Massive Propagation of Bamboos –Ever Existing Major Problem World-over, Solved Through the Development of ICFRE's[1] Macroproliferation Technology

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Abstract

Mass propagation of bamboos for raising industrial and commercial plantations was an ever existing major enigma/problem till the later years of 20th century i.e. till 1991. The traditional / conventional vegetative propagation methods of bamboos are of limited value for the large scale propagation of clump forming sympodial bamboos.

A latest new low cost Macroproliferation Technology for production of massive field planting stocks, was developed first time world-over at Forest Research Institute (FRI), Dehra Dun under Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, India, in the beginning of the last decade of the 20th century, in 1991, for mass propagation of economically important sympodial bamboos for raising larger bamboo plantations. The development of macroproliferation technology – a new universally applicable method for vegetative propagation of bamboo, has been stated to be a major breakthrough and a great achievement in the field of bamboo research. This technology is simple, easy, cost effective and involved the use of locally available materials. The planting stocks produced can be handled easily as these remain small in size. It is highly useful for sustained production of field plantable bamboo saplings in massive numbers rapidly, perpetually and plentifully for any desired number of years depending upon the targets and the facilities available. It solved, the ever existing major enigma regarding non availability of massive field planting stocks.

It has also opened up many new avenues for research activities in the field of bamboo research. It is highly flexible as the mass propagation of bamboos can either be undertaken from seed, off-set, branch cuttings, culm cuttings or micro propagated tissue cultured (TC) plants. In turn, these can be successfully used for production of massive field planting stocks through this newly developed macroproliferation technology for several years.

Introduction

Bamboo is now emerging as major source of raw material for bamboo mat boards, bamboo mat veneer composites, bamboo mat corrugated sheets etc. These developments have created a new interest in bamboo across the world. The fascinating bamboo has many remarkable properties, including strength, lightness and flexibility as well as nutritional and environmental value having many applications ranging from medicines, toys to air craft. In last few decades, increased knowledge about bamboo has given rise to

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Theme: Propagation, Plantations & Management

many industries and products. Increased research on bamboo right from bamboo propagation to production of value added products improves socio-economic conditions. The requirement of 'bamboo timber' for multiple uses by the industries and the common man will definitely increase in far greater dimensions. Indian subcontinent needs another green revolution – the "Bamboo Based Green Revolution" in order to meet the future demand of bamboo for the industry and for sustainable development assisting poverty alleviation, employment generation and prosperity accumulation. These industrial uses suddenly enhanced the demand for bamboo by an order of magnitude over the traditional uses. Adequate attention in raising bamboo plantations is needed to be given.

Bamboo presents a viable alternative to check deforestation. Due to shrinkage in extent alarming decrease in the density, the supply of industrial wood from forests have been greatly reduced and there is an urgent need to look for alternative source to meet the increasing demands of our growing society. In this search, bamboo has emerged as a very ideal naturally renewable alternative source. With the trend of decrease in production and rise in population, the gap between demand and supply is going to be larger. This position clearly elucidates the need for increasing bamboo production. Based on India's rich biodiversity and rich culture of bamboo utilization with greater potentials has triggered programs nation-wide for economic and industrial development through the use of bamboo in a most environmental friendly way. Large targets for plantations across India have been fixed. The National Bamboo Mission (India) envisages covering over 1.76 Lakh hectare area through bamboo plantations. This will need over 70 million field plantable saplings to raise bamboo plantations. The emphasis of National Bamboo Mission (India) is on an area based regionally differentiated strategy, for both forest and non-forest areas. Besides ensuring proper post harvest storage and treatment facilities, marketing and export, National Bamboo Mission (India) is committed to assure appropriate returns to growers/producers. Also to use bamboo development as an instrument of poverty alleviation and employment generation for skilled and unskilled persons, especially unemployed youth particularly in the rural sector for eco-rehabilitation purposes. Ecologically bamboo plants are also valuable for wind breaks and soil conservation because of their heavy foliage and extensive rhizome system for ecological protection to river banks, lake shores, hill sides and homesteads besides these ensure returns and productivity. Bamboo has also been recommended as a target species for plantations in order to progress towards a greener world for pollution free environment besides for economic prosperity. Hence, the bamboo plantations not only decrease the quantity of carbon di oxide in the environment but will also be of great advantage in fighting the war against global warming world over.

Mass Propagation of Bamboos –Ever Existing Major Enigma World Over

The anomalous and often mystical flowering of bamboo species over very long cycles of gestation has been a major bottle neck in the bamboo researches. Mass propagation of bamboos for raising industrial and commercial plantations was an ever existing major enigma world over till the later years of 20th century (Adarsh Kumar, 2012). Propagation of bamboo by seed is the best method but the main hurdle in raising plantation is the rare seed production in nature due to very long seeding intervals. The requirement of 'bamboo timber' for multiple uses by the industries and the common man will definitely increase in far greater dimentions. For this purpose larger bamboo plantations, intensive plantings of bamboo around villages, farmer's land, wastelands and other non bamboo areas etc. need to be carried out. In order to meet the future requirements, more and more bamboo needs to be grown (Kamesh Salam, 2002). The conventional methods of vegetative propagation of bamboos appear to be inadequate to meet the desired level of demand for field plantable saplings in massive numbers for raising larger plantations.

Theme: Propagation, Plantations & Management

Prof. Liese (1985) stated that vegetative propagations by cuttings from culm, branch or rhizome is commonly practiced. So far several methods are applied, but for practical purposes especially for establishing larger plantations, the degree of failure is still rather high. Prof. Liese (1991) further added that in spite of intensive efforts made at various institutions, universally applicable method for vegetative propagation of bamboo is not yet available. Banik (1987) stated that detail scientific study is essential to develop a new dependable technique for bamboo propagation at least for a few years. Bamboo seems to be a difficult species to multiply, no body seems to understand the bamboo just enough to propagate it in massive numbers (Anon., 1990). None of the conventional methods of propagation is universal and effective for all the species of bamboos. Each carries its own inherent risks (Anon., 1994).

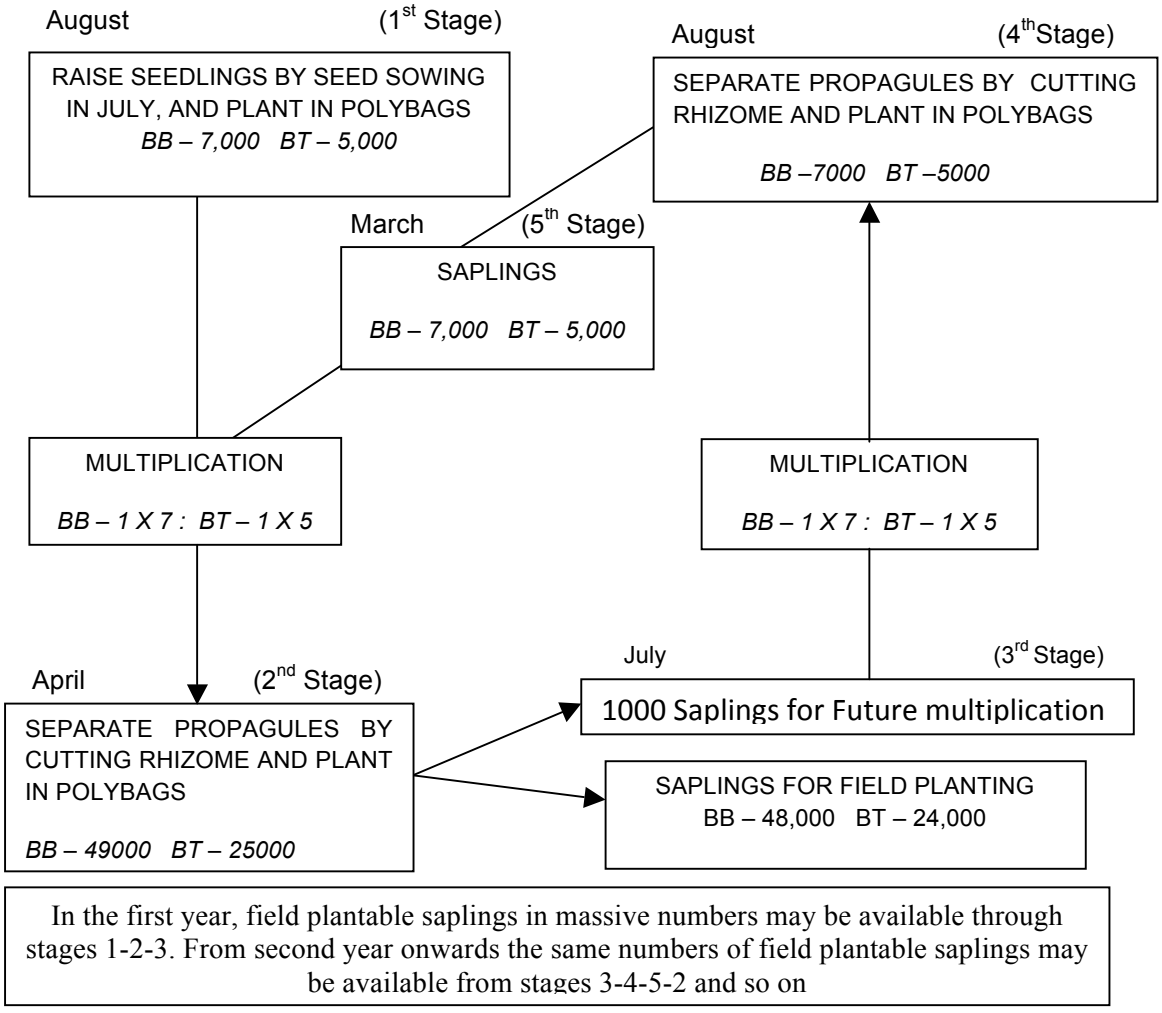
Prof. Sharma (1990) stated that Pathak (1899) was perhaps the first to attempt the propagation of the common 'male bamboo' (*Dendrocalamus strictus*) by cuttings. Since then several papers have appeared dealing with the vegetative propagation of bamboos. None of these earlier attempts have standardized the technique of bamboo propagation by vegetative methods. Rao and Rao (1990) are of opinion that the vegetative methods of bamboo propagation viz. off-set planting, rooting of culm and branch cuttings are of limited value for the large scale propagation of clump forming sympodials. The propagules, thus produced are bulky heavy, difficult to handle and transport. Thus to generate field planting stocks of bamboos on mass scale for raising industrial and commercial plantations is definitely an uphill task. Srinivasan (Anon. 1994) mentioned that the key to the success will be cost effective and simple plant propagation techniques. John et al., (1995) emphasized that large scale cultivation is the only way to prevent further depletion, and to ensure a constant and sustained supply of raw material for growing industrial uses. Nawa Bahar and Singh (2008) stated that bamboos can be multiplied vegetatively with ease but large plantations are difficult to raise because lack of regular and plentiful supply of seed / propagation material is a serious constraint for mass propagation of bamboos. Nautiyal et al. (2008) are of opinion that the traditional/conventional rhizome-off-set methods of propagation can be used only for production of few propagules. It is very expensive method as it is labour intensive for excavation and transport. The availability of off-sets / rhizomes per clump is limited as only young (1-2 years old) culms can be used as propagules. The field survival percentage remains between 5-50%. Both whole culm cutting and ground layering methods need sufficient space near the clump, which may not always be available. The culm cutting method of propagation is comparatively well studied but the survival percentage is quite low and the method is also expensive.

Massive Propagation of Bamboos: An Ever Existing Major Enigma World Over - Solved Through the Development of ICFRE's Macroproliferation Technology

Adarsh Kumar (1991, 1992, 1993,1995 & 1996) first developed and described world-over, a new low cost universal technology which was first named by him as "Macroproliferation Technology" in the beginning of the last decade of 20th century *i.e.* in 1991, for mass propagation of economically important sympodial bamboos at Forest Research Institute (FRI) Dehra Dun, under Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, India. This newly developed latest technology solved the ever existing major enigma regarding mass propagation of bamboos. This new method of bamboo propagation suggests solution to the problems relating to the sustained regeneration through mass propagation of sympodial bamboo species suitable to the task and the location in which they are found. The above mentioned new, low cost technology developed is simple, easy, cost effective and involved the use of locally available materials. The planting stocks produced can be handled easily as these remain small in size. The development of macroproliferation

technology has been reported to be a major breakthrough (Anon.1992), thus, it can solve the existing difficulties of vegetative propagation (Liese, 1992) and is one of the pioneer achievements in the field of bamboo research, picked up by the media (Rawat et al. 2009; 2011).

It has now become possible to produce bamboo field planting stocks plentifully, depending upon the targets and the facilities available, for raising larger industrial and commercial plantations perpetually for any desired number of years without dependence on seed production in nature. Schematic pathways (Plan-1) were developed, for perpetual mass production of field planting stocks of sympodial bamboos vegetatively through macroproliferation technology. The whole cycle (Plan-1), in multiples, is repeatable for several years.



Plan-1. Schematic pathways for perpetual mass production of field planting stocks of sympodial bamboos vegetatively through macroproliferation technology. *(BB=Bambusa bambos; BT=Bambusa ulda; DH=Dendrocalamus hamiltonii; DS=Dendrocalamus strictus).* (Source : Adarsh Kumar, 1991,1992,1993,1995).

Prof. Liese (1992) described this latest newly developed macroproliferation technology as 'most remarkable' and stated that 'it can solve the existing difficulties' of mass propagation of bamboos. Tewari (1992) stated that macroproliferation technology of vegetative propagation is potentially universally applicable and can be used for mass production of field plantable saplings of sympodial bamboos. Gupta (1992) expressed that the technology on multiplication of bamboo seedlings through macroproliferation developed by Adarsh Kumar (1991,1992) has great potential in

solving the problem regarding bamboo propagation on mass scale which is a great achievement in the field of bamboo research. Breyer (1993) described propagation of container grown bamboos *Fargesia murielae* and *Phyllostachys nigra* through division of rhizomes with attached culms. Joshi and Dhiman (1994) are of opinion that singling of macroproliferated shoots appear to be potential method of multiplying bamboo particularly with short seed supply. Banik (1994) stated, "Recently in India a detailed plan (Plan-1) has been developed by Adarsh Kumar (1991, 1992) for continuous production of field plantable saplings in massive numbers every year for any desired number of years". Dransfield and Widjaja (1995) stated that vegetative propagation system called 'macroproliferation of seedlings' has been successfully developed in India for large scale propagule production. This method ensures a continuous supply of propagules. Katwal (2002) stated that macroproliferation technology will help farmers to carry out bamboo propagation of selected bamboo germplasm quickly and economically without using any sophisticated facility. Jagdish Kishwan et al. (2005) considered macroproliferation technique as the current technique of mass multiplication of bamboos. Prasad (2008) produced large planting stocks of bamboos by the use of macroproliferation technique whereas Nautiyal et al. (2008) reported the mass propagation of *Arundinaria falcate, Bambusa bambos, B. nutans, B. vulgaris, B. multiplex, Dendrocalamus asper and D. membrenaceous* through macroproliferation technology.

Nath et al. (2008) stated that the bamboo plantation efforts constrained due to the non availability of quality planting stock may be overcome through the research and developmental activities of Indian Council of Forestry Research and Education (ICFRE), Dehra Dun (India), by the use of newly developed macroproliferation technology for mass propagation of sympodial bamboos. Rawat et al. (2011) are of opinion that this technology may also eliminates the need for establishment of a separate rhizome bank (for sympodial bamboos), which involves heavy investments, vast land areas and huge manpower. Nautiyal *et al.* (2011) described 'Macroproliferation Technique' is probably the best method for raising large quantity of seedlings within a short span of time. Bakshi et al. (2012) studied vegetative propagation of *Thamnocalamus falconeri* through macroproliferation technique, together with the other conventional methods of bamboo propagation *viz.* off-set, clump division, rhizome cuttings, air layering. ground layering, culm cuttings and reported that of all the techniques investigated, macroproliferation technique yielded maximum planting stock, with survival rate of 98-100%.

Nautiyal et al. (2008) reported that unlimited planting stock may be produced at the lowest cost i.e. @ Indian Rupees - Rs. 2.50 (=US$ 0.05) per sapling through macroproliferation technology. In addition, they have also worked out the comparative economics of bamboo planting stock production by different conventional methods of vegetative propagation viz. Rs. 50.00, 30.00, 15.00, 5.00, 8.00, 3.00 per plant by Off-set planting, Rhizome planting, whole culm cutting, layering, culm cutting, and branch cutting respectively.

The newly developed latest low cost macroproliferation technology has opened up many new avenues for research activities in the field of bamboo research. Rawat et al. (2009, 2011) stated that ever since macroproliferation technology was developed by Adarsh Kumar (1991,1992,1993) great interest is being continuously shown by the bamboo researchers and bamboo growers to further explore the full potential of this technology. This technology is highly flexible as mass propagation of bamboos can be undertaken from seed (Adarsh Kumar, 1991,1992,1993); off-set and branch cuttings (Koshi and Gopakumar, 2005); Rain Forest Research Institute, Jorhat, India, has developed protocol to induce juvenility and generate saplings from the mature culms, followed by mass multiplication through macroproliferation technology (Katwal,2002), culm cuttings (Dubey et al. 2008) and tissue

culture (TC) plants (Preetha et al. 1993; Arya and Arya 1999). The saplings available from selected superior mother clumps by using conventional clonal methods of propagation of bamboos viz. off-sets, culm and branch cuttings etc. and tissue culture (TC) plants besides seedlings raised by seed sowing, can be used for the macroproliferation technology for production of quality field planting stocks of bamboos in massive numbers for raising industrial and commercial plantations during the prolonged vegetative phase of the bamboo clumps.

ICFRE's macroproliferation technology of mass propagation of bamboos has also been found highly advantageous by the tissue culture specialists to multiply *Dendrocalamus asper* plants which were earlier developed through tissue culture. Arya and Arya (1999) reported that the macroproliferation technology enhanced the multiplication rate of tissue culture raised bamboo plants *(Dendrocalamus asper)* and ensured a very high rate of establishment and survival (95 per cent and above) in the field in a short interval of time. These plants were multiplied twice a year for two years as per the technology. Preetha et al. (1993) used macroproliferation technology to enhance the quantity of *Dendrocalamus stictus* and *Bambusa bambos* rooted plants which were earlier developed through tissue culture and hardened in the shade house for 20-30 days. The field planting stock was increased 4-5 times by adopting this technology. Shanmughavel et al. (1997) suggested that in order to increase the tissue culture plants before transfer to the field, macroproliferation should be practiced. By this technology a large number of identified planting stock of *Bambusa bambos, B. polymorpha, Dendrocalamus asper, D. giganteus, D. strictus and Phyllostachys edulis* can be made available. The operational guidelines (Anon. 2007) for production of quality planting material of bamboos through tissue culture, suggested the mass multiplication of tissue culture (TC) plants through the macroproliferation technology for the enhancement of the planting stocks. The technology not only enhances the multiplication rate of tissue culture (TC) bamboo planting stocks massively but also results in the reduction of the cost of production of field plantable saplings (of TC plants) remarkably due to enhancement in production of field planting stocks through the macroproliferation technology (Adarsh Kumar, 2012).

The plantation activities also involve safe transportation of bamboo planting stocks from nurseries to planting sites. According to Adarsh Kumar and Jain (2009) their safe transportation from nursery to field planting site is as vital as production of field plantable bamboo planting stocks in nurseries. It is absolutely essential that the saplings reach the destination in undamaged and uninjured condition. This is one of the most practical and applied aspect of the plantation technology. Despite constantly improving afforestation technologies, many organizations often face decline in early survival of planted material for raising plantations. Many a times these failures cannot be attributed to insects, diseases or adverse weather. The Most common reasons for these failures may be due to breakdowns in what can be thought of as the "afforestation system". At various points between nursery bed and the field planting site, seedlings/saplings get "critically wounded" by events that are considered to be insignificant. Combination of these "insignificant events" add up to poor seedling/sapling survival or complete plantation failures. All the investment in tree breeding/selection, nursery culture and careful handling can be lost if transportation of seedlings/saplings for raising plantations is not given due attention. The bamboo seedlings/saplings are live, tender and delicate plants which need proper protection against high ambient temperature, gusty wind and mechanical vibrations due to speed of the trucks (carrying field planting stocks) during transit. Beside these, proper care for the planting stock is also utmost requirement to maintain sufficient moisture for the plants to maintain uptake of nutrients, during transit.

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