ISSUES IN PRODUCTION OF BAMBOO PLANTING MATERIALS – LESSONS AND STRATEGIES

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Introduction

The major constraint for raising fairly large scale plantations of bamboo is the limited availability of quality planting materials of desired species. As bamboo flowers after long intervals, the availability of seeds and seedlings as planting materials is also uncertain. Further, knowledge on different aspects of seed propagation including storage is very limited. Often the information on seeding in different bamboo species with localities is rarely known to the nursery men and growers. A grower can not make a plan beforehand due to the unpredictable availability of seeds and seedlings of a desired bamboo species. If the seeds of a bamboo species are received at nurseries, in most cases the species may not be identified correctly unless certified. Excepting a few, seeds of most of the bamboo species are more or less similar to look at. Planting stocks raised from seeds and seedlings show enormous variability in health and growing nature, and are therefore usually not favoured for raising commercial plantation of bamboo as yield per unit of land is variable, usually less and not uniform. Therefore, bamboos have been propagated by various vegetative methods. The basic principle underlying vegetative propagation is a division of a part of the plant. The selected part should have growth buds which will multiply to produce the plant. This type of Planting Materials (PMs) can be produced almost round the year. True-to-type progeny with genetic qualities identical to the mother plant are obtained through vegetative propagation, so these PMs are physically less variable with uniform good growth for obtaining optimum yield per unit of land.

This presentation reviews the lessons that have been learnt by visiting different nurseries during last decade regarding the production of bamboo Planting Materials and suggests some strategies to deal with the issues.

Issues and Strategies

(A) *Species specific technology for the production of Planting Materials*

The vegetative organs like offsets and rhizomes of a bamboo species have been conventionally used as planting materials (PMs) for cultivating a few groves in homesteads and rural areas, but seldom used for raising large scale bamboo plantations in India and other South Asian countries due to their limited availability and high cost. *Bambusa balcooa* and *B. vulgaris,* the most commonly cultivated in the villages of North-East India and Bangladesh, rarely flower but do not seed (Banik, 1979, 1981; Banik and Alam, 1987). In another species, *Dendrocalamus stocksii*

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(syn. *Pseudoxytenthera stocksii),* cultivated in Konkan area of Maharastra, isolated clumps are often seen to flower without any seed production. Thus, these three bamboo species have been propagated and planted only through vegetative means. Compared to all known vegetative propagation methods for bamboo (McClure, 1966; Banik, 1995), Branch and Culm-cutting are cost effective, popular and preferred planting materials for raising large scale plantations of common bamboo species (Table 1) in India and other South Asian countries. Large sized and thick walled bamboo species are usually multiplied through culm cuttings. Species having stout branches with rhizomatous swelling at bases are easily propagated through branch cuttings (Banik, 1980, 1987). In general bamboo species having comparatively thin culm wall and thin branches (e.g. *Melocanna baccifera, Schizostachyum dullooa, Thyrsostachys oliveri*) are either shy or difficult to root. All bamboo species do not respond similarly in rooting ability (Table 1).

The success mostly depends on the type and age of plant part used, collecting season, maintenance of overall conditions at the propagation nursery, the seriousness and skill of the nurserymen. Buds are the key organs from which a new plant system can be formed. So buds on the culm segments (culm cutting) and branches (branch cuttings) must be healthy, and should not be dead, infected, injured or old.

It has been observed that rooting is comparatively quick and maximum in sand medium compared to conventional soil medium. Sand is chemically inert, has high

Table 1

Preferred planting materials with variation in rooting ability in some common bamboo species.

Species	Culm cuttings		Branch cuttings		Offsets	Preferred PM for large scale plantation
	Rooting time (days)	Rooting (%)	Rooting time (days)	Rooting (%)	Survival (%)	
Bambusa balcooa	40 - 50	50 - 80		60 - 85		Br/Cl cutting
B. cacharensis	60 - 70	30 - 50		25 - 35		Cl/Br cutting
B. nutans	70 - 75	30 - 55	70 - 75	35 - 40		Cl/Br cutting
B. polymorpha	55 - 75	35 - 45	60 - 70	65 - 80		Br/Cl cutting
B. tulda	50 - 65	45 - 65	55 - 70	30 - 55		Cl/Br cutting
B. vulgaris	30 - 40	80 - 90	30 - 45	90 - 98		Br/Cl cutting
Dendrocalamus giganteus	60 - 70	20 - 40	45 - 55	60 - 70		Br/Cl cutting
D. hamiltonii	45 - 60	60 - 80	40 - 55	55 - 85		Cl/Br cutting
D. stocksii	55 - 70	65 - 80	60 - 75	55 - 70		Cl/Br cutting
Thyrsostachys oliveri	70 - 85	25 - 45	70 - 78	20 - 35	80-95	Offset small, handy

porosity, provides aeration and well drained condition, and maintains temperature in the rooting medium (Banik, 1994a). The intermittent misting has to be started immediately after placing the culm segments and sticking branches in the propagation beds. It is very important to maintain high humidity of the air surrounding the sprouted cuttings at rooting time to reduce water loss from the leaves. Misting also slows down the rate of respiration by bathing the cuttings (lowering the temperature) thus prolonging the storage of food required for rooting. *Bambusa balcooa, B. vulgaris, Dendrocalamus giganteus, D. hamiltonii* (took 45-60 days) and other thick walled species root well while species like *B. tulda, B. nutans* and *B. polymorpha* take comparatively longer time (75 days) to develop adequate amount of roots.

Foliar spray with nutrient solution on the cuttings in the propagation bed was found useful in rooting bamboo species (like *B. tulda*) that poorly root or are slow-to-root. It also improved rooting per cent to about 70 per cent in *B. tulda.* Such foliar spray fertilizer is available in packets in local markets and can be used occasionally.

The cuttings treated with 200 ppm (parts per million) of rooting hormones like Indole Butyric Acid (IBA), and Naphthalene Acetic Acid (NAA) are found to have increased rooting ability as in case of *B. tulda, B. nutans, B. cacharensis, D. giganteus* and *Ochlandra travancorica.* In some cases, a mixture of NAA (100 ppm) and IBA (200 ppm) is also used to root the cuttings. However, the properly collected bamboo materials placed in right type of media (generally sand) under warm humid propagation conditions normally do not require any application of hormone for rooting.

After placing the culm segments and branches in the propagation beds they first develop shoots within a week, and then take 45 to 70 days for rooting. During this period, cuttings may develop rhizomes and thus produce new shoot(s). However, on many occasions cuttings may take more time to develop rhizomes. A bamboo propagule must develop all the three morphologic structures – the leafy axis, rhizome and root; its inability in development of any of these phases leads to complete failure of a bamboo propagule (Banik, 1980). So the cuttings are to be maintained in the nursery till they produce new shoots meaning rhizomes have developed.

Mass production of bamboo PMs through *in-vitro* proliferation and rooting of minute axillary buds (micropropagation) and somatic embryogenesis has shown great promise in production of PMs to raise plantations of some bamboo species within specific time-frames (Banik, 1983; Rao, 1994). These methods can be carried out all the year round. So far, about 3 to 4 organizations in the country have been producing micropropagated (axillary bud proliferation) tissue cultured (TC) plants of *Bambusa bambos, B. balcooa, B. nutans*, *Dendrocalumus asper, D. hamiltonii* and *D. strictus.* Further research is needed to develop dependable protocol of micropropagation and somatic embryogenesis for producing the PMs of *B. tulda, B. polymorpha, B. cacharensis, D. giganteus* and *Thyrsostachys oliveri,* etc. Small TC plants (10-15 cm tall) either in net-pots or with small ball of earth have been found to suffer damage during transportation and high mortality in simultaneous planting. Immediately after receiving such small TC plants from the suppliers, it is found essential to maintain them in the nursery shed by fogging the leaves with a spray nozzle (may use hand-sprayer by pressing the fingers) at frequent intervals, till they recover from transportation shock. These plants should be maintained and hardened for a few weeks in the Transit Nursery having facility for proper watering and shade management till they attain the height of 30-35 cm.

Macroproliferation method has been, subsequently, also used to multiply plants generated by culm cuttings, branch cuttings and micropropagated tissue cultured (TC) plants. Often nurserymen make mistakes in application of macroproliferation technology. The total number of the shoots in the mother cutting/seedling is counted and on the basis of this number rhizome with one shoot is separated. As a result some individual pieces contain only an old shoot with old portion of rhizome and so fail to produce new shoots and ultimately die. The other pieces are only young and tender, thus suffer casualties. The right way of separating the shoots (culms) is cutting the rhizome with secateur so that each unit includes old and young shoots with a portion of rhizome and rhizome buds and some amount of roots (Banik, 1987). Each of these individual is transplanted into a separate nursery bag, hardened for 3-5 days and then maintained in nursery under full sun. However in continuous macroproliferation, plant vitality gets reduced over time and the last multiplication might start flowering due to a physiological maturity (Banik, 1987), thus fresh stock will be needed.

(B) ***Focusing on priority species***

While raising a large scale plantation, growers always like to select some bamboo species specifically for their market demand and value. Due to their utility values and high social demand, the bamboos listed in Table 2 are the most preferred in India.

Majority of the nurseries remain busy in producing planting materials (PMs) of one, few or some of bamboo species (eg., *B. balcooa, B. vulgaris, D. hamiltonii, D. stocksii*), whose rooting ability is very high. Thus the PMs of other common priority bamboo species (eg., *B. tulda, B. nutans, B. polymorpha, D. giganteus,* and *B. cacharensis*) are not available in large numbers. As a result growers, most of the time, can not get PMs of desired bamboo species. The nurserymen usually show reluctance to produce PMs of a bamboo species which roots poorly. Unavailability of mother clumps of a species also limits the production of PMs for that species. Production of PM with genetic quality and on time safe delivery systems will need to focus more on the limited number of high priority bamboo species (Table 2), if significant benefits are to be realized in the short-term.

(C) ***Operational efficiency of Propagation Nurseries***

It is observed that most of the bamboo nurseries located in different parts of the country do not have adequate technical know how, skilled manpower, and logistics. The nursery site should be on level ground and well drained, with an adequate supply of water throughout the year.

Sincere application of proper

Table 2

A list of commercially important bamboo species of Indian sub-continent.

Scientific Name	Main uses	Preferred type of planting material to use
Bambusa balcooa	Construction, Scaffolding, house posts, agarbatti sticks, also shoots are edible	Branch/culm cutting, TC plants, do not produce seeds
B. cacharensis	Weaving, Handicraft, furniture	Seedling, culm cutting
B. nutans	Construction, Handicrafts, toys, novelty items	Branch/culm cutting, TC plants
B. polymorpha	Handicrafts, toys, novelty items, also shoots are edible tasty	Branch/culm cutting
B. tulda	Construction, Handicrafts, toys, novelty items, Panels	Branch/culm cutting, TC plants, Seedling
B. vulgaris	Construcrtion, agarbatti sticks	Branch/culm cutting, TC plants, do not produce seeds
Dendrocalamus hamiltonii	Construction, Handicrafts, Agarbatti sticks, also shoots are edible tasty	Branch/culm cutting, TC plants, Seedling
D. stocksii	Handicrafts, toys, novelty items, Furniture	Branch/culm cutting
D. asper	Famous for edible shoot	Exotic species. Cutting, TC plants now produced in India
Guadua angustifolia	Construction works, high resistance to both rot fungi and wood-eating insects	Exotic species recently introduced, limited availability at Bangalore. Cutting.
Thyrsostachys oliveri	Handicraft, furniture, Javelin	Offsets, Cutting,
Melocanna baccifera	Matting, roofing, thatching, housing works; Handicraft, pulp and paper industry, edible shoot.	Seeds now available in NE India.
Ochlandra travancorica.	Mat and basket making; Pulp and paper industry,	Cuttings, Seeds available in Travancore.

techniques to propagate a bamboo are critical to obtain success. From the experience of different nurseries, it is felt necessary to highlight some following points for optimizing the production of bamboo PMs :

- Culms that emerge in the early part of the growing season respond better in root induction; these culms should be marked for next year collection.
- Culm segments taken from the mid-culm nodal positions mostly root well in *Bambusa vulgaris, B. balcooa, B. polymorpha, B. multiplex* (syn. *B. glaucescens*), *B. cacharensis, Dendrocalamus giganteus, D. hamiltonii, Guadua angustifolia*, etc.; while mid to lower culm nodal positions are suitable for *B. bambos, B. tulda, D. stocksii, Thyrostachys oliveri,* etc. So, the top portion should not be used for propagation purposes.
- The best time of culm collection is April-May for preparing the culm cuttings.
- Culms emerging in the later part of season produce branches in the spring, such branches usually do not have well developed root primordia and can not root efficiently
- For branch cutting the best time of collection is after 1-2 showers, that is May-June in the North-East, in the North – July-August.
- Select the branch with basal rhizomatous swelling and prominent root primordia or aerial roots and collect by excising the branch base from the culm using a saw, preferably in the morning (Banik, 1980). Remove the sub-branches and leaves using a secateur. Seal the cut end with wax/ cow dung.
- While transporting to the nursery, the collected culm segments and branches should be covered in gunny bags soaked fully with water.
- The culm segments and branches have to be treated with fungicides (0.1% Bavistin/Captan for 30 minutes) before placing into the propagation bed.
- Placing the culm segments at appropriate depth inside the rooting medium so that 4-5 cm of basal portion of shoot(s) that sprouts from the nodal bud of culm cutting should always remain under media as this is the portion from where roots develop.
- The branch cuttings should be placed vertically at 8-10 cm spacing by burying the rhizomatous swelling base in rooting media 6-8 cm deep holes.
- Providing partial shade to the cuttings by placing the agro-net (50-70% shade) over the propagation beds on a sloping roof for protecting them from excessive heat and wind; some amount of sunlight is also necessary to carry on photosynthesis. Heavy shading promotes mould growth and rotting of cuttings.
- Cleaning the surrounding weeds and maintaining sanitary conditions at the nursery; removing the dead cuttings from the propagation beds and controlling pests (using light trap) and diseases are to be followed regularly.
- Bagging of adequately rooted cuttings, hardening them for 5-7 days under shed net and gradually shifting them under open sky

To enhance the efficiencies and skill of producing bamboo PMs, several practical training programmes and field days are being arranged every year by NMBA (National Mission on Bamboo Applications). Two Training Manuals with step-wise pictorial description on 'Propagating Bamboos' and 'Cultivating Bamboo' have also been published by

NMBA/TIFAC (Technology Information, Forecasting and Assessment Council) in English, Hindi, Assamese, and Bengali languages so that at grassroots level, people can easily follow it.

It is learnt that the National Bamboo Mission (NBM) has a plan to develop bamboo cover of 1.76 lakh hectares in the next five years. To fulfill the target would require, assuming a planting distance 5m x 5m, over 70 million planting materials of different priority bamboo species. So all the organizations (both government and non-government) having bamboo nursery urgently need to be well equipped to assist the programme. The nurseries and bamboo planters of nearby areas should communicate and coordinate with each other for ensuring the production and on time delivery of required number of PMs of the desired bamboo species for raising large scale plantation. In any case the quality of PMs should be dependable.

(D) ***Requirement of huge amount of plant parts for mass scale production of bamboo planting materials***

Say, a propagation bed size is 6.0 m in length, 1.2 m of inner width, and 21 cm deep. Considering the height of the brick to be 7.0 cm in all 3-layers of bricks are placed (not be joined with mortar) at the edges of a bed. Let us make an estimate of amount of plant parts (culms, branches, etc.) required for filling one bed to produce the rooted cuttings :

(i) *Culm cuttings* : Three 2-node culm segments, 40 cm in length, placed horizontally in 1 row of propagation bed of 1.2mx 6.0m. Say 20 to 25 rows (15 cm, space between the culm segment) placed along the bed length. Such 3 columns can be placed. So, 3x20 = 60 to 3x25 =75 pieces of 2-nodes culm cuttings, i.e in total 60x2 (nodes) to 75x2 or 120 to 150 potential cuttings are put in one bed.

- One bed 6m long (on an average 70 % rooting) may provide 120 x 0.7 = 84 or 150 x 0.7 = 105 rooted cuttings, 84 x 4 or 105 x 4 times a year = 336 to 420 cuttings expected.
- Say 30 nodes can be used from one *B. balcooa* or *D. hamiltonii* culm, 4 to 5 culms yield 120 to 150 node cuttings (from 1 bed); about 85 to 100 rooted cuttings in 1 time of the year. So to produce 1000 node cuttings 50 culms are required.

(ii) *Branch cuttings* : About 55 branch cutting can be placed in one row along the length (6.0m) of a bed and 8 numbers in the width, so 55 x 8 = 440 branch cuttings can be placed in a bed.

- From one bed (70 % rooting) can get 440x0.7 = 308 rooted cuttings x 4 times a year = 1200 branch cuttings are expected.
- May be able to collect 50 branches from a clump, so for 440 branches, need to visit 9 clumps = 300 rooted branch cuttings.

So to produce 1000 rooted branch cuttings one has to visit about 30 clumps. Therefore, many mother clumps are required to supply the huge amount of vegetative parts for mass scale production of rooted culm/branch cuttings.

(E) ***Necessity to have many superior quality mother clumps to ensure clonal production of planting materials of bamboo***

Among the total 1,250 bamboo species

of the world it is about 90 per cent species are still in a 'wild' state and therefore possess maximum amount of natural variability which the breeder can profitably utilize for the improvement of the productivity of this crop (Banik, 1994b, 1997). Individual superior clumps or plus clumps may be selected from a population of a bamboo species on the basis of their growth potentials (number of culms per clump, height, diameter and wall thickness of culms, length of internode), resistance to diseases and pests and some end-use characters (fibre length, lignin and silica content, value of modulus of elasticity, etc.) (Banik, 1997). Such propagules are called as clonally propagated planting materials.

The plant parts for vegetative propagation should preferably be collected from Candidate Plus Clumps (CPCs) of locally grown priority species. Record of such mother clumps shall be maintained for future references. In case the Plus Clumps are not yet selected, collect the plant material at least from healthy and disease free clump.

Therefore efforts have to be made to explore, identify and select more CPCs of priority bamboo species. It is essential to make use of local experience of the people and information for identifying the potential mother clumps for germplasm collection. Once the CPCs are selected, they have to be centralized in germplasm garden near the Propagation Nursery for ease in collecting the fresh and healthy materials with minimum expenditure. At least five hundred provisionally selected CPCs in each species for producing the quality planting materials (culm and branch cuttings).

Cataloguing superior (Plus) genotypes and 'biotypes' should be pursued.

Maintain the selected mother clumps well ahead with manure/fertilizer and regular watering especially during drought.

(F) ***Information, Sourcing, collection and transportation of Planting materials***

Lessons learnt from a case study : During 2005, National Mission on Bamboo Applications (NMBA)/TIFAC started a Multi-Location Trial (MLT) of 12 bamboo species (*Bambusa bambos, B. balcooa, B. nutans, B. polymorpha, B. tulda, B. vulgaris, Dendrocalamus asper, D. giganteus, D. hamiltonii, D. stocksii* (syn. *Pseudoxytenanthera stocksii*), *Ochlandra travancorica, Thyrsostachys oliveri*) at 13 different sites in the country coordinated through the Bamboo Coordinating Centre, Department of Agroforestry, GB Pant University of Agriculture at Pantnagar, Uttarakhand. Under the MLT, nine experiments were included, of which one experiment was to investigate the comparative survival and growth performance of two types of planting materials (Tissue culture plants versus Vegetatively propagated plants – offsets, cuttings) of *D. hamiltonii, D. asper, B. balcooa, B. nutans*. A total of 15,000 planting materials, varying from 100 to 2,300 in number of the above 12 bamboo species were required for conducting all the experiments. Emphasis was given on the quality and the species-wise quantity of planting materials (PM) required for conducting the experiments.

During outsourcing it was observed that excepting a few common species, the availability of PM of majority of above bamboo species could not be confirmed. A few organizations that could supply the PMs of the desired bamboo species were identified. The organizations were KFRI (Kerala Forest Research Institute) Peechi, IWST (Institute of Wood Science and Technology) Bangalore, IHBT (Institute of Himalayan Bioresource Technology) Palampur and SFRI (State Forest Research Institute) Itanagar, Arunachal Pradesh. Most of the Tissue Culture (TC) plants were procured from TERI (Tata Energy Resource Institute) Gwalpahari, Gurgaon; Aditya Biotech Raipur, Chhattisgarh; IHBT Palampur and Marino Biotech, Hapur, Uttar Pradesh. Not a single organisation was able to supply the required number of PMs of all the above bamboo species. Advertisement should be made about the availability of bamboo planting materials (species, quality, unit price, etc.) through internet, newspapers and other media so that buyers can easily make contact. Market study is needed to determine the species, the size and requirements of the market and also to identify clients/buyers.

Collecting, packing and transporting the PMs of all the species from different corners of the country was also an experience to learn. The PMs of different bamboo species were collected from South India (KFRI, IFGTB and IWST), the North-East (SFRI Arunachal Pradesh and Tripura), the North-West (IHBT, TERI, Merino Biotch) and from Chhattisgarh covering 3-4,000 km distance and finally distributed to all the 13 Centres responsible for conducting the experiments. A substantial number of PMs were partly damaged and injured while being transported a such long distance by trucks. Thus it was felt necessary to have more number of efficient Bamboo Propagation Centres established at different parts of the country to supply the local need with less transportation distance. This would minimize the transportation time and damage to the PMs.

With this objective NMBA/TIFAC, since 2006, has been supporting different organizations of the country to establish Vegetative Propagation Centres for producing quality planting materials of bamboo. The Centres are located at :

1. Kokrajhar (Kakrikhola, BTC, Assam);
2. Karigaon (BTC, Assam);
3. Basistha (Silviculture Division, Basistha Forest Complex, Guwahati, Assam),
4. Namsai (Arunachal Pradesh),
5. Bidhan Chandra Krishi Vishwavidyalaya (BCKV, West Bengal),
6. Bamboo Centre (GB Pant University of Agriculture and Technology, Agroforestry Deptt., Uttarakhand),
7. IHBT (Palampur, Himachal Pradesh),
8. IWST (Bangalore, Karnataka), and
9. Tripura Bamboo Mission (Agartala, Tripura).

Bamboo nurseries have been established where quality planting materials are being produced from selected CPCs to meet the large scale local demand of the farmers/Forest Department. The nurseries have been gradually getting equipped with the capacity of producing 50,000 planting materials annually.

(G) ***Taking advantage of seeding and make juvenile selection***

Since bamboos are highly cross-pollinating species (Banik, 1986), they give enormous opportunity for selection of superior seedlings with desired combination of characters after each gregarious flowering (Banik, 1997). Therefore, in many cases seedling populations of bamboos showing genotypic diversity provides an opportunity for selecting tall, vigorously growing individuals, as clones (McClure, 1966). Therefore, in bamboos early recognition of individuals (Juvenile Selection or Seedling selection) with a high yield potential would be a great advantage. Generally in a population of one lakh about 20-30 per cent seedlings are with desired characters and can be selected. They may be multiplied further by macroproliferation method. Avoid seed collection from isolated flowering clumps, as abnormalities in germination and albino seedlings are often produced from these stocks (Banik, 1994c).

There are also a few reports of grassy, grassy erect, erect, and very erect types of seedlings in *B. bambos* (Kondas *et al.,* 1973) and *B. glaucescens* (Banik 1980). The erect and very erect types were more vigorous and fast growing, and should be selected for plantation. The grassy type individuals were also found among the seedling populations of *Dendrocalamus strictus*, *B. polymorpha* and *Thyrsostachys regia* (syn. *T. siamensis*) and could be selected only for ornamental purposes as a bonsai plant. The grassy and grassy erect seedlings have more shoots, and nurserymen usually get tempted to macroproliferate them for producing more individuals. However, uses of these as PMs continue to produce bushy plants in the field as observed in the *B. tulda* plantation at BCKV in Kalyani, West Bengal. This character is not desirable for culm pole production.

There is also serious risk with the vegetatively raised bamboo PMs as these may flower precociously and die before the duration of flowering cycle (Banik, 1994a). Most of the bamboo species of India, usually maintain 20-80 years, a definite period of vegetative state before flowering and synchronized death. Suppose the PMs of *Dendrocalamus hamiltonii* (clumps flowers after a 45 ± 1 years interval and die) are produced from a 30 years old adult mother clump and planted in the field. It is very likely that all the clumps raised from these PMs would flower within the next 15 years of planting and die. Thus, the productive vegetative life of any vegetatively produced planting stocks is always less than naturally grown propagules (seeds, seedlings). Although some morphological characters have been identified and suggested for determining the age of a clump, it is not yet possible to determine the clump age of a bamboo species (Banik, 1993). It is also impossible to recognize a bamboo clump that is going to flower within the next 1-2 years. Therefore, any PMs produced from a ripe 'to flower' clump will flower within a few years of planting, incurring heavy loss to the planter. It was observed that in many bamboo species (as for example, *Bambusa bambos, B. balcooa, B. tulda, B. vulgaris, Dendrocalamus giganteus, D. hamiltonii, D. stocksii, D. strictus*) cuttings even at rooting stage in nursery bed or newly planted offsets start flowering and die.

(H) ***Identification of populations having diverse seeding periodicity in a bamboo species and their centralization to establish a Bamboo Seed Orchard***

Variations in flowering periodicity have been observed and documented among the clumps under the same bamboo species. In addition to the gregarious habit of flowering *Bambusa bambos, B. longispiculata, B. nutans, B. tulda, Dendrocalamus hamiltonii, D. longispathus* and *D. strictus* have also showed sporadic flowering in isolated clumps, or in small groups of clumps (Brandis, 1899; Janzen, 1976; Banik, 1980; 1986, 1994b). Records show that in lower Bengal, *B. tulda* flowered on four to five occasions within 16-18 years of time during the period of 1866 to 1884 (Brandis, 1899). Similarly, the species also flowered sporadically on 9 occasions in Chittagong, Bangladesh within 12 years (1978-1990) (Banik, 1995). A number of "flowering genotypes" have been reported for *D. strictus*. In South India, it is 24-28 years (Kadambi, 1949); in North-East and Central India 40-44 years (Kadambi, 1949; Gupta, 1952); Western India 65 years (Mathauda, 1952) and 45 years in Chittagong, Bangladesh (Banik, 1981). *Dendrocalamus hamiltonii* flowered during 1996 to 2001 in Sylhet (Banik, 2000), and since 1998 it has been flowering sporadically as well as gregariously in Himachal Pradesh, Uttarakhand, Assam, Meghalaya, Arunachal Pradesh, Manipur, Nagaland, Mizoram and Tripura. Kawamura (1927) and Janzen (1976) inferred that such variation in flowering is due to different clones within the same species of bamboo that are slightly "out-of-phase" in flowering with each other. According to Hasan (1980), Watanabe and Hamada (1981), such out-of-phase flowering clumps are the expression of different pedigrees and may have evolved through mutation. Such out-of-phase flowering clumps or "flowering genotypes" should be identified in nature and centralised in one place. In the next flowering time, these "genotypes" are likely to flower and seed one by one and also in between the normal gregarious flowering period. Such centralised plots may be termed as bamboo "seed orchard" or "seed stands" (Banik, 1994b, 1997) likely to make frequent availability of seed for utilizing as PM.

(I) ***Using PMs with diversified wide genetic base for introduction of exotic bamboo species***

For the introduction of a bamboo species one must identify and select the species of desired end-use and habitat suitability. It is worth trying to introduce some exotic valuable bamboo species on a limited scale. *Dendrocalamus asper* and *Thyrsostachys regia* are well known commercial bamboo species for the production of quality edible shoots and raw materials for bamboo furniture and handicraft industries respectively. The species has have been cultivated in Thailand, South China and other neighbouring countries. Another famous shoot yielding as well as main industrial bamboo species of China is *Phyllostachys pubescence*, has also attracted the attention of planners and some bamboo growers in India. *Guadua angustifolia,* an indigenous bamboo of South America, is naturally durable and therefore, has great promise in this region. In recent years, in a limited scale one or some of these bamboo species have been planted (introduced) in a limited areas located in different parts of Assam, Arunachal Pradesh, Himachal Pradesh, Kerala, Maharashtra, Manipur, Nagaland, Tripura, Uttar Pradesh, Uttarakhand, West Bangal, etc. The present stocks of planting materials of these bamboo species are either tissue culture (TC) plants, vegetatively propagated or seeds of very limited and narrow genetic base.

Therefore many more PMs have to be brought from abroad having diversified wide genetic sources to raise pilot plantations mainly for commercial objectives. Raising forest plantations of these exotic bamboo species may be discouraged as the existing forestry management in India has been guided mainly by ecological considerations and secondarily to produce raw materials for industries. Although ecosystem modification or ecosystem conversion through introduction of exotic species has over time resulted in short-term economic gains, these gains have often been obtained at the long-lasting environmental damage (Williums, 1994).

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SUMMARY

Some important observations on the present status in production and delivery of bamboo planting materials (PMs) have been presented. A number of strategies to deal with the issues are suggested. Immediate emphasis has to be made on operational efficiency of bamboo Propagation Nurseries, species specific technology focusing priority species and requirement of many selected Candidate Plus Clumps (CPC) to supply the huge amount of vegetative parts for mass scale clonal production of bamboo PMs. Establishment of well equipped bamboo propagation nursery in different parts of the country would cater the need of supplying quality PMs of local priority bamboo species. Much importance is given on the necessity to have information, sourcing, collection and safe transportation of bamboo PMs. Further selection of superior seedlings (juvenile selection) by taking advantage of bamboo seeding and multiplication of these seedlings through macroproliferation, and identification of diverse seeding populations in a bamboo species and their centralization to establish a 'Bamboo Seed Orchard' have also been suggested as mid- and long-term strategy. Emphasis has been laid on the need of using PMs with wide genetic base for introduction of exotic bamboo species for raising commercial plantations.

Key words **: Bamboo Planting Material, Micropropagation.**

बांसों की रोपणी सामग्री उत्पादन करने की समस्याएं–उससे मिले पाठ और समरनीतियां

रतन लाल बनिक

सारांश

इस अभिपत्र में बांसों की रोपण सामग्री उत्पादित करने और उसे पहुंचाने की वर्तमान स्थिति के बारे में कुछ महत्वपूर्ण पर्यवेक्षण प्रस्तुत किए गए हैं। इस समस्याओं से निपटने को कुछ समरनीतियां भी सुझाई गई हैं। इनमें तुरन्त जोर बांसों की प्रवर्धन रोपणियों की कार्यात्मक कार्यदक्षता बढ़ाने को प्राथमिकता दी जाने वाली

जातियों पर ध्यान केन्द्रित कर उनकी जाति विशिष्ट प्रौद्योगिकी और बृहत परिमाण पर कृन्तकीय उत्पादन के लिए वर्धी भागों (कलमों) की विशाल मात्रा उपलब्ध कराने को बांसों की रोपण सामग्री तैयार करने पर दिए जाने की आवश्यकता है। देश के विभिन्न भागों में सुसज्जित बांस प्रवर्धन रोपणियां स्थापित करने से स्थानीय प्राथमिकता वाली बांस जातियों की उत्तमकोटि रोपण–सामग्री उपलब्ध कराने की जरूरतें पूरी की जा सकेंगी। रोपण–सामग्री से सम्बन्धित जानकारी, प्राप्ति स्रोत, उसके संग्रह और निरापद परिवहन की आवश्यकता को अधिक महत्व दिया जाता है। बांस बीजों की बुआई करके उनसे बने पौधों का लाभ उठा श्रेष्ठतर पौधों का चुनाव (बाल पादपों का चुनाव) और फिर बृहत्प्रवर्धन द्वारा उनका बहुलन भी कराया जाना बांस जाति के उगे हुए विविध पौधों की पहचान करके और उन्हें केन्द्र बना ''बांस बीजोद्यान'' स्थापित करना भी मध्यवर्ती और दीर्घकालिक समरनीतियों के रूप में सुझाए गए हैं। व्यापारिक रोपवन उगाने के लिए परदेशीय बांस जातियों को बाहर से मंगवाकर विस्तृत आधार पर उनकी रोपणसामग्री उपयोग करने की जरूरत पर जोर दिया गया है।

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