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Abstract of Project Proposal

Project Number	**: KFRI/560/08**
Title	**: Planting stock production of selected commercial species of Bamboos**
Objectives	**:** Planting stock production of selected commercial species of bamboos
Principal Investigator	**:** C.K. Somen
Co-Investigators	: K.K. Seethalakshmi K.K. Unni V.P. Raveendran
Duration	**:** One year (1.12.2008 – 30.11.2009)
Budget	**:** 5.46 lakhs
Funded by	**:** Bamboo Technical Support Group (BTSG)

ABSTRACT

Planting stock of 25 commercial species of bamboos . (1. *Bambusa balcooa, 2.B. bambos ,3. B. nutans, 4. B. polymorpha 5. B. striata, 6. B. tulda, 7. B. vulgaris, 8. B. wamin, 9. Dendrocalamus asper, 10. D. brandisii, 11. D. giganteus, 12. D. hamiltoni, 13. D. longispathus, 14. D. sikkimensis, 15. D. strictus, 16.Gigantochloa atroviolacea, 17. Gigantochloa rostrata, 18. Guadua angustifolia, 19. Melocanna bambusoides, 20. Ochlandra scriptoria, 21. O. travancorica, 22. O. travancorica* var.*hirsuta, 23. Oxytenanthera stocksii* 24. *Thyrsostachys oliveri* and *25. Teinostachyum dullooa*) belonging to 10 genera was produced using macro and micro-propagation techniques with in short period The propagules were produced in the nurseries at the Field Research Centre, Veluppadam and the main campus of Kerala Forest Research Institute (KFRI), Peechi. Seedlings of *Bambusa bambos*, *B. tulda, Dendrocalamus hamiltonii, D. strictus*, *Melocanna bambusoides, Ochlandra travancorica* and *O. scriptoria* were raised in nursery beds and potted in polythene bags. Macro-proliferation of seedlings of *Bambusa tulda* previously raised in the nursery was carried out by splitting the rhizome portion bearing two or more shoots. Vegetative propagation of *Bambusa balcooa, B. vulgaris* (green)*, B. vulgaris* var *striata* (yellow), *Dendrocalamus brandisii, D. giganteus, D. longispathus, D. stocksii, D. sikkimensis, Gigantochloa atroviolacea,* and *Thyrsostachys oliveri* was done by treating culm cuttings with growth regulators viz. naphthalene acetic acid (NAA) and indole butyric acid (IBA). The proliferation capacity was about 2.5 times (1000 seedlings to 2500 propagules). A total of 83,570 propagules were produced of which 24,336 plants were supplied to farmers, voluntary organisations, schools and Government Departments for different types of planting activities such as boundary

or block planting, strip planting on river banks and bio-shield in coastal areas, landscaping, establishment of bambusetum, explants for tissue culture laboratories etc. The remaining planting stock is maintained in the nurseries at FRC, Velupadam and KFRI Campus, Peechi. Macro-proliferation is being continued and the planting stock will be distributed as per the requirement for plantations in future.

INTRODUCTION

Bamboos are multipurpose C_3 plants, growing rapidly producing very high biomass and are commonly found in wet evergreen, moist deciduous and dry deciduous forests in the tropical parts of south-eastern Asia. Most of the continents except Europe have native bamboos. Different growth forms such as herbs, shrubs, climbers and arborescent types are seen among bamboos. Most of the commercial bamboo species are arborescent woody perennials. Majority of the bamboo species occur in the tropics and in mild climates, while some species occur naturally in China, Japan, Chile and in the United States, under temperate conditions. In India nearly 8.96 million hectares of forest area is occupied by bamboos, which constitutes 11.7% of the recorded forest area and 14.01%, forest cover (Rai and Chauhan, 1998). Reports show the existence of 1525 bamboo species coming under 111 genera spread over the tropics, subtropics and temperate regions. India holds the second position in terms of species diversity of bamboos in the world, having 26 genera and 122 species. From Kerala 7 genera 34 species of bamboo have been reported (Kumar, unpublished). Bamboo has been associated with people since ancient times and is very popular due to its multi purpose use, fast growth, easy propagation, soil binding properties and short gestation period as compared to trees. Every part of bamboo is utilized in one way or the other. It has a high calorific value ranging from 4600 to 5400 cal/kg, which makes it an important energy crop. Bamboo has a variety of uses which can be broadly grouped into agriculture, industries, transportation, food, construction, weapons and so on.

During last decade Government of India focused on the development of bamboo sector by launching different projects covering resource

enhancement, value addition and export. To implement the projects in a mission mode, National Bamboo Mission on Bamboo Application (NMBA) and National Bamboo Mission (NBM) were set up. While considering the resource availability and procedure for mobilization of raw materials to industries in private and public sector, various bottlenecks were identified. It was the prime reason for both NMBA and NBM to focus on increase of area under bamboo by establishing new plantations and increasing the productivity of existing bamboo areas. A target of 176000 ha was set up for the current five year plan. Although a large number of species are available, only about 20 are identified as commercially useful. Others are limited in occurrence and their use is restricted in the locality of occurrence.

Availability of planting stock of selected species is a constraint for cultivation of bamboos. KFRI has established Bambuseta in three places with live collection of bamboos collected from all over India and abroad. The bambusetum at FRC Veluppadam is one of the largest with about 65 species. For production of planting materials parent material for most of the species were used from this collection.

Different methods for propagation were also developed by the Institute as a result of the R&D activities for last three decades. With the strength in bamboo collection and technical know-how on multiplication methods, this project was allotted to KFRI by NBM to produce and distribute planting stock of selected species to public for establishment of plantation. Although propagation of 15 species was envisaged in the project 25 species could be propagated. Some of the main characters, habitat and main uses along with the important research findings concerned with the selected species are given below.

1. ***Bambusa balcooa*** Roxb.

Bambusa balcooa is a common homestead bamboo in North East India and West Bengal. It also occurs in Bihar, Orissa, Jharkhand and Uttaranchal. The culms are 20 - 30 m tall, dark green and thick-walled, 8-15 cm in diameter. Culms are coarse, stout, dull grayish-green with pointed recurved branches towards the base. The nodes are thickened with a whitish ring above, hairy below. The internodes may be 20-40 cm long with branches from the lower nodes. The clump/plant dies after flowering without setting any seed. The flowering cycle is 35-45 years. The most common use of this sturdy and strong bamboo is in house construction. It is a good bamboo for scaffolding and ladders. It is also used for agarbathi sticks and in bamboo wood chip industry.

2. Bambusa bambos (L.) Voss.

Bambusa bambos (*Bambusa arundinacea*) is one of the species commonly planted in the homesteads for fencing purpose. This thorny bamboo occupies about ffifteen percent of the bamboo growing area in India. The culms are thick walled and grow up to 30 m with a diameter of 15 to 18 cm, having branches at all nodes, the upper leafy branches bearing small spines. Nodes are slightly swollen and a few lower nodes produce short aerial roots. The flowering cycle may vary between 40-45 years. One kilogram may contain 75000 seeds. The seeds can be stored up to one year. Viability can be prolonged by adopting suitable storage conditions. Storing at low temperature accompanied with low moisture content (10-11%) using desiccants, the viability can prolong for more than a year (Somen and Seethalakshmi, 1989). Seeds, vegetative propagation and tissue culture methods are used for

producing new plants. Large scale production of planting stock is reported by macro-proliferation (Adarsh Kumar, 1992). Offset planting can be done during the onset of monsoon. Two-noded culm cuttings treated with NAA or IBA during summer months have shown good rooting. (Surendran and Seethalakshmi, 1985; Saharia and Sen, 1990). Tissue culture methods using embryo, seeds, callus, seedlings, nodes, shoots and leaves are also reported for multiple shoot induction and rooting (Zamora, 1994).

3. ***Bambusa nutans*** Wall. ex Munro. occurs naturally in the Sub-Himalayan tracts from Yamuna eastwards to Arunachal Pradesh, Brahmaputra valley. It grows well in moist hill slopes and flat uplands. It is a medium sized graceful bamboo with culms reaching a height of 6-20 m and 5-10 cm in diameter. It is loosely clumped, much-branched above, usually unbranched below, straight, green, smooth, white-ringed below the nodes; node slightly thickened, often hairy, lower ones bearing rootlets; internodes usually 25-45 cm long, thick-walled. The plants are ornamental, mainly used for house construction, basketry and poles.

4. *Bambusa polymorpha* Munro.

Bambusa polymorpha is an indigenous bamboo species growing in Madhya Pradesh. It is also found in Myanmar and Bangladesh. The culms may reach a height of 16-25 meters with a diameter of 8-15 cm. The culms are gray in colour with an internodal length of 40-60 cm. The flowering cycle is 35-60 years. One kilogram may contain 21000 – 40000 seeds having 40 percent of germination.

5. *Bambusa tulda* Roxb.

Bambusa tulda is commonly found in the states of Assam, Bihar, Meghalaya, Mizoram, Nagaland and Tripura. The culms may reach a height of 7-23 meters with a diameter of 5-10 cm. The culms are glabrous, green when young, gray-green on maturity. The lower part is unbranched with fibrous roots; nodes slightly thickened, internodes 40-70 cm long, white-scurfy when young, with white ring below the nodes, thin-walled. Flowering cycle is reported to vary from 30-60 years. Seeds are long, 2.49 cm, with 13900 to 14000 seeds per kilogram. Under natural conditions seeds are viable for 30-35 days but can be stored for about 18 months over anhydrous silica gel in a desiccator. Complete germination of the seeds in the nursery beds may take 5-25 days. The seeds exhibit orthodox behaviour and can be stored by proper control of moisture content and temperature (Thapliyal *et al*., 1991). Vegetative propagation using one-year-old, 2-noded culm cuttings treated with NAA or IAA with kinetin is effective. (Adarsh Kumar *et al*.,1988). Saxena (1990) developed a protocol for *in vitro* propagation through shoot proliferation. The seedlings may take six to ten years to mature. This species is used for making toys, flute, mats, screens, wall plates, wall hangers, hats, baskets, food grain containers etc. The tender shoots are used for making pickles. It is suitable for the manufacture of wrapping, writing and printing paper making, covering the houses and scaffolding.

6. *Bambusa vulgaris* (Green) is a moderate sized bamboo with green colour that differs from the yellow variety in its green colour. Culms may reach a height of 10-20 m with a diameter of 4-10 cm. The walls may have a thickness of 7-15mm. Branching usually occurs from the mid-culm to the top. Nodes prominent, internodes up to 45 cm long.

Young shoots are dark brown to yellowish green. It is commonly grown along the river sides and as ornamental purpose. It flowers but no seed setting is reported (Banik 1987). It is mainly used for paper making, scaffolding, construction, poles, curios and handicrafts. Rings prepared from the split culms are being used as ear ornaments by Naga tribes.

7. *Bambusa vulgaris* var. ***Striata*** (Yellow bamboo) is a moderate sized bamboo with culms reaching a height of 8-20 m and a diameter of 5-10 cm. Branching is usually from mid-culm to top; nodes prominent, internodes up to 45 cm long. It is easy to propagate by culm and branch cuttings. Cuttings taken from 1-2-year-old culms, planted in summer months may give maximum rooting. Multiple shoot production has also been reported from mature shoots in MS medium supplemented with coconut milk, kinetin and BAP. Pre-rooted rhizome and culm cuttings can also be used. Ground layering and air layering are also found successful. *Bambusa vulgaris* is used for paper-making, scaffolding, poles, curios, handicraft, fencing, edible shoots, medicine etc. Rings prepared from the split culms are put into ear perforations by the Naga tribes of Manipur. Pulp made from this species is used for mixing with hardwood pulps.

8. *Bambusa wamin* Camus.

Bambusa wamin is a cultivated exotic ornamental species introduced from China or Thailand. Culms are dark green, 4-8 meter high, with swollen internodes. It is usually propagated by culm and branch cuttings.

9. *Dendrocalamus asper* (Schult.f.) Back.ex Heyne native Malaysia and Indonesia, has been introduced to South-East Asia. *D. asper* grows well on various soil types, even on sandy and rather acidic soils, but prefers well-drained heavy soils. It is a large bamboo with culms reaching a height of 20-30 m with an average diameter of 8-20 cm. The internodal length may range from 20-45 cm. It has relatively thick walls (11-20 mm) growing thinner towards the top of the culm. The culms are pale green and covered with short hairs, the lower nodes covered with a circle of rootlets. Buds or branches are present on lower quarter of the culm. It is used as structural timber for heavy construction in rural communities, bamboo boards, furniture, musical instruments, containers, household utensils and handicrafts. The young shoot is sweet and considered a delicious vegetable. Two-noded culm cuttings of *Dendrocalamus asper* treated with 500 ppm of IBA have reported to root in vermiculite medium. (Ramoran 1993).

10. *Dendrocalamus brandisii* (Munro) Kurz. The culms are large ash-gray reaching a height of 19-33 m with 13-20 cm diameter. The nodes are slightly swollen, lower ones with rootlets; internodes being 30-38 cm long. The species is distributed in Manipur and Andamans. It is also found growing in the tropical forests, chiefly on calcareous rocks up to an altitude of 1300 m. Apart from seeds, this species can also be propagated vegetatively using culm cuttings. Use of growth regulating substances (NAA and IBA) promotes rooting of culm cuttings. Propagation by tissue culture has also been reported from seeds as explant (Zamora, 1994). The species is known to flower sporadically as well as gregariously. It is used for house building, baskets and decoratives. Young shoots are edible.

11. *Dendrocalamus giganteus* Munro. is the tallest of bamboos with close culms and slender branches. Culms may reach a height of 24-30 m, 20-30 cm diameter with a wall thickness of 2-2.5 cm. The culms are dull green, covered with white waxy crust when young and have an internodal length of 35-40 cm. It is a native of Myanmar and cultivated in Arunachal Pradesh, Assam, Manipur, Nagaland and West Bengal. It grows well in humid tropical and sub-tropical regions, in the North East, West Bengal and Bihar. It is one among the twelve high yielding bamboos worth for planting as a large scale plantation (Uppin, 1980). Growth of new culms starts by August and is complete by November. Initially the growth is slow. Culm cuttings planted in nursery beds in polyethylene or a fiber-glass tents may give 45-56 per cent rooting. Propagules from the basal section gave the highest rooting and survival rate. Pre-rooted, pre-rhizomed branch cuttings are good planting materials. Propagation by tissue culture is also reported. (Zamora, 1994). In North-Eastern States of India the culm is used for building purposes, boat masts, vases, buckets, and various other decorative purposes. Young shoots are used for the preparation of many delicacies in Manipur.

12*. Dendrocalamus hamiltonii* Arn. ex Munro. is a large tufted thin-walled bamboo, with erect culms and large branches. The culms reach a height of 24-27 m with a diameter of 15-18 cm. The culms are thick walled, strong and upright, smooth and greyish-green; lower nodes marked with root scars. The internodes may be 30-50 cm long. This species is distributed in the North-West Himalaya, Sikkim, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. The species can be multiplied from seedlings by separating the tillers (Adarsh Kumar et al., 1992). This can also be propagated easily by

rooting culm cuttings using growth regulators (Nath *et al*., 1986). For rooting of culm cuttings basal ten nodes of less than one-year-old culms are ideal (Sharma and Kaushal, 1985). In this species, the flowering cycle is reported to be 30-40 years. The species is used for making walls of native huts, construction purposes, baskets, mats, water and milk vessels, fuel, floats for timber-rafts, binding and caning of chairs. The tribals of Arunachal Pradesh use the tender shoot for the preparation of *'hiyup'* a sour pickle.

13. *Dendrocalamus longispathus* Kurz.

Dendrocalamus longispathus is commonly found in Mizoram, Tripura and Bihar. Culms usually reach a height of 10-18 meters with an internodal length of 25-60 cm. The diameter may be 6-10 cm. One kilogram may have 134880-135220 seeds. Vegetative propagation by rhizome and two-noded-culm cuttings treated with NAA or IBA are promising. This species is mainly used for making tooth pticks, baskets and manufacture of paper.

14. *Dendrocalamus sikkimensis* Gamble

Dendrocalamus sikkimensis is commonly found in Sikkim, West Bengal, Arunachl Pradesh, Nagaland and Meghalaya. The culms are dark green reaching a height of 17-20 meters with 12-20 cm diameter. The internodes are 40-45 cm long with a rough nature. The species is used mainly for fencing, posts, huts, ropes, boxes, water pipes, Chungas for carrying milk and for manufacuturing paper.

15. *Dendrocalamus strictus* (Roxb.) Nees. is a predominant bamboo species common in Uttar Pradesh, Madhya Pradesh, Orissa, and Western Ghats, occupying about 53 per cent of total bamboo growing

area in India. *D. strictus* can be grown in all types of soils except in water-logged or heavy soils such as pure clay or a mixture of clay and lime. Well-drained localities with sandy loam are the best. It prefers hilly ground and is resistant to frost and drought. The culms may reach a height of 8-16 m with a diameter of 2.5-8 cm. The culms are pale blue green when young, dull green or yellow on maturity, much curved above half of its height. The nodes are somewhat swollen the basal ones having roots and branches. The internodes may be 30-45 cm long, thick-walled. The flowering cycle in *Dendrocalamus strictus* varies from 25-45 years. One kilogram contains approximately 30,000 seeds. Germination varies from 25 to 61 per cent. De-gluming the seeds accelerates germination. Seeds are pretreated for 24-48 hrs in cold water. Germination may be over within a period of 7-17 days. One-year-old seedlings are transplanted in pits of 30x30x30 cm with a spacing of 6x6 m. Different methods like offset planting, rhizome planting, rooting of culm cuttings and tissue culture are practiced. One-year-old culms are cut at about 90 cm above the ground and the rhizomes are dug up with roots and cut into a length sufficient to include a well- developed bud. Culm cuttings can be used for propagation when seeds are not available. About 40 to 70 per cent of rooting can be obtained in culm cuttings depending on the period of collection, age of culm and treatment with growth regulating substances. Cuttings treated with NAA 100 ppm during February and March may give maximum rooting (Surendran and Seethalakshmi, 1985). Seasonal variation in rooting response is reported and it is attributed to the variation in nutrient contents in the culm (Gupta and Pattanath, 1976). Tissue culture using nodes, seeds, seedlings, shoots, excised embryos and other methods like multiple shoot production, rooting and in vitro flower induction are reported (Zamora, 1994). *D.*

strictus is suitable for reclamation of ravine land and is extensively used as raw material in paper mills and also for a variety of purposes such as construction, agricultural implements, musical instruments, furniture etc. Young shoots are commonly used as food. Decoction of leaves, nodes and the silicious matter is used in traditional medicine.

16. *Gigantochloa atroviolacea* Widjaja.

Gigantochloa atroviolacea is an exotic species growing in Jawa. The purple colour is prominent when it is grown in dry areas. It attains 8-12 meter height with basal diameter of 6-8 cm. The internodes are 30-50 cm long. The species can be propagated vegetatively by culm cuttings or rhizomes. The culms are used as building material, furniture and for making musical instruments.

17. *Gigantochloa rostrata* Wong.

Gigantochloa rostrata (*Oxytenanthera nigrociliata*) is distributed in Assam, Meghalaya, Tripura, Orissa, Bihar, Madhya Pradesh Maharashtra and Karnataka. It is a tufted green bamboo growing to a height of 5-8 meters with a culm diameter of 2-2.5 cm. The culms are thick walled with an internodal length of 20-30 cm. A flowering cycle of 30-50 years has been reported. One kilogram may contain approximately 26500 seeds. Banik (1987) has observed 39 percent germination. The seeds may germinate within 9 days. Culm cuttings can be used for vegetative propagation. The culms are used for building huts, making baskets and as a raw material for paper industry.

18. *Guadua angustifolia* Kunth.

Guadua angustifolia is an exotic bamboo species growing in Columbia, Latin America. Its diameter is consistent for the first 15 meters and then at the top it becomes tapered. The average size may vary from 20-30 meters with a diameter of 10-13 cm. It is easily identified by the short internodes ringed with a broad white band and thorny branches. A suitable method for large-scale production is cutting of culms at ground level at the time of harvesting. Many small delicate shoots and new plants will grow around the original plant. It is mainly used as a construction material in Columbia, Peru, Costa Rica and Mexico.

19. *Melocanna baccifera* (Roxb.) Kurz.

Melocanna baccifera syn. *Melocanna bambusoides* is an evergreen arborescent bamboo with monopodial culms growing up to 20 meters with a diameter of 1.5 -5 cm. It is common in North eastern states such as Assam, Meghalaya, Manipur, Mizoram and Tripura. The flowering cycle in *Melocanna baccifera* is reported to be 60 years. It is unique among New World bamboos in its production of fruits that are large and fleshy. The fruit looks like an apple and there will be 6-8 seeds/kg. Seeds germinate with in 3-7 days. Seedlings can be transplanted when they are at three leaf stage to polybags/pots. The transplanted seedlings are kept in partial shade initially for a month and then to open beds. Seedlings have to be shifted after 3 months locally to avoid root penetration. Six month to 1-year-old seedlings can be used for plantation purpose. These bamboos are used for making agarbathis/incense sticks.

20. *Ochlandra scriptoria* (Dennst.) Fisch.

Ochlandra scriptoria is endemic to Western Ghats growing mostly on river banks. Culms are erect and may reach a height of 5 meters with a culm diameter of 2.5 cm. The internodes are approximately 45 cm long. Annual flowering may occur and the plants may die. Fruits are comparatively small, about 625 fruits weighing one kilogram. Seeds are viable for two months and can be sown in nursery beds filled with sand and soil mixture (Seethalakshmi, 1993). One-year-old seedlings can be used for planting. The species is used mainly in paper and pulp industry, making baskets, floats, rafts, bamboo boards, flutes, etc.

21*. Ochlandra travancorica* Benth. is common in South Kerala part of Western Ghats growing along the sides of rivers and streams. The culms are erect, 2-6 m high, grayish green, 2.5-5 cm in diameter. The nodes are swollen and internodes are 45-60 cm long. This species has been found to be efficient in soil conservation (Sujatha *et al*. 2002). Flowering is reported to be after 7 years. The fruits are large having a length 4.5- 5.1 cm, 45-57 numbers weighing one kilogram. The seeds are viable only for a period of 45 days (Seethalakshmi 1993). Vegetative propagation using culm cuttings has also been reported (Seethalakshmi etal. 1990). The species can be propagated by seeds and vegetative methods. Seeds are sown in nursery beds and seedlings are transplanted after one year. Vegetative propagation by tissue culture methods is also reported (Shaji Philip and Baby Chacko, 1996).

22. *Ochlandra travancorica* var. ***hirsuta*** Gamble.

Ochlandra travancorica var. *hirsuta* is endemic to the states of Kerala and Tamil Nadu, India. It is an erect, shrubby or arborescent, reed-

like, gregarious bamboo. Culms are 2-6 m high, grayish-green, rough, 2.5-5 cm diameter with swollen nodes and marked with base of fallen sheaths. The internodes are 45-60 cm long, with thin walls having a thickness of 2.5 mm. The culm sheaths are 20 cm long and longitudinally wrinkled and striated covered with golden bulbous hairs in the young stage. The fruit is large in size. One kilogram may contain 45 to 57 fresh fruits, depending up on the size. Fruit length in small, medium and big sized fruits may vary from 4.1 to 5.7 cm. The fruits are largest among the species of *Ochlandra* and come next to *Melocanna baccifera*. The moisture content of the fruits varies from 62 to 72 per cent. The seeds are found to be viable for 45 days. (Seethalakshmi, 1993).

Natural regeneration occurs from seeds and rhizomes. Soon after the fruits/seeds fall, they germinate and height growth is completed within two months. One year growth is sufficient for a culm to attain full size. The sprouting season is usually after pre-monsoon showers and during rainy season. Within a period of 6-8 years clumps attain full growth and may last for a period of 25 years.

O. travancorica var. *hirsuta* is usually propagated from seeds and by vegetative methods. Seeds are sown in partial shade in nursery beds filled with sand and soil mixture. Seedlings are transplanted after a period of one year. Rhizomes can be separated from the culms during the onset of monsoon and used for field planting. Reeds are ideal raw material for paper manufacture. Culms are used for mat and basket making, umbrella handles, fishing rods, handicraft and for making walls of huts. Leaves are used for thatching. The mats made from reeds are used for making 'Bamboo ply'.

23*. Oxytenanthera stocksii* (Munro) Naithani

Pseudoxytenanthera stocksii, a bamboo species, endemic to southern peninsular India, has been reported for the first time from Kerala. Typically the species grows from sea level to altitudes of 800 m. The culms may be 10 m tall, straight at the top, yellowish green and erect. *O. stocksii* is a useful medium-sized bamboo cultivated in Karnataka and vegetatively propagated. The present method is to use rhizomes, but trials are reported with stem cuttings. Cuttings with 2 nodes were prepared from the one-year-old culms and planted in seedbeds. Sprouting will start within 15-20 days, a root system may develop after 2 months, and culms after 8 months. Sporadic flowering has been reported. *Pseudoxytenanthera stocksii* is mainly suited for construction purposes, making furniture, ladders and supports.

24. *Teinostachyum dulloova* Gamble.

Teinostachyum dulloova is distributed in Bengal, Sikkim and some of the North-eastern regions of India. Culms are 6-9 meter tall with a diameter of 2.5-7.5 cm. having dark green colour and a few white hairs. The internode length may vary from 40 cm to 100 cm. Regeneration period is reported to be 15 years (Rao and Ramakrishnan, 1987). The culms are used for carrying water and for making umbrellas, baskets, mats, and boxes.

25.*Thyrsostachys oliveri* Gamble.

Thyrsostachys oliveri is a handsome, straight growing, moderate-sized bamboo with persistent culm-sheath and branching from node. It is native of Myanmar and cultivated in many parts of the country. The culms are 5-20 m tall, 5 cm in diameter, with whitish silky surface when young, green or yellowish at maturity. The flowering cycle has

been reported to be 48 years (Chaturvedi, 1988). The plants are vegetatively propagated through layering, branch cutting / culm cutting or offset planting. It is a very useful bamboo for the local people for making baskets, mat, thatching the roof, fishing rods, javelins, pole vault poles, modified poles with knives for plucking fruits, reinforcement for concrete slabs and handicrafts. Young shoots are commonly used in Thailand for edible purposes.

Depending on the species and experience gained from earlier programmes were tried in the present study also. The common methods tried include seedling production through seeds, production of propagules through offset cuttings, rooted cuttings, macro-proliferation techniques and tissue culture methods.

REVIEW OF LITERATURE

1. Propagation through Seeds

The information on different aspects of seed propagation is limited as many bamboos produce seeds after long time intervals. In general, bamboos produce one-seeded fruit, known as a caryopsis with thin pericarp close to the seed coat and covered with a number of persistent glumes. Orthodox and recalcitrant types of seeds are found in different genera of bamboo. Orthodox type tolerates desiccation and may be of Caryopsis or glans type. In *Melocanna* and reeds the fruits are sensitive to desiccation and are called bacca type of recalcitrant seeds. Depending on the species, the size and weight of seeds may vary. Seeds are generally small, grain-like and wheat-coloured; but those of *Melocanna baccifera* are onion-shaped, big and green coloured. Generally large-sized bamboos produce smaller seeds than small-sized bamboos (Anantachote 1988). Seed production per culm varies from 3~80g in *B. bambos*, and 40-90g in *Dendrocalamus longispathus*. One full grown clump of *Melocanna baccifera* produces 5-7 kg seeds. In general, the number of seeds per kg varies depending on the species (Banik 1987b, Liese 1985).

Seeds of different bamboo species possess embryos at their swollen stalk-ends which need to be buried in the soil during sowing to protect germinating radicles from being desiccated. Bamboo seeds germinate at higher percentage under shade than in direct sunlight. The germination media (soil and cowdung 3:1) should be wet, but not waterlogged. Seeds start germinating within 3-7 days of sowing and continue up to 15-25 days (Banik 1987b). Some bamboo species do not produce seed (e.g. *Bambusa balcooa*, *Bambusa vulgaris*) while others often flower at long intervals varying from 30 to 70 years (e.g.

Bambusa bambos, B. polymorpha, Dendrocalamus strictus and *Melocanna baccifea*). In many species of bamboos flowering may lead to the death of parent clumps, while in some cases the plants may rejuvenate and in some species a combination of both patterns are reported (e.g. *B. tulda, B. longispiculata*). Only in few species there is more frequent flowering and seed production (e.g. *Ochlandra* spp.). These flowering patterns mean that seed is rarely available for propagation, when it is needed. Also bamboo seeds tend to be relatively short-lived and difficult to store without sophisticated controlled drying and sealing in containers.

Reports show that storing the orthodox seeds of bamboos over calcium chloride with a moisture content of 10-11 % is ideal. The viability of seeds of *B. bambos* and *B. tulda* was extended by storing the seeds over calcium chloride at room temperature. Also by soaking and drying the seeds of *D. strictus* with low concentration of disodium hydrogen phosphate the germination and viability were found to improve (Sur *et al*. 1988). Varmah and Bahadur (1980) could also extend the viability of the seeds of *D. strictus* up to 34 months by reducing moisture content to 8% by storing over silica gel or anhydrous calcium chloride in a desiccator, or at 3-5^{o}C ambient temperature after reduction of its moisture content to 8 %. In *B. tulda,* Banik (1987b) was able to increase the seed longevity period up to 18 months by storing over silica gel in a desiccator. Efforts to prolong the viability of fleshy recalcitrant bamboo seeds by conventional storage methods were not promising. However the fleshy seeds of *M. baccifera*, when stored in an air-conditioned room, the viability was prolonged to 45 days, instead of 35 days in normal room conditions and when mixed with dry sand and stored in jute bags the

viability was prolonged up to 60 days. The seeds of *M. baccifera* can be carried with dry sand in jute bags during long distance transportation to minimise damage and to retain viability (Banik, 1991).

Seedlings grow well in partial shade compared to direct sunlight. The germinating plumules are very thin in *B. tulda* and thick in *M. baccifera*. Within 1-4 weeks, plumules elongate rapidly into stems bearing single leaves arising alternately. The stems of *B. tulda, B. longispathus,* and *B. polymorpha* are more or less woody in nature, but *M. baccifera* has a soft and succulent stem with vigorous growth. A rhizome system starts to develop in the seedling one or two months after germination. Roots and rhizomes of the seedlings may penetrate the neighbouring polythene bags of other seedlings in a nursery creating twisted roots and rhizomes of seedlings. Due to this, the roots and rhizomes are damaged at the time of transportation. Frequent shifting of seedlings from one bed to another may help in minimising the root rhizome intermingling. Seedlings need regular weeding and daily watering in the nursery.

2. Macro proliferation of seedlings

By utilising the inherent proliferating capacity of bamboos Banik (1987a) has developed a technique for multiplication of seedlings through the rhizome separation method known as macro-proliferation. He reported that 5-9 month old seedlings of *B. tulda* can be multiplied 3-5 times in number through this technique. Every year the seedling can be multiplied at the same rate, keeping a stock for future macro proliferation. The survival rate of these multiplied seedlings is 90-100%. It has also been observed that seedlings of *B. bambos, B.*

tulda, and *D. strictus* raised in big-sized polythene bags (15x23cm) produced a higher number of shoots (6-8 number) within one year than in small sized bags (10x15cm). Later, Adarsh Kumar et al. (1988) also used this method successfully for multiplication of the seedlings of *B. bambos*, *D. strictus*, and *D. hamiltonii.* Advantages of this method are that once seedlings of a bamboo are available, the process can be continued for a couple of years. Proliferated seedlings remain small in size due to continuous rhizome separation, thereby making it easy to handle and transport (Banik 1987a, Tewari 1992). When seeds are ripe after collecting the seedlings have to be raised in nurseries or polybags containing soil: cow dung (3:1) mixture. Usually the clump forming species may produce sufficient young shoots over a period of 150–270 days and they are ready for multiplication. Soil is washed from the root and rhizome portion and the old roots are trimmed. The rhizome is cut into pieces, each replanted, hardened under shade for 3–5 days and well watered. Thereafter the transplanted pieces are brought to the nursery bed under sun. It is noticed that while proliferation, at least two shoots should be maintained in the newly proliferated seedling or else it may die or will not grow properly. A seedling can be multiplied in this way in any month of the year and as the seedling pieces develop they can be used as original seedlings. Once seedlings are available the process can be continued for a number of years. Proliferated seedlings are small, hence easy to handle and transport. Finally, a small initial stock can produce large numbers of plants. The only disadvantage would be if the propagation is continued for many years the later multiplied plants might approach the physiological maturity/flowering.

3. Vegetative propagation

Rhizome and offset planting: Over the centuries, villagers used to plant bamboos by dividing up clumps and their underground stems or cutting up the underground stems (rhizomes). Conventional methods of bamboo propagation are based on three morphological parts viz: the aerial culm, underground rhizome and root. Due to the scarcity of seeds, bamboo is generally propagated by vegetative methods. Clump division is a traditional method and is generally done in two ways - offset planting and rhizome planting. An offset is the lower part of a single culm (usually with 3–5 nodes i.e. about 1–2.5 m) with the rhizome axis basal to it and its roots. Planting of these is the most conventional way of propagating bamboo. The culm, which is between 1 and 2 year old is cut with a slanting cut and the rhizome to which it is attached is dug up and cut off to a suitable length to include well developed buds. Offsets of *Bambusa balcooa*, *B. tulda*, *B. vulgaris*, *D. longispathus* and *M. baccifera* can be planted in April and June. Rhizome planting is generally used for non-clump forming species. The culms are cut to about 1-m high and planted during the rainy season. Planting of rhizomes have advantage over offsets, being lighter and less bulky. But, offsets are physiologically more suitable for plantations as they have some foliage.

Layering: Different types of layering are used for bamboos. Of the three types in simple layering either a whole culm or a branch bearing part of it is bent down to a shallow trench on the ground, fastened in place by means of hooked or crossed stakes, and covering it with suitable propagating medium. Similarly in stump layering the 1-2 node stumps of severed culms are covered with a suitable propagating medium and allowed to root.

Culm / branch cuttings: Propagation of bamboos through culm-or stem-cutting needs culm segments of 1, or 2-3 nodes bearing healthy buds or branches. The branches on each culm segment are generally pruned to a length of less than 25cm and no foliage is retained. Such cuttings are usually set upright or at an angle, with at least one node well covered. This method was common for propagating 1or 2-noded culm cuttings of *D. strictus*. Improvements to this method were done by Dabral (1950), Sharma and Kaushal (1985). Further work on culm cutting methods gave good success and survival rates for *B. nutans* and *B. tulda.* (Bohidar 1989, Stapleton 1987). By the application of growth regulators (IBA and NAA) Surendran and Seethalakshmi (1985) were able to induce better rooting and sprouting in *B. arundinacea*, *D. strictus*, *B. balcooa* and *Ochlandra scriptoria.* Das (1988) had obtained good results by using single noded culm cuttings of *Bambusa balcooa*, *B. nutans*, *Dendrocalamus hamiltonii*, and *Oxytenanthera nigrociliata*. Two nodded cuttings of several bamboo species were found suitable for root induction (Vivekanandan, 1987).

Effect of growth regulators in enhancing the rooting response of bamboo is well known. Uchimura (1977) found that, of the three growth regulators (IAA, IBA and NAA), cuttings treated with 100 ppm IBA for 24 hours gave better rooting percentage and formation of longer roots in *B. vulgaris*. Palijon (1983) reported that cuttings treated with rooting hormones were higher in shoot production and the shoots were taller and wider in diameter than those of untreated cuttings, but there was no difference in survival rate at field level between them. The starch content and the levels of various nutrients in the cuttings have influenced the rooting. Joseph (1958) found high amount of starch content in culm cuttings of *B. bambos* (*B.*

arundinacea) during February and March. Banik (1987a) emphasised that preparation of culm segments in the month of April-May from the mid-zone of a young culm was critical for obtaining successful results in *B. vulgaris*, *B. balcooa*, *B. tulda*, *Dendrocalamus giganteus*, *D. longispathus* and *Melocanna baccifera.*

In many bamboo species branch cuttings could be rooted under mist tents (Hasan, 1977). Artificial rhizome induction was possible by chopping the culm tops and removal of newly emerging culm (Banik 1980). Such pre-rooted and pre-rhizomed branch cuttings performed better than normal branch cuttings. These cuttings have to be collected through excising the branch base from the nodes of the standing culms during April to June. For activating the aerial roots and rhizome, branch cuttings are to be inserted to a depth of 7cm in sand and to be maintained under misting for one month. In each layer, clean sand is placed so that the bed remains well-drained. Within 30 days, each of the pre-rooted and pre-rhizomed branch cuttings produce profuse active roots in the propagation bed. Once profusely rooted, the cuttings are transferred to polythene bags and kept in the nursery. By using this method rooting and rhizome formation can be achieved in the branch cuttings *B. balcooa*, *B. nutans*, *B. polymorpha*, *B. vulgaris* and *D. giganteus* (Banik 1984, 1991).

MATERIALS AND METHODS

For vegetative propagation, usually culm segments are selected from the lower to mid zone. The upper part and the lateral branches of the upper portion of the culm are discarded. March to May is the best period for taking cuttings. The branches on the selected part of the culm are pruned to a length of 10–30 cm, without injuring the existing buds. A segment is cut with a sharp knife or saw keeping 5–10 cm on either side of the node, without splitting at the cut end. Water loss from cut ends by wrapping the cut segments with moist gunny bags and keeping them in shade. The cuttings are to transported to the to the propagation bed as quickly as possible. Depending up on the length of the internodes the segment may be 1–2 or 3 noded. If the cuttings are two or more noded, approximately 2 cm long and 1 cm wide opening is made in the centre of the internode. A rooting hormone solution is poured into the segment cavity and the holes are closed by wrapping and tying with a polythene strip. Hormone solution may be NAA 200 mg/l or 200 ppm. This is prepared by dissolving 2 g of NAA (1-Naphthaleneaceticacid), in 20 ml 90% ethyl alcohol by stirring. By adding distilled water, this can be made up to 10 litres. Normally 50-100 ml solution will be sufficient for filling the cavity. Hence 10 litre of the solution can be used for treating 100–200 cuttings.

Propagation beds (1x 10m) are built on level ground and should be 20–30 cm deep. At the base, medium to coarse sand should be laid for 10–15 cm. Over that a top layer of fine sand should be laid for 10–15 cm. Waterlogging can be avoided by making this type of three-layered bed. Culm cuttings are placed horizontally in the bed, spaced 15–30 cm apart. The cuttings are placed in the top fine sand layer about 3–5

cm above the coarse sand and covered by 3–6 cm of the fine sand. The bed is misted or manually kept moist by providing partial shade. Most of the thick-walled bamboo species respond to vegetative propagation techniques. Thin-walled species are usually difficult to propagate by the conventional methods. There is no universal and effective method of vegetative propagation for all the bamboo species. It is also true that there is an optimum age for rooting in each type of propagating material (rhizome, offset, culm segment, branch cuttings, etc.). Propagation methods commonly used for various species in different countries are given in Table 1.

Polythene bags of various size are used for potting the bamboo cuttings depending on the nature of the cutting and the species. Usually for planting rooted portion of the culm cutting, polybags of size 10 x 15 cm with a thickness of 0.06 mm are used. In some cases bigger ones (15x23, 40x50 cm) are also used depending up on the size of the rooted cutting. The bags may be black or transparent. As the bamboo cuttings raised are potted during August to September, it may not be possible to transplant them to the field in the same season and have to be kept for 2–3 months to produce well-developed rhizome. A one meter wide lengthy polythene sheet with thickness of 0.1 mm may be placed on the bed before arranging the seedlings so that the roots do not penetrate into the soil. The cuttings in polybags should first be placed for a week under partial shade, after that, gradually exposed to full sunlight. Generally the survival percentage of branch cuttings, culm cuttings and macro proliferated seedlings ishigher than those of offset and rhizomes. The size (height and diameter) of the fully grown culms produced from offsets, rhizome and

culm cuttings is comparatively greater in the first year of plantation than those produced from branch cuttings.

Table1. Propagation methods commonly used for different bamboo species

Sl. No.	Species	Seedlings	Macro Proliferation	Culm Cuttings	Layering	Branch cuttings	Offset / Rhizome	Tissue culture
1.	*Bambusa balcooa*		√	√		√	√	√
2.	*Bambusa bambos*	√		√			√	√
3.	*Bambusa nutans*		√	√		√	√	
4.	*Bambusa polymorpha*	√		√		√	√	
5.	*Bambusa tulda*	√	√	√			√	√
6.	*Bambusa vulgaris* (green)			√	√	√	√	√
7.	*Bambusa vulgaris* var *striata*			√	√	√	√	√
8.	*Bambusa wamin*		√	√			√	
9.	*Dendrocalamus asper*		√	√				√
10.	*Dendrocalamus brandisii*	√		√		√	√	√
11.	*Dendrocalamus giganteus*			√	√	√	√	√
12.	*Dendrocalamus hamiltonii*	√	√	√			√	
13.	*Dendrocalamus longispathus*	√	√	√			√	
14.	*Dendrocalamus sikkimensis,*	√		√			√	
15.	*Dendrocalamus stocksii*	√		√			√	
16.	*Dendrocalamus strictus*	√	√	√		√	√	√
17.	*Guadua angustifolia*	√	√	√			√	
18.	*Gigantochloa atroviolacea*			√			√	
19.	*Melocanna baccifera*	√					√	√
20.	*Ochlandra scriptoria*	√		√			√	
21.	*Ochlandra travancorica*	√		√			√	√
22.	*Ochlandra travancorica* var.*hirsuta*	√		√			√	
23.	*Oxytenanthera nigrociliata*	√	√					√
24.	*Teinostachyum dulloova*	√	√	√			√	
25.	*Thyrsostachys oliverii*		√	√			√	

Details of nursery sites

This project envisaged production of about one lakh planting stock of selected species and supply of the same for establishing plantation in the private and public sector. Planting stock production of 25 species occurring in the country were done by establishing Nursery sites at Field Research Centre, Veluppadam and KFRI main campus, Peechi. Four different nursery sites with 33 beds were

maintained for vegetative propagation of bamboos at FRC Veluppadam and provided with 50 percent shade. After potting, the plants were kept over polythene sheet. For sowing fruits of *Ochlandra travancorica* var. *hirsuta* raised beds were prepared at Peechi and Veluppadam. At Peechi two sites were maintained mainly for vegetative propagation of *Bambusa balcooa*, *Thyrsostachys oliveri,* sowing seeds of *O.travancorica*, *Bambusa bambos* and for proliferating seedlings of *O.nigrociliata*, *D. asper* etc. Temporary nurseries at Akathethara, Palakkad and Kozhikode were also made use of for potting and keeping *O.travancorica* plants.

Nursery bed preparation

Thirty-three beds with a length of 10 x 1 m were prepared. The upper layer of beds was filled with sand and provided with 50 percent shade. The sides of the beds were paved with bricks or concrete slabs.

Source of mother plants

The mother plants used for vegetative propagation were mainly from the identified clumps near the bambusetum, Field Research Centre, Veluppadam. Fruits of *Ochlandra travancorica* var *hirsuta* were collected from the natural stands of Mankulam Forest Division. Similarly seeds of *Dendrocalamus hamiltonii* and *D.brandisii* were procured from Karnataka and that of *Bambusa bambos* from Wayanad, Kerala. Fruits of *Ochlandra scriptoria* were collected from the Bambusetum itself, when the clumps flowered. Seedlings of *Melocanna baccifera* were of Tripura origin.

Methods of production of planting stock

i). Seedlings - In the nurseries seedlings of *Bambusa bambos*, *Bambusa tulda, Dendrocalamus hamiltonii, D. strictus*, *Melocanna baccifera* and *Ochlandra travancorica* were raised in beds and potted

in polythene bags. The seeds of *B.bambos* and *D. strictus* were of Wayanad origin and showed 90 percent germination. Macroproliferation of seedlings of *Bambusa tulda* was conducted by splitting the rhizome portion with at least two shoots. Macroproliferation was repeated for *Bambusa tulda.* Fruits of *Melocanna baccifera* were brought from North Eastern region. In the case of *Ochlandra travancorica* var. *hirsuta* 50000 fruits/seeds were procured from Mankulam Forest Range Adimaly, Kerala and sown in raised beds. The seeds were graded as they showed variation in size. Within a week about 50% percent of the seeds germinated. The seedlings grew faster and top portion was chopped before potting to avoid swaying. Casualty was high by the end of October. In the case of *Bambusa bambos* seeds were purchased Kerala Forest Seed Centre and sown at Peechi and Veluppadam. The seedlings were potted during the month of October. Seeds of *Dendrocalamus brandisii* were procured from Karnataka, but the germination percentage was found to be poor. Seedlings of *Ochlandra scriptoria* were raised from the seeds and also from naturally germinated plants growing in the Bambusetum. 500 seedlings of *Dendrocalamus hamiltoni*, 200 seedlings of *D. strictus*, 1500 seedlings of *Oxytenanthera nigrociliata* (*Gigantochloa rostrata*) were also subjected to repeated macro proliferation.

ii). Culm cuttings **-** Vegetative propagation of *Bambusa vulgaris* (green), *Bambusa vulgaris* var *striata* (yellow), *Dendrocalamus brandisii, Dendrocalamus giganteus, D. longispathus, D. stocksii, D. sikkimensis, Gigantochloa atroviolacea, Bambusa balcooa* and *Thyrsostachys oliveri* were carried out by treating culm cuttings with growth regulating substances (GRS) viz. Naphthalene Acetic Acid

(NAA) and Indole Buteric Acid (IBA) in February and March 2009. One to two year old culms of different species were selected and 2 -3 noded cuttings filled with 50 ml of GRS solution were planted in soil. Regular watering was done in the morning and evening. Observation of sprouting and rooting of different species was carried out. After 3 months, the rooted cuttings were uprooted, detached from the culm and potted in polybags. In the case *B. polymorpha* and *Thyrsostachys oliveri* only very small percentage of rooting was observed. For *T. oliveri* only the basal portions of the culms were rooted.

iii). Tissue culture - Tissue culture plants of *Bambusa balcooa* which were showing comparatively good growth were macroproliferated and kept in the nursery. Tissue culture plants of *Dendrocalamus asper* were also multiplied by this method.

RESULTS AND DISCUSSION

Planting stock production

1. *Bambusa balcooa* Roxb.

Two types of propagation methods were used: tissue culture and rooting of culm cuttings. About 1000 plants were produced by tissue culture. The plantlets were grown and then multiplied by macro-proliferation after one year. By macro-proliferation 2-3 plants were got from single plantlet.

Vegetative propagation of 1-2 year old culms of *B. balcooa* was also done during the month of April. Two-noded cuttings, filled with 50 ml of NAA -250 ppm solution were used for root induction. The cuttings were planted horizontally in beds filled with sand and watered daily in the morning and evening. The beds were provided with 50% shade. Sprouting and rooting was good. Rooting started within 30-40 days. A total of 3016 plants were produced, 350 plants were supplied and 2586 plants were kept in the nursery for proliferation and distribution (Fig.1).

2. *Bambusa bambos* (L.) Voss.

Fresh seeds of *Bambusa bambos*, flowered at Pulpally, Wayanad Forest Division, in 2008 were procured through Kerala Forest Seed Centre and sown in trays filled with sand. Seeds sown in trays filled with sand gave 80-85 % germination within a period of 8 to 14 days. Wet polyurethane foam sheet was also used for germinating seeds. The seedlings were transplanted after one month to polythene bags filled with soil, sand, cowdung mixture. The seedlings were supplied with small quantities of cowdung solution at the base (300gm/litre). A total

of 10924 seedlings were potted. 1300 seedlings were supplied to various farmers. The seedlings were used for planting mainly along the boundary of rubber plantations, fencing and research purpose (Fig.2).

3. *Bambusa nutans* Wall. ex Munro

Propagation trials conducted with culm cuttings have shown the possibility of rooting 3-noded culm cuttings from base and middle portions of one-year-old culms. Trials with culm cuttings have shown 38 per cent of rooting under controlled conditions. Offsets are also used as a planting material. The culm is good, strong, straight and used locally for various purposes, mainly as poles. Flowering cycle is reported to be 35 years. One-two year old culms were taken from *B. nutans* culms during the month of April. Two noded cuttings, prepared from the culms were filled with 50 ml of NAA-150 ppm solution and tied with a polythene strip. The cuttings were planted horizontally in beds filled with sand and watered daily in the morning and evening. The beds were provided with 50% shade. Sprouting occured within 8 to 15 days and rooting by 20 to 30 days. Only 6 plants were produced and supplied (Fig.3).

4. *Bambusa polymorpha* Munro.

Seedlings of *Bambusa polymorpha* were produced by vegetative propagation. Vegetative propagation trials were carried out with 388 two noded cuttings treated with NAA 200 ppm and planted horizontanlly in beds. This included 172 basal, 101 middle and 115 top portion of the culms. Cuttings began to sprout within 20 to 30 days. The middle and top portion were found to show more response to rooting. Comparatively this is a difficult-to-root species. After three months, the cuttings were uprooted and checked for rooting. 36 rooted

plants were found to be rooted and potted, but many of them did not survive. Out of the 36 plants produced only 6 plants survived and were distributed (Fig.4).

5. *Bambusa tulda* Roxb.

Seedlings of *Bambusa tulda* raised from seeds were used for macro proliferation. Ten-month-old seedlings were maintained well by supplying dilute cowdung solution at monthly interval. The seedlings having 6- 8 shoots were washed with water, the rhizome portion having one old and one new shoot was split with a secature to split and potted in polybags filled with potting mixture. The plants are kept in 50% shade for two weeks for hardening. Proper watering was done in the morning and evening. A total of 9076 seedlings were raised by way of repeated macro-proliferation and 3732 seedlings were supplied to various farmers (Fig.5).

6. *Bambusa vulgaris* Schrad ex Wendl. (Green)

During the month of April, 1-2 year old culms were cut and made into 2-noded cuttings, filled with 50 ml of NAA -150 ppm solution and tied with a polythene strip. The cuttings were planted horizontally in beds filled with sand and watered daily in the morning and evening. The beds were provided with 50% shade. Within 8-15 days most of the cuttings sprouted. Sprouting and rooting was good (76.8%) for basal, middle and top portions. Rooting started within 30-40 days. Potting was done after two months. About 2084 plants were produced and 725 plants were distributed. About 1000 plants were kept in the nurseries, 100 with rhizomes in beds (Fig.6).

7. *Bambusa vulgaris* Sch. ex Wend. var. ***striata*** (Lodd.) Gamble.

In KFRI, during the month of April, 1-2 year old culms were made into 2-noded cuttings, filled with 50 ml of NAA -150 ppm solution and tied with a polythene strip. The cuttings were planted horizontally in beds filled with sand and watered daily in the morning and evening . The beds were provided with 50% shade. Sprouting started within 8-15 days and rooting occurred between 20-25 days. About 5500 plants were produced and 2490 plants were distributed. About 900 plants were kept in the nursery and 100 with rhizomes in beds. This species is easy to root and thrives well in coastal areas, the species was given for various agencies (Fig.7).

8. *Bambusa wamin* Camus.

Plants of *Bambusa wamin* were produced by vegetative propagation. Branch cuttings were also used for vegetative propagation by resorting to overnight dip method. Trials with 223 two noded cuttings treated with 50 ml of NAA 200 ppm and planted horizontanlly in beds. This included 72 basal, 87 middle and 64 top portions of the culms. Sprouting started within 12 to 20 days and rooting after 30 days. After three months, the cuttings were uprooted and 204 rooted plants were potted but some of them did not survive. Out of the 204 plants produced, 148 plants survived, 56 plants were distributed (Fig.8).

9. *Dendrocalamus asper* (Schult.f.) Back.ex Heyne

Seedlings of *D. asper* produced by tissue culture method were grown for one year and macro-proliferated. For enhancing growth cowdung slurry was applied to the seedlings every month. From one seedling 2-3 propagules with shoot, root and rhizome can be separated using a secature and potted in polybags filled with soil, sand and cowdung

mixture. The propagules have to be kept in shade and water regularly. 2500 plants were produced and 2200 plants were distributed (Fig.9).

10. *Dendrocalamus brandisii* (Munro) Kurz

In KFRI vegetative propagation of *Dendrocalamus brandisii* were done during the month of March. 1-2 year-old culm cuttings were taken during the month of March, and 2-noded cuttings were prepared, filled with 50 ml of NAA-250 ppm solution and tied with a polythene strip. As many as 118 two noded culm cuttings were planted horizontally in beds filled with sand and watered daily in the morning and evening. The beds were provided with 50% shade. Sprouting occurred within 12 to 25 days and rooting by 30 to 40 days. The rooted cuttings were separated and poly-potted after 3 months. 840 plants were produced and 548 plants were supplied to farmers (Fig.10).

11. *Dendrocalamus giganteus* Munro.

cuttings were taken from 1-2-year-old culms of *Dendrocalamus giganteus* during the month of March. Two noded cuttings, filled with 50 ml of IBA -250 ppm solution and tied with a polythene strip. About 232 numbers of culm cuttings were planted horizontally in beds filled with sand and watered daily in the morning and evening. The beds were provided with 50% shade. The top portions of the culms were found to be more effective in rooting. Sprouting occurerd within 12 to 20 days and rooting by 30 to 40 days. After one month the sprouts showed wilting and foliar spray of Indofil-M45 (5ml/l) was given. The rooted cuttings were separated and poly-potted after 3 months. Nearly 637 plants were potted and 160 plants were supplied. Seeds were collected from a clump growing in Kottayam District, but they failed to germinate (Fig.11).

12*. Dendrocalamus hamiltonii* Arn. ex Munro

Seedlings of *Dendrocalamus hamiltonii* raised from seeds, were used for macro-proliferation. Six-month-old seedlings were maintained well by supplying light cowdung solution at monthly interval. The seedlings were macro-proliferated and maintained in the nursery. The plants are kept in 50% shade for two weeks for hardening. Proper watering is done in the morning and evening. A total of 795 seedlings were raised by way of macro proliferation and 286 seedlings were supplied to various farmers (Fig.12).

13. *Dendrocalamus longispathus* Kurz.

Plants of *Dendrocalamus longispathus* were produced by vegetative propagation. Trials with 440 two-noded cuttings treated with 50 ml of NAA 200 ppm and planted horizontanlly in beds. This included 120 basal, 121 middle and 112 top portion of the culms. Sprouting started within 12 to 20 days and rooting after 25 days. After three months the cuttings were uprooted and potted in polythene bags filled with soil, sand and cowdung mixture. Out of the 254 plants produced, 133 plants were supplied while 56 plants met with casualty (Fig.13).

14. *Dendrocalamus sikkimensis* Gamble.

Planting stock of *Dendrocalamus sikkimensis* was produced by vegetative propagation. Trials were conducted with 350 two-noded cuttings treated with 50 ml of NAA 200 ppm and planted horizontanlly in beds. This included 139 basal, 102 middle and 109 top portion of the culms. Sprouting started within 15 to 20 days and rooting after 30 days. After one month a fungicide spray was done to control decay. After three months the cuttings were uprooted and potted in polythene bags filled with soil, sand and cowdung mixture. Out of the 188

plants produced, 83 plants were supplied while 103 plants met with casualty. Two plants are available in the nursery (Fig.14).

15. *Dendrocalamus strictus* (Roxb.) Nees

Seeds collected from Wayanad, Kerala were sown in trays and poly-potted after 45 days. The seedlings were maintained well by supplying dilute cowdung solution at monthly interval. After 8 months the seedlings having 4- 6 shoots were taken out with the rhizome portion and using a secature split into 3 propagules having at least one old and one new shoot and potted in polybags containing potting mixture. The plants were kept in 50% shade for two weeks for hardening. Proper watering was done in the morning and evening. A total of 589 seedlings were raised in this way and 302 seedlings were supplied to various farmers (Fig.15).

16. *Gigantochloa atroviolacea* Widjaja.

Seedlings of *Gigantochloa atroviolacea* were produced by vegetative propagation. Trials were conducted with two noded cuttings treated with 50 ml of NAA 200 ppm and planted horizontally in beds. After three months the cuttings were uprooted and potted in polythene bags filled with soil, sand and cowdung mixture. Out of the 75 plants produced, 55 plants were supplied while 20 plants met with casualty (Fig.16).

17. *Gigantochloa rostrata* Wong. Seeds of *Gigantochloa rostrta* (*Oxytenanthera nigrociliata* Munro) procured from Tripura were germinated in trays and potted in polybags filled with soil. One-year-old seedlings were macro-proliferated during March 2009. Out of the 2100 plants survived, 100 plants were distributed, 64 plants met with

casualty and the rest 1936 plants were kept in the nursery for macroproliferation (Fig.17).

18. *Guadua angustifolia* Kunth.

Out of the 50 seedlings received from Costa Rica, potted in Polythene bags, 18 were supplied and 32 are kept in the nursery. (Fig.18).

19. *Melocanna baccifera* (Roxb.) Kurz.

Seedlings of *Melocanna baccifera* raised in KFRI, from seeds, were kept separately for uprooting in the bed. One-year-old seedlings were maintained in the nursery. A few seedlings were given to farmers (Fig.19).

20. *Ochlandra scriptoria* (Dennst.) Fisch.

Germinated seedlings and ripe fruits of *O. scriptoria* were collected from the bambusetum at FRC Veluppdam during June, 2009 and potted in polybags. 18146 seedlings were bagged, 2538 were supplied and 1328 did not survive. 14280 seedlings are kept in the nursery (Fig.20).

21. *Ochlandra travancorica* Benth.

Seedlings of *Ochlandra travancorica* maintained in the nurseries of KFRI, were multiplied and kept separately for uprooting in the bed. Out of the 1701 plants produced, 806 were supplied to various agencies and 200 plants were left in the nursery. One-year-old seedlings were also maintained in the nursery (Fig.21).

22. *Ochlandra travancorica* var. ***hirsuta*** Gamble.

Fresh fruits of *O. travancorica* var. *hirsuta* were collected from Adimali, Mankulam Forest Division during June, 2009 and sown in raised beds. The seeds were of three classes: viz. large, medium and small, 60 seeds weighing 1 kilogram. The seeds were sown at Peechi, Veluppadam, Palakkad and Kozhikode. One-month-old seedlings were polypotted and kept in nursery after chopping the top leaves. Nearly 24,000 seedlings were bagged but casualty was very high after potting. Potting seems to be not good for *Ochlandra travancorica* var. *hirsuta* as the seedlings are big. For planting one-year-old seedlings, uprooted rhizome along with culms from the beds is reported to be better for establishing near river banks. About 8932 seedlings were given for river bank afforestation by various agencies (Fig.22).

23*. Oxytenanthera stocksii* (Munro) Naithani

In KFRI, planting stock production was done by vegetative propagation of culm cuttings. As the culms were solid, overnight dipping method (NAA 500 ppm) was followed for vegetative propagation of *Pseudoxytenanthera stocksii* during the month of March. As many as 127 culm cuttings were planted horizontally and 48 numbers began to sprout within 15 to 20 days. The culm cuttings were taken from top, middle and bottom portion, the bottom part responding better. Rooting was observed between 40 to 50 days. The rooted cuttings were potted after 2 months. Out of the 277 plants produced, 127 plants did not survive and 150 plants were supplied to various agencies. More plants are required for meeting the demand (Fig.23).

24. *Teinostachyum dulloova* Gamble.

Seeds received from Tripura were sown in trays and potted after 45 days. The germination percentage was 20-30 percent. As many as 1338 plants are potted in polythene bags and are kept in the nursery (Fig.24).

25.*Thyrsostachys oliveri* Gamble.

Offsets are used for getting propagules. Three saplings can be separated from one planted rhizome after a year. Basal portion of 1-2-year old culm cuttings were also used for vegetative propagation. Treatment of culm cuttings by cavity method either by filling with 50 ml of IBA-250 ppm or NAA-250 ppm may give rooting. But the rooting percentage is very low. Sprouting may occur within 12 to 25 days but rooting may take six to eight months. The beds may be provided with 50% shade. The basal portions of the culms with buds were found to be more effective in rooting. Cowdung slurry (3kg/ 10 liters of water) is added to the beds to improve growth and rooting. Rooted cuttings were separated and polypotted after one year. 50 plants were produced and supplied (Fig.25).

Distribution of Seedlings

According to the norms of Bamboo Technical Support Group the propagules of selected species raised using different methods are meant for free distribution. Even though much publicity was not given, people showed interest in raising plantations, growing in bamboos in homesteads, planting along the river banks, sea shore as a barrier against Tsunami, schools for growing different species, Forest Department for making bambusetum, researchers for studies etc.

1. Homestead planting

People showed more interest in commercial and ornamental species produced by rooting culm cuttings. There was high demand for *Thyrsostachys oliveri*, but enough planting material was not available due to poor rooting percentage. *Dendrocalamus giganteus* was also of high demand. There were not enough culms for treatment and rooting time also was more. Similarly most people wanted thornless bamboos and bamboos having thick culms to plant in their homesteads. Individuals from different parts of the State came to collect seedlings for planting in their homesteads. In some cases farmers wanted to plant bamboo as a permanent crop in the agricultural lands to overcome the high labour costs existing in Kerala. A few requests to protect landscapes of certain individuals were not taken up as we were not able to spare workers for planting.

2. Riverbank afforestation programme

Various NGO groups showed interest to plant bamboo to afforest river banks. Nearly 750 seedlings of various bamboo species were provided to Ms. Save Idukki Campaign, for Thodupuzha river bank afforestation programme. Seedlings provided included species like *Bambusa vulgaris*, *Bambusa tulda*, *Dendrocalamus asper*, *Ochalandra scriptoria* and *Ochlandra travancorica*. Two agencies from Calicut requested plants for distributing to various homesteads and took selected species.

3. Bamboo plantations

Seedlings were provided to raise plantations in the private sector. Details were collected before supplying plants to them. A proforma was also given to the farmers to get feed back after planting. The

details of individuals and planting material supplied are given in Table 2.

Table 2. Details of individuals and planting material supplied

Sl No	Name	Species supplied
1.	Dr.C.P. Biju Chirayath, Vandithavalam, Palakkad- Muthumala	*Bambusa tulda, B. asper, D.strctus*
2.	Mr. C.B. Anilkumar- Kavakkad, Palakkad	*Bambusa tulda, B. asper, D.strictus B. vulgaris, O.travancorica O.travancorica* var *hirsuta* and *D. giganteus*
3.	Mr N. Raveendran- Palakkad	*Bambusa tulda, B.vulgaris, D. asper, D.strictus* and *O. trvancorica*
4.	Mr. Jibi, P.O. - Palakkad	*Bambusa tulda, B.vulgaris, D. asper, D.strictus* and *O. trvancorica*
5.	Mr. U.N. Nandakumar, Palakkad	*B. vulgaris, B. vulgaris var. striata, Bambusa tulda, B. wamin, D.brandisii, D. asper, B.polymorpha, D.longispathus, D.sikkimensis, G.atroviolaceae, Melocanna, D.stocksii, T.oliveri. O.travancorica, D.stocksii, D.giganteus , D.strictus, D.hamltonii, O.travancorica O.travancorica* var *hirsuta, O.scriptoria*
6.	Mr Shanmugha Sundaram - Pollachi	*Bambusa tulda, B.vulgaris, D. asper*
7.	Mr. Granet from Kodakara	*Bambusa tulda, B.vulgaris, D. asper*
8.	Mr. Samuel from Kannur	*Bambusa tulda, B.vulgaris, D. asper*
9.	Mr V.P. Raveendran, Palakkad	*Bambusa bambos, B. tulda, D. asper, D.strictus* and *D.hamiltoniana*
10.	Mr. Tomy Thomas, Palakkad	*D. asper, D.strictus* and *D. giganteus*
11.	DFO, N.S.E Kalady	*O.travancorica, B. vulgaris, B. vulgaris var. striata, Bambusa bambos, B. tulda, D. asper, B.polymorpha, T.oliveri.*
12.	Mr. V.P. Raveendran	*Bambusa bambos, B. tulda, D. asper*
13.	Mr. C.J. John	*O.travancorica*
14.	Mr. Samed	*O.travancorica*
15.	Dr. V.J. Vijayan	*O.travancorica, B. vulgaris, B. vulgaris var. striata, Bambusa bambos, B. tulda, D. asper, B.polymorpha, T.oliveri.*
16.	DFO, Kozhikode	*B. vulgaris, B. vulgaris var. striata, Bambusa tulda, B. wamin, D.brandisii, D. asper, B.polymorpha, D.longispathus, D.sikkimensis, G.atroviolaceae, Melocanna, D.stocksii, T.oliveri. O.travancorica*
17.	Dr. K. Mohanadas, Irinjalakuda	*B. vulgaris, B. vulgaris var. striata, Bambusa tulda, B. wamin, D.brandisii, D. asper, B.polymorpha, D.longispathus, D.sikkimensis, G.atroviolaceae, Melocanna, D.stocksii, T.oliveri. O.travancorica, D.stocksii, D.giganteus, B.nutans D.strictus, D.hamltonii, O.travancorica O.travancorica* var *hirsuta, O.scriptoria*
18.	Sri. Joly Joseph, Pulayamparambil, Edamaruku, P.O. Kottayam	*B. vulgaris, Bambusa tulda, B. wamin, D.brandisii, D. asper, D.giganteus, D.hamltonii, O.travancorica, O.scriptoria*
19.	Sri. Rajan, K.R, Alwaye	*B. vulgaris, B. vulgaris var. striata, Bambusa tulda, B. wamin, D.brandisii, D. asper, B.polymorpha, D.longispathus, D.sikkimensis, G.atroviolaceae, Melocanna, D.stocksii, T.oliveri. O.travancorica, D.stocksii, D.giganteus , D.strictus, D.hamltonii, O.travancorica O.travancorica* var *hirsuta, O.scriptoria*
20.	Principal, Central School, Puranatukara, Thrissur	*B. vulgaris, B. vulgaris var. striata, Bambusa tulda, B. wamin, D.brandisii, D. asper, B.polymorpha, D.longispathus, D.sikkimensis, G.atroviolaceae, Melocanna, D.stocksii, T.oliveri. O.travancorica, D.stocksii, D.giganteus , D.strictus, D.hamltonii,*
21.	Mr. Davis Mathew, Kallarackal House, Thodupuzha	*Bambusa balcooa, Bbambos,Oxytenanthera nigrociliata,Ochlandra travancorica. var. hirsuta*
22.	The Secretary,Kadambari Jaiva Karshaka Samiti, Regd No : 345/04, Kattullamala, Cherukad 673527	*Bambusa balcooa, B bambos, Oxytenanthera nigrociliata, B vulgaris, B.tulda,Ochlandra travancorica. var. hirsuta, O. scriptoria Dendrocalamus strictus, D. asper*
23.	Babu V, Vachaparambil Changanachery, Kottayam	*Bambusa balcooa, Ochlandra travancorica. var. hirsuta, Oxytenanthera nigrociliata, Thyrsostachys oliverii*
24.	Jose Joseph Tharappel House, Kizhaparayar, P.O.,Palai	*Bambusa balcooa, Ochlandra travancorica. var. hirsuta, Oxytenanthera nigrociliata, Thyrsostachys oliverii, B.tulda, D. hamiltonii, D.asper*
25.	Sri. Suresh Manuel, Pottenkulam House, Kappadu,P.O., Kanjirappilly	*Bambusa balcooa, Ochlandra travancorica. var. hirsuta, Oxytenanthera nigrociliata, Thyrsostachys oliverii, B.tulda, D. hamiltonii, D.asper*

4. Bambusetum by Kerala Forest Department

The DFO, Kerala Forest Department was supplied with 840 plants belonging to 20 different species of bamboo for establishing a Bambusetum at Thamarassery, in Kozhikode district. Some of species like *Ochlandra travancorica*, *Bambusa vulgaris* etc. were also supplied to establish plots and to plant along the boundary.

5. Bamboo as a boundary barrier for security

Voluntary organisations and private parties showed much interest to plant bamboo along the boundary to protect their campus and rubber plantations. For planting at Defence Security Corps, Kannur, 250 seedlings were provided to make a natural barrier along the boundary of their campus. Mr. George Thomas from Kottayam was given 90 seedlings of 3 species for planting in his plot. Mr. Rajan from Alwaye showed interest to plant bamboo as a fencing around his rubber plantation. He was given 366 plants after verifying the plot. People were interested with high yielding bamboos like *D. giganteus* so as to get good yield at the time of felling.

6. Beautification in school compounds

Different schools and hospitals showed interest to beautify their campus with bamboos. At Kendriya Vidyalaya, Puranatukara, Thrissur 96 plants of 10 different species of bamboos were planted along the boundary wall. The planting was done after making a chart of the play ground boundary and planting selected species by envisaging a symmetry with their approximate height and beauty at the time of maturity. since the news appeared in the dailies, various schools and colleges approached KFRI for getting different species. Seedlings were

supplied after ensuring availability of facilities for watering the plants during the first year summer. Similarly 40 plants were supplied to Nirmalagiri College, Coimbatore and 125 plants to College of Agriculture, Maharashtra. Some schools reserved plants for planting during the coming year but were not able to plant.

Follow up actions and monitoring of plants supplied

An observation sheet was also given to the parties along with plants to report the survival of plants after 3 months. KFRI is being approached by farmers and other stakeholders to collect planting stock of various species. The demand for selected species is not met in many cases. Vegetatively propagated plants were in great demand and more number of plants have to be produced. As the demand for *Thyrsostachys oliveri, Dendrocalamus giganteus, Bambusa polymorpha, D. stocksii, D. brandisii* and *D. strictus* was high, more number of such seedlings have to be produced. The existing seedlings of rare species have also to be proliferated. Seeds of rare species have to be procured and seedlings have to be raised. The plants are maintained in the nurseries and proliferation is done in selected species in time.

Seedlings of *Bambusa bambos*, *Bambusa tulda, Dendrocalamus hamiltonii, D. strictus*, *Melocanna bambusoides, Ochlandra travancorica* and *O. scriptoria* were raised in beds and potted in polythene bags. Macroproliferation of seedlings of *Bambusa tulda* was conducted by splitting the rhizome portion with at least two shoots. About 9100 seedlings of *Bambusa tulda* were raised by this method. In the case of *Ochlandra travancorica* var. *hirsuta* 50000 seeds were procured from Mankulam Forest Range, Adimaly, Kerala and sown in raised beds. The seeds showed variation in size. Within a week about

50% percent of the seeds germinated. The growth of the seedlings was remarkably fast. The top portion were chopped before potting to avoid swaying. Even though precautions were taken, casuality was very high after transplanting into polybags. Out of the 24000 potted plants only 15700 plants survived after the monsoon. Seeds of *Bambusa bambos* were sown at Peechi and Veluppadam of which 6600 seedlingswere ready for potting in polybags. Eventhough seeds of *Dendrocalamus brandisii* were procured from Karnataka and sown in trays with treatment, germination was poor. Apart from the selected species, 12900 Seedlings of *Ochlandra scriptoria* were raised from the seeds collected from the Bambusetum. Through macroproliferation technique, from the available seedlings we were able to produce 1400 seedlings of *Dendrocalamus hamiltoni*, 950 seedlings of *D. strictus*, and 4136 seedlings of *Oxytenanthera nigrociliata* (New name - *Gigantochloa*).

Plants of eight species of bamboos were to be produced from culm cuttings. Vegetative propagation of *Bambusa vulgaris* (green), *Bambusa vulgaris* var *striata* (yellow), *Dendrocalamus brandisii*, *Dendrocalamus giganteus*, *D. longispathus*, *D. stocksii*, *D. sikkimensis*, *Gigantochloa atroviolacea*, *Bambusa balcooa* and *Thyrsostachys oliveri* was done by treating culm cuttings with growth regulators viz. Naphthalene Acetic Acid (NAA) and Indole Buteric Acid (IBA). We were able to produce 100 plants of *Bambusa balcooa*, 5200 plants of *B. vugaris* var. striata, 2284 plants of *B. vulgaris*, 254 plants of *Dendrocalamus brandisii,* 637 plants of *D. giganteus* and 50 plants of *Thyrsostachys oliveri*. In the case *B. polymorpha* and *Thyrsostachys oliveri* only very small percentage of rooting was observed. For *T. oliveri* only the basal portions rooted. Basal portion of the culm with

rhizome planted separately produced 4-6 new shoots and these shoots with rhizome were split and bagged after one year. Anyway in the case of culm cuttings also it may take more time to root.

By tissue culture method, propagation of two species was envisaged. From 1000 tissue cultured plants of *Bambusa balcooa* we were able to enhance the number to 2910. Six months to one year will be needed to have enough new shoots for proliferation. In the case of *D. asper* about 2250 plants were proliferated from the tissue cultured plants. The tissue cultured plants can be proliferated as in the case of seedlings raised from seeds. All the plants are showing comparatively good growth.

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Annexure-1

Details of production and supply of bamboo seedlings during the year 2008 - 2010 under BTSG project

	Bamboo Species	Number of seedlings			
a	**Seedlings**	**Produced**	**Supplied**	**Casuality**	**Balance as on 30-11-2010**
1.	*Bambusa bambos*	10924	1045	4919	4960
2.	*Bambusa tulda*	9076	3732	0	5344
3.	*Dendrocalamus hamiltonii*	795	286	181	328
4.	*Dendrocalamus strictus*	589	302	237	50
5.	*Melocanna bambusoides*	100	10	70	20
6.	*Ochlandra travancorica*	1069	806	63	200
7.	*Oxytenanthera nigrociliata*	2100	100	64	1936
8.	*Ochlandra travancorica* var.*hirsuta*	24000	8832	8304	6864
9.	*Ochlandra scriptoria*	18146	2538	1328	14280
10.	*Dendrocalamus brandisii*	254	0	0	254
11.	*Teinostachyum dulloova*	1338	0	0	1338
b	**Culm cuttings**				
12.	*Bambusa balcooa*	116	16	0	100
13.	*Bambusa striata*	5200	2490	1594	1116
14.	*Bambusa vulgaris-green*	2084	725	159	1200
15.	*Dendrocalamus brandisii*	840	548	292	0
16.	*Dendrocalamus giganteus*	637	160	477	0
17.	*Thyrsostachys oliveri*	50	30	15	5
18.	*Dendrocalamus. longispathus*	254	133	121	0
19.	*Psuedo-oxytenanthera stocksii*	277	150	127	0
20.	*Bambusa wamin*	204	148	56	0
21.	*Gigantochloa atroviolacea*	75	55	20	0
22.	*Dendrocalamus sikkimensis*	188	83	103	2
23.	*Bambusa polymorpha*	36	6	30	0
24.	*Bambusa nutans*	10	4	0	6
25.	*Guadua angustifolia*	50	18	0	32
c	**Tissue culture**				
26.	*Bambusa balcooa*	2910	300	124	2486
27.	*Dendrocalamus asper*	2248	1819	14	415

Fig.1. *Bambusa balcooa* - a-Clumps of *B.balcooa* growing in the campus, b- young plants of *B.balcooa,* c -cleaning of soil for splitting the rhizome, d,e, f, g- Macroproliferation of *B.balcooa* plants raised through tissue culture,.h- pruning roots and rhizome, i-potted plants

Fig.2. *Bambusa bambos* - a-Clump of *B.bambos* growing in the campus, b-seeds, c-seedlings

Fig.3. *Bambusa nutans* - a-Clump of *Bnutans* growing in the campus, b-potted plants of *B.nutans*

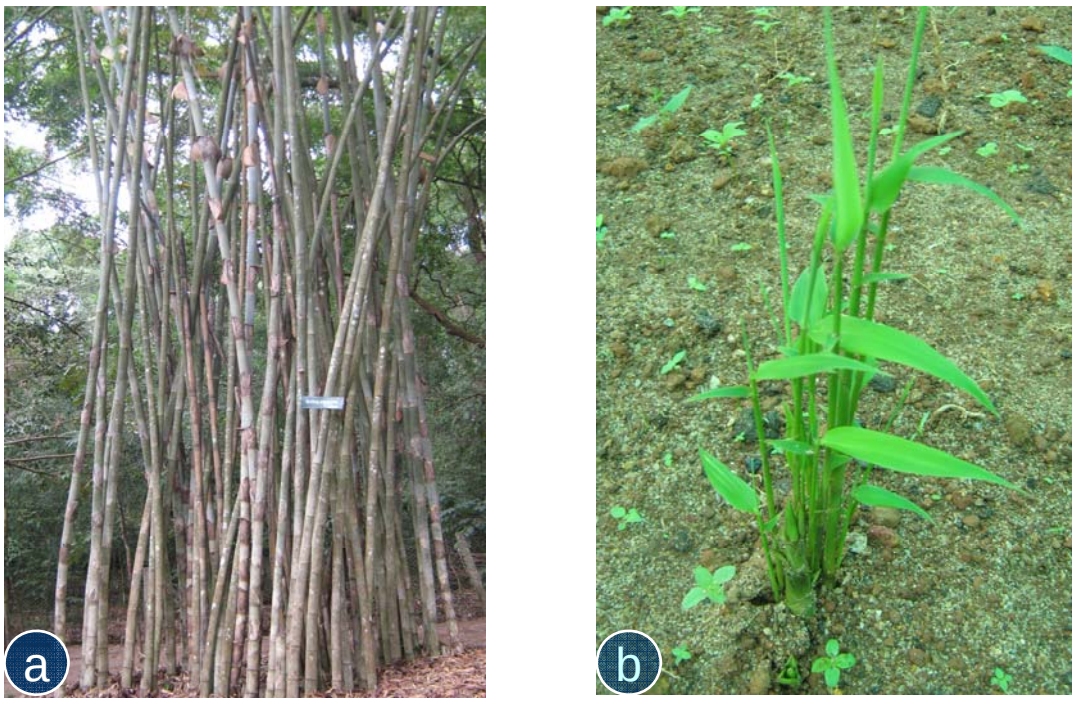

Fig-4. a- A clump of *Bambusa polymorpha* growing in KFRI campus, b- Sprouted cuttings of *B. polymorpaha*

Fig.5. *Bambusa tulda* - a-Clump of *B..tulda* growing in the campus, b-rooted plants of *B.tulda*

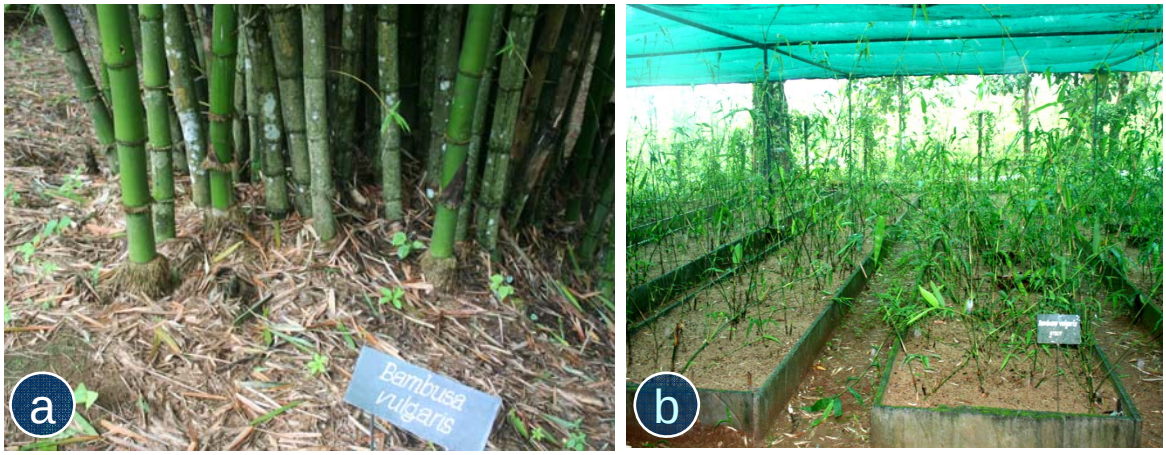

Fig.6. *Bambusa vulgaris (green)* - a-Clump of *B.vulgaris* growing in the campus, b-sprouted cuttings after one month of treatment, c-potted plants

Fig.7. *Bambusa vulgaris* var *striata (yellow)* - a-Clump of *B.vulgaris* var *striata* growing in the campus, b-sprouted cuttings after one month of treatment, c-potted plants

Fig-8. a-Clump of *Bambusa wamin,* b- Culm cuttings of *B.wamin* after sprouting in the nursery bed, c – Potted plants after rooting

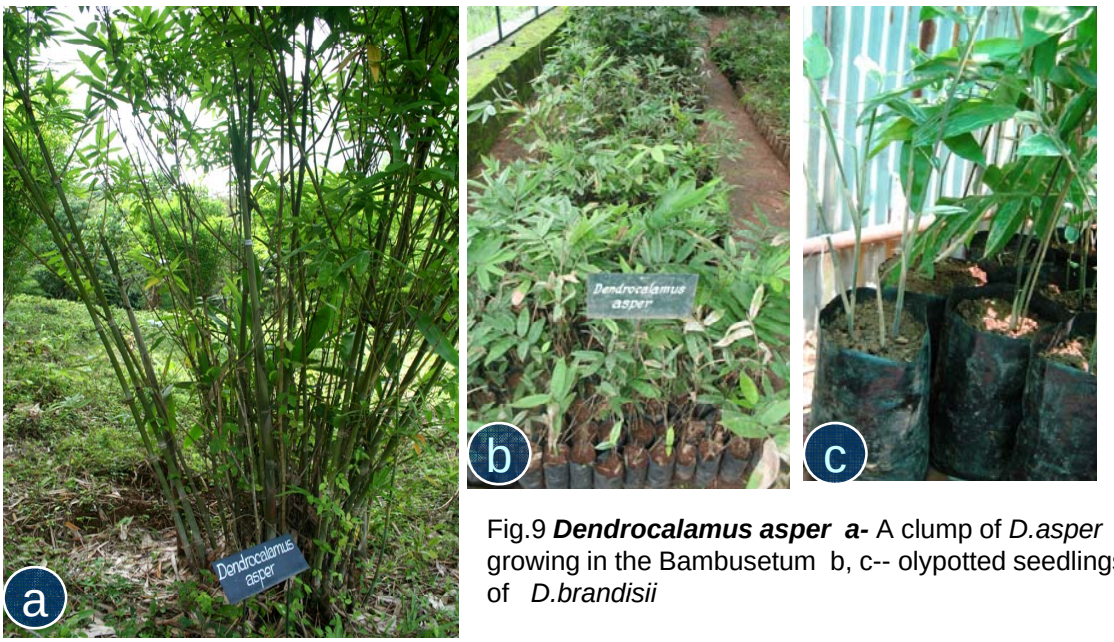

Fig.9 ***Dendrocalamus asper*** ***a-*** A clump of *D.asper* growing in the Bambusetum b, c-- olypotted seedlings of *D.brandisii*

Fig.10. ***Dendrocalamus brandisii*** a- Growing clump of *D.brandisii* , b-Seeds of *D.brandisii, c-Sprouted culm cuttings of D.brandisii in the beds* , d-Rooted culm cutting of *D.brandisii* ,e-Polypotted seedlings of *D.brandisii*

Fig.11. *Dendrocalamus giganteus* ***a-*** *Growing clumps of Dendrocalamus giganteus* in the Bambusetum b- seeds of *D.giganteus*, c-potted seedlings d- sprouted cuttings in the beds

Fig.12. *Dendrocalamus hamilttonii* ***a-*** *Growing clumps of Dendrocalamus hamiltonii* in the Bambusetum b- seeds of *D.hamiltonii*, c-potted seedlings

Fig-13. a-Clump of *Dendrocalamus longispathus,* b- Culm cuttings of D.*longispathus* after sprouting in the nursery bed

Fig-14. a-A clump of *Dendrocalamus sikkimensis* growing in the bambusetum, b-Culm cuttings of *B.wamin* after sprouting in the nursery bed

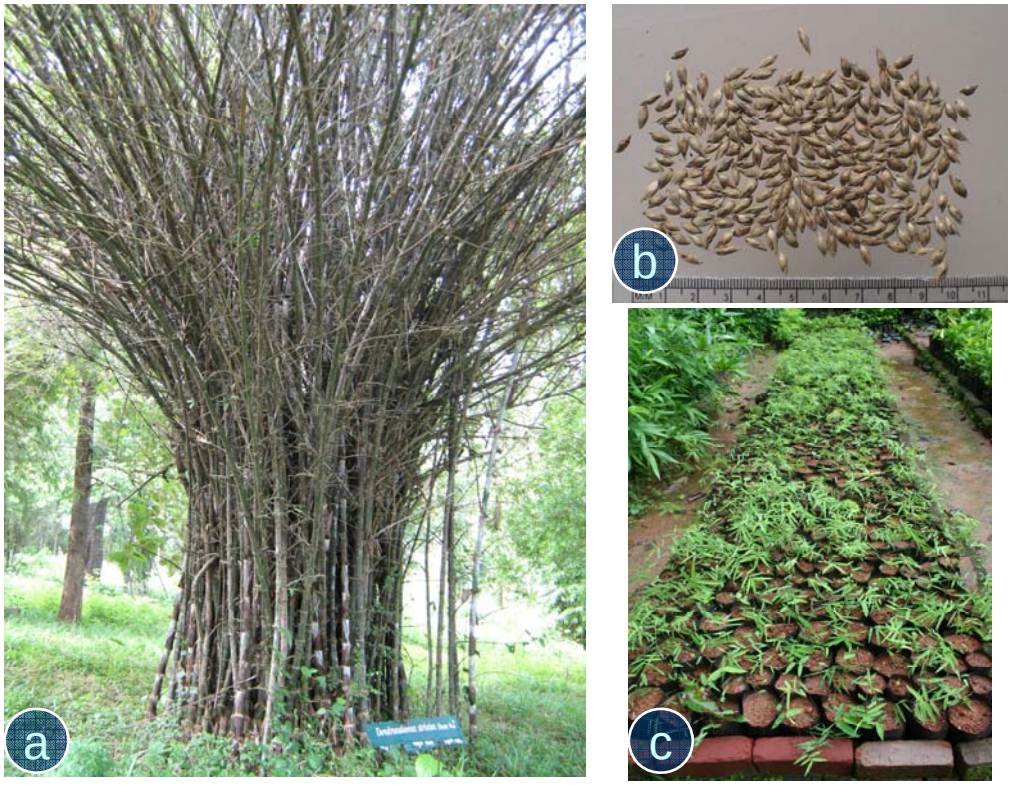

Fig.15. ***Dendrocalamus strictus - a*** *A growing clump of Dendrocalamus strictus* in the Bambusetum b- seeds of *D.strictus*, c-potted seedlings

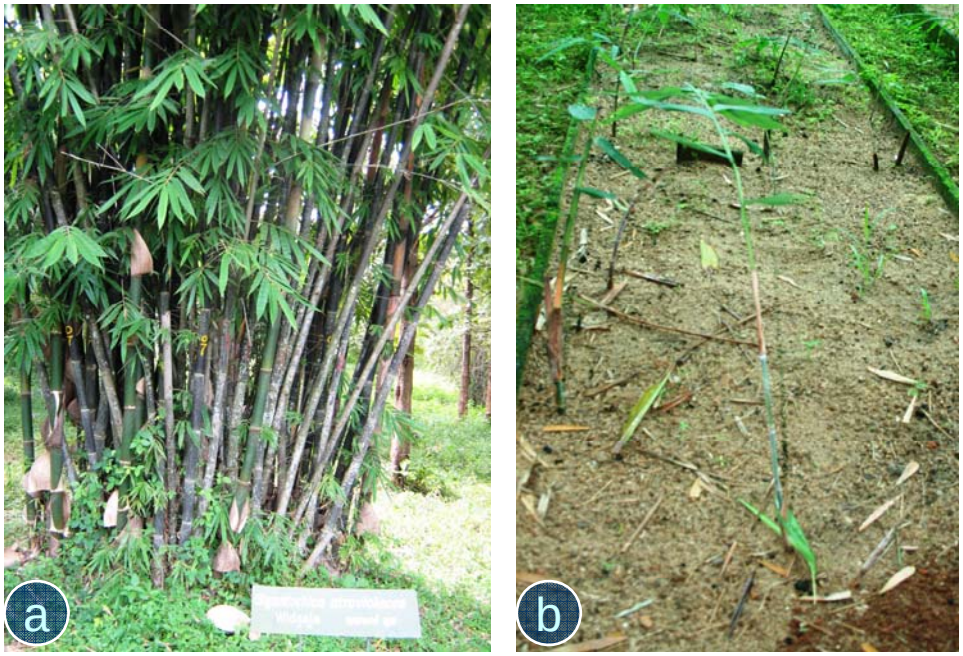

Fig-16. a-A clump of *Gigantochloa atroviolacea* growing in the bambusetum, b-Culm cuttings of *G.atroviolacea* after sprouting in the nursery bed

Fig-17. a-Seedlings of *Gigantochloa rostrata* , b-Macro-proliferated seedlings of *Gigantochloa rostrata*

Fig-18. a-Seedlings of *Guadua angustifolia* b- Macroproliferated seedling of *Guadua angustifolia*

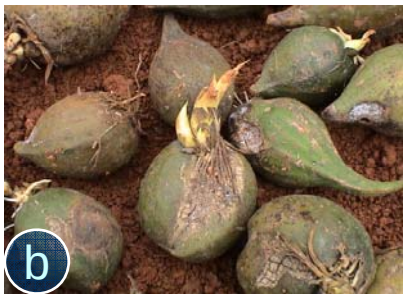

Fig.19. ***Melocanna baccifera* – a-** growing culms of *Melocanna baccifera* in the Bambusetum b- germinating fruits of *M. buccifera,* c-potted seedlings

Fig-20.a- A clump of *Ochlandra scriptoria* growing in the bambusetum, b- Potted seedlings of of *O.scriptoria,* – Natural regeneration

Fig-21. a- Clump of *Ochlandra travancorica,* b-Seedlings of *Ochlandra travancorica*

Fig-22. a-Growing clumps of *O.travancorica* var *hirsuta* with fruits, b- different size class of fruits of *O. travancorica*, c-Sowing fruits of *O. travancorica* in raised beds, d- Germinated seedlings of *O. travancorica* after 2 weeks

Fig-23. a-Clump of O*xytenanthera stocksii,* b-Sprouted cuttings of *Pseudoxytenanthera stocksii* in the nursery beds

Fig-24. a-A clump of *Teinostachyum dulloova* growing in the bambusetum , b-Seedling of *Teinostachyum dulloova*

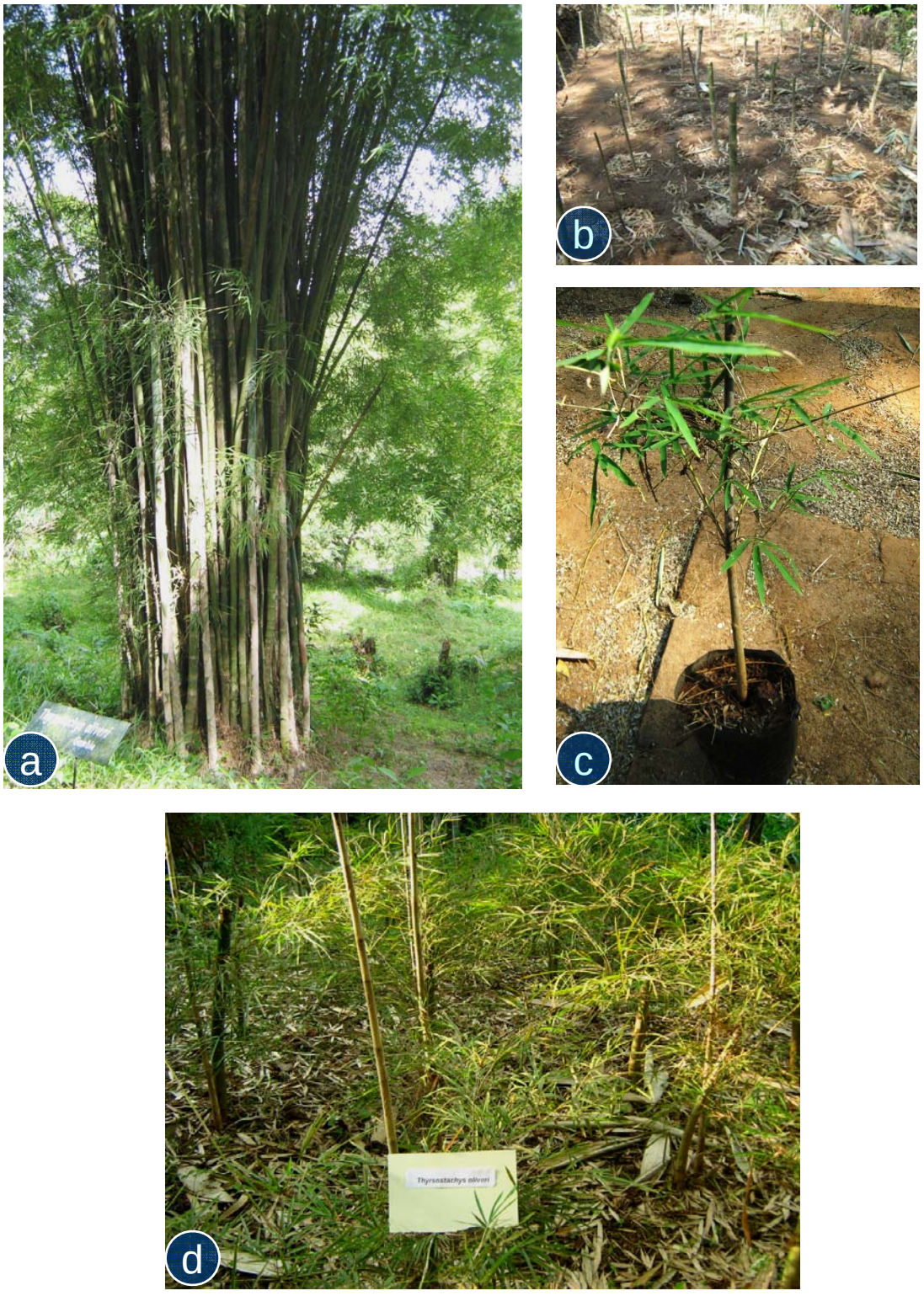

Fig-25. a-Clump of *Thyrsostachys oliveri,* b- Offsets of *T. oliveri* planted for getting new plants, c -Proliferated plants *of T. oliveri* potted d- Offset with new shoots ready for splitting .