it also reaches its peak strength. After the fifth year it becomes increasingly brittle and weak.
Most bamboo culms are green in colour, although there are bamboos that are yellow, black, rust or even purple-black. Some bamboos are striped, in yellow or green. In many species, variations in shade take place as the culm matures.

The tallest India bamboo, in fact the tallest bamboo in the world, is Dendrocalamus giganteus, with culm heights ranging between 25–30 metres. In Aruncachal Pradesh, one culm was measured at a little over 46 metres!

SHOOT

The bamboo shoot is an emerging stem or culm. It originates from buds on the underground rhizome. When the shoot pierces the ground it is fully formed, with nodes and internodes, and tightly encased in a protective sheath. Once it has emerged over the ground, biochemical processes cause it to grow rapidly and harden into a culm.

Sympodial bamboo culms reach their full height in 80-105 days. Atypical culm of Dendrocalamus giganteus attains a height of 30 meters in about 90 days, its growth averaging 30-35 centimeters a day. The growth is not evenly spaced, however: there are phases of rapid growth and of relative inactivity. During the growth phases, there is more activity at night, when the culm can grow at rates of 5-7 centimeters an hour.

NODES AND INTERNODES

The rhizome, culm and branches of the bamboo plant are segmented by solid nodes. These are key growth points, from where new vegetative axes develop and grow.

The portion between two successive nodes is called an internode. Internodes are invariable, but not always, hollow. They are covered by sheaths at the initial stages of growth, which fall off as the plant matures. Internodal lengths vary considerably across bamboo species, ranging from 5 to over 60 centimetres. In general, the internodal length increases upwards along the culm from the lower portion to the

middle, and then decreases.

BUDS AND BRANCESH

The internodes of the culm bear branch buds, arranged on alternate sides of the culm. The number of buds at a node is directly related to the number of potential branches. There are buds also at the nodes of the rhizome, which develop over the ground into culms.

RHIZOME

There is as much of the bamboo plant below the ground as there is above the ground. Over a period of time, the rhizomes and roots of the plant form a stubborn and extensive network below the ground. In a mature plantation, the weight of the rhizomes can be as much as 100 tonnes per hectare.

The rhizome is the underground portion of the bamboo plant. It is the plants' structural foundation. It grows laterally under the soil surface, extending the domain of the plant, and enlarging and consolidating its area. It is a food reserve, and contributes to growth and vegetative reproduction.

The rhizome consists of nodes from which roots emerge to forage for nutrition, and of buds that develop into other rhizomes under the ground, which in turn develop into culms over the ground. In comparison to culm nodes, rhizome nodes are compressed. As with culms and branches, rhizome

nodes too are protected by sheaths.

There are two broad types of rhizomes:

- Pachymorph (sympodial): typically clump-forming
- Leptomorph (monopidial): non-clump-forming, horizontally growing

Most Indian bamboos have sympodial rhizomes, and are therefore clump-forming.

Some bamboos have rhizomes with traits common to both these types (sympodial and monopodial). These are called amphipodial rhizomes.

ROOTS

Roots provide anchorage in the soil, and make possible the uptake and distribution of water and nutrients to other parts of the plant. They emerge from rhizome nodes and culm nodes that are below the soil surface. In some species, roots may alos appear on the overground portions of culms and branches.

Most of the underground roots of the bamboo plant (75–85 per cent) are concentrated in the upper layers of the soil, close to its surface and at depths of up to 35 centimeters. Rarely do roots penetrate more than a metre below the surface of the soil.

LEAVES

The branches of the bamboo plant bear leaves, which are important for photosynthesis. Leaves protect the plant from rain and frost.

Most bamboos produce a profusion of leaves that annually fall to the ground, forming deep carpets of nutritious organic matter. They are also a good source of fodder.

FLOWERS AND FLOWERING

Bamboo flowers are varied in colour, size and other characteristics. Flowering takes place with the growth of clusters of specialised leaves, with the specific aim of participating in reproduction.

The flowering behaviour of the bamboo plant is one of its least understood aspects; its study is hampered by the fact that flowering occurs infrequently and at along intervals. Flowering cycles may vary from one year to over a hundred years. They are of two types:

- Gregarious: All the culms in a bamboo clump flower together over a period of time, and then die.

- Sporadic: Some culms in a bamboo clump flower, and die thereafter. Sporadic flowering can occur either across a larger population of clumps or in a small population. Some bamboos are known to flower sporadically every year.

There are bamboo species that exhibit both kinds of flowering behaviour. A small number of clumps of *Dendrocalamus hamiltonii*, for example, flower sporadically across scattered locations. This species also flowers gregariously over large tracts at long intervals of 30–40 years.

Growing Bamboo

BAMBOO IS NOT a tree, but a grass. Culms from a mature bamboo clump can be harvested after 4 years, and thereafter every year, whereas production cycles from fast-growing commercial timber species, like eucalyptus and poplar, are typically 7–8 years. This is what makes bamboo a truly renewable resource.

Bamboo cultivation can be undertaken at different scales and for a variety of reasons.

Bamboo can be raised as plantations for commercial profit, on land ranging in area from an acre or less, to a few hundred hectares. Bamboo plantations assist in soil conservation and reclamation of wasteland.

Bamboo clumps in a plantation

They stabilise and rejuvenate the soil, and provide protection against erosion: a single bamboo clump can bind up to 6–7 cubic metres of soil.

At the homestead level, bamboo can be grown to provide culms or shoots for household needs, and to generate additional income by selling surplus quantities of these.

In home gardens and in public spaces, bamboo can be grown as ornamentals and for landscaping. Bamboo can also be used to screen a house and provide privacy.

Bamboo grown in avenue plantations or on the periphery of farmland acts as an effective windbreak, and a noise and climate buffer.

BAMBOO IN HOMESTEADS

For most homestead growers, bamboo clumps are both their ensure that their bamboo clumps stay healthy by periodically harvesting culms, even if not at regular or prescribed intervals. They normally extract culms from the clumps to meet household needs such as house-building or fencing, or when they require cash to discharge a debt or fulfil a familial obligation such as marriage.

Throughout the country, people cultivate bamboo in homesteads, on community land or on small plots or private land. The pattern of cultivation varies, from a couple of clumps adjacent to the home to groves with 40–50 clumps.

The selection of bamboo species for homestead cultivation is done carefully, and generally conforms to established patterns of local usage.

The productivity of homestead cultivation is high, for the growers look after their clumps. They use the experience and techniques handed down over generations to ensure that their clumps are healthy and productive. It is rate to see congested and unworked clumps in homestead cultivation. The growers are carefully not to let the culms become old, weak and brittle.

Bamboo clump in a homestead

Bamboo Hedge

Landscaping with bamboo

Bamboo plant in a pot

BAMBOO HEDGES

Ornamental bamboo hedges are common in upper Assam. They are nurtured on tea estates to function as borders of well-manicured lawns in the bungalows of garden managers. *Bamboo multiplex* I invariably used for this purpose. Its culms, which are slender and thin-walled, grow in a tight clump, with profuse branching from the lower nodes. It is amenable to pruning, and is a good bamboo for ornamental hedges.

BAMBOO WINDREAKS

Bamboo windbreaks or shelter belts protect cropland from wind and dust, and improve crop quality and yield. Bamboo that is planted closely and linearly, preferably in at least two rows and in triangulated formation, helps conserve moisture by reducing evaporation, and creates an appropriate microclimate in the leeward area. Over time, bamboo windbreaks also provide a supply of culms for use by the farmer.

Bamboo Plantations

THE FOUCS OF this manual is on intensive cultivation and management of sympodial bamboo as a plantation crop. Although bamboo has been cultivated in India for thousands of years, plantations raised for commercial reasons are of relatively recent origin.

PLANTATIONS

A plantation is a plot of land on which intensive cultivation of any preferred species is regularly over a period of time, using high-quality inputs and scientific methods of cultivation and management.

Traditional Plantations

The Apa Tani tribe in the Subansiri area of Arunachal Pradesh cultivate bamboo intensively on family-owned and managed plantations varying in size from 1 acre to 3–4 hectares. The species grown is a monopodial bamboo, Phyllostachys bambusoides (local name: Bije). The culms are used by the Apa Tanis for house construction (roofing, walls), for fencing and to make mats. The shoots are eaten.

Phyllostachys bambusoides plantation

Plantations provide opportunities, efficiencies and economies of scale.

- They ensure optimal use of land.
- They effect economies in the purchase of planting material and inputs such as fertiliser.
- They enable planned irrigation systems.
- They ensure optimal utilisation of labour for planting, maintenance and harvesting operations.

The objective of a plantation is generally to maximise yield, production and profit. There is thus a strong commercial orientation to plantations.

In some cases, however, plantations may be established without a primary commercial motive: for soil stabilization and rejuvenation, and reclamation of wasteland.

BAMBOO PLANTATIONS

Bamboo is a good crop for commercial plantations, for many reasons.

- Bamboo can be grown in a wide variety of soil and climatic conditions.
- Once clump maturity has been attained, bamboo can be harvested every year and can provide regular returns.
- Harvesting of bamboo can be staggered – either brought forward or delayed - to cater to market demands.

***Dendrocalamus asper* plantation**

The primary products of a bamboo plantation are culm (timber) and shoot. There are also secondary products – branches, which add to the woody biomass generated by the plantation; and leaves which are a good source of nutrients and organic matter, and a fodder supplement.

- Bamboo plantations have relatively few requirements of labour and maintenance.
- The demand for bamboo is increasing.

Commercial bamboo plantations may be established:

- to maximise the yield of bamboo culms
- to maximise the yield of bamboo shoots
- to produce a mix of bamboo culms and shoots
- to maximise biomass production

While the basic principles of establishing a plantation will remain the same in each case, there will be variations depending on its product focus. These variations include choice of species, spacing, input intensity and content, harvesting technique and, most importantly, clump management.

Raising bamboo plantations can be a profitable activity.

- A well-managed mature plantation can yield 23–30 tonnes of culms per hectare. From another perspective, 5–6 culms per clump of medium-diameter bamboo can be obtained, i.e. 2500–3000 culms per hectare.
- Bamboo can be sold in bulk to meet the needs of large users. Pulping units and paper mills buy bamboo (air-dry, i.e. moisture levels between 12–15 per cent) in large quantities at rates varying from Rs. 800–Rs. 1,300 per tonne.

Well-managed, intensively cultivated bamboo plantations in north India, an attaining maturity, have been realising net profits of Rs. 22–24,000 per acre per year. Some plantations have secured additional income through vermicomposting.

- Bamboo can also be sold by the piece (culm), and the price it fetches is generally higher than when sold by the tonne. Culms sold by the piece must be of good quality and mature to attract a higher price. The price per culm varies considerably across the country in retail markets, ranging from Rs. 25 to Rs. 80, it increases with distance from growing areas.

- There is a growing demand for high-quality and mature bamboo from architects and builders. For good-quality bamboo, such users are ready to pay between Rs. 40 to Rs. 80 per culm.

- Manufactures of bamboo boards and composite material also require large quantities of good-quality bamboo.

SIZE AND SCALE

A bamboo plantation can be established on land ranging in area from half an acre to a couple of hundred hectares. Most commercial plantations fall into one two size-categories: large (over 20 acres) and small (5 to 20 acres). These offer the best economies of scale and inputs, and of organizations and management.

The decision on the size of plantation will depend on the following factors:

- Availability of land

- Invisible capital

- Availability of labour and other inputs

Culm of Dendrocalamus giganteus (above) and Bambusa balcooa (below)

- Management capacity
- The market for bamboo culms or shoots.

SELECTING THE SITE

A bamboo plantation, once established, can be expected to last for many years, even decades. Bamboo should not therefore be raised at a site where an alternative crop is visualised.

Bamboo plantations in the form of compact blocks are easier to manage. Hence, as far as possible, a compact area of land should be selected as the plantation site. This will provide for economies of management and inputs.

A plantation scattered over several locations takes away some of the economies of scale. It also requires proportionately more inputs, like fencing, and stretches management capacities. Further, intensive cultivation in compact areas brings down the costs of harvesting and marketing.

Bamboo is a surface feeder with a shallow root system. Its rhizome network tends to spread and colonise the surrounding area. It can be invasive and compete with adjacent crops for nutrients and moisture. It is therefore advisable to choose the plantation site keeping in mind the active spreading habit of the plant.

If bamboo is planted in close proximity to intensively cropped land, measure should be taken to prevent its roots and rhizomes from spreading into the cropped area. This can be done by digging an open trench between the two areas, at least 3–4 feet deep and 2–3 feet wide. Trench inspection and maintenance should be done annually.

A good planting site

✘ **should not**	✓ **should**
be heavily sloped	be level or gently sloped
be exposed to gusty or very	be protected from strong winds
be waterlogged	have well-drained soil
be very dry	be moist

NURSERY AS PART OF A PLANTATION

It is useful to plan a nursery as an integral part of the process of establishing and maintaining a bamboo plantation.

A nursery can be:

- an important source of initial plant material
- a primary source of plant material to replace plants that have not survived.

A nursery is a useful training ground for the workers in a plantation. It enables them to be familiar with different parts of the bamboo plant, and with their roles and functions. It also instills knowledge of the processes of growth and maintenance of young and mature plants.

Nursery activates can be scheduled during relatively lean periods of activity, to optimize the deployment and time utilization of plantation workers.

A plantation is a good source of base material (rhizomes, culms and branch cuttings) for vegetative propagation. These can be used independently to sustain the nursery, and to provide incremental profits.

A nursery can be established at different scales of production and activity, depending on its objectives. It can be set up on a small scale initially and later developed to larger one, as and when the need arises, and once experience, skill and confidence have been gained in operating and managing it.

The essential requirements of a nursery are:

- A plot of land within the plantation area, with similar site and soil conditions.
- Propagation and nursery beds of equal parts of sand, soil and farm yard manure (FYM), raised and laid out in convenient strips.
- Provision of shade, either through simple structures of bamboo and thatch, or through more complex arrangements such as poly-houses and shade netting.

Choice of Species

AROUND 130 BAMBOO species are known to exist in India, which make up a wide range to choose from, in establishing a plantation. Some of these, however, are herbarium species, imported from outside the country, and only a few specimens of clumps may be available.

Of the bamboo that exist in India in significant concentrations, the following have been identified as good species for plantations: *Bambusa balcooa, Bambusa bambos, Bambusa nutans, Bambusa pallida, Bambusa polymorpha, Bambusa tulda, Bambusa vulgaris, Dendrocalamus brandisii, Dendocalamus giganteus,Dendrocalamus hamiltonii, Dendrocalamus strictus, Melocanna baccifera, Ochlandra travancorica, Oxtenanthera stocksii, Schizostachyum dullooa and Thyrsostachys oliveri*.

This identification is based on criteria such as established or common usage, ready markets or market preference (that is, properties that make the species especially suitable for particular uses), and widespread distribution or availability. The distribution and local names of these species are given in Chapter 2 of this manual. It is useful to bear in mind that they can also be grown at locations other than their natural habitat, under managed conditions.

In addition to these 16 species, there are some that have been brought into India over the last decade and are now being grown in plantations. An example is *Dendrocalamus asper*, which is extensively cultivated in Southeast Asia. This bamboo produces excellent edible shoots as well as valuable cum timber.

A bamboo plantation should ideally have a mix of species – at least two, preferably three. This will reduce the risk of the entire plantation being destroyed when simultaneous flowering takes place. Multi-species planting has other benefits as well. For example, the timing and availability of fresh

bamboo shoots can be staggered, resulting in availability over a longer period of time. A multi-species plantation, especially a large-sizes one, can cater to different markets and preferences, and thereby increase its options and viability.

The choice of species will depend on:

- the location, climatic and soil conditions
- the end-use to which the bamboo will be put
- the availability of planting material

It is a good idea to ascertain which species are naturally available or cultivated in the area in which the plantation is to be established. This will confirm the suitability of such species. Also, there will be a local tradition of usage, and therefore a market.

The choice of species, in turn, will determine the cultivation regime – the spacing between plants and clump management practices, for example.

USES OF DIFFERENT SPECIES

- Pulp and paper mills are at present the largest users of bamboo on an industrial scale. The criteria for this use are biomass, moisture content and price. Most bamboo species are suitable for pulping.
- Manufactures of wood substitutes and bamboo composites need bamboo that is mature (at least 4 years old) and of good quality. Thick-walled and

Bambusa tulda **(left) and** ***Bambusa nutans*** **(right): bamboos used as wood substitutes**

- strong bamboos like *Bambusa tulda*, *Bambusa nutans* and *Dendrocalamus hamiltonii* are preferred by such units.

- For construction and structural purposes and for scaffolding, sturdy bamboos, like *Bambusa balcooa* and *Oxytenanthera stocksii*, and species. *Dendrocalamus brandisii*, *Bambusa balcoaa* and *Dendrocalamus strictus* too can be used. Irrespective of the species, it is important to remember that only mature culms should be used for these purposes.

***Bambusa balcooa* (left) and *Oxytenanthera stocksii* (right): bamboos for structural uses**

***Shoots of Dendrocalamus asper* (left) and *Dendrocalamus hamiltonii* (right)**

- Most bamboo species can be used for making functional household can craft articles; but, traditionally, locally available species are used for this purpose. For example, baskets are made from *Dendrocalamus stratus* in central India, *Melocanna baccifera* in Tripura, *Dendrocalamus hamiltonii* in Himachal Prades, *Oxytenanthera stocksii* in Karnataka and *Ochlandra travancorica* in Kerala. For woven applications, bamboo culms of lesser strength are acceptable.

- While most bamboo species can be used for edible shoots, the following are preferred by processors for organised markets: *Dendrocalamus asper, Bambusa balcooa, Dendrocalamus hamiltonii, Schizostachyum dullooa.*

Traditionally, household and craft articles have been made from locally available bamboo. Bamboo availability in an area is itself the outcome of a process of selection and care over hundred of years. Although the ability of craftsperson to create is not limited by the availability of species, they prefer working with familiar bamboos. Artisans also prefer freshly cut or green bamboo. which is eaiser to work with.

Traditional uses: bamboo basket as plant protector (above left), bamboo shoots (above right), bamboo structure for selling vegetables (below).

Agroclimatic Requirements

SEVERAL FACTORS HAVE an impact on the health and vitality of bamboo clumps, and on the growth of culms. These include soil conditions, temperature, light, altitude, slope of the land, wind conditions, rainfall and moisture regimes.

Bamboo flourishes on level or gently sloping land, in soil that is fertile, organically rich, moist, porous, well-drained and pH-neutral or marginally acidic. The moisture regime, on average, should conform to well-distributed rainfall, with shortfalls being made up through irrigation. Under unmanaged

Bamboo achieves its full growth potential, in terms of quantity and physical dimensions, in ideal agro climatic conditions. However, even in less-than-ideal conditions, bamboo is capable of adapting remarkably well. Thus bamboo can be grown in a wide range of environments, under varying input and management intensities.

conditions, in forests and natural environments, bamboo flourishes in valley, on the lower slopes of hills, and in the vicinity of streams, rivers, ponds and other water bodies.

It is not that bamboo will not grow elsewhere, but plantations on dry and infertile land will throw up smaller and fewer culms, and therefore provide lesser profits.

Most Indian bamboos are susceptible to damage through prolonged exposure to the cold and frost. They do not grow well in arid conditions – like in the cold deserts of Ladakh and the hot deserts of western Rajasthan. Most sympodial bamboos tend not to do well on steep slopes.

Although bamboos are hardy, adaptable and forgiving plants, they are intolerant of waterlogging, salinity and rocky environments. In waterlogged conditions and in swamps, the roots and rhizome of the bamboo tend to rot, and the plant dies. Rotting can also take place in cultivated conditions as a result of over-watering or poorly drained soil. The groundwater level at any time of the year should not be higher than 1 metre, from bamboo to grow well.

ALTITUDE

Most bamboos of the listed commercially significant species (see Chapter 2) grow well in the plains and at altitudes of 400–500 metres. Some of these species also thrive at higher altitudes – from 500 to 1500 metres, while others do not do well in the plains but flourish at altitudes above 500 metres. The table on the next page is an indicative species guide to commercially-oriented planting at different altitudes.

A Bamboo in the high hills

High in the Himalayas, growing at altitudes from 1220 to 2500 metres, is a shrubby bamboo, Sinarundinaria falcata (Ringal). It is commonly found at these heights in the Kumaon and Garhwal hills of Uttaranchal and in Himachal Pradesh. Ringal bamboo plays an important role in the economy of these hilly regions. It is used to make baskets, mats, fishing rods, hookahs and household articles. Its leaves are used for thatching.

	Up to
Bambusa balcooa	*300 metres*
Bambusa bambos	*800 metres*
Bambusa nutans	*1200 metres*
Bambusa pallida	*1800 metres*
Bambusa polymorpha	*800 metres*
Bambusa tulda	*1200 metres*
Bambusa Vulgaris	*1000 metres*
Dendrocalamus Brandisii	*1200 metres*
Dendrocalamus giganteus	*900 metres*
Dendrocalamus hamiltonii	*1200 metres*
Dendrocalamus strictus	*800 metres*
Melocanna baccifera	*800 metres*
Ochlandra travancorica	*1500 metres*
Oxytenanthera stocksii	*700 metres*
Schizostachyum dullooa	*1500 metres*
Thyrsostachys oliveri	*1200 metres*

Site Preparation

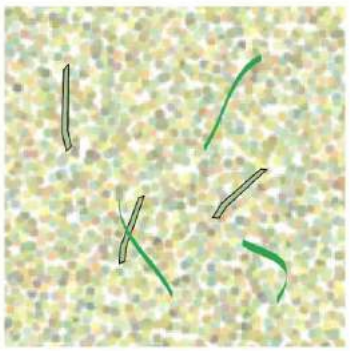
BEFORE TAKING UP planting, the land at the site should be prepared, to make it fit for cultivation. A prior survey is essential, and a rough site plan will make eaiser the task of estimating the labour and other resources needed.

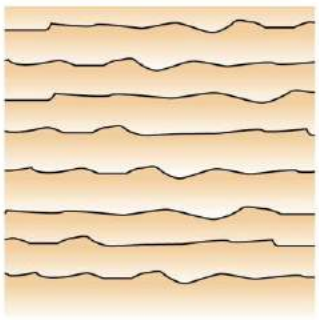
CLEARING AND PLOUGHING

The site should be cleared of shrubs, bushes, weeds and other grasses, which could compete with bamboo for nutrients and moisture. Removal of such vegetation facilitates the planting of bamboo with appropriate spacing. Sparsely distributed trees may be retained to provide protection and shade.

- The land should be ploughed as thoroughly and deeply as possible. Churning rearranges the layers of the soil, and improves its quality.

- Clearing and ploughing should be done at least three weeks ahead of the planting. This will provide sufficient time for weathering of the churned soil.





Fly-ash –amended soil in a bamboo plantation

Soil Amendment

Soil amendments like fly-ash have been tested to be beneficial. Fly-ash can be used a soil enricher and conditioner in bamboo plantations, especially where the soil is nutritionally and physically inadequate.

FENCING AND PROTECTION

A fenced and protected plantation makes its management easier. Although fencing involves costs, there is saving over a period of time, through better culm yield. A plantation needs to be fenced to protect it from:

- Grazing by domesticated animals and trampling by humans and animals, especially when the plants are young and the culms immature.
- Foraging for bamboo shoots which are relished by both animals and humans.
- Culm theft.

Fencing also serves to demarcate the plantation area. The type of fencing could be one of the following.

- Fencing with GI barbed wire. This is a relatively expensive option, but it is neat, easily arranged and durable.

- Innovative fencing through use of local material, like stones, thorny bushes and bamboo.

- Cattle-proof trenches. This is a partial but cost-effective option.

Irrespective of the type of fencing, breaches and openings should be avoided, supplementation with watch and ward ensured, and regular maintenance carried out to increase effectiveness.

It is preferable for the fencing to be in place before the initial establishment activities, such as land preparation, pit digging and planting, are taken up.

Planting Material

SOURCING

Large-scale planting of bamboo requires nursery-raised planting material. While the cost of the plant is a major consideration, the reputation of the nursery from where it comes is very important. Planting material can also be sourced from forest departments and government nurseries.

Planting material of vegetative origin is a replica of the parental stock. This can be a major advantage, provided information about its origin (including year of flowering) is revealed/certified by the nursery.

Young plants in nursery bed

Planting material in polybags

Planting material from seeds has the advantage of 'known physiological age', allaying the uncertainties of gregarious flowering. However, seedlings take longer to produce full-sized, mature culms than rhizome offsets and culm cuttings.

Tissue-cultured planting material based on superior genotypes and hardened to plantable condition is now available for some species, and at cost that can reasonably be borne by a commercial plantation. Such material normally carries lower mortality risks and will produce good-quality culms of uniform size and characteristics.

STORING

Planting material should be placed in pits at the plantation site as soon as possible. It may be necessary sometimes to store the planting material for some time, for logistical reasons, or because the site is not ready, or because of adverse climatic conditions. In such cases the material should be stored in a shady, moist and cool location. It may require regular watering, depending on the local conditions and the period of storage. Watering also help recovery of its root system.

TRANSPORTING

Transportation should preferably be done in the early hours of the morning or in the evening, when temperatures are lower. As far as possible, the hot mid-day sun should be avoided.

Planting material will generally need to be transported from the nursery or holding area, to the plantation site. This is especially true for larger plantations, since direct planting is neither practical nor likely to be successful on this scale. Other than rhizome offsets (of which a limited number can, and should, be planted directly), all other planting material, irrespective of the propagation method, should have been cared for under nursery or managed conditions some months before planting in the field.

Most nurseries provide planting material in polybags. As a general rule, these polybags should not be watered 1–2 days before transportation, to prevent loosening and cracking of the earth surrounding the young roots and rhizome. This norm need not apply, however, in hot weather, or if the planning material is to be transported over a long distance.

When transporting rhizome offsets, it should be ensured that they are partly encased in soil, placed in gunny bags and stacked vertically, to avoid damage to the buds.

Planting

PLACING THE PLANTING material in previously prepared pits is an important activity, signifying the initiation of a bamboo plantation.

Planting should be done in the early hours of the morning, with the planting material being stored in a convenient and shaded part of the plantation site. It natural shade is not available, arrangements should be made for temporary cover.

Planting should be completed in a short period of time and, as far as possible, should be undertaken simultaneously. After the first year, further planting may be needed to cover gaps due to mortality of plants.

SPACING

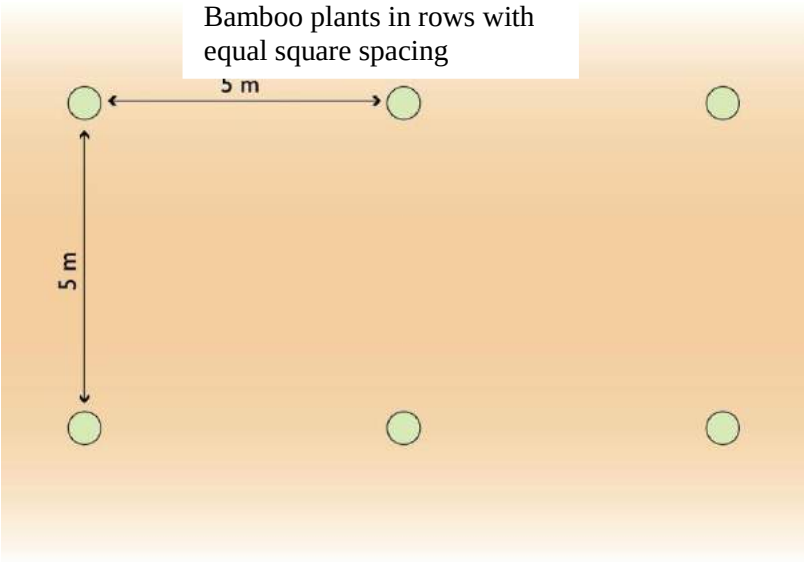
The spacing to be followed while planting bamboo will depend on the species to be planted, the primary objective of the plantation, and local climatic and soil conditions.

The size and physical dimensions of the species to be planted is an important determinant of planting density. Higher densities (i.e. closer spacing) are appropriate for small-sized bamboos, and lower densities (i.e. more spaced out) are appropriate for larger-sized bamboos.

If the plants are spaced too far apart, the plantation will suffer from canopy exposure, loss of soil moisture through evaporation, and competition from weeds and other vegetation. An unduly dense plantation will lead to bamboo plants competing amongst themselves for light, space, soil moisture and nutrients.

If the main objective of the plantation is to have steady stream of culm output, the following guides to spacing may be followed.

- For medium-diameter, thick-walled species, 5 x 5 metres. This requires 400 clumps per hectare, or 160 clumps per acre. This spacing is good for *Bambusa tulda, Bambusa nutans, Dendrocalamus asper* and *Dendrocalamus brandisii*. Under well-managed conditions it can go up 6 x 6 or 7 x 7 metres.



Bamboo plants in rows with equal square spacing

- For smaller species, like *Ochlandra travancorica*, 4 x 4 metres spacing will suffice. This requires 625 plants per hectare.

- For larger species, like *Dendrocalamus hamiltonii,* the spacing can be 7 x 7 metres, or 205 plants per hectare. For *Dendrocalamus giganteus* this can go up to even 10 x 10 metres, or 100 plants per hectare.

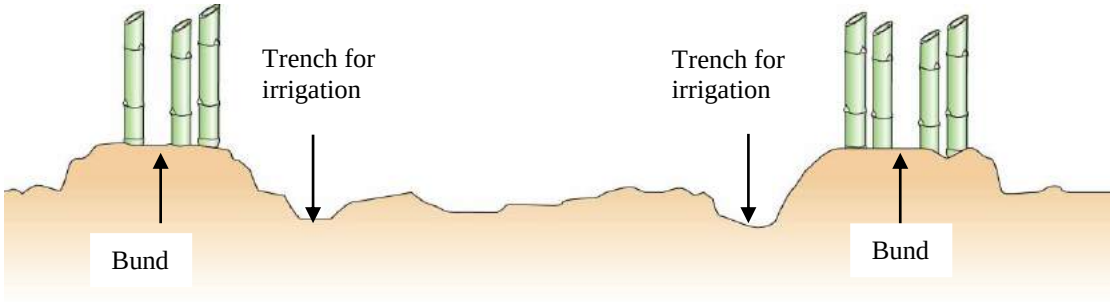
If the primary objective is soil stabilization, smaller spacing may be followed: even 3 x 3 metres (1,100 plants per hectare) will suffice.

If the objective is erosion control along river banks or landslide/avalanche protection, the spacing can be 3 x 3 metres or even 2.5 x 2.5 metres. In such cases, bamboo can be interspersed with appropriate, fast-growing timber species.

Bund and Trench Method

The bund and trench method of spacing involves planting bamboo on 1-metre-wide and 50-centimetre-high bunds. The bunds are prepared by digging trenches and heaping the dug-out soil. The distance from the centre of one bund to that of the next on a 5 x 5-metre plantation should be 5 metres. Bunds and trenches should be prepared sufficiently in advance so as to stabilise them before planting is taken up.

The bund and trench method has several advantages. Bamboo planted on bunds with a base of well-worked soil, turned over from the trenches, will



grow well. In subsequent years, more soil can be dug out of the trenches and heaped or mounded around the bamboo clumps.

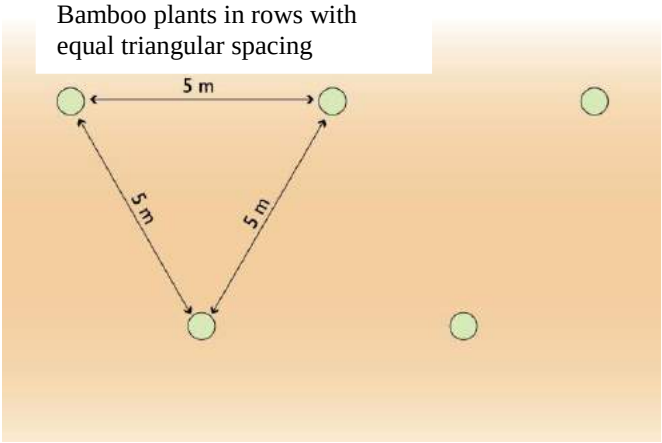
The method facilitates mounding as the plants grow. The trenches can be used for irrigation, or for preparing vermicompost.

The initial cost of establishing a plantation using this method may be slightly high compared to conventional planting. This cost is however likely to be more than recovered in subsequent mounding and management operations, and through improved productivity.

Triangular Spacing

For commercial plantations raised for culm timber or for shoot, staggered planting in a triangular grid is recommended. This involves digging pits in alternating rows in the same line, with the row in the middle consisting of pits placed at the centre point of the preceding row.

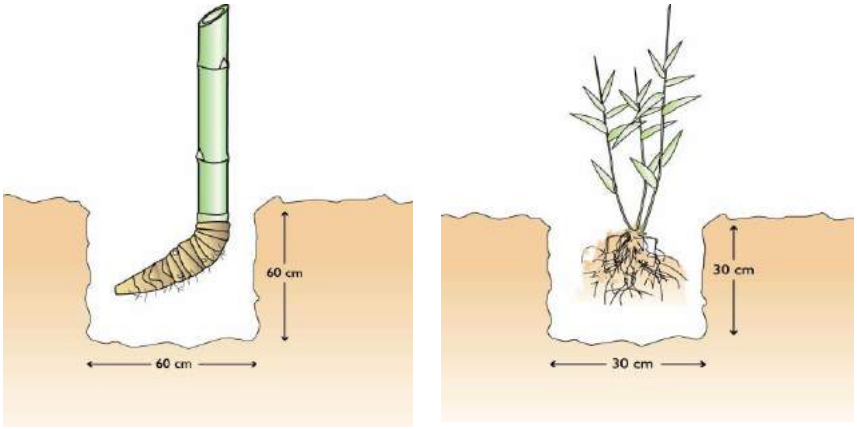
Bamboo plants in rows with equal triangular spacing



This allows for optimum utilisation of land area, and maximizes the spreading space available to each clump. At the same time, it ensures a uniform distance between rows of plants, which can be used for intercropping and vermicomposting, and allows for easy passage.

PITS

After clearing the land and before digging the pits, pit sites should be identified by using a measuring tape to ensure the desired spacing, and then



market with wooden or bamboo sticks at the spot that will be the centre of the pit. The pit should be deep enough to ensure that the roots of the plants do not curl up once the planting material is placed in it, and are not cramped in their search for moisture and nutrients.

A thumb rule is, 'the larger the pit, the better the growth of rhizomes', but this rule has a trade-off in terms of cost-effectiveness. Offsets and rhizomes should be planted in pits measuring 60 x 60 x 60 to 100 x 100 x 100 centimeters.

Pits should be dug much before the rainy season and the dug-out soil exposed to weathering.

Pits should be spaced according to the requirement of the bamboo species or the management objective of the plantation.

Careful planting minimizes the risks of failure.

- A few days before planting, thoroughly turn the soil in the pit.
- Remove weeds and competing vegetation within a radius of 3–4 feet from the pit.
- For a pit size of 60 x 60 x 60 centimeters, mix the soil with one basket (5 kilograms) of farm yard manure (FYM), 100 grams urea, 100 grams super phosphate, and 50 grams muriate of potash. Nitrogen in the ammonium form increases water uptake, resulting in faster growth.
- Place the plant vertically in the pit, ensuring that the roots do not curl.
- Level the pit with the mixed and enriched soil.
- After planting, irrigate with 12–20 liters of water, depending on the prevailing climatic conditions. This will provide the needed moisture to the rhizome and roots, and compact the loose soil around the plant.
- Repeat the watering the next day, moderating the quantity of water if warranted. For the next 10 weeks, provide water if there is no rain or little rain, at daily intervals initially, extending later to once in three days.

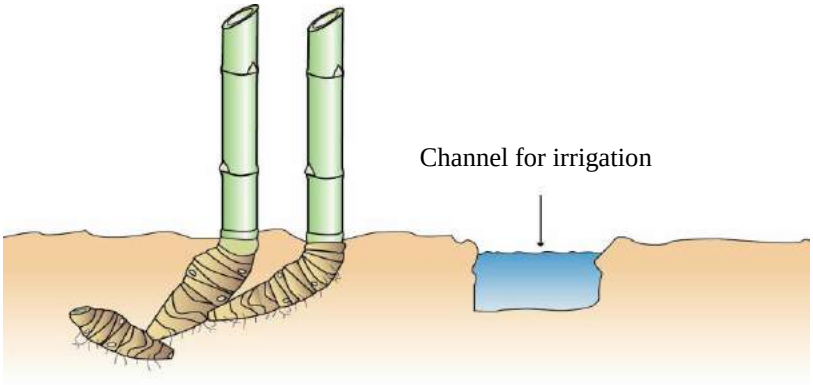
Irrigation

BAMBOOS THRIVE IN conditions of adequate moisture. In the initial years of a plantation, the young plants need extra nurturing and water. Scarcity of moisture in the soil adversely affects the growth of rhizomes and the emergence of culms. Irrigation reduces mortality in young plants, and increases the health and productivity of bamboo clumps.

The requirement of irrigation will vary with the local climatic conditions and the micro-environment. The irrigation method will be determined by the

actual (site-specific) moisture in the soil, especially in the growing season.

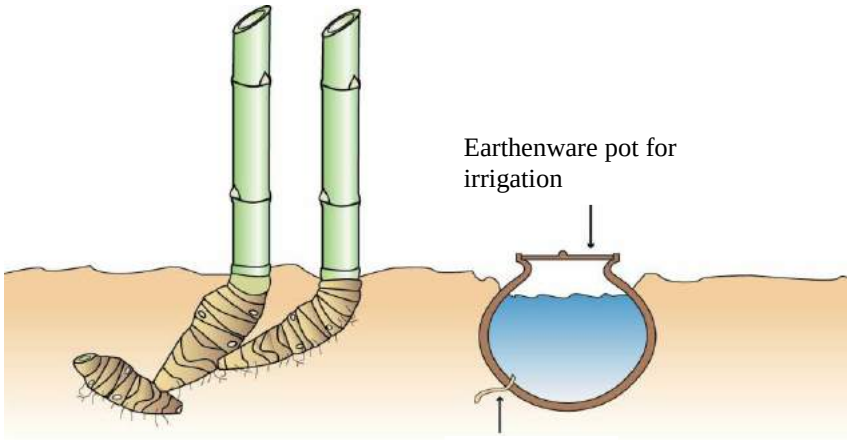
- Channel irrigation, at least once a week, is recommended in the dry season.



- In relatively water-scarce situations, drip irrigations has been found to be cost-effective, but this requires technology and investment during site preparation.

- The traditional earthen pitcher with a wick' method of irrigation is effective and uses water frugally. A 2-litre pitcher would require refilling thrice a week.

Traditionally practiced by farmers in central India, the 'pitcher with wick' irrigation method uses water from an earthen pot (of about 2-litre capacity) with a small hole at the bottom, through which a piece of cloth is pushed to function as a wick. The pot releases about half a litre of water every day. A lid on the pot helps reduce evaporation. A young bamboo clump will get adequate water by refilling the pot thrice a week.



Irrespective of the irrigation method and frequency, waterlogging should be avoided. Bamboos thrive in moist but not waterlogged conditions.

Compact plantations provide opportunities of scale for investment in irrigation that are more than compensated by the returns. In such plantations, especially in areas with annual rainfall less than 700 mm, irrigations channels and sources of water should be planned at the very outset.

Fertiliser Application

APPLICATION OF FERTILISER is an important part of the management practices associates with intensively managed plantations. Bamboo plants are heavy feeders and respond well to fertilisers, growing more vigorously with fertilizer application than without. Fertilisers are important to ensure high yield and overall profitability of plantations.

CHEMICAL FERTILISERS

In general, bamboo needs the complete range of fertilization, including phosphorous, potassium and nitrogen, and often a higher amount of nitrogen. For intensively managed plantations, chemical and commercially available fertilizers offer established and straightforward solutions. It is a good ides, however, to carry out soil analysis prior to establishment of the plantation, and at annual intervals thereafter, to fix and confirm the dosages. Specialist advice should also be south, it necessary. Over-fertilisation is a risk and a hazard. Under normal soil conditions, the composition of NPK should be 5:2:1 or 4:2:1; this should be finalized after soil testing and analysis.

As a norm, the fertiliser regime for shoot plantations will need to be more intensive than that for culm plantations. In the case of cultivation for culms, chemical fertiliser application may be to the extent of 1,500 kilograms per hectare per year. Cultivation for shoot will require additional nutrients, and the fertiliser application required may go up to 4,000 kilorgams per hectare per year.

Fertiliser application is required to be done first during planting; the fertiliser should be placed and mixed in the pits. Subsequently, in the first year of the plantation, fertilizers should be applied within two months of planting, and

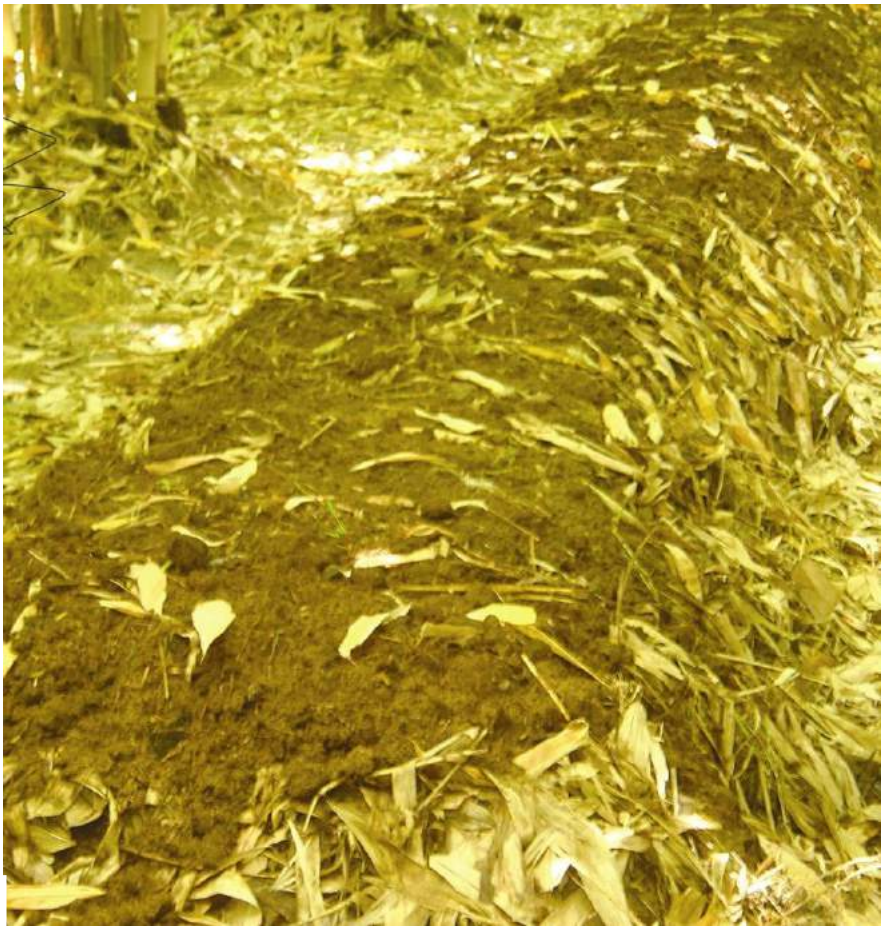
then again, in the later part of the dormancy period, preferably around 4–6 weeks of anticipated shoot emergence. A general dosage norm that may be followed is 150 grams N + 150 grams P + 150 grams K.

Care should be taken to see that chemical or strong fertilizers are not applied directly to the rhizome and other sensitive parts of the plant. The applied fertiliser should not touch sprouting shoots, to avoid damage. Fertiliser should be applied in ditches around the clump when the soil has enough moisture, and then covered with soil.

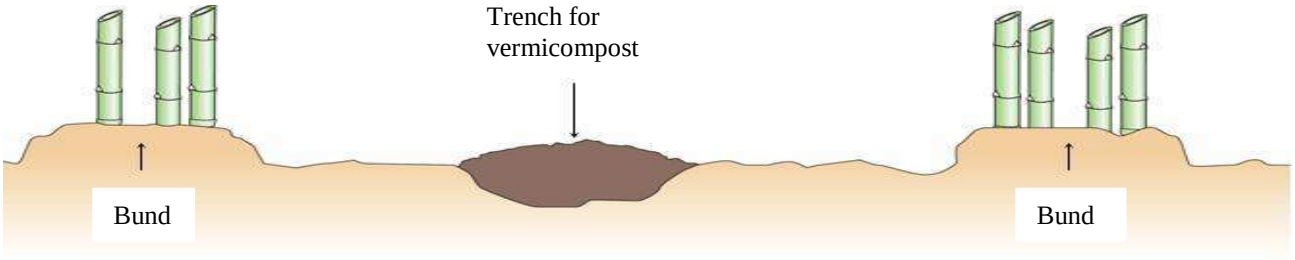
ORGANIC NUTRIENTS

It is also possible to cultivate bamboo without the use of chemical fertilisers, relying on compost, vermicompost and leaf litter for the necessary nutrients. In fact, organic farming of bamboo imparts positive attributes to markets perceptions of bamboo shoot and even bamboo culm. There is also increasing concern that although chemical fertilizers boost production, in the long run they adversely affect soil health and fertility.

To increase productivity, and to cater to the needs of organised and intensively managed plantations, however, it is necessary to systematically plan and implement an organic farming regime.



A vermicompost bed



Organic fertilizers can provide a range of nutrients to the soil. They encourage microbial activity, which allows the fertiliser to provide nutrients over a longer period of time. Unlike chemical fertilizers, the nutrients in organic fertilisers are less likely to leach away in rainwater.

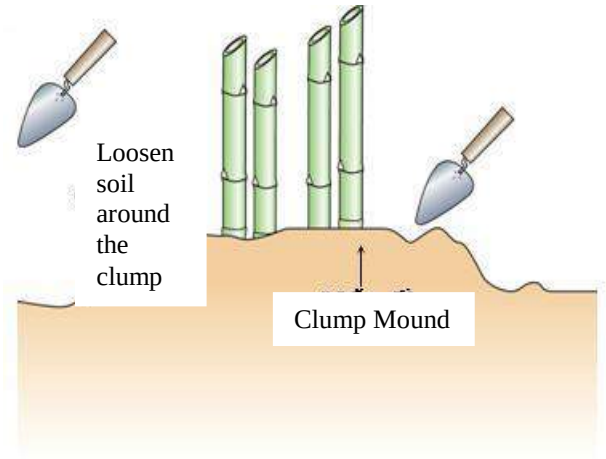
Manure and compost are established sources of nutrients, and simple to prepare and use. (See annexure on Vermicomposting). There are many other sources of organic and naturally occurring fertilisers.

Clump Management

EFFICIENT AND REGULAR clump management is important to ensure high productivity and to minimise wastage. The micro-environment should be maintained in a way that is conducive to good growth. Clump congestion must be avoided.

SOIL LOOSENING

Loosening the soil around the clumps at least twice a year, and more often if warranted, is important to maintain a good soil structure. This is turn improves the growth of shoots and the root system. Soil should be loosened to a depth of 10–15 centimetres, and 30–45 centrimetres away from the bamboo clump.



WEEDING

In the initial years of the plantation, regular weeding is necessary to prevent weeds and other vegetation from competing with the young bamboo for sustenance. Intensive weeding is required at least for the first 2 years after the rains, and towards the end of the wet season. The intensity and frequency of the weeding, however, will be site-specific, depending upon the weed/grass infestation, and will come down in later years. At some places, it may be required even after non-seasonal rains.

Once the clump gets established there is considerable leaf-shedding, and this acts as a barrier to the emergence of weeds/grasses.

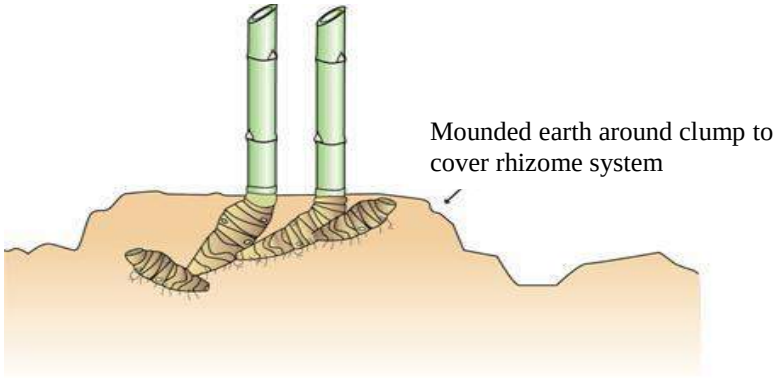
MULCHING

Fallen bamboo leaves serve as good on-site mulching material. Mulching reduces loss of moisture due to evaporation from the planting pits and checks weed growth. Biodegradation of the mulch by natural processes releases valuable nutrients into the soil slowly and improves its texture by adding organic carbon. Bamboos have a requirement of silica for growth that can also be contributed by bamboo leaf mulch.

Bamboo leaf mulch

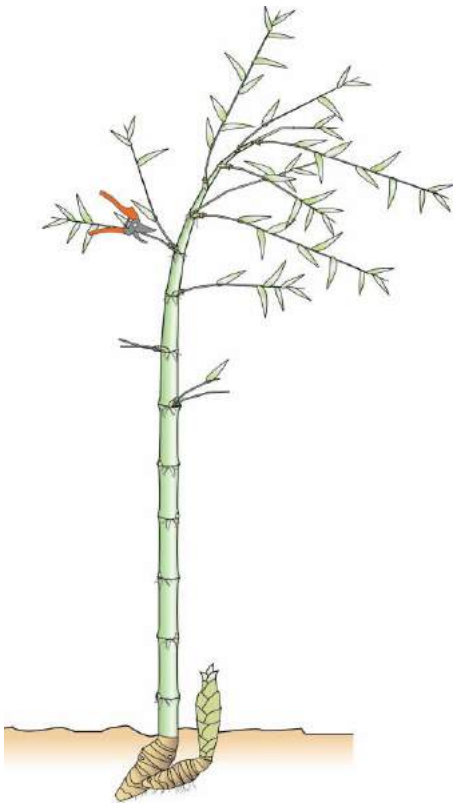
MOUNDING

Rhizomes grow laterally under the soil surface, and when ready to throw up shoots, to grow upwards as well. They therefore emerge from the ground at an upwardly inclined angle. In this period of growth, exposure to sunlight retards, and may even stop, the growth of rhizomes. Mounding, or heaping fresh, loose soil around and over the base of the plant, is therefore recommended.



PRUNING

In some species (*Dendrocalamus hamiltonii* and *Bambusa balcooa*, example), there is heavy branching at the lower nodes of the plant. Pruning of these branches reduces clump congestion and helps provide a healthy, airy environment within the clump. Mild pruning should be undertaken in the second and third years of growth, and intensive pruning from the fourth year onwards. It should be completed before the end of the dormancy period, well before shoots emerge. Good months in which to carry out pruning are December and January.



CLEANING

Once clump formation starts (generally in the third year), its management is of great importance. Rhizomes grow centrifugally (outwards), throwing up new shoots in enlarging circular formation.

Bamboos can throw up many branches, which, if left unattended, can get deeply entangled. This not only curbs access to older culms towards the centre of the clump, but also obstructs free vertical growth of new culms. While trying to negotiate/force their way through the maze of branches, the new culms may get twisted and turned, which further congests the clump. Such malformed culms make harvesting of the better culms difficult. Beyond a certain stage, it will not be possible to redeem the natural architecture of the clump that is unique to the species, and the only remedy lies in feeling it prematurely.

Therefore, it is important to clean clumps early, and to remove all dead and malformed culms. A well-aired clump results in the emergence and growth of healthy culms. Dead stems are not only vulnerable to pathogens, but also dry up fast and are a potential fire hazard. In conditions of low humidity and high temperatures the rubbing of culms against each other is known to cause sparking and conflagration of the entire clump/forest/plantation.

A good time carry out clump-cleaning operations is February–March. In this period of dormancy, after the rigours of winter are over and before the cycle of active growth begins again, the plant system is better prepared to withstand the stress of cleaning activities.

Tangled Culms

Thinning should not be carried out too enthusiastically. Over –thinning results in a less dense canopy of leaves and branches, allowing sunlight to filter through. This can place stress on the plant system, turning clumps to shades of yellow and making the leaves curl. It also dries the ground, reducing its moisture content.

THINNING

Thinning the clump is essential from the third year onwards, to avoid congestion and to ensure proper growth and easy extraction of culms. Weak and deformed culms should not be retained in the culm.

An appropriate clump structure should be maintained through thinning as well as through extraction/retention of shoots. Only shoots sprouting in the middle of the shooting season should be retained.

MATURITY MARKING

The age of culm is an important determinant of its physical, mechanical and chemical properties, and therefore of its utility and value. There are no scientifically established methods as yet for determining the age of a culm from a mature clump. It is therefore important to mark the year of origin of the clump. One way is to have a single-band colour system, using a cycle of four colours. It is easy to implement and allows for easy identification as well, during clump management operations and harvesting.

The following colour scheme has been developed, and is increasingly being used.

Year 1 (2004): Red
Year 2 (2005): Yellow
Year 3 (2006): Blue
Year 4 (20074): Black

This cycle may be repeated every five years.

An alternative system of denoting the age of bamboo culms is to use a single colour, but to mark the culm with successive bands of that colour. In the year of culm emergence, one band is marked, at a height of 1.5 metres from the base (or at least at breast height), preferably just above a node. Each

subsequent year another band is marked, just above the band of the previous year. Thus the number of bands denotes the age of the culm.

A third system is to simply mark the year of emergence of the culm, in numerals, on the culm.

Irrespective of which system is used, the intention is to provide to the cultivator – and the marked or user – information about the age of the culm.

Intercropping

IT IS POSSIBLE to raise a bamboo plantation adjacent to cropland, provided a reasonable space (minimum 5 metres) is maintained. Additional protection can be provided by trenching or by a rhizome barrier.

Intercropping is also possible, and can be beneficial, in the early years of a bamboo plantation, before the clumps attain maturity and canopy formation is completed.

The crops should, however, be carefully selected, taking care to avoid intense consumers of nutrients. Further, the crops should not be placed too close to the bamboo plants.

Bamboo plantation adjacent to cropland

Bamboo canopy

In the first two years of the plantation, short-duration or shade-loving plants like turmeric and ginger, or medicinal plants, can be grown. Off-season tomatoes, soyabean and maize have also been found to be successful for intercropping in bamboo plantations.

In subsequent years, the possibility of intercropping will increasingly diminish because of the closing of the canopy, as the culms reach upwards and outwards, and the laterally spreading network of roots and rhizomes. Some medicinal plants can continue to be grown in the shade, under the canopy of leaves and branches.

If the plantation is established with higher spacing than what is normally recommended (ranging from 5 x 5 to 7 x 7 metres), intercropping can be continued for a longer period of time.

Harvesting

A BAMBOO PLANTATION must be ‘worked’ and culms harvested every year. This induces the emergence of new shoots and ensures regular and healthy culm production, resulting in a steady stream of culms and shoots for sale.

Harvesting of bamboo for commercial purpose can begin from the third year of establishing a plantation. However, the clump will mature and yield culms of full physical dimensions only after the fourth year.

The age of the culm is an important factor in the uses to which it is put.

- For non-structural applications, and those that do not require their peak physical and mechanical properties, 2–3-year-old culms from a mature clump may be harvested.

- For most purposes, however, culms should be harvested when they are 4 years old.

- Culms that are more than 5 years old begin to turn brittle and weak, and then die. As a norm, culms over 5 years should not be retained in a commercial plantation.

The best time of the year to harvest culms in the post-monsoon season, extending through the winter. This is the period of dormancy, during which culms tend to have lower starch content. They are therefore less susceptible to borers, termites and other pests.

Clums should not be harvested in the growing season, which is normally during the monsoon months. Harvesting in this period can damage young and emerging shoots, and retard the future growth of the clump.

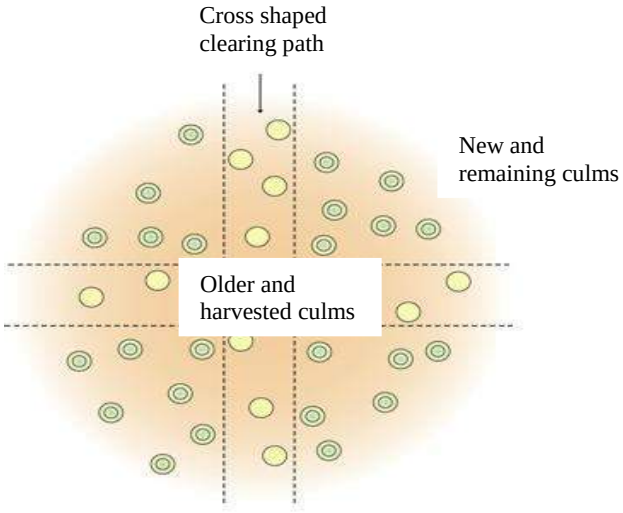
HARVESTING CONGESTED CLUMPS

A bamboo clump can get congested for many reasons, of which a major one could be that the clump has not been worked or harvested for a year or two. This is often true of bamboo in forestland, where harvesting or working may take place in rotational cycles of once in 4 years or at even greater intervals. This, however, should not be a feature of an intensively and regularly managed bamboo plantation.

Some bamboo species, like *Bambusa bambos, Bambusa balcooa* and *Dendrocalamus strictus,* tend to have closely spaced culms in the clump. In such cases the chances of clump congestion are relatively higher. Further, *Bambusa bambos* tends to have thorny branches, and this makes working the clump more difficult. In such situations, it may be necessary to resort to the 'tunnel' or 'horse-shoe' system of extraction/harvesting.

The Tunnel System of Harvesting

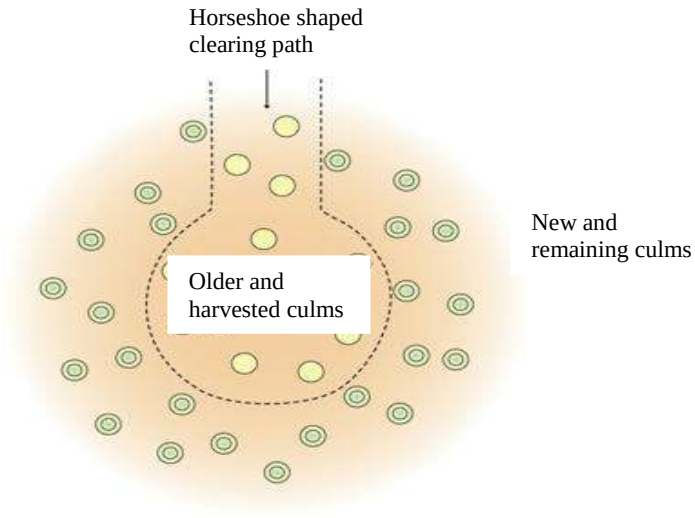
- Two tunnels are created through the centre of the clump, effectively dividing it into four sections. The tunnels provide access to the inside of the clump and allow ease of working.
- Culms of adequate maturity are then selected and extracted from each section.
- It is also useful to remove weak and stunted culms from the periphery of the clump, retaining only the healthy ones.



The Horse-shoe System of Harvesting

- The clump is worked in a horse-shoe pattern, or in an inverted V, by making an opening opposite the densest concentration of culms.

- All the old, dry and rotten culms are extracted, leaving only 1-year-old, vigorously growing culms, along with an appropriate number of evenly spaced and healthy older culms.



Although these methods of extraction involve high initial costs and may result in removal of some mature and immature culms, they prevent congestion and provide space for appropriate growth of shoots and culms. They also ensure easy working of the clump in subsequent years.

GOOD HARVESTING PRACTICES

- The ideal clump structure for plantations raised primarily for culm production is in the ratio of 3:3:3:1 in the first, second, third and fourth years, respectively. Plantations raised for shoot production require a different clump structure.

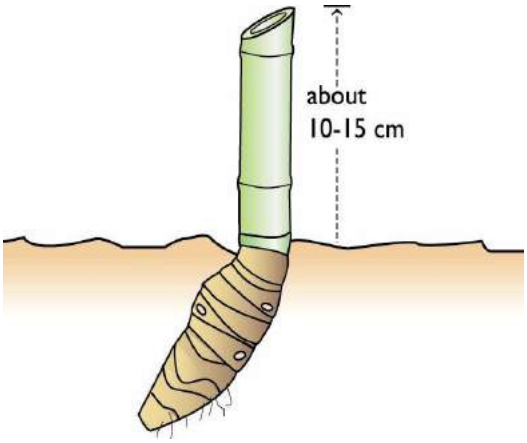
- The number of harvested mature culms should not normally exceed the number of healthy shoots that sprouted and grew into young culms in the preceding year.

- 'Aborted', stunted and diseased shoots should be removed from the clump as soon as they are identified.

- The clump should be visually examined and the culms to be harvested selected, before beginning cutting operations.

- Adherence to a maturity marking system will facilitate and expedite such selection.

- Branches extending from the lower nodes of the selected culms should be removed. This makes cutting and extraction easier.



- The culm should be harvested at least one, preferably two nodes, above the ground. This reduces the risk of injuring the rhizome.

- The culm should be cut obliquely, that is, with a slanted cut. This ensures that rainwater, debris and twigs do not collect in the uncut portion above the last remaining node, and become a breeding ground for fungus, parasites and insects.

- Twigs and remnants of branches should be removed from the area surrounding the clump.

- The felled culms should not be dragged along the ground to the collection or stacking point. This may injure or scratch their epidermal layer, lowering their value.

Stacking and Storage

HARVESTED BAMBOO MAY often have to be stacked and stored for a period of time, at or near the plantation. This may need to be done for any of the following reasons: to bulk a quantity for supply in the market, to hold supplies till a better price is obtained, to carry out preservation and treatment activities.

Immediately after harvesting, and through the storage period, culms should be stacked vertically rather than horizontally. Horizontal stacking puts pressure on culms at the bottom of the pile, and can injure, deform or break culms.

Vertical stacking of green bamboo is better, because a larger surface area is exposed. This facilitates uniform and quicker drying.

If possible, the stacking area should have a PCC (pucca) floor. In contact with the ground, bamboo culms are vulnerable to borers and termites. Less expensive options include polythene sheets and tarpaulin.

A covered, or at least shaded, area is recommended for storage, to protect the bamboo from direct sunlight and rain. Exposure to rain will lead to reabsorption of lost moisture and delay the drying process. Exposure to sunlight may cause rapid drying, resulting in splits and cracks.

Raising a Plantation: Sequence and Timing

INDIA IS A vast country. It has many agroclimatic zones and variations in topography, climate and soil conditions. It is not easy, therefore, to provide a calendar of operations for bamboo plantations, that will apply in all conditions and locations. There are, however, some basic principles that should be adhered to, irrespective of the variations.

The country's most important climatic even is the monsoon. The life-cycle of the bamboo plant is dependent on it, and is vitally affected by it. The wet season is a period of intense activity for the plant. New shoots emerge, taking advantage of the conducive moisture, humidity and temperature. Most of these shoots will develop into healthy culms, growing taller over a period of a little over three months after emergence. After the monsoon, and with the onset of cooler and drier conditions, the plant system enters a period of dormancy during which it limits its activities, seeks out and stores food and nutrients.

	To be completed by month (M)
• Soil sampling and testing	M – 6
• Site Selection and finalization, survey and demarcation	M – 5
• Selection of species, preparation of planting plan and layout	M – 4
• Establishment of a nursery/plant material production facility, if intended	
• Fencing and protection, making trenches	M – 3
• Acquisition of plant material	M – 3
• Clearing the land and ploughing	M – 3
• Pit staking	M – 3
• Pit digging	M – 3
• Soil preparation, application of compost/chemical fertiliser in the pits	
• Planting in pit, irrigating the pit and its environs	M – 2

Establishing and managing a plantation involves a wide range of activities. Using the onset of the monsoon as a benchmark (indicated as M, the expected month, in the table on the previous page), and allowing for local variations, it is possible to classify, list the sequence and give the timing of these activities.

POST-PLANTING ACTIVITIES: YEAR I

- *Fertiliser*. Beyond the initial application of fertiliser in the pit at the time of planting, chemical fertiliser, if used, should be applied again within a period of 1–2 months after planting. The does will need to be repeated 5–6 months after the close of the monsoon. A general norm that can be followed for application of chemical fertiliser, per plant, is: 150 grams N + 150 grams P + 75 grams K. If an organic fertilization regime is taken up, organic nutrients should be regularly and continuously applied over the year.

- *Irrigation*. In the first year, special care should be taken that the plant does not suffer prolonged periods of drought. As a norm, in the first month after planting, irrigation should be ensured at 2–3 days' intervals initially, extending to once a week. If the rainfall is adequate, irrigation may be tapered off or discontinued. After the monsoon, and depending on the rainfall/moisture regime, adequate irrigation to compensate for moisture deficiency should be maintained. In the first year, the irrigation required will be relatively higher than in succeeding years. In most parts of the country, at least two major irrigation cycles will be needed – two months after the close of the monsoon, and four months after the close of the monsoon.

Young clump:
Dendrocalamus hamiltonii

- *Weeding.* Regular weeding is necessary in the first year, to tilt the balance in favour of the bamboo plant in its battle against competing vegetation. In most parts of the country, this implies two weeding operations – once in the second or third month after planting, and once two months after the close of the monsoon. This regime will need to be modified in climatic conditions that favour weed growth – in wetter areas, for example.

- *Loosening the soil, mulching and mounding.* These should be carried out in the colder months, later by three months after the close of the monsoon, and should be repeated five months after the monsoon ends.

NURSING A PLANTATION: YEAR 2

In the second year, the pattern of activities outlined for the first year will continue, in the same broad timeperiods. The clump structure of the plantation will be nascent and it will continue to look sparse, although greener.

- Fresh planting will be needed to cover the gaps caused by plant mortalities, if any that have occurred in the first year.

- The timing and dosages of fertiliser application will remain the same as in the first year, unless specifically warranted or recommended by specialists and the experience of the preceding year.

- Irrigation intensities, as well as soil loosening, mulching and mounding, will continue in the same manner, with appropriate modifications where necessary.

- Fencing should be checked and gaps attended to.

NURTURING A PLANTATION: YEAR 3

In this year, shoots will grow into culms that are substantially taller than those of the preceding year, and the clump structure will be apparent. A canopy begins to form, and the bamboo plant, including its rhizomes and roots, will have begun to spread itself. While the basic sets of activities will remain the same as in the preceding two years, there will be come modifications depending on the emerging clump structure.

- During the monsoon, shoot growth should be monitored. Weak shoots should be discarded.

- Manipulation of the clump structure and cleaning operations should be carried out in the middle of the period of dormancy, typically in the month of January.

- The need for weeding may be less, but is still important.

Older clump:
Dendrocalamus hamiltonii

THE BEGINNINGS OF MATURITY: YEARS 4 AND 5

By now, the plantation will have begun to command the site, with arching canopies, highly visible and established clump structures, and a profusion of tall culms,.

It will now be possible to make out differences in health and vitality across clumps, locate the reasons for differential performance, and address special needs. These may be due to variations in the microclimate (moisture, soil), or inappropriate thinning and maintenance.

The core activities will have to be continued, but clump management begins to assume crucial importance from now onwards.

Special attention should be paid to selective cutting of older culms (those that originated in the second year), thinning, pruning of lower branches, removing diseased shoots, and mulching and mounding activities. By now the leaf litter on the ground will be considerable, and can be put to use on the plantation. Weeding needs be less, as the clump structures have established themselves.

In plantations raised from rhizomes, offsets and culm cuttings, culms can be harvested as early as from the fourth vear onwards.

REAPING THE BENEFITS: YEARS 5, 6, 7 AND ONWARDS

By this time the bamboo plantation would have dominated the site and grown into a self-sustaining system, managing many of its needs.

While fertiliser and irrigation needs will continue, maintenance needs will be less. Management and harvesting are the most important activities to be carried out in these years.

Third-year culms can now be harvested and extracted. This will help maintain an appropriate clump structure, and provide income.

Plantation: ***Dendrocalamus hamiltonii***

Cultivating Bamboo for Shoot

THERE IS A growing market for bamboo shoots. They can be sold fresh to processing units, or, in simple processed and packaged from, in local markets.

A plantation dedicated to bamboo shoots, or to a product mix of both shoots and culm timber, requires more inputs (nutrients) and a more intensive management regime than a plantation for culm timber alone. Such a plantation also has qualitatively higher requirements of site and soil conditions, light and water.

The shoots should be harvested when they are between 15 and 18 inches above the ground; this can happen within days. Shoots that are older tend to be woody, and younger shoots, although more tender, have less edible matter. A shoot plantation needs to be inspected and worked every day during the season.

It is advisable to harvest shoots only from mature clumps. Shoots from immature clumps will have insufficient biomass and edible content.

HARVESTING SHOOTS

In addition to input and management intensity, the key differences in shoot-centred cultivation relate to harvesting practices.

- A good clump structure for plantations devoted to shoot production is in the ration of 4:4:2, for the first, second and third years, respectively.
- As in harvesting for timber, a prior visual inspection of the clump should be conducted, to identify the shoots that can be cut.
- Shoots in the middle of the shooting period will tend to be healthier than shoots at the extremes of the season.
- In timber-cum-shoot plantations, as a thumb rule, 30 per cent of the shoots can be harvested every year, excluding aborted and diseased ones. In plantations dedicated to only shoot, this can be raised to 50–60 per cent.

Harvesting should be done carefully, so as not to damage the rhizome or other shoots. Early morning and late evening are good times to harvest shoots. Shoots harvested at these times will remain moist longer, and desiccation will be delayed. The steps are as follows:

- Dig around the base of the shoot, to locate its base.
- Sever the shoot a couple of inches above its base, taking care not to approach or cut into the rhizome.
- Use a clean cutting tool, to minimise the risk of infection to the plant system.
- Do not cut away any part of the shoot sheath.
- After extracting the shoot, cover the dug away portion with soil.

After harvesting, it is important to keep the shoot in as moist and fresh a condition as possible.

The Reangs of Tripura have developed ingenious techniques to retard and delay woodiness, and to secure larger quantities of edible matter. The first step is to identify, as early as possible, a shoot that is about to break through the surface. This is achieved by regular and careful inspection. Walking barefoot in and around the clump is one way: the pointed tips of the shoots will prick the soles of the feet.

The second step is to place an earthen pot (matka) over the very young shoot. It is useful to heap soil and leaves over the pot, to weigh it down. Encased in darkness, and protected from the atmosphere and environment, the bamboo shoot continues to grow as if still below the soil. It is not able to grow upwards as it would have normally done. Instead, it bulges in the pot as it grown larger, sometimes coiling around the inside. After a few days, the pot is lifted and the shoot is dug cut.

Annexure: Vermicomposting

Vermicompost is a good alternative to chemical fertilisers. Apart from providing organic nutrients for the plantation, vermiculture can be a profitable activity, providing a steady income over and above that from the sale of bamboo shoot and culm.

In vermiculture, earthworms convert organic wastes into fertile manure. The excreta of earthworms contains five times the nitrogen of ordinary soil, seven times the phosphorus, eleven times the potash, two times the calcium and magnesium, and eight times the useful bacteria.

PREPARING VERMICOMPOST

Cowdung, agricultural and vegetable waste and fallen bamboo leaves are good materials with which to establish a vermicomposting bed. One hectare of bamboo plantation can produce up to 6–8 tonnes of leaf litter every year.

- Collect fresh cowdung and agricultural/vegetable waste. Leave the collected biowaste for a period of time, to enable and facilitate decomposition. Fresh cowdung should be left for 8–10 days to decay and agricultural waste for 15 days.

- After the biowastes have decomposed, mix the cow dung (or slurry from gobar gas plants) with the agricultural waste (including bamboo leaf litter), to make the feel material. A 2:1 ration, or marginally higher, of agricultural waste and cow dung is recommended.

- Buy or source earthworms from the market of from suppliers. A working norm is 671–700 earthworms per kilogram.

- Layer the mixture of cow dung and agricultural waste on the bed.
- Leave the bed undisturbed for a day to allow the mixture to cool. Earthworms cannot tolerate high temperatures.
- Release the earthworms on to the bed at a rate of about 350 grams per cubic foot.
- Cover the bed with rice straw or bamboo litter to provide an environment that is protected from light and comfortable for the earthworms.
- Spray water at regular intervals (3–4 days in summer and 7–8 days in winter) to maintain a humidity level of around50 per cent.
- Turn the soil on the bed every 10 days or so, to maintain porosity and aeration. This also counters one of the impacts of spraying water, which is to compact the soil.
- The process is complete and the vermicompost ready to use when the bed attains a dark brown colour, and a powdery/crumbly appearance and texture.
- Finally, remove the rice straw/bamboo litter, and lift the vermicompost from the bed.

Weather and the micro-environment play a critical role in this process.

- In winter vermicomposting takes 105–120 days.
- In summer it takes 80–90 days.
- In the rainy season it takes 70–80 days.

A VERMICOMPOSTING MODEL

Vermicomposting operations can be carried out between the rows of a bamboo plantations. The assumption in this model is of a plantation on 5 x 5 metres spacing, in regularly spaced, triangulated rows. The vermiculture bed can be 1-metre wide, and raised to a height of 25-30 centimeters. The length depends on the available space, that is, on the length of the rows of the plantation. As a norm, 10% of the plantation area can be utilized for vermiculture. Care should be taken to see that the vermicompost beds are not intersected by irrigation channels.

The feed material (inclusive of moisture) per cubic metre of the bed will be 636 kg/m^3. This feed material consists of a mix of soil and cowdung, leaf litter and other agrowatse, in the propagation 70:30. The time cycle assumed is an average of 100 days throughout the year, i.e. 3.5 production cycles in a

year. The market price of vermiculture manure is taken to be Rs 2 per kilogram.

Basic Assumptions

- Feed material including moisture per cubic foot of bed, cow/buffalo dung and agrowaste mixed in a proportion of 30:70 = 18 kg = 365.8 kg/m^3
- Output (vermiculture) as % of input = 30
- Cycle time = 120 days in winter and 60 days in summer. An average of 100 days may be assumed.
- Number of cycles in one year = 3.5
- Market price of vermiculture manure = Rs 2/kg

Basic Calculations

- Plantation area = 10,000 sq. metres (1 hectare)
- Area for vermiculture = 1,000 sq. metres (10%)
- Volume of the bed = 10,760 cu. ft, 305 m^3 and 1 ft height
- Total feed material = 1,93,680 kg
- Output/cycle = 58,104 kg (30% of input)
- Output/annum = 2,03,364 kg, 230.364 m. tons (3.5 cycles per year)

  = Rs 4,06,728 @ Rs 2/kg

Glossary

a

acre and area of land measuring about 43,560 square feet of 0.405 hectare.
amphipodial a system of rhizome axes in which both sympodial and monopodial branching occur **axis** an imaginary central line of development of any plant or organ

b

bud early stage of development of a flower or plant growth.

c

canopy layer or multiple layers of branches and foliage at the top of a bamboo plant system
clump the whole bamboo plant, consisting of many culms **complete fertiliser** plant food that contains all three of the primary elements: nitrogen, phosphorus and potassium
compost an organic soil amendment based on the decomposition of organic matter
culm most clearly identified as ‘bamboo’, it is pole or stem that extends from the rhizome, growing vertically

f

farm yard manure (FYM) agro and animal waste and residues used to enrich soil
fertiliser organic or inorganic plant foods in either liquid or granular form, used to amend the soil in order to improve the quality or quantity of plant growth
flowering a phenomenon by which a cluster of highly specialized leaves grow with the specific aim of participation in reproduction.

g

gregarious flowering when all the culms in a bamboo clump and all the clumps in an area of more that 5 heaters flower and subsequently die after seed-setting

h

habitat natural environment of a plant of organism; the place where it is usually found
hectare and area of land measuring 100 square metres or 2.47 acres g

i

inflorescence an aggregation of flowers
intercropping growing more than one crop at one time on a given area of land
internode portion of a culm, branch or rhizome between two successive nodes
irrigation artificial application of water to the soil for the benefit of growing crops

l

leptomorph one of two general types of rhizomes; characterised by a slender stem, long internode and indeterminate growth.

m

mulch any loose material or coarse organic matter such as leaves, placed over soil to control weeds and conserve soil moisture
monopodial bamboos bamboos that thrive in temperate conditions, occasionally enduring below-freezing temperatures; characterized by lengthy rhizomes with symmetrical internodes, more long that broad; individual culms tend to be freestanding and not clumped

n

node junction of adjacent internodes in the culm; the place where the culm sheath, foliage leaves, branches or flowers arise
nutrients elements necessary for growth and reproduction of plants; primary plant nutrients are nitrogen,

p

pH a measure of the amount of lime (calcium) contained in the soil; pH values of o to 6.5 indicate acidic conditions, a pH value of 7.0 is neutral and pH values greater than 7.0 are alkaline
plantation a plot of land on which intensive cultivations is practiced using scientific principles of management
pruning cutting and trimming of plants to remove dead or injured elements, and to control and direct and new growth of plant

r

rhizome underground stem or the portion of a stem with nodes and internodes, bearing scales of leaves and usually rooting at the noes

s

shoot young culm at any stage of its development

species basic unit of classification of living things, consists of all individuals that are closely related such that they appear very similar and often interbreed to produce offspring
sympodial of a stem in which the growth either terminates in an inflorescence or dies, the growth being continued by a new lateral growing point

t

thinning removal of some culms in a clump to improve the vigour and quality of the remaining culms, reducing culm density and competition

V

vermiculture the raising of earth-worms and their products to produce manure

W

windbreak planting of trees, bamboos or vegetation designed to protect soil, crops, homes or woods from wind and reduce erosion