Cane and Bamboo Technology Centre's Technical Papers III

International Conference on

Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood

15th - 17th April, 2008, New Delhi

Proceedings

Organized by
National Bamboo Mission
Department of Agriculture and Cooperation
Ministry of Agriculture, Government of India

Conference Coordinator
Cane and Bamboo Technology Centre
Guwahati, Assam, India

International Conference on Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood

Supported by

State Mission Directorates under the
National Bamboo Mission of Mizoram, Nagaland,
Arunachal Pradesh, Sikkim, Assam, Manipur, Meghalaya, Tripura and Kerala

NBDA

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Development Commissioner (Handicrafts),
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Building Materials Technology Promotion Council (BMTPC)

North Eastern Council, Govt. of India, Shillong

Ministry of Environment and Forests, Govt. of India

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World Bamboo
Organization (WBO)

INBAR

International Network for
Bamboo & Rattan (INBAR)

NMBA
National
Mission on
Bamboo
Applications

National Mission on
Bamboo Application (NMBA), DST

International Conference on

Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood

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Guwahati, Assam, India

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2008

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राष्ट्रपति
भारत गणतंत्र
PRESIDENT
REPUBLIC OF INDIA

MESSAGE

I am happy to learn that the Ministry of Agriculture is organizing an International Conference in New Delhi on 'Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood' under the aegis of the National Bamboo Mission.

India is home to 130 species of bamboo that are found in natural habitats and homestead farms. Owing to its varied uses as timber, paper pulp, raw material for furniture, construction material, farm tools and implements and ethnic handicrafts, the demand for bamboo has increased over the years. Increasing demand has led to indiscriminate harvesting and trading of bamboo in the country, particularly in the North Eastern States. In order to prevent the depletion of precious natural reserves of bamboo, the Government of India has launched a National Bamboo Mission to promote its overall development in a sustained manner. I hope that the deliberations of the Conference will help in developing a road map for increasing the production, productivity and value addition in bamboo.

I wish the Conference every success.

Pratibha Patil

(Pratibha Devisingh Patil)

प्रधान मंत्री
Prime Minister

MESSAGE

I am happy to note that the Ministry of Agriculture is organizing an International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood" from 15-17 April, 2008 in New Delhi to bring the researchers, growers, technologists, policy makers, users, processing industries, financial institutions on a common platform to deliberate on various issues. I am sure the discussions in the Conference will identify the missing links and evolve appropriate strategies to address these gaps. India and the world, I am sure, will benefit from the conclusions arrived at in the Conference.

With the advancement of technology, bamboo is being increasingly utilized in varied applications like furniture, paper, handicrafts, construction etc. Nearly 4000 commercial products made out of bamboo or its products are available and in use in day-to-day life in the world. Because of its versatile applications, it is also called ***Green gold*** and has the potential to provide economic security to the rural population. Realizing the potential of bamboo, the Government of India took a major initiative by launching a National Bamboo Mission with the objective of promoting the systematic and scientific production and use of bamboo.

I wish the Conference all success.

(Manmohan Singh)

कृषि, उपभोक्ता मामले, खाद्य और
सार्वजनिक वितरण मंत्री
भारत सरकार

MINISTER OF AGRICULTURE
& CONSUMER AFFAIRS
FOOD & PUBLIC DISTRIBUTION
GOVERNMENT OF INDIA

MESSAGE

Bamboo, an important natural resource, is found in abundance in the homestead farms and the forests throughout the country, particularly in the North Eastern Region. It is a versatile and highly prolific woody grass extensively used in everyday life. Young and tender bamboo shoots find their way into many exquisite culinary preparations including unique pickles. It is the major source of pulp and hence a vital raw material for paper industry. Use of bamboo in furniture and construction industry is being practiced in India and elsewhere for centuries. Ayurveda, the ancient Indian system of medicine, recommends bamboo and its products for treatment of various ailments. In the present age, it provides livelihood to large segments of rural population and has the enormous potential to address problems arising out of climate change and can be an important means of carbon emission reduction and earning of carbon credits.

The world market for bamboo is valued at US $ 10 billion of which China's share alone is to the tune of US $ 5 billion. Global market for bamboo is expected to touch about US $ 20 billion by 2015. The size of the domestic bamboo industry is estimated to be about Rs. 6505 crores, which may grow to Rs.26,000 crores by 2015. The domestic bamboo sector is faced with many constraints including non-application of scientific methods for propagation and cultivation, lack of post-harvest treatment and technology, inadequate trained manpower and infrastructure for large scale harvesting in the event of gregarious flowering. To address these issues and to promote the sector in all its dimensions, the Government of India has launched a National Bamboo Mission during 2006-07.

I am indeed happy to note that the National Bamboo Mission is organizing an International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood" in New Delhi during 15-17 April, 2008 to focus attention on various issues related to production, productivity, product development, processing and promotion of value added products. The three day deliberations, I am sure, will help the Ministry to chalk out a roadmap for the future growth of the sector.

I wish the Conference all success.

(Sharad Pawar)

विज्ञान एवं प्रौद्योगिकी तथा पृथ्वी विज्ञान मंत्री
भारत सरकार, नई दिल्ली
MINISTER FOR SCIENCE & TECHNOLOGY
AND EARTH SCIENCES
GOVERNMENT OF INDIA

MESSAGE

I am happy to note that the Ministry of Agriculture, under the aegis of the National Bamboo Mission, is organising an International Conference on "Improvement of bamboo Productivity and Marketing for Sustainable Livelihood" in New Delhi from 15-17 April, 2008. The global scientific and technological revolution has equipped the mankind to harness the nature's resources at a pace which outstrips the natural process of rejuvenation. Although the technological revolution has given us comforts and enriched our lives, the costs of these developments in terms of environmental pollution, climate change, etc. have been enormous. These concerns compel the scientific community and policy makers to rethink about the developmental priorities and develop new technologies and products which are environmental-friendly and sustainable. Bamboo, the Wonder Grass, is known to have characteristics which make it an ideal raw material for a number of high-value industrial products. Being an environmental friendly and naturally regenerating fast growing resource, bamboo is now catching the attention of the scientists and technologists around the world.

It is high time that we in India also make serious efforts to harness the full potential of Bamboo. India is rich in bamboo resources, being the second largest bamboo growing country in the world. We must improve our practices for bamboo cultivation and its conversion into industrial products so that better quality raw materials as well as superior value-added products are generated for optimal growth of bamboo sector to serve as an eco-friendly source of goods, services and livelihood to our millions of rural people living below poverty line. I am sure that the discussions in the Conference will lead to new understanding and innovations for development of innovative and relevant technologies and sharing of existing knowledge for improved production and sustainable utilization of bamboo globally.

My best wishes for the success of the Conference.

(Kapil Sibal)

राज्य मंत्री
पर्यावरण एवं वन
भारत सरकार
MINISTER OF STATE
ENVIRONMENT & FORESTS
GOVERNMENT OF INDIA

MESSAGE

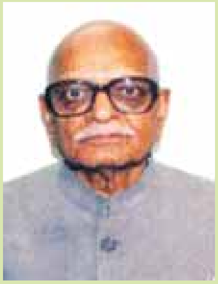
Forests have a vital role in social, cultural, historical, economic and industrial development of any country and in maintaining its ecological balance. Forests form the major storehouses of the biological diversity which are utilized by the mankind as a viable and renewable resource for ensuring livelihood of rural and urban populace. Bamboo, a woody member of the grass family, is the major species found in abundance in the forests of India. It provides livelihood security to a large tribal population across the country, besides supplementing their nutritional requirements. Owing to its fast growth and development, major portion of the bamboo is used by the rural people for construction, handicrafts, furniture and cottage industry.

Bamboo and its products contribute a handsome share of Rs.6,505 crores to the exchequer and has the potential to contribute Rs.26,000 crores by 2015. Realizing the potential of this sector, the Government of India took a major initiative to implement the National Bamboo Mission to address some of the major bottlenecks faced by this sector.

I am delighted to note that the Ministry of Agriculture is organizing the International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood" from 15-17, April, 2008 in New Delhi under the aegis of the National Bamboo Mission to deliberate on issues relevant to Bamboo.

I wish the Conference success.

(S. Regupathy)



उत्तर पूर्वी सचिवालय
शिलांग
N E C Secretariat
Shillong

MESSAGE

It gives me immense pleasure to learn that the Cane and Bamboo Technology Centre, which is the Bamboo Technical Support Group (BTSG) under the National Bamboo Mission (NBM), in active cooperation with the Department of Agriculture and Cooperation of the Union Ministry of Agriculture, is organizing an International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood: at New Delhi from 15th to 17th April, 2008. It is also heartening to know that a publication would be brought out on this occasion to mark the completion of one year of operation of NBM in the eight States of the North Eastern Region and four in the Eastern Region of the country, viz., West Bengal, Jharkhand, Orissa and Bihar. This is a notable milestone in the progress made in several significant areas related to Bamboo. These include Plantation Development, Handicrafts Development, Croft Bazaar & Marketing, Capacity Building and Training & Research. The target groups include Farmers, Self-Help Groups, Non-Governmental Organisations, Cooperative Societies, Panchayati Raj Institutions, Joint Forest Management Committees etc.

It is amply evident from the past year's experience that with its professional excellence, expertise, experience and enthusiasm, the Cane and Bamboo Technology Centre (CBTC) in its role as Bamboo Technical Support Group (BTSG) of NBM, has been highly successful in converting the targets conceived on paper to achievements on the ground.

Bamboo is a precious gift of nature for the country in general and the North Eastern Region in particular since it holds two thirds of the country's bamboo reserves. Transformation of this fast-regenerating and plentiful natural resource from 'green grass' to 'green gold' through proper management and systematic value-addition, is crucial not only for employment generation and poverty alleviation but also for maintenance of ecology and environment.

I wish the Conference a grand success.

(P. P. Shrivastav)
Member, NEC

भारत सरकार
कृषि मंत्रालय
कृषि एवं सहकारिता विभाग
Government of India
Ministry of Agriculture
Department of Agriculture & Cooperation

MESSAGE

I am glad that the International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood" is being organized in India under the aegis of the National Bamboo Mission during 15-17 April 2008. It is indeed a historic event. Agriculture in India is critical to food and nutritional security for a billion plus population. Agriculture in India has many challenges. Land-holding, productivity and income per head are declining, which has serious implications for the country. Researchers and policy makers have to evolve strategies for increasing productivity and income in farming sector. Emphasis has also to be on finding alternatives to traditional agricultural crops which can sustain income and livelihood of the poor. Bamboo with its fast growth, multiplicity of uses and products, besides environmental benefits, has caught the imagination of the world. More and more research & development efforts are being directed at developing new technologies for mass production of quality planting stock, cultivation, harvest and post-harvest management, and production of new value-added products of bamboo. It is high time for scientists, cultivators and entrepreneurs to deliberate on related issues and share their experiences so that the pace of development of the bamboo sector is accelerated.

I am sure the International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood" will be an important step forward in this direction and help in exchange and dissemination of knowledge to generate new ideas and create meaningful links among the stakeholders.

My best wishes for the success of the Conference.

(P.K. Mishra, PhD., IAS)
Secretary, Government of India

Government of India
Ministry of Development of
North East Region,
North Eastern Council
Shillong

MESSAGE

Bamboo is a product of nature abundantly available and which if acientifically farmed can be a major source of sustenance for people living in remote and difficult areas in the world. In India the Northeastern Regions forms an important source of this gift of nature. Beside being an alternative source of raw material for handicrafts, artifacts, bamboo is also a major source for various new usages. With tremendous technological research and innovation treated bamboo is not only aesthetically highly acceptable today but has also proved to be a major alternative source of raw-material for timber and wood. In fact, in many applications and usages bamboo is preferred item over wood and steel.

Seen in this perspective the international conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood" being held in New Delhi in India is most timely. Given therefore, the new application and usages that bamboo has now started to provide, an international conference of the proportion being held in Delhi is indeed welcome.

On behalf of the large number of artisans, craftsmen and industrialists who depend on bamboo I would like to extend my sincere wishes for the success of the conference. Further we in the Cane and Bamboo Technology Centre (CBTC), Guwahati in the Northeast of India, wish to convey our heartiest congratulation and wish the Conference a grand success. It is hoped that the findings and conclusions arrived at the conference would go a long way in enabling the scientific exploration of bamboo and a much more aggressive marketing af its product in the years to come.

(Falguni Rajkumar, IAS)
Secretary, NEC and
Chairman, CBTC

बागवानी आयुक्त
भारत सरकार
कृषि मंत्रालय
(कृषि एवं सहकारिता विभाग)
Horticulture Commissioner
Government of India
Ministry of Agriculture
(Dept. of Agriculture & Cooperation)

Preface

The Centrally Sponsored Scheme on National Bamboo Mission (NBM) was launched in the last quarter of financial year 2006-07 with an outlay of Rs. 56,823.00 lakh for five years. The Mission envisages promoting holistic growth of the bamboo sector through area-based regionally differentiated strategies, to increase the area under bamboo in potential cultivation (both in forest and non forest), post felling management, processing and marketing, etc. It is intended to introduce selected species of bamboo in an area of about 1.76 lakh ha. with an intensive management practices. The anticipated yield is about 18-20 tonnes/ ha per annum from the present yield of about 3 tonnes/ ha. The expansion in area under improved species of bamboo will ensure supply of quality raw materials to the user units on sustainable basis which will be an important part in the value chain, right from the growers to the processors. As a backward integration to plantation, adequate steps are being ensured for availability of quality planting material for which nurseries/tissue culture units are being established/ strengthened. To address forward integration, the Mission is taking adequate steps to strengthen marketing of bamboo products, especially those of handicraft items.

In a short duration, the NBM has made headway and is being implemented in 27 states. Apart from the regular activities, the NBM is also funding some activities as a model unit under the Innovative Interventions so that such models can be replicated elsewhere successfully. The exact impact of the activities of this Mission will be visible after about three years.

A number of countries are well ahead of India in the technologies on bamboo production and uses. India can benefit from their knowledge and practices, usages and markets for its products. In order to share experiences and knowledge in the bamboo sector from other countries and experts/ researchers, we felt it prudent to organize an International Conference on 'Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood'. This Conference will provide a platform for exchange of information on the subject and for exploring the possibilities of cooperation.

The task assigned has been a challenging one, the accomplishment of which would not have been possible without the cooperation and support of many. I take this opportunity to place on record my thanks to my colleagues in the Ministry, Conference Coordinator (Cane and Bamboo Technology Centre). I also express my thanks to all those who have unwittingly or anonymously, contributed in organizing this conference. As a memento to this conference, this Souvenir is being published.

(Dr. M.L. Choudhary)
Horticulture Commissioner &
Mission Director, NBM

Speech of Shri Sevugan Regupathy, Hon'ble Minister of State, Environment and Forests, Govt. of India on the occasion of the Inaugural Ceremony of International Conference on Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood.

15th April 2008, New Delhi

Hon'ble Union Minister of Agriculture, Shri Sharad Pawar, Hon'ble Union Minister of Panchayati Raj and Development of North Eastern Region Shri Mani Shankar Aiyar, Secretary, Department of Agriculture and Cooperation, Ladies and Gentlemen.

I am honoured and humbled to be here in front of this august body of captains of the bamboo sector, policy makers and entrepreneurs. Bamboo is one of the oldest plants and needs no introduction. But despite plenty of bamboo resources available in our country and although it meets various needs of the rural poor, it is re-invigorated now in the context of its modern uses and applications. Bamboo is emerging as a major source of raw material for several industries, viz. bamboo mat boards, bamboo mat veneer composites, bamboo mat corrugated sheets etc. All this has kindled new interest in bamboo development across the world. I had the opportunity to lead a team from India to China under the National Bamboo Mission to oversee the development of this sector. I was delighted to see the bamboo plantations and its industrial uses there. Bamboo based products are exported to more than 70 countries worldwide, and total turnover generated out of bamboo annually is more than Rs. 20,000 crores.

Bamboo is the world's strongest and fastest growing woody plant capable of providing ecological, economic and livelihood security to the people. Next only to China, India has the richest Bamboo genetic resources in 136 species, including 11 exotic species out of which 58 species belong to 10 genera and are found in the North Eastern Region. The total forest area under Bamboo is 8.96 million ha. This is about 12.8% of total Forest Area of our country.

Bamboo development has to be market and technology driven. It has been estimated that the combined value of internal and commercial consumption of Bamboo in the world is to the tune of US $ 10 billion (approximately Rs. 50,000 crores) which is expected to reach about US $ 20 billion by 2015.

India is endowed with rich bamboo resource and we have all the potentials to become a leader in this sector. The commitment and conducive policies and innovations are required to be made so that bamboo sector attains optimal growth within a span of about 10 years. Due to the requirement of conservation-oriented forest management, the supply of industrial wood from forests has been greatly reduced and there is an urgent need to look for alternate source to meet the demands of our growing society. In this search, bamboo emerges to be a very ideal and alternate renewable resource. With the trend of decrease in production and rise in population, the gap between demand and supply is going to be wider. This position clearly elucidates the need for increasing bamboo production. It is in this backdrop that the Government of India under the Ministry of Agriculture launched the National Bamboo Mission (NBM) to cater to the demand of bamboo industries for supply of quality raw material on a sustainable basis. NBM contemplates planting bamboo not in the forest land alone but also in the non-forest lands involving farmers and villagers in bamboo production. Nobody has earlier given much thought to the fact that Bamboo, like any other plant can be cultivated and on attaining maturity, harvested. Such bamboo plantations are necessary at the present juncture because with industries coming up in the Region, Bamboo of uniform size, shape and dimension is vitally important. This will only be possible if bamboo were to come up in plantation mode.

As is said, the process of learning never stops and so we have to learn more from others. Sharing of experience and expertise is knowledge and this kind of conference at the international level is an excellent opportunity to know more. I am confident that the input provided by the experts, scientists and the participants will facilitate in developing an appropriate action plan for better bamboo resource management, its utilization in the form of more value added products and establishment of the required linkage with the market. All this can go a long way in ensuring sustainable development of the bamboo resources.

Thank you. Jai Hind.

Glimpses of the Inaugural Ceremony


Organised by
National Bamboo Mission
Department of Agriculture and Cooperation
Ministry of Agriculture, Government of India
Conference Co ordinator
Cane and Bamboo Technology Centre, Guwahati
bmtpc
Dr. P.K Mishra
Shri Sevugan Regupathy


Organised by
National Bamboo Mission
bmtpc
INBAR

PROGRAMME

Wednesday, April 15, 2008

10:00 - 14:00 Hrs	Registration, Lobby, Hotel Ashoka
14:30 - 15:45 Hrs	Inauguration of the Conference, Convention Hall, Hotel Ashoka

TECHNICAL SESSIONS, NASC Complex, PUSA

Thursday, April 16, 2008

10:00 - 18:00 Hrs	Registration, Symposia Hall
10:00 - 13:00 Technical Session 1:	Mass production and certification of quality planting stock, Symposia Hall

Chairman : Cherla Sastry
Co- chairman: S.K Pande

10:00-10:30	**Plenary Speaker**	**Cherla Sastry: A 2020 vision for bamboo in India: Opportunities and challenges**
10:30-10:50	Speaker, **N. Barathi**	Commercial production of tissue cultured propagules of bamboo
10:50-11:10	Speaker, **Victor Brias**	Tissue culture of bamboo: The experience of Oprins and its relevance within the Indian context
11.10-11:30	Speaker, **Renu Swarup**	Mass production, certification and field evaluation of bamboo planting stock produced by tissue culture
11:30 - 11:45	**TEA/COFFEE BREAK**	
11:45 - 12:05	Speaker, **Jozef De Rezo**	Ornamental bamboo in Europe: Nursery management and marketing
12:05 - 12:25	Speaker, **K. K. Seethalaxami**	Traditional methods for bamboo propagation in nursery
12:25 - 13:00	DISCUSSIONS	
13:00-13:45	**LUNCH BREAK**	
13:45 - 15:15	**Technical Session 2:**	**Post-harvest Management and Storage, Symposia Hall**
Chairman: Mr. Lionel Jayanetti; Co- chairman: Shri Raji Philip		
13:45 - 14:05	Speaker, **Satish Kumar**	Post harvesting operations and traditional protection
14:05 - 14:25	Speaker, **C N Pandey**	Post harvest management and storage of bamboo culms
14:25 - 14:45	Speaker, **R Gnanaharan**	Post-harvest management of bamboo
14:45 - 15:15	DISCUSSIONS	
15:15 - 15:30	**TEA/COFFEE BREAK**	
15:30 - 19:00	**Technical Session 3:**	**New Generation Value Added Products, Symposia Hall**
Chairman: Falguni Rajkumar; Co- chairman: Shri S.M. Desalphine		
15:30 - 15:50	Speaker, **Rajasekharan**	Value addition to bamboo through agarbatti (incense sticks)
15:50 - 16:10	Speaker, **Kamesh Salam**	Cluster approach for bamboo based handicraft units
16:10 - 16:30	Speaker, M. M. Jalan	Revival of closed mills in Arunachal Pradesh: A first hand experience

16:30 - 16:50	Speaker, **Zheng & Guan**	Magical functions of bamboo charcoal-guardian of human being's health
16:50 - 17:10	Speaker, **A G Rao** & **Sukumar**	Tools and small technologies for spread of design innovations in bamboo craft at grass root level
17:10 - 17:30	Speaker, **Zheng & Guan**	Industrial utilisation of bamboo in China
17:30 - 17:50	Speaker, **Suneel Pande**	New generation-value added products and their production economics under Indian context
17:50 - 18:10	Speaker, **Stephen Tekpetey**	Development of bamboo utilization tools in Ghana: A need strategy for sustainable utilization of sympodial bamboo.
18:10 - 18:30	Speaker, **Anum Isaac Nnamdi**	The development and utilisation of Bamboo in Nigeria
18:30 - 19:00	DISCUSSIONS	
19:00 - 19:15	**TEA/COFFEE BREAK**	
19:15 - 20:00	Business Session, Presentations by Chinese delegates and Yes Bank	
20:00	Dinner Host: GreenPort Corporation and YES Bank	

Friday, April 17, 2008

10:00 - 14:00 Hrs	Registration, Symposia Hall	
9:30 -13:15	**Technical Session 4: Investment Potential and Marketing, Symposia Hall**	
Chairman: D N Tiwari; Co- chairman: Jitender Choudhury		
09:30 - 10:00	Plenary Speaker, D.N. Tewari : Bamboo based livelihoods	
10:00 - 10:20	Speaker, **Lin Hai**	Research and marketing of bamboo based decorative materials in China
10:20 - 10:40	Speaker, **Lionel Jayanetti**	Market for bamboo housing
10:40 - 11:00	Speaker, **J. Coosje Hoogendoorn**	Bamboo products: An overview of marketing and market opportunities
11:00 - 11:20	Speaker, **Lin Chuanbao**	Bamboo handicraft products designs and its International market
11:20 - 11:35	**TEA/COFFEE BREAK**	
11:35 - 11:55	Speaker, **M S Haque**	Investment opportunities for banks in channelizing credit for raising bamboo plantations
11:55 - 12:15	Speaker, **Ajay Kumar**	Investment potential and marketing
12:15 - 12:35	Speaker, **Sanjeev Karpe**	Success story of KONBAC
12:35 - 13:30	DISCUSSIONS	
10:00 - 13:30	**Technical Session 5:**	**Cultivation and Stand Management, Training Hall**
Chairman: Dr. C.D. Mayee; Co- chairman: Victor Brias		
10:00 - 10:20	Speaker, **Ding Yulong**	Intensive management practices followed in China for Moso bamboo for both timber and shoot production.
10:20 - 10:40	Speaker, **Sanjay V. Desmukh**	Bamboo based livelihoods: The Maharashtra Model

10:40 - 11:00	Speaker, **Shozo Shibata**	Mautam- Melocana baccifera flowering-ecological characteristics and influence to the Jhum agriculture system.
11:00 - 11:20	Speaker, **S.S. Negi**	Stand management of sympodial bamboos
11:20 - 11:35	**TEA/COFFEE BREAK**	
11:35 - 11:55	Speaker, **R Gnanaharan**	Bamboo cultivation in homestand garden of Kerala, India
11:55 - 12:15	Speaker, **Raji Phillip**	Intensive management of bamboo plantations
12:15 - 12:35	Speaker, **Thomas Lindley**	Bamboo in Australia- A snap shot
12:35 - 12:55	Speaker, **L. P. Jaysinghe**	Bamboo- The renewable energy resource for Sri Lanka
12:55 - 13:30	DISCUSSIONS	
13:30-14:15	**LUNCH BREAK**	
14:15-16:30	**Technical Session 6:**	**Policy Issues, Symposia Hall**

Chairman: J N L Shrivastava; Co- chairman: T. M. Manoharan

14:15 - 14:35	Speaker, **Ding Xingcui**	The systematic analysis on the fast successful development of bamboo industry in Zhejiang province, China
14:35 - 14:55	Speaker, **J V Sharma**	Policy and regulatory, constraints in development of bamboo in India.
14:55 - 15:15	Speaker, **T M Manoharan**	Forest, policy and laws governing cultivation, harvesting, transport and trade of Bamboo in Kerala
15:15 - 15:35	Speaker, **Amir Ullah Khan**	Industrialisation agenda for bamboo sector- opportunities and challenges
15:35 - 15:55	Speaker, **I. Panger Jamir**	Forest, policy and laws governing cultivation, harvesting, transport and trade of Bamboo in Nagaland
15:55 - 16:30	DISCUSSIONS	
16:30:16:45	**TEA/COFFEE BREAK**	
16:45 - 18:10	**Plenary and Concluding Session, Symposia Hall**	
16:45 -17:10	Dr M L Choudhary, Organizing Secretary and Horticulture Commissioner *Welcome Note & Report Presentation*	
17:10-17:20	Shri S.L.Bhat, Additional Secretary, Department of Agriculture & Cooperation, GOI *Address*	
17:20-17:30	Mr Rockybul Hussain, Forest Minister of Assam, *Address*	
17:30-17:40	Mr Jitendra Choudhury, Forest Minister of Tripura, *Address*	
17:40-17:50	Mr Zoramthanga, Chief Minister Mizoram, *Address*	
17:50-18:00	Brij Mohan Agarwal, Minister for Forests, Revenue, and Tourism, Chhattisgarh *Address*	
18:00-18:10	Kamesh Salam, Conference Co-ordinator, *Vote of thanks*	

POSTER SESSIONS, NASC Complex, PUSA

Posters of all Technical Sessions will be displayed in Dining Hall, NASC Complex, PUSA from the 16th April, 2008 at 10:00 a.m. to 17th April, 2008 at 16:00 p.m.

EXHIBITIONS, NASC Complex, PUSA

April 16, 2008	09:00 Hrs	Inauguration, Dining Hall
April 16, 2008	09:00 - 18:00 Hrs	Exhibition, Dining Hall
April 17, 2008	09:00 - 16:00 Hrs	Exhibition, Dining Hall

Articles

INTRODUCTION

An International Conference on **Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood** was held from April 15 to 17, 2008 at NASC Complex, New Delhi. It was organised by the National Bamboo Mission (NBM), Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India. The Conference was coordinated by the Cane and Bamboo Technology Centre, Guwahati, Assam and supported among others by the World Bamboo Organisation, the International Network for Bamboo and Rattan, Central and State ministries and organisations.

The Conference had six technical sessions, a plenary and concluding session, a business session and a poster session covering all aspects with an emphasis on productivity, marketing and sustainable livelihoods. Simultaneously, an exhibition was also organised at NASC Complex in which many private entrepreneurs from all over the country exhibited bamboo crafts and other value-added products of utility, and many government and non-government organisations highlighted their activities on bamboo development.

RECOMMENDATIONS

The Conference was attended by over 500 national and international participants representing governments, non-government organisations, international agencies, private enterprise, educational and research institutions, farmers and artisans. The following are the recommendations of the Conference:

Technical Session 1

Mass Production and certification of quality planting stock

Recognising that non-availability of quality planting stock of desired species of bamboo is the major constraint in improving productivity and quality of bamboo, it is recommended that:

i) NBM should take necessary initiative in collaboration with States, for establishment of clonal banks and clonal nurseries in different agro-climatic zones in India. At least one bamboo clonal bank and clonal nursery should be established in each cluster with the financial support of NBM.

ii) Guidelines and provision should be made for certification of nurseries and planting stock.

iii) States in collaboration with R&D organisations should develop and implement programme for genetic improvement of bamboos which should be coordinated and funded by NBM.

iv) Tissue culture has potential for mass production of quality planting stock but ways should be found out to make it affordable via tax credits etc.

v) Presently bamboo is not eligible for carbon credits. Ministry of Environment & Forests, Government of India jointly with International Network for Bamboo and Rattan (INBAR), should pursue vigorously to make bamboo eligible for carbon credits under CDM so that investment in bamboo sector becomes more attractive for the bankers, farmers and others.

vi) To strengthen and generate human resources in bamboo sector there is need for urgency to establish a National Bamboo Institute or to strengthen the existing institute with financial help and guidelines from NBM.

Technical Session 2

Post-harvest management and storage

Realising that there are significant losses and damage to raw material due to inappropriate management and storage of harvested bamboo, it is recommended that:

i) Standard harvest schedules and methods should be developed for priority species of bamboo.

ii) Standard techniques should be developed for treatment of harvested bamboo for its protection during transport and storage period.

iii) Appropriate methods should be developed for seasoning of bamboo and bamboo products to avoid possible defects which may deteriorate the quality of raw bamboo as well as products.

iv) Ecofriendly, cost effective preservatives and efficient bamboo treatment techniques should be developed.

v) Existing and upcoming technologies for post-harvest management and storage of bamboo would be transferred to end users by organising specific trainings with NBM support.

vi) NBM should extend financial and technical support for setting up common facility centre in each cluster for post harvest treatment and seasoning of bamboo culms.

vii) NBM should lay more emphasis on development of edible bamboo shoot as an economically viable sector by investing more on R&D, training and marketing of edible bamboo shoot.

Technical Session 3

New Generation value-added products

Realisation that low return from bamboo plantation and bamboo product detracts cultivators and entrepreneurs from investing in bamboo sector, it is recommended that:

i) More emphasis should be laid on development of value-added products and the necessary technologies. NBM should fund R&D proposal for development of such products.

ii) Inventory of high value products, technologies, production houses and R&D institutions should be prepared and the information made available on the web. NBM should identify suitable organisations and extend the necessary financial support for this activity.

iii) More emphasis should be laid on R&D for use of bamboo as a modern green engineering material for constructing multilevel houses in cities and earthquake resistant structures in earthquake prone areas. NBM should develop such projects in collaboration with organisations like ICFRE, IPIRTI or IITs and support specific R&D proposals to promote

iv) Use of bamboo for construction purposes.

v) NBM should financially support setting up of bamboo technology parks in different regions.

Technical Session 4

Investment potential and marketing

Realising that difficulties faced by cultivators and artisans in marketing their produce is the major hurdle in the way of growth of bamboo sector in India, it is recommended that:

i) Marketing facilities should be created for disposal of bamboo and bamboo products in key bamboo areas. At least one such market place should be established in each cluster with NBM support.

ii) Daily market news bulletin should be displayed on bamboo web. NBM should develop and/ or financially support such proposals.

iii) Farmers, artisans and entrepreneurs should be made aware of availability and price of quality planting stock, new products, product designs and technologies through interactive web and TV programme.

iv) Public sector banks and financial institutions should be sensitised for extending easy loan facility to farmers and entrepreneurs by holding awareness workshops in each region.

Technical Session 5

Cultivation and Strand Management

Realising that unscientific cultivation and strand management practices have led to very poor productivity and quality in bamboo, it is recommended that:

i) Package of practices should be developed for improved productivity and quality of desired species of bamboo for different agro climatic zone.

ii) Suitable agro forestry models and practices should be developed for cultivation of bamboo together with agriculture/ horticultural crops. NBM should develop and implement, in collaboration with agricultural universities, an R&D programme on developing and demonstrating economically viable bamboo-based agro forestry models. One such model should be established for demonstration in each cluster.

iii) Necessary training should be imparted to farmers for scientific bamboo cultivation and strand management.

Technical Session 6

Policy Issues

Realising that forest laws regulating harvest and transport of trees are the major impediment to the growth of bamboo sector in India, it is recommended that:

i) State governments should relax rules for cultivation, harvest and transport of bamboo within and between different states to facilitate private cultivation and trade of bamboo.

A meeting of PCCFs of State Forest Departments, under the chairmanship of Minister/ Secretary, Ministry of Environment & Forests, Government of India, should be held to deliberate on the policy issues and to suggest the effective steps to overcome impediments placed by existing forest policies/ laws to private cultivation, harvest, conversion and trade of bamboo and bamboo products.

A 2020 Vision for Bamboo in India Opportunities & Challenges

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Abstract

"BESTOW UPON US A HUNDRED BAMBOO CLUMPS" – RIG VEDA

As it happened with the Information Technology (IT) sector, India has the potential to become a world leader in Bamboo Technology by 2020, given the dynamism that the country is showing today, the enormity of its bamboo resources – 8.9 million ha – its professional expertise and innovation as well as skilled labour and entrepreneurship. The Government's recent key initiatives – the National Mission on Bamboo Application (NMBA) of the department of Science and Technology and the National Bamboo Mission (NBM) under the Ministry of Agriculture and Cooperation – for the Tenth Plan have given a kick-start towards this end. However, there are still barriers and mind-set to overcome, to achieve the goal. Bamboo is still considered an 'orphan crop' and largely ignored and/or given minor status by the main land-holding agencies, forestry and agriculture. Standards and policies are still lacking for the full integration of bamboo into the mainstream activity such as the housing/building sector. Other challenges include building up of strong linkages between various stakeholders as well as monitoring and evaluation of the various government and external aid programmes, for impact assessment. This paper will look at some of these and other constraints and possible remedies …. So that the sector could benefit from the opportunities and challenges of the global market place that have opened up through diversification and new uses for the resource (e.g. bio-fuels, textile products and other high-tech/value items) with an emphasis on innovation and the knowledge economy.

Introduction

Bamboo has a rich history, and a promising future as apart of the solution to 21st century challenges. A giant, fast-growing, wood like grass and one of earth's oldest and most precious plant materials, it has benefited human societies since times before recorded history. Today, it helps more than two billion people meet their basic needs, and – as a widespread, renewable, productive, versatile, low- or no-cost, easily accessed, environment-enhancing resource – it has great potential to improve life even more in the years ahead, especially in the villages and countryside of the developing world (Sastry, 2003a; Sastry, 2003b).

As global population climbs and resources are stretched, bamboo can continue to serve the poor, in particular, across a huge spectrum of uses, ranging from shelter and piping to tools and musical instruments. And with demand exceeding the sustainable yield of the world's forests, it offers many ways – through traditional as well as modern industrial applications – of bridging a growing gap (Sastry, 1999, 2000).

However, Bamboo is so familiar, ever-present and commonplace that it has long been taken for granted and overlooked. Only in recent years has long neglect given way to the beginnings of serious attention. The resurgence of interest in bamboo as a substitute for tropical timber and the recent developments may be called 'Golden Revolution' (analog of Green revolution) to address global wood security (Jiang, 2007).

With this backdrop, in recent years, India has embarked on a major initiative to realise the full potential of the country's substantial bamboo resources. This initiative is a response to clear opportunities for growth and entrepreneurship in the bamboo sector, which are, unfortunately, presently hindered by problematic cultivation and poor productivity of natural strands, and inefficient marketing and utilisation practices. The National Mission on Bamboo Application (NMBA) of the department of Science and Technology and the National Bamboo Mission (NBM) under the Ministry of Agriculture and Cooperation for the 10th Five Year Plan have been set up to kick-start activities to maximise ecological and economic benefits of the resource. The primary objective is to consolidate the diverse activities of the various stake holders and to focus on accelerating where possible the pace of strategic, adaptive and development work, thereby enhancing the micro-enterprise development and increased employment.

The Resource

Bamboos occupy 8.96 million ha of forest area (12.8% of the forest) and exist as sporadic clumps in agricultural lands and homesteads. About 66% of the growing stock is concentrated in the North Eastern States of the country. As per the latest taxonomic descriptions, there are 18 genera and 128 species of Bamboo in India, which include 87 naturally occurring and 41, introduced or cultivated species (Seethalakshmi and Muktesh Kumar, 1998). Three species make up 78% of the growing stock: *Dendrocalamus strictus* (45%), *Melocanna baccifera* (20% - could be less due to recent flowering) and *Bambusa bambos* (13%). There are other species of commercial importance with localised distribution and some short-sized Bamboos in the temperate climate of high hills (Adkoli, 2003).

The total growing stock of Bamboos in the forest area is assessed by the Forest Survey of India as 80.4 million tons. The average works out to be about 10 tons/ha (Adkoli, 2002). The estimated annual harvest of Bamboos in India, for various uses, is about 13.5 million tons against the demand estimated at 17 million tons (Deshmukh and Karpe, 2007). Utilisation of Bamboo is high in rural areas for household, handicrafts, katcha houses and agricultural purposes – mostly low-value items and by the industrial sector in the urban areas – bulk of it by the pulp and paper industry. In more recent years, a few mills have sprung up to produce composites, furniture items and other value-added products. There is still a large gap between the supply and demand, and there is thus an urgent need in the first place to increase the productivity of the natural strands by better management. The country (mostly in the public sector) is also embarking on the establishment of 'Industrial Plantations' to raise special-purpose species needed by the industry and/ or crafts. A few small-scale private sector farm forestry plantations and agro-forestry situations have also been established in recent years.

The GoI's ambitious national Bamboo Mission Scheme, with an outlay of Rs 5.68 billion (@ US$ 140 Million), and with a focus on the NE India plans to establish 1,76,000 ha of bamboo plantations over the next five years time to improve the supply side problem. The programme is expected to help over five million families cross the poverty line and to increase the country's share in the global market from 4% to 27%. It would generate 505 million workdays through the creation of 505 nurseries and several micro enterprises for producing and marketing value-added bamboo products.

According to the latest figures, the Indian domestic sector of bamboo is estimated to be worth Rs 2.1 billion or roughly US$ 500 million annually (Arun Kumar, 2007). Probably this figure does not take into account the turnover in the unorganised sector, which handles substantial amounts of Bamboo. As a comparison, China's Bamboo industry has an annual production value of Yuan 40 billion (about US$ 5 billion) (Jiang, 2007). The export of Bamboo products by India is miniscule both in terms of its resource base and as compared with other Asian countries like China, which nearly has captured 50% of the global trade of all Bamboo products (including the bamboo shoots). Even smaller ASEAN countries like Vietnam have exports of US$ 640 million of Bamboo handicrafts. The GoI envisages expansion of India's Bamboo activity to US$ 5.0 billion by 2015 through systematic improvement.

Opportunities

India is at a crossroads, where the potential economic benefits of bamboo, thanks to the government initiatives, are becoming better understood within the context of its resource base and as exemplified by the remarkable growth and success of the Chinese Bamboo sector in the past decade. However, it is difficult for India, in the near term, to penetrate the global markets and compete with the Chinese especially in the Bamboo shoots, flooring, bamboo-based board and other fibre-based items, and more recently bamboo textile products. China has invested mor time, money and effort for many more years than India on innovation and product development, besides the development of base technology (Ranjan, 2005). In addition, there is a flourishing domestic market in China and a large number of private sector companies and cooperatives involved in the export of a variety of specialised products to the First world. It has an established highly competitive export-based industry.

No doubt, India over the years, has invested extensively on science and technology but accelerated developments and value-added innovation have not received their due. The use of Bamboo is still largely traditional, in subsistence housing, for rustic tools and domestic implements and other low value items. There is no significant export industry perhaps with the exception of pulp and rayon. As noted earlier, this situation is changing rapidly. The way forward will be investing in the local bamboos by a massive programme of sustained innovations across many application horizons (Ranjan, 2005). India should therefore develop a strategy initially for a handful of products – for major markets – in order to build skills and expertise needed to compete globally and expand gradually to other products and niche areas where it has an edge, such as the pulp and rayon products. Private enterprise should take the lead to make this endeavour competitive. Some joint public/ private initiatives could be considered in under-developed areas. To promote viable operation, consideration may be given in building micro-enterprises and/ or complexes, closer to the resource base, where a range of products could be produced economically.

The Government has declared the goal of 'Housing for all by 2010' and anticipates building two million low-cost houses per year by the public sector agencies in addition to the ongoing housing construction in the private and informal sectors (Deshmukh and Karpe, 2007). The National Housing and Habitat Policy recognised the housing sector as a medium to promote environment friendly and cost-effective building materials, where bamboo can be promoted.

Bamboo panel products – such as bamboo mat board and Bamboo wafer board – and derived products – such as roofing sheets – will find massive off-take by the housing industry. It is understood that a plant using 30,000 tons of Bamboo can be built at a cost of Rs 60 million @ US$ 1.6 million (Ramanuja Rao, 2008). Other products include:

Bamboo thermo-plastic composites – from polystyrene and waste generated from other Bamboo industrial operations, with their superior strength, moisture resistance and pest-proof properties will be useful as building materials, automobile and railway carriage interiors and for packaging.

Laminated Bamboo furniture for household use, school desks, chairs and other uses.

School buildings and tourist places are ideal for using Bamboo panel products and flooring materials and furniture.

Bamboo for power generation could be practical and economical in some situations (Ranjan, 2005). Various alternatives exist:

- Biomass gasification
- Biofuels
- Bamboo charcoal for energy, medicine and water purification
- Micro-power plants/small scale energy systems
- Compressed Bamboo biomass pellets (for export) – A plant producing 5,000 tons/month can be set up as a micro enterprise at a cost of US$ 2,50,000 (Ramanuja Rao, 2008)

Preservation units/ depots for selling treated bamboo poles. A unit can be set up at a cost of US$ 25,000 (Ramanuja Rao, 2008) near to resource bases.

Rayon/ cellulose fibre/ pulp plants for export of high quality Bamboo clothing – bath robes, towels, baby wear, T-shirts, socks, jackets and suits. The latter items are being sold in high priced department stores in the west at high prices. In Japan, a bamboo fibre suit apparently is selling at US$ 7,000. It looks like in China alone, there are over a 100 companies involved in bamboo textiles as evidenced by a quick Google search. A sports jacket in Toronto at Harry Rosen is going for C$ 750. Given its long history and expertise the Indian rayon industry could easily penetrate this global niche market. Bamboo pulp has other uses besides paper. A large cement manufacturer, Santos, in Brazil has successfully planted 32,000 ha of *Bambusa vulgaris*, to provide paper pulp for making cement bags (Martin, 2005).

Many specialised items such as musical instruments, activated charcoal, surf boards and pharmaceuticals have small but lucrative markets (Sastry, 2000).

Last but not the least will be promoting bamboo for carbon sinks. Bamboo plantations could be promoted to become part of a global carbon credit mechanism to benefit the country and attract investments. Bamboo has several advantages over tree species in terms of sustainability and carbon fixing capacity. Available data indicate that Bamboo biomass and carbon production may be 7% - 30% higher compared to fast growing wood species (Jiang, 2007).

Sastry (1999, 2000, 2003a, 2003b) outlined several other areas where bamboo can be promoted as a substitute for timber.

Constraints

It is difficult to pinpoint major constraints faced by the bamboo sector in India, without a detailed study. Sastry (2003 b) has outlined some general areas of concern. In addition, the organisers of the Conference identified the following constraints:

- Lack of scientific methods for propagation and cultivation;
- Lack of post-harvest treatment and technology for product development;
- Inadequate trained workforce;
- Inadequate infrastructure for large-scale harvesting in the event of gregarious flowering.

As noted above, the demand is outstripping the supplies and requires urgent attention to address problems related to supply chain management and logistics. Better management and increasing the productivity of the natural strands is a first priority given that the yield is a mere 5 kg/ha/yr compared to 30 kg in China (mostly well managed plantations).

Establishment of small-to large-scale plantations, as envisaged in the NBM, should receive equal priority. Experience elsewhere (in China, Brazil and Indonesia) indicates bamboo plantations are commercially viable as a cash crop. Farm forestry and Agro forestry approaches should be explored as well to attract farmer's participation and social contracts with the industry. Hindustan paper Mill has term relationships with farmers in the vicinity of the Mill (Daukia, 2008).

Supply of planting material for large-scale commercial plantations, of the desired species (tied to a specific commercial product), could be a limiting factor due to lack of seed and/ or other propagules. Development of commercial scale tissue culture facilities are an urgent necessity for the supply of large-scale improved planting stock.... Linkages are presently lacking between the various stakeholders in this area. Incentives are needed to promote farmers to undertake small and medium size Bamboo plantations for specific end products e.g. Bamboo shoots and agarbatti, with support from NABARD, SIDBI and similar bodies. It has worked very well in China where a bulk of the supply of bamboo shoots comes from, for export through cooperative marketing channels. Social contracts between industry and farmers as noted is another area that requires further attention.

Bulk of the large handicrafts industry is small, fragmented and slow in adopting improved technology and innovative designs, and as well dogged by high delivery and transportation costs. Being isolated they lack access and infrastructure facilities. Many such operations are 'being unconnected'. Creating social networks will benefit such operations in learning from each others experiences, access to specialists, financial services, market trends and other support. The Federation of Rajasthan handicraft Producers in India has helped its members in building synergy, sharing technology, market intelligence and export promotion. It awards outstanding handicraft producers. It organises an annual symposium to share designs and runs seminars on trends in home furnishings, visual merchandising and export promotion (Bose et al., 2006).

Another approach is that part of a larger production process can be carried out efficiently by outsourcing to small/ other entrepreneurs. A whole village is sometimes involved in such ventures in China and Vietnam. The handicraft industry in Vietnam has increased export value by nearly 30% but still trying to reform to compete with other regional exporters. In 2000 the industry earned US$ 235 million and US$ 630 million in 2006, which accounted for 3% of the country's total exports. The handicraft industry has created jobs for more than 1.35 million workers, 60 per cent of whom are women. Most women make Bamboo and rattan articles, weave carpets and sleeping mats and make embroidered products (Vietnam News, 2007).

In countries like China and Vietnam, bamboo has been revered as the farmer's friend, but in India the use of bamboo is by and large tribal and ignored by society at large. Although perceptions have changed somewhat recently, largely due to pressures from the resource-rich North east, and public awareness programmes and activities of international organisations like UNIDO and INBAR, it is still a long way to go before policies and standards are put in place for the full integration of Bamboo into the mainstream activity in the country.

Furthermore, although technology packages are available from various Government Institutions and programmes (e.g. TIFAC), no one seems to have put together all the information from the point of view of an investor and this is very critical to attract private capital.

Lastly, there appears to be an urgent need for a comprehensive monitoring and evaluation of the various schemes and programmes and other inputs into the sector to determine the status and future directions (viz. regional competition) in order to benefit from the rapidly growing green markets world wide and the realisation of Bamboo's full commercial potential.

An Action Plan

Today, the bamboo sector in India is growing in various directions presenting new opportunities and challenges ahead. In order for India to achieve the target and the objectives as set forth by the government under the two ambitious programmes in the 10th Plan, more focussed attention, tight planning and evaluations are needed for a successful outcome. This perhaps can best be achieved by taking stock of the achievements to date and formulating a bamboo 2020 Vision. A vision with strategic process, with benchmarks and target dates is needed to optimise the 'Indian Bamboo Value Chain' regardless of what the future unfolds. The objectives are to:

- Provide a comprehensive vision and strategies for all segments of the Bamboo sector to succeed/ win in what is increasingly global and changing environment, and
- Promote formal/ informal links and collaboration among virtually all Bamboo stakeholder groups including various government entities.

It is most likely that such a plan be best implemented by creating a separate autonomous body and empowering it. The pros and cons of such a move are discussed among a smaller group of interested bamboo enthusiasts, investors, bankers and the bureaucrats and action taken as agreed upon by the group.

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Epilogue

As noted, we are at a crossroads. We could take this moment to make a journey on the road to development – an inclusive development – judiciously using a resource that is a versatile vehicle for both grassroots and industrial development. In China impoverished regions have travelled this road to prosperity, and there is no reason why India, with its larger and more diverse bamboo resource, cannot do the same. The key to this would be development from grassroots upward, so that such prosperity is more rooted and sustainable...

This then is a critical time to develop a coherent strategy for bamboo in a way that it is responsible to the three key players:

- The poor and the small and marginal farmer;
- The environment; and
- The industry

The Governments must ensure ethical distribution and sustainable use of the resource. Here are some issues to be addressed in developing a strategic plan:

Better management of the resource for higher yields and making sure new supplies happen through well managed plantations;

Continue to promote consciousness of Bamboo in the New World (export promotion) while whittling away at prejudice at home regarding the "poor man's timber."

Continue to refine technologies and development of new uses;

Information sharing within the country and globally through INBAR, FAO and similar bodies; and

Overcoming prejudices of Greens against commercialisation as this is crucial for rural people/ farmers to benefit from the resource and start getting a decent income.

CBS/Mar, 2008

"Tissue culture of Bamboo: The experience of Oprins in Europe and its relevance within the Indian Context"

By Victor Brias

Oprins Plant NV, www.oprins.com

For over two decades the Belgian firms Oprins Plants has been involved in R & D on bamboo tissue culture(TC).The company has been successful in developing TC protocols hundreds of bamboo species, and it has been effective in managing its production such that the TC of bamboo is a cost effective means of mass propagating numerous bamboo species for commercialization, particularly in the Western European horticultural market.

Although many researchers and scientists have been successful with TC propagation of bamboo in the laboratory, few laboratories have actually been effective in achieving results that have commercial added value. Research results that, for example, showed a success rate of 50% rooting and survival of transplanted plants in the greenhouse obviously also implied a 50% failure rate for commercial production. At Oprins Plant, overall mortality of TC bamboo in the laboratory is reduced to less than 10%. At this level of efficiency, TC becomes a very viable method for commercial production of bamboo.

There are two basic reasons for the success of Oprins in bamboo TC: (1) intensive scientific R & D and (2) implementation of management strategies for effective production from the TC lab to the nursery.

The development of TC protocols at Oprins dates back to 1985, and is mainly the achievement of Johan Gielis who focused his efforts on understanding the botanical and genetic aspects of bamboo. Intensive research and experimentation on the micropropagation of bamboo led to one breakthrough after another. The innovation of this research involved the in-vitro multiplication of tissues of mature bamboos, thus enabling mother plants with superior traits to be cloned by means of axillary branching. The elite clones or "super bamboos" are " true-to-type" and possess all remarkable qualities of the mother plant.

For the scientific development to be implemented in a commercial production system, it was necessary for Oprins to invest in infrastructure and apply management regimes that enable the natural conditions of growth of bamboo species to be mimicked in the laboratory and in the nursery. This implied adjusting and controlling environmental variables to optimize the growth of bamboo plants: from irrigation and fogging, temperature control of soil and air, and fertilization.

At Oprins, bamboo plants are grown in growth chambers under controlled environmental conditions. On 1 m2 shelf area in a conditioned growth room, up to 2000 plants can grown at one time.

The selection of mother plants that will be micropropogated is crucial. Because micropropagation via axillary branching mimics the natural growth of bamboo, the propagated plants are genetically identical to the mother plant. Therefore a lot of time and energy is used to select elite genotypes. In this selection DNA-fingerprinting techniques are used, both to unequivocally identify genotypes, and to improve selection procedures for elite genotypes.

Starting from only a few nodal pieces, within a period of 4-8 months thousands of new plants can be produced. These plants are multiplied every 3-5 weeks and yield 3-6 new plants each. This is an excellent method to propagate new introductions or new selections very rapidly. Moreover, micropropagated plants are small but vigorous growers, free from diseases or pests.

The effective implementations of both scientific findings and management techniques opened significant commercial perspectives and possibilities for bamboo. Tissue culture protocols foe bamboo were developed so that millions of ornamental bamboos could be supplied to the horticultural sector.

Successful mass propogation of bamboo by means of tissue culture has placed Oprins in a privileged and leading position in this field of research. Oprins continues to engage in biotechnical research on bamboos and other plants and through its dedicated research team of scientists and Ph.D. students. Most of Oprins research is commercially oriented and results and innovations are protected as trade secrets. Oprins however openly contributes to the scientific community in areas of fundamental research such as taxonomy, particularly in the identification and classification of bamboo genera, species, and varities by means of DNA fingerprinting.

With the success of TC in the ornamental sector, prospects for developing large scale plantation of tropical bamboo also become a reality. This led to the development of protocols for many priority tropical bamboo species, including most species of Dendrocalamus and *Bambusa,* as well as some species of *Guadua* and *Gigantochloa.*

As mention earlier, the main technique used by Oprins for micropropagation of bamboo is the axillary branching method. Although this method is highly dependable, it is also very labour intensive because it relies on cutting techniques of explants. For ornamental plants, this technique is economical especially in Europe, where the added value of ornamental bamboo plants is very high. Oprins bolsters this added value through aggressive marketing and in particular 'branding' to differentiate its high quality plants from those of competitors. In Europe and the USA, Oprins has registered the trade mark Bamboo Select® to identify its plants with a quality label, thereby placing them in a separate category from plants of the competition.

This branding strategy has been very effective. This lending position of Bamboo Select® is the result of a mix of fundamental and applied research, and of the integration of micropropagation in the plant production chain. Bamboo Select® plants are the results of efficient and up-to-date propagation technologies that ensure the highest quality plants at friendly prices. Severe quality control procedures ensure that each plant conforms to the highest standards of excellence. The quality of each Bamboo Select® plant is not only evident in its healthy green foliage, but also in its well-developed and vigorous rhizome system. It is precisely this lower part of the plant that will determine its establishment and growth after planting.

Since micropropagation is a method using tissue culture technology, to produce large quantities of bamboo plants in a very short time, the potential for TC bamboo in forestry applications was apparent.

However, there are fundamental differences between the market for ornamental plants and forestry plants. With regards to bamboo, these differences can be summarizes in the following table:

Characteristic	**Ornamental Bamboo**	**Bamboo for Forestry**
Market	Ornamental Plants	Forestry Plants
TC Technology	Axillary Branching required to bring out true-type propagation	Axillary Branching, but somatic embryogenesis prefably for economic reasons
Explants	Selected adults plants	Adults plants or selected seedlings batches
Final Product	Yes-Garden plant	No-planting material is one input in the bambooplantation scheme
Product Type	Luxury/Hobby	Basic Agriculture/forestry input
Vigour	Important	Very Important

Characteristic	Ornamental Bamboo	Bamboo for Forestry
Aesthetic	Very Important-the plant has to be very attractive	Minor importance
Feedback on Performance	2 to 5 years	7 to 15 years
Price/quality premium	Acceptable- Customers are generally willingto pay a premium foe quality and the brand reputation	Not acceptable- Customers want to have the lowest price possible, even at the expenbse of quality
Propagation by user/ end user	Rare-Garden Centres or End Users do not multiply ther plants	Common- buyers of ploants usually do further propagation
Plant Size	Small to Very Large	Very Small to Small
Seller Margins	High	Low
Volume Levels for Break Even	Medium (sales of hundreds of thousands of plants required for break even)	High to Very High (sales of million of plants are needed to break even)

Given the above, we see that the requirement of the forestry market for bamboo plants are very different from those of ornamental plants. Oprins has experienced these differences over the years, and is addressing these differences through its production strategies, which require significant modifications in its TC techniques for tropical bamboos.

Over the years Oprins has delivered tropical bamboos to numerous countries around the world. Most of the plants were provided to small plantation projects where, either the projects developers had good sources of funding, or where Oprins itself delivered plants free of charge or at subsidized prices for testing purposes.

On the whole, the performance of Oprins tropical bamboos has been excellent in all areas planted. Agronomists immediately recognize the high quality of the plants, as seen in their vigorous and well developed root system and fast growth, which leads to the development of a superior quality true-to-type bamboo species.

Given an average price of about US$ 1.00 per plant (ex lab), the cost of planting material is unaffordable for most farmers in developing countries. One reason for this is that profits from a bamboo plantation can only be generated only 5 years after planting.The capital input for planting material alone represents one of the major costs for a bamboo plantation. Given this situation, it is difficult for a TC culture lab to be competitive unless two requirements are satisfied:

1) The market demand for bamboo planting material is great, i.e., large acreage of land will be planted with bamboo.
2) The TC lab is able to reduce its costs significantly in order to deliver plants at a lower price, while at the same time maintaining an acceptable level of profitability.

At Oprins, R&D efforts have been placed at reducing costs of TC by shifting from the axillary branching method of propagation to the method of somatic embryogenesis. In 2007 Oprins' scientists published their ground breaking research on the development of a reliable protocol for mass propagation via somatic embryogenesis2.

"The research in mature bamboos has been established using pseudospikelets of *Bambusa balcooa.* 40% of the explants gave rise to multiple regenerants within 4 months. This conversion rate is sufficiently high to use the process in commercial mass production. Further, shoot apical meristems can also be used as primary explants without lost of efficiency. Regenerated plants were uniform and identical to the mother plant and to plants obtained by axillary branching with respect to growth characteristics and morphology….The process allows for a cost reduction for this tropical bamboo for forestry upto 57% compare to micropropagation via axillary branching. For the first time, a reliable process based on somatic embryogenesis has been developed that is well suited for commercial micropropagation of elite mature bamboos." (Gillis,K., et al., 2007).

The significant production cost reductions of this methopd are making TC plants much more affordable for forestry projects in India and tropical countries. Evidently, the method still needs to be applied to other species such as *Dendrocalamus asper, Bambusa tulda,* and *Guadua* species, to name a few. Research on somatic embryogenesis starting from adult, selected plants is also ongoing in India and other countries but, as with research done in the past, it is essential to combine production techniques with effective management strategies at the nursery level to secure a very low mortality rate and high economy of scale.

For any such method to become economically viable, it is also a prerequisite for great market demand to be present. This seems to be the case in India with the National Bamboo Strategy in place, but it is still too soon to say whether the targets of plantation development will be achieved so that India can take global lead in bamboo production.

Comment (2): For example in Dehra Dunn starting from adult tissue

India certainly has the capacity to develop highly efficient TC production systems locally, and at least one laboratory (viz. Growmore Boitech) is already operational and commercializing TC bamboo plantlets.

There are some lessons learned by Oprins over the years that may be relevant to India vis-à-vis TC production of bamboos. These points are, in conclusion, summarized below:

Tissue Culture is without doubt the best production method when you need to propagate millions of plants annually producing such large quantaties of bamboo is not workable using other means. TC bamboo plants are smaller and more transportable, facilitating the logistics and cost of plantation development.

TC is a time effective method production. About 18 months are required from initation to mass production. Without TC, the process of producing millions of plants could take many years.

Mass propagation requires a well planned and organized production system. Nurseries are needed; the key to success of a bamboo nursery is not the quality of equipment but rather the quality and dedication of management and labour force.

TC is by far the most effective way of mass propagation bamboo. TC involves a substantial start up investment for the laboratory infrastructure and equipment. Given the presence of market demand, annual returns will increase as efficiency increases in the lab.

The quality of the infrastructure and equipments is very important. Cutting costs on these items can lead to unpredictable results (e.g. contamination, low multiplication rates and high mortality rates). The cheap way is not always the best way.

TC of bamboo involves high technical expertise, advanced knowhow (protocols), dedicated management, disciplined workforce, implementation of strict procedures from hygiene to the minute details of production.

Babmoo TC strategies need to be coupled with nursery and logistic systems. Nurseries should be located in strategic locations throughout the country and they should: (1) have good road access; (2) be in the proximity of plantation areas; (3) have basic infrastructure, utilities, water supplies, shaded areas, and good drainage; (4) include areas of composting; (5) a competent full-time manager; (6) have access to phytosanitary expertise and/or services; and (7) have available space for expansion.

1. *Gielis, J. and Oprins J. Micropropagation of Temperate and Tropical Woody Bamboo: From Biotechnological Dream to Commercial Reality.*

2. *Gillis, K., Gielis, J. Gielis, Peeters., Dhooghe, E., and Oprins, J.(2006). " Somatic embryogenesis from mature Bambusa balcooa Roxburgh as basis for mass production of elite forestry Bamboos." In Plant Cell Tissue Culture, Springer Science +Business Media B. V. 2007*

Mass Production, Certification & Field Evaluation of Bamboo Planting Stock Produced by Tissue Culture

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Introduction

Bamboo represents one of the world's best natural and renewable resources with large number of uses and applications which server as an eco-friendly alternative to the rapidly depleting wood resources. There are 91 genera and about 1,000 species of bamboo. They are found in diverse climates, from cold mountains to hot tropical regions. They are of economic and high cultural significance in East Asia and South East Asia where they are used extensively in gardens, as building material as well as food source. Several hundreds and millions of people worldwide depend on bamboo and rattan for their livelihoods. According to International Network foe Bamboo and Rattan(INBAR), annual world trade in bamboo and rattan is currently estimated at US$14 billion.

Relatively limited amount of basic research has done on bamboos specially on their importance to tropical, subtropical and even temperate economics. Information available from basic research is today fundamental to improved capacity, considered planning and decision making. India has 42.95 thousand ha. bamboo plantation, which is only 8% among the species wise plantation raised by the forest department (State Forest Report 1999).

Recognizing the potential of Bamboo and its contributions to the economic trade of our country, a National Mission on Bamboo Technology and Trade Development was launched by the Planning Commission. To meet the envisaged targets of production, it is essential to increase the areas of plantation through production of quality planting material.

Why Micro propagation

Bamboo is a critical resource, which has not easily lent itself to modern methods of macro-propagation and genetic improvement owing to its long vegetative phase and monocarpic flowering behavior. Conventional breeding is difficult because of the near impossibility of getting two desirable parents to flower simultaneously. Thus for meeting the raw material demand the best possible way to manage the bamboo forest is through scientific management. Major limitation to bamboo production have been overcome by propagation methods. Tissue culture is playing a major role in realizing this objective for the production to meet the demand. Tissue culture offers enormous potential in producing large quantities of the desired material in a short time frame. However it is essential that enough care is taken in selection of the initial material, production of the plants, nursery development and field plantation. Bamboo plantation is by and large through seeds, offsets and clum cuttings. The *in vitro* methods offer an attractive alternative to conventional methods for the mass propagation of bamboos.

Bamboo plantations can be raised by several methods :

1. Direct sowing of seeds.
2. By culm roots and rhizome.
3. By the stock with roots and rhizome.
4. By rhizome with roots.
5. By offset planting.
6. By the cutting of culm.
7. By branch cutting.
8. By tissue culture and macro proliferation.

A two-way approach is advocated for production of bamboo planting material for forestation/reforestation purposes as described below :

First approach aims at the bulk production of seedlings from seed origin. The abundance of seeds, in some species, during gregarious flowering and the scanty of seeds during the infrequent sporadic flowerings is made use of for production of base population (seedlings). This base population is further multiplied using the technique of macro-proliferation. This approach bypasses the dangers associated with clonal propagation, therefore, cannot be ignored as a mean for production of bulk planting stock.

The second approach aims at producing quality stock, by utilizing the natural variation existing in bamboos, through selection ad clonal propagation. Only the best performers are selected, based on certain morphological yardsticks, by following the selection index method. The selected germplasm bank cum vegetative multiplication garden. The base population (seedlings) is produced through clonal propagation using two noded culm cuttings, which is further multiplied using the technique of macro-proliferation. The rate of multiplication increases, depending on species, with each cycle of macro-proliferation till it reaches an optimum rate(4-5 fold).

Depending on the availability of seeds, technical feasibility of propagation by conventional vegetative propagules and suitability of micro propagation protocols for large-scale multiplication, the bamboo species under consideration can be propagated either by conventional methods or through tissue culture.

Department of Biotechnology Programme

Demonstration

The Department of Biotechnology is coordinating a Programme on "Large Scale Production and Demonstration of Quality Planting Material of bamboo". Under this programme 9 species are being produced and demonstrated on large scale *Dendrocalamus strictus, Dendrocalamus asper, Bambusa bambos, Psuedooxytanthera stocksii, Bambusa balcooa, Bambusa tulda, Dendrocalamus hamiltonii and Gauda angustifolia*. Under the network programme 9 states (Andhra Pradesh/ Karnataka, Tamil Nadu, Gujrat, Himachal Pradesh, Uttaranchal, Kerela, Rajasthan and Haryana) have been covered and all the 7 states of North East. So far nearly 706 has been covered with tissue culture planting material of the identified 9 species.

SL. No.	State	Implementing Institute	Area covered in hectare	Species
1.	Andhra Pradesh/ Karnataka	Institute of Wood Science & Technology(IWST), Bangalore	36.7	*D.strictus* *D.asper* *B.bambos* *P.stocksii* *B. balcooa* *G.angustifolia* *P.stocksii*
2.	Goa	Institute of Wood Science & Technology(IWST), Bangalore	05	*B.bambos* *B.nutans* *D.asper* *D.hamiltonii*
3.	Gujarat	Arid Forest Research Institute (AFRI), Jodhpur	25	*D.strictus* *B.bambosa*

SL. No.	State	Implementing Institute	Area covered in hectare	Species
4.	Haryana	Center for Plant Biotechnology,Hissar	70	*B.bambos* *D.asper*
5.	Himachal Pradesh	Institute of Himalayan Bioresource Technology (IHBT), Palampur & Himalayan Forest Research Institute(HFRI), Shimla	68	*D.hamiltonii*
6.	Kerala	Kerala Forest Research Institute(KFRI), Peechi	38.38	*B.balcooa* *B.bambos* *D.asper* *D.stocksii* *D.strictus*
7.	Northeast India	Rain Forest Research Institute (RFRI), Jorhat The Energy and Resources Institute (TERI), Guwahati		*B.balcooa* *B.nutans* *D.hamiltonii* *D.asper* *B.bambos*
	Assam		140	
	Arunachal Pradesh		18	
	Manipur		20	
	Meghalaya		14.5	
	Mizoram		20	
	Nagaland		20	
	Tripura		14	
8.	Rajasthan	Arid Forest Research Institute(AFRI), Jodhpur	25	*D.strictus* *B.bambos*
9.	Tamil Nadu	Institute of Forest Genetics and Tree Breading (IFGTB), Coimbatore	67	*D.strictus* *D.stocksii* *B. tulda* *B.nutans* *B.balcooa* *B.bambos* *B.valgaris*

SL. No.	State	Implementing Institute	Area covered in hectare	Species
10.	Uttaranchal	Uttarakhand bamboo & Fiber Development Board(UBFDB), Dehradun & Uttaranchal Forest Academy (UFA), Haldwani	125	*D.hamiltonii* *D.asper* *B.bambos* *B.nutans* *B.balcooa*
		Total	**706.58**	

This is the first plantation of tissue culture plants on such a large scale. The tissue culture industry has also shown keen interest to multiply the material. For this the technologies developed at R&D Institutes have been transformed to the industry. In addition research groups are also working on perfecting the protocols for other species of importance. So far, tissue culture protocols have been developed for important species required for plantation in different parts of the country. Protocols have been developed for *B. nutans* from nodal segments while somatic embryogenesis has also been achieved. Basic protocol has been developed for B. pallida, rooting has also been obtained. For *D. Hamilton* has developed a protocol and raised about 8,000 plants, the protocol has been well established for commercial production.

A special initiative taken by the department is the formulation of operational guidelines defining the criteria for selection of superior material, tissue culture production, molecular characterization of germplasm, nursery development and experimental designs for field plantation. The management practices and monitoring and evaluation parameters have also been standardized and circulated to all researchers and field workers involved in the programme. Standards foe production of quality planting material through tissue culture have been developed, which include virus indexing and quality certification with specific references to genetic fidelity. The technologies perfected under this programme would be useful for large scale adoption in different agro climatic zones of the country.

Research and Development : Under this demonstration a germplasm is being collected from different parts of the country and is being conserved and characterized using molecular marker at two centers. The Energy Resource Institute (TERI), New Delhi and Institute and Institute of Himalayan Bioresource Technology (IHBT), Palampur. This would provide useful information with reference to traits of specific interest. Genetic diversity analysis for characterization of Bamboo germplasm have also been attempted. Nearly 300 superior accessions have been conserved so far.

Molecular characterization of bamboo has been undertaken using AFLP markers. Eighty nine accessions of bamboo comprising forty seven accessions of *Dendrocalamus hamiltonii* and remaining accessions representing the 26 other species of Bambusoideae have been characterized. Cluster analysis based on preliminary AFLP data grouped all the eighty nine bamboo accessions into three major clusters. Work for establishing genetic fidelity of TC raised plants has reveled high level og genetic uniformity in tissue culture raised plants. AFLP profile generated with selected six primer combination has shown uniform pattern across the tested samples including mother plants.

Research has also been supported on production of transgenics in bamboo, protocol particle bombardment has been standardized using plasmid harboring gfp, gus, Osmotin and SOD genres. In addition 7 Institutes were supported for developing/standardizing Micro propagation protocols for 8 species.

In Conclusion

The Bamboo planting stock is now being produced through tissue culture on a large and has been tested at multilocations. A national certification system is in place and it is imperative that any large scale plantation of Bamboo should necessarily source its material from the superior genotypes identified and to the extent possible only certified tissue culture raised material should be used for obtaining the best performance in the field. This would help in providing economic benefit to the large farming communities would adopt this technology and will ensure that the only best germplasm in plantation across the country.

Traditional Methods for Bamboo Propagation in Nursery

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Introduction

The diversity of species and capacity for adaptation to site conditions makes bamboo suitable for growing in different and difficult sites. Natural distribution is mainly dependent on rainfall, temperature and soil type. Different species of bamboos grow in areas, which receive an annual rainfall of 700 to 4000 mm and where mean annual temperature ranges from 8 to 36^{o}C. Government of India has focused attention on the development of bamboo sector by launching an integrated project in 1999. Subsequently several sponsoring agencies such as UNDP, INBAR, Development Commissioner (handicrafts) etc. developed networking projects to develop bamboo sector. In 2003 National Mission on Bamboo Application (NMBA) was set up under Ministry of Science and Technology and of late in 2006 National Bamboo Mission (NBM) was launched under Ministry of Agriculture and Cooperation to implement bamboo development programmes in a mission mode.

Since existing bamboo resources is insufficient to meet the growing demand at present and in future, development of bamboo resources was considered as the primary requirement by both the missions. In consultation with the experts, considering the growth characteristics and industrial applications NMBA has suggested 16 species for large-scale cultivation. It includes seven species of the genus *Bambusa* (*B. balcooa, B. bambos, B. nutans, B. pallida, B. polymorpha B. tulda B. vulgaris)* five species of *Dendrocalamus (D. brandisii, D. giganteus, D. hamiltonii, D. stocksii* and *D. strictus)* one species each of *Melocanna, Ochlandra, Schizostachyum* and *Thyrostachys (M. bambusoides, O. travancorica, S. dullooa, T. oliveri).*The target of NBM for planting in eleventh five year plan is 176000 ha of which half is in forest and another half is in non-forest areas for which planting stock requirement will be about 8.8 crores (@ 400 plants/ha at a spacing of 5 x 5m and about 100 plants for casualty replacement). Considering the nature of flowering and seed set, response to vegetative propagation techniques such as micro and macro propagation methods, it is a very difficult target to achieve within the time span specified. Different methods known for production of planting stock for each species of bamboo need to used in combination to achieve the target.

In this paper different traditional methods for propagation of bamboo in the nursery is given along with the status of propagation protocols for the commercial species of bamboos selected by NMBA.

Based on flowering behaviour three categories can be identified among different bamboo species.

1. ***Abundant or profuse seed forming***: flowering is followed with profuse seed formation. Eg. *Bambusa bambos, Dendrocalamus hamiltonii, D. strictus, Melocanna baccifera* and *Ochlandra travancorica*.
2. ***Sparse or diffuse seed forming***: Although profuse flowering is reported seed formation is very limited. Eg. *Dendrocalamus giganteus*.
3. ***Sterile or no seed forming***: Either sparse flowering such as *B. balcooa, B. vulgaris* or profuse flowering such as *D. stocksii* or *Pseudoxytenanthera modalepha* without seed formation are found in this category.

Seed handling and seedling production

Due to long flowering intervals, poor seed setting, synchronous flowering and death, short viability, lack of storage methods for recalcitrant seed types, availability of seeds every year for production of planting stock of a selected species is the main bottleneck in establishing bamboo plantations on regular basis. Of the commercial species selected above, seeds of *Dendrocalamus strictus* and *Bambusa bambos* are frequently available due to the availability of different cohorts (populations of the same species that flower during different years). Seed production in *Dendrocalamus hamiltonii*, *Melocanna baccifera* (Northeastern India) and *Ochlandra travancorica* (Southern India) has been reported recently. Most of the commercially important bamboos belong to the group of plants that flower periodically and gregariously in cycles ranging from 25 to 60 years and die after seed ripening. When gregarious flowering occurs seeds are produced in bulk.

Three types of seeds have been reported for bamboos (1) Caryopsis (eg. seeds of *Bambusa bambos*) glans (*eg*. Seeds of *Dendrocalamus strictus*) and bacca (*eg*. Seeds of *Ochlandra travancorica*). Seed longevity and storage behaviour are based on the type of seed.

Collection of seeds: For collection of caryopsis and bacca type of seeds, the ground area under clumps is cleared prior to onset of seed fall or plastic sheets are spread on the ground and the seeds fallen are collected by sweeping. Good seeds are separated from the chaff by winnowing and the soil particles, stones and other impurities were removed by hand picking. For seeds of bacca type (*Ochlandra sp)* mature seeds, which were distinct from immature seeds by their characteristic colour were collected by hand picking from the ground and clumps directly. Germination and moisture content of seed lots were determined immediately after collection.

Storage of seeds: Two storage methods have been used for caryopsis and glans type of seeds. For both the methods Seed lots should be processed as quickly and transferred to storage condition. Only seed lots with high percentage of germination and without fungal and insect attack should be taken for storage.

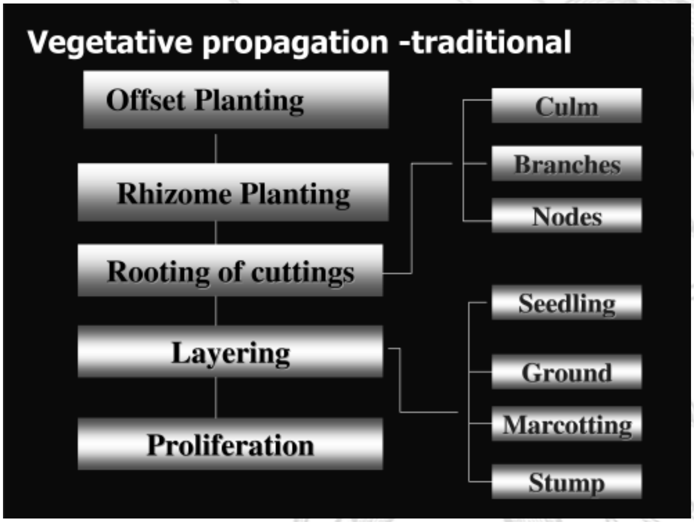
1. ***Dry storage with control of moisture content***: Keeping seeds in relatively lower humidity will help to maintain the seeds with slow respiration and thus prolong aging. Seed lots having high germination percentage (above 80 per cent) initially dried to 8-10 per cent MC are filled in air tight plastic containers. These containers are placed in a desiccators with anhydrous calcium chloride or silica gel as desiccant. The weight of desiccant required is about one-tenth of the weight of seeds. Seeds can be stored in this condition for about four years.

2. ***Dry storage with control of moisture content and temperature*****:** Like MC, temperature also affects seed viability. At lower temperature, as a result of lower rate of respiration, the life span of seeds can be increased. For this a deep-freeze or cold-room can be used depending on the size of sample. Plastic containers with seeds having a MC of 8-10 per cent is stored at temperature -10 to -14 $^{\circ}$ C. Continuous power supply to the storage unit is required.

Production of seedlings: Bamboo seeds have no dormancy. Seeds can be sown directly in nursery beds or soil filled poly-bags. Partial shade is necessary for initial germination and establishment. Protection from ant and rodents is essential. The seedlings can be poly-potted after 45 days if sown in nursery beds. One or two- year - old seedlings can be used for field planting.

Vegetative propagation

Since seeds are not available regularly and viability of the seeds is very short, propagation by vegetative methods is required for many bamboos. Both macro and micro propagation techniques have been used for vegetative propagation of bamboos. Macro-propagation includes conventional propagation methods such as seedling multiplication, rooting of culm, branch and node cuttings, layering etc and micro-propagation includes tissue culture methods. Of the different vegetative propagation methods rooting of culm and branch cuttings proved better when compared to other methods with reference to number of plants. Traditional methods of vegetative propagation practiced for bamboos are given in the flow chart below.



Rooting of culm cuttings

The procedure standardized for rooting of bamboo culm cuttings at KFRI is given below.

Extract two or three-year-old healthy culms from clump by cutting just above the first node. Trim the leaves and side branches without damaging the axillary buds. After shifting the culms to the nursery site two-noded culm cuttings are prepared using a sharp knife or saw.

It is necessary to leave about 5 cm on either side of the nodes to protect the axillary buds from drying.

Treatment with growth regulating substances **(GRS)** like naphthyl acetic acid **(NAA)** and indole butyric acid **(IBA)** enhances rooting response in bamboo. Since NAA is cheaper than IBA, generally NAA is preferred. For bamboos with hollow internode (e.g. *Bambusa bambos*), GRS solution is poured into the cavity and for solid bamboos (e.g. *Dendrocalamus strictus),* dip method of treatment (the basal part is dipped in GRS solution overnight) is given. For cavity method of treatment in two-noded culm cutting, an opening (2 cm long and 1 cm wide) is made on the internode using a small sharp chisel or two holes of 0.2-0.3 cm is made using a drill. For most of the bamboo species 100 ppm solution of GRS is used. Volume of the solution required will depend on the size of the cavity. Generally 50-100 ml is used for bamboos like *Bambusa balcooa, B. bambos, Dendrocalamus brandisii*, etc. For large diameter bamboos like *D. giganteus* about 250 to 500 ml of the solution will be required. The solution is poured into the internodal cavity and wrapping and tying with a polythene strip close the hole and if it is a drill hole it can be easily sealed with plaster or any other adhesive tapes.

Planting of the culm cuttings in the nursery

The treated cuttings can be planted horizontally in nursery beds. One week prior to planting, the nursery beds are drenched with insecticides and fungicides to prevent the attack of termites and fungi. Culm cuttings are placed horizontally (the opening facing upwards) in nursery bed, 15-30 cm apart. About 50-60 cuttings can be planted in a nursery bed of size 10 m x 1 m. Sprouting from the nodes takes place within a week initially a cluster of sprouts develops and completes its height growth within one month. Natural thinning occurs retaining two to five dominant sprouts. Slender roots develop within one month and rhizome development takes place within three to six months. At this stage the rooted cuttings can be transferred to polybags for macro-proliferation or planted in the field directly. If rooting occurs in two nodes they can be separated into two plants by cutting in the middle. The method is very successful with thick walled species (rooting 60-95%) but not that encouraging in thin walled species (0-40%).

Rooting of branch cuttings

It is the simple and easy method of propagation but the success of rooting is not as high as in culm cuttings. Considering the availability in large number and ease in handling, even 50% rooting is good if this method of propagation is successful. It is promising for bamboo species having prominent primary branches from the base of the culm like *Bambusa balcooa, B. vulgaris*, but very difficult in species like *Dendrocalamus giganteus* and *Thyrsostachys oliveri*. Propagation through branch cuttings is one of the easiest methods due to the ease in handling.

Treatment with GRS enhances rooting response in branch cuttings and dip method of treatment can be used. The time taken for rooting is about four to eight months and rhizome formation takes still longer periods of about a year.

Preparing pre-rooted and pre-rhizomed branch cuttings can reduce the time taken for rooting and rhizome development in branch cuttings. In some species natural aerial rooting and rhizome formation is seen and planting material can be collected from this region. Chopping off the top part of the culm and covering the nodal buds with moist medium like moss or coir can also induce pre-rooting. For preparation of branch cuttings the branches are excised using sharp knife or saw. The cuttings are made by trimming the leaves and small branches. Cuttings with four to eight nodes are made and the basal part is dipped in GRS solution for 24 hours. Planting and aftercare is similar to culm cuttings. Sprouting and rooting time depends on the season and varies from 30 to 70 days. When rooting occurs the cuttings should be removed from nursery beds and poly-potted.

The planting materials raised through traditional methods of vegetative propagation and plantations raised using this stock flower along with the parent clumps from which the materials was extracted for propagation. This phenomenon which is called synchronous flowering is a major disadvantage while using vegetative propagation methods for production of planting stock for large-scale plantation. Recently plantlets have been produced in bulk using tissue culture methods from mature nodal buds but the fate of these plantlets are not known in relation to synchronous flowering since the plantations are in early stages.

Although different methods of propagation have been used for time immemorial each method has its advantages and disadvantages. Some of them are consolidated in **Table - 1.**

Table – 1. Advantages/disadvantages of different propagation methods

Method	**Advantages**	**Disadvantages**
Seeds	Simple and cheapest, familiarity with the technology, large-scale production possible, harvest from the crop possible for full life time, protocol for storage available for orthodox types	Seeds not available and hence not dependable, poor seed setting or absence of seed setting for many priority species, variability, short viability and attack of seed predators
Offset planting, Rhizome cutting	Good survival percentage, traditionally known and suitable for both thin walled and thick walled bamboo species.	Limited in number, labour intensive for extraction, heavy and difficult to transport, Synchronous flowering of vegetatively propagated plant with that of parent clumps.
Culm cutting	Comparatively better than offset planting, culm cutting are available in more numbers, method of rooting is simple	Low rooting percentage for thin walled species. Requires larger nursery area than seedling. Rooting is season bound. Synchronous flowering of vegetatively propagated plant with that of parent clumps.

Method	Advantages	Disadvantages
Culm cutting	Comparatively better than offset planting, culm cutting are available in more numbers, method of rooting is simple	Low rooting percentage for thin walled species. Requires larger nursery area than seedling. Rooting is season bound. Synchronous flowering of vegetatively propagated plant with that of parent clumps.
Branch cutting	Branched are available in larger numbers than culm cuttings.	Rooting percentage is low, not standardized for many species, availability of branches are limited in species which branch only from top one-third of the culm, synchronous flowering
Layering methods	Good for isolated clumps and seedlings	Rooting response is poor and season bound, labour intensive, synchro-nous flowering Macro-proliferation Cost effective and simple Requires mother stock produced by other methods. synchronous flowering
Micro-propagation	Suitable for large-scale production of planting stock of selected clones	Costly and requires sophisticated laboratories for production of first set of plantlets.

Precautions

It is evident from the above that production of planting stock is one of the difficult tasks for establishment of plantations of preferred species. Ultimate care and commitment is required in each step and some of the points that need to be considered are short listed below.

Continuous observation is required covering natural stands, plantations and bambusetum for the onset of flowering. Since synchronous flowering is reported in most of the species when flowering is seen in bambuseta, back tracing to the original place from where the collection is made leads to the identification of flowered area.

After the onset of flowering it takes more than two to four months for seeds to mature and during this period proper planning and preparation of the area under flowered clumps for seed collection can be done.

Since availability of moisture results in germination of seeds and there are several seed predators seed collection should be done at short intervals, if possible every day.

After collection the seeds should be cleaned and dried to about 8 % MC for caryopsis and glans type of seeds (such as *B. bambos*, *D. strictus* etc) and it should not be dried in bacca type of seeds (*M. baccifera.* When bacca seeds are dried below 20% viability is lost.

Seed sowing should be done soon after collection or the seeds should be stored in proper storage atmosphere. Before sowing seeds in nursery beds, viability testing with small sample will help to estimate the quantity of seed required per bed based on the quality of seed lot at hand.

Protection from predators is a must for nursery beds to get seeds germinated. Otherwise the seeds are consumed by rodents or ants.

Keeping lights on during night and hanging plastic strips which makes sound and movements along with wind has helped to keep rodents in our experience. This is required for only one week.

Care must be taken for proper labelling of all seedling lots at all stages in order to avoid confusion later. It is practically difficult to distinguish between different related species at seedling stage.

While carrying out vegetative propagation, the material should be collected from clumps that are not going to flower in near future. By consulting the local people in the area about the history of the source material can help to some extent if previous flowering is not documented.

The axillary buds on the either side of the culm should not be damaged at any cause while processing the cuttings.

The preparations of growth regulating substances should be done without precipitation.

Maximum care should be given to avoid desiccation after taking the cuttings till planting in nursery beds.

Action plan

For production of planting stock the following action need to be taken at various levels.

Selection of species that are suitable to the area in which plantations is planned is the first step. Along with the site suitability the possibility of using the species for industries in adjacent area also need to be considered.

A good collection of mother plants with selected plus clumps of as many cohorts as possible need to be established near the nursery site.

If the seeds are available, raise seedlings, select superior seedlings at nursery stage and use it for plantation. The number of superior seedlings can be increased by macro-proliferation.

If seeds are not available go for the suitable vegetative propagation techniques along with macro-proliferation and establish plantations.

It is likely that mother clumps and the plantations established using them will flower at one stage. Collection of seeds and starting a seedling population with selected superior seedlings is only way left after gregarious flowering.

The experience reveals that if continuous observation is made, flowering is recorded in many species. An organized effort is required for documentation of flowering, seed collection, seed handling, exchange of seeds, storage of all types of seeds, selection at seedling stage, establishment of commercial nurseries, training centres for transfer of technology in planting stock production and management, centres for supply of identified and quality mother stock and proper documentation of all the process involved. With the National Missions established in India during the current decade and the integrated networking projects initiated by them involving all the stake-holders involved in the development of bamboo sector through out the country target planting stock production could be attained.

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Post Harvesting Operations and Traditional Protection

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Abstract

Bamboo, classified as a grass, produces a woody stem matching properties of the strongest wood. Being a fast growing plant and available at relatively low costs, it has been used mostly in rural and tribal areas for making handicrafts as a source of livelihood and hutments for living. Acute vulnerability to degradation by rot-fungi, borers and termites has limited its use and it is better known as "Poor Man's Timber".

Durability of bamboo has been of great concern since its recognition as a useful material especially in structures. Its vulnerability to insect attack has also been well known to the early users. Absence of any toxic components and presence of high amounts of sugar and starch make it an attractive food source for a variety of organisms. Only borers were considered the major destroyers and most of the early work was limited to protection against borers and beetles.

These primitive methods dwelled mostly on reduction of starch, and were found effective to control beetle attack but failed to protect against fungal decay and termites, a major issue in tropical countries. Although these methods have lost importance because of development of more reliable scientific methods, these may still be useful, where the bamboo is protected from moisture and ground contact, such as in handicrafts and utility articles or for temporary protection of small quantities of bamboos.

Chemical protection is most suited for storing larger stocks, which are essential for keeping the factories running through out the year. For erection of durable structures, there is no proper substitute for proper protection using established chemical formulation.

Key words: bamboo degradation, traditional protection methods, harvesting age and season, prophylactic treatments, storage methods.

Introduction

Bamboo classified as a grass produces a woody stem matching properties of the strongest wood. Being a fast growing plant, it is relatively available at low cost and if harvested scientifically, on a sustainable basis. Being a low cost material, it is mostly used in rural and tribal areas for making handicrafts at as a source of livelihood and hutments for living. Despite its versatile and favorable characteristics, its use in high end structures is very limited in India. Acute vulnerability to degradation by rot-fungi, borers and termites has limited its use and it is better known as "Poor Man's Timber". Structures built using bamboos are regarded temporary as per current BIS specializations.

Durability of bamboo has been of great concern since its recognition as a useful material especially in structures. Apart from physical degrade such s splitting, erosion due to UV irradiation (weathering), its vulnerability to insect attacks has also been well known to the early users. Protection efforts started almost at the same time. Absence of any toxic components and presence of high amounts of sugars and starch make it an attractive food source for a variety of organisms. Mostly non-chemical protection methods were tried as use of chemicals for preservation was still I nascent stage. Only borers were considered the major destroyers and most of the early work was limited to protection against borers and beetle. Degradation by fungi was considered much later(Banerjee & Ghosh 1942, Liese 1959)

These primitive methods dwelled mostly on reduction of starch, present in large quantities in the bamboo culms, which attracts borers and beetles. These methods were found effective to control beetle attack but failed to protect against fungal decay and termites, a major issue in tropical countries, where bamboos grow and also find extensive use. Most of these methods have therefore lost importance because of development of more reliable scientific methods to protect bamboo to ensure a trouble free long service. These methods may still be useful, where the bamboo is protected from moisture and ground contact, such as in handicrafts and utility articles or for temporary protection of small quantities of bamboos.

Freshly felled bamboos containing high moisture and high levels of sugar/starch fall an easy victim to degradation if proper measures are not taken. Protection at this stage is therefore important as any damage occurring at this stage may not become physically visible immediately but become critical during storage of raw material or in the finished end product resulting in total loss of material and labor.

Several technique non-chemical as well as using chemicals have been suggested for protection of bamboo. Most non chemical protection methods are based on depletion of starch or denial of physical contact of the material with possible degrading organism. Chemical protection is most suited for storing larger stocks, which are essential for keeping the factories running throughout the year.

Bamboo Protection Practices

Harvesting Practices

Harvesting & Moon Phase: It is commonly believed that wood harvesting in a particular phase of moon(new moon) develops immunity to fungal and insect attack, while the same if harvested in other season is prone to degradation. The same myth applies to bamboo as well. Several studies carried out in India in the early 20th century refuted this myth (Jackson 1901, Stebbing 1907, Smith 1908) and established that moon phase has no effect on the durability of bamboo or its resistance to insect attack. The belief prevails in many countries and several studies have been carried out to verify the same (India Beeson 1946 ; Trinidad, Kirkpatrick and Simmonds 1958). A recent presentation by Yamamoto, a Japanese scientist at International Research group on Wood Protection Amnnual Meeting 2005 indicates that this myth still prevails in several countries (Yamamoto et al. 2005)

Harvesting Age: A Bamboo shoot matures to full height in 3-4 years. At maturity, the bamboo culms develop full strength and the starch content is also lowered. Bamboos harvested prior to maturity tend to collapse on drying and have no strength. Harvesting mature bamboos thus make sense. Handicraft and bamboo furniture manufacturers sometimes prefer to work with immature culms as they tave more pliability and are easy to bend to proper shapes.

Harvesting Season: Felling season has great influence on susceptibility to fungal as well as beetle attack. Susceptibility to degradation decreases with the decrease in starch content at the time of harvesting. Starch content in bamboo varies with the season and is higher in spring than in winter. There have been several studies to determine the best season to fell bamboos to reduce biological degradation from fungi and insects. Winter season is considered to be the best for felling bamboo(Mimura 1911, Anon.1912, Anon.1915, Anon.1929, Channigaraya 1939, Plank 1950, Hamaguchi 1953). In colder months, the beetle population is low(non swarming period of insects), and the sap is also down which reduces chances of beetle infestation (Tae 1931). Winter temperatures do not promote growth of most fungi also and thus reduce chances of fungal infection as well.

Non- Chemical Protection Practices/Traditional Methods

Because of strong belief of starch being the main culprit for bamboo degradation, the traditional workers developed various protection methods involving leaching/destroying of starch to improve its durability. All non chemical protection methods are thus based on lowering or destroying of starch present in the bamboo. These workers had no access to prevailing scientific protection techniques, making them more dependent on traditional methods, which were simple in nature and involved little expense. Protection involving chemicals is more expensive and requires special skills to handle these chemicals, which further prevented their adoption for a low cost material like bamboo.

Short – term Protection (Protection During Storage)

Storage of bamboo raw material is necessary to maintain inventory for regular requirements. Wherever the bamboo is stored, the main principle should be to reduce the moisture content and to avoid any additional uptake of moisture, either by rain or by ground contact. At the felling site the culms should be left in the open without overhead shade to facilitate initial drying to avoid fungal attack. As prolonged storage on the ground invites infections by fungi and beetles, the culms should be transported t the earliest to a proper storage site/yard.

Water Storage: Storage in running water is a widely adopted common practice in many Asian countries as an easy non-chemical method of improving resistance to borers and blue –stain. Water tanks may be used for storage if running water facility is not available. Water in such cases should be changed every fortnight to avoid stains and bad odor due to bacterial attack in stagnant waters. As bamboos are lighter than water, sinker load may be tied to bundles of bamboo culms to keep them totally immersed in water. Even split bamboo can be stored in water. If pond storage is also not possible, bamboos may be stacked on raised platforms and sprayed continuously with water from the top. To conserve water, erect platforms on a cemented sloping floor and re-circulate the water dripping from the stacks. Water storage is advantageous I several ways

1. Bamboo remaining green and more pliable.
2. Water logging prevents fungal attack.
3. Water storage eliminates physical contact with insects.
4. No cracking or splitting occurs due to non-drying conditions.

It is difficult to store large quantities of bamboo in water. If bamboo has to be used in dry condition, water storage increases the drying period and costs. Ie the bamboo are to be used after preservative treatment (pressure treatment), water storage is not desirable, as pressure treatment requires fairly dry bamboo, proper penetration and loading of preservatives.

Water Storage in Tanks (Courtesy Dr. Walter Liese)

Dry storage: When bamboos are to be used in dry condition, dry storage is preferred as it eliminates time required for drying. Bamboos are generally air dried, as kiln drying is highly expensive and is not justified for small requirements. Wherever bamboo is stored, the main purpose should be to reduce the moisture and avoid any additional moisture uptake by rain or ground contact. Freshly felled bamboos should be stacked properly on raised platforms on above specially prepared ground, about 10 cm layer of boiled ash and powdered lime sludge to prevent termite attack and induce uniform drying. The best method to tore and dry bamboo n small quantities is to lean single culms against a wall keeping them in upright position under cover protecting them in upright position under cover protecting them from rain and sunshine. Vertical stacking has been found useful in quicker drying as well as low incidence of fungal decay especially in reed bamboos(Ochlandra travancorica). If the area is infested with termites, oil poisoning should be considered. Good ventilation not only improves drying rate but also reduces chances of fungal attack especially mold. Regular inspection of the stacks is a good practice to reduce damage. Culms with signs of beetle attack should be burned, or removed for soaking in a preservative.

Prophylactic Treatment for dry storage: If the bamboo material is not likely to be used immediately, prophylactic treatment with proper chemical formulations should invariably be adopted for dry storage to prevent biological degradation. Application is limited to the surface and is only applicable for a couple of months. The various methods of applying preservatives are:

Spraying: Bamboos are stacked as per standard techniques on raised platforms preferably on sloping floor and chemicals are sprayed on the top so as to cover the entire surface. Special care should be taken to spray the ends as most of the damage starts from the ends. As bamboo has a smooth epidermis layer, most of the solution is likely to drip down. Nevertheless, cut ends created by chopping of branches, which are the main spots for initiation of biodegradation, get treated. Drained solution is recycled. Industrial sprays are best suited for larger stacks, while normal backpack type pesticide sprayers can be used for smaller quantities. Spraying can cause considerable environmental pollution, since part of the solution will blow away. Facemasks and eyewear are recommended during such sprays.

Fire tenders can be used for spraying solutions for very large stacks normally raised in paper mill yards. Spraying should be done while building the stack, dousing with solutions at 1 meter, 2.5 meters and finally at the top of the stack. The storage ground should be prepared with layer of 50:50 mixtures of boiler ash and powdered lime sludge to prevent termite attack from the ground.

Brushing: For very small quantities to be used for handicrafts or cottage industry items, two or three brush coats may be applied one after the other covering the entire surface. Depending on size of the material, a 50 or 75 mm brush can be used.

Dipping: dipping is more effective than spraying or brushing and is more appropriate for small and medium quantities of bamboos to be used for handicrafts, furniture and specialty products. A momentary dip of about 30 seconds is sufficient to offer protection. The material has to be placed on a draining board to collect excess solution for reuse.

Chemicals Recommended for Prophylactic Treatment:

1. 1% solution of Sodium pentachlorophenate for protection against blue stain.
2. Mixture of 0.1% TCMTB and 1% MBT were use of sodium pentachlorophenate is not permissible (for protection against stain fungi).
3. 2% solution of Boric acid and Borax (50:50) for protection against fungi, borers and termites (Kumar et al; 1985,)
4. 2.55 solution of Sodium pentachlorophenate: boric acid:Borax(0.5:1:1) for total protection against stain fungi, decay fungi, borers and termites. (Kumar et al; 1985, 1990)
5. 2.1% solution TCTMB: Boric acid: Borax (0.1:1:1) for total protection against stain fungi, decay fungi, borers and termites, where use of Sodium pentachlorophenate is not permissible.

Long –Term Protection

For long term protection treatment with preservative formulations developed for treating wood are best. Protection of bamboo with properly formulated compositions is use specific and details are available in several publications (Kumar rt al 1994:Liese nad Kumar 2003). Here only some of the traditional methods developed and used over the years are described. The problem accorded is limited and depends mostly on the conditions of use of the end product. These treatments may be adopted, where chemical protection is not considered feasible due to economic, environmental or technical reasons. No guarantee for performance of such treatments can be given.

Mechanical Barriers: The early efforts to improve durability relied on denying access to organisms by application of water repellent coatings. Application of Rangoon oil was tried in India (Stebbing 1903, 1910). A similar approach using coal tar was used in South Africa (Anon). Some ad-hoc experiments to protect bamboo posts by dipping in coal tar, Paris green, salts etc. were done in Phillipines in 1937(Pangga 1937). All these studies had limited success. A variety of coatings have been traditionally used for protecting bamboo. A coat of lime-wash reduces the pH at the surface, inhibiting fungal growth. Coating with tar seals the surface pores denying access to borers and also protection against water absorption. Bamboos used in ground contact or alternate drying or wetting conditions will not benefit much from such treatments, which are only skin deep and fail to protect the inner layers, which are easily destroyed by fungi and termites over period of time.

Reducing Starch Content: Reducing starch, the main food source for borers was the earliest concept to combat borer attack. Several approaches were followed for the same. The two most commonly followed practices are:

i) Water – leaching: Water leaching of bamboo as a possible protection method by reducing starch content was suggested by Stebbing (1910) in his studies on protection of Indian bamboos during 1903-10. Studies were also carried out in Burma in mid thirties (Atkinson 1934, 1936). Water soaking for several days was adopted for bamboos used for building houses, barns and rustic dwellings in Jamaika (Edwards 1938). Water soaking was studied and different soaking periods were suggested for different species in different countries vis. 3-4 days' soaking in Figi (Lever 1943),3 months for *D. strictus* (Hocking 1942), 4-6 months for *Bambusa tuldoides* (White et al. 1946). Water soaking for 6-8 weeks was used in Uganda to protect bamboo stickers used for storing plywood (Anon. 1947-8). Water leaching dissolves out sugars and improves immunity to borer attack(Boodle and Dallimore 1920). It is still being practiced by rural folks for manufacture of handicrafts and utility articles in many countries.

Water soaking not only helps reducing the starch content, it prevents fungal stains and keeps the bamboo green and pliable. Leaching out starch reduces the chances of borer attack but plays no role in protecting the lingo-cellulose matrix of bamboo from fungal decay and termite attack when used in adverse conditions(high humidity/ground contact). Bamboo should probably be leached in running water such as water steams, brooks etc. if soaked in tanks, containers, water should be changed at frequent intervals. Prolonged soaking of freshly felled bamboos in stagnant water results in staining/discoloring of bamboo stem and emission of bad smell due to bacterial growth.

Four – week storage is sufficient for most species. Split bamboo will take less time.

ii) Boiling: simply boiling of water or weak solution of caustic soda ash improves color, destroys sugars & starch also kills any existing infestation with borers/fungus. The treatment changes the surface ph to slightly alkaline side offering protection against fungi, which requires an acidic environment.

iii)Clump curing: Another method of reducing starch developed in Latin America is "Clump Curing". The freshly felled bamboo culms with foliage intact are leaned against the main clump for several days. The living parenchyma cells in the culms consume the starchy food. The foliage is removed when it turns yellowish brown (Burkill 1935, white et al. 1946, Plank 1950).

A variation in this method is transpiration or leaf suction method. The basal portion of the culms is placed in a bucket of water-soluble preserving chemicals(gardener 1945). As the leaves transpire, the preservative solution is sucked up and distributed through out of the bamboo Culm. The treatment is reported to complete in about 24 hours in African alpine bamboo (Wimbush 1945).

Heat Treatments

Heat Treatments protect bamboo in several ways. It partially destroys starch, kills any existing infestation near the surface and may create a carbonaceous layer on the surface, eliminating chances of borer or fungal settlement due to modification of the chemical nature of the surface layers. Several techniques have been developed for bamboo.

i. Baking: Baking over gentle open fire after application of oil (usually linseed) on the surface is a well known traditional method used for protection of green round bamboo. The bamboo Culm is kept rotating so as to avoid local charring. Heat causes hardening of skin decomposing starch and sugars. Partial charring helps producing insect repellents on the surface. Controlled heating moist bamboo plasticizes the same and helps and helps straitening and stabilization of crooked pieces. Heating is also used to bend bamboo components to give it special shapes. Excessive heat and moisture los may cause severe collapse.

ii. Deep Frying: Split bamboo are subject to temperatures above 210oc for 2 hours in a bath of vegetable oil (like linseed). The treatment causes an enhanced durability against fungal, beetles and termites due to decomposition of starch and sugars. Oil impregnation makes the bamboo water repellent. The mechanical properties, especially the elasticity of the material are evidently reduced, as observed for timber. This is an upcoming treatment now being developed to treat wood to replace toxic formulations used for treating wood. Soya bean oil has been tried to protect wood.

iii. Smoking : Smoking of wood and bamboo is an old method of making wood and bamboo immune to degrading organisms. Wood/Bamboo is stored in attics and exposed to kitchen fumes for a couple of months. The slow deposit of carbonaceous matter renders the woody material immune to insect attack. This method is reported to be of Japanese origin but some houses using such treated materials are reported to be in good condition after several decades in India as well. Efforts have been made in Columbia to develop artificially generated smoking chambers for commercial treatment of bamboo. However, material so treated was found to be invalid by fungi in Germany in a short period.

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Post Harvest Management and Storage of Bamboo Culms

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Preamble

Bamboo is a marvelous material bestowed by nature to mankind. Its utility in different areas of life has drawn attention of man to exploit this raw material to the fullest. It is one of the very fast growing plants on earth. Its short rotation period, ease in extraction and workability have rendered this material a special area of interest for mankind. Bamboo is especially used by people in rural areas of the country for their shelter and day-to-day utilities. This is particularly true in the northeastern parts of the country that is why it is described as “poor man’s timber”. Because of its varied utility, it is also known as “green gold of the forest” or “friend of the rural people”. Bamboo has versatile uses as building material, paper and pulp resources, scaffolding, food, agriculture implements, fishing rods, weaving materials, plywood and particle board manufacturing. Besides these there are nearly two thousand recorded uses of bamboo now such as fuel, fodder, food, laminates, furniture, mats, construction material, chop sticks, toothpicks, musical instruments, vinegar, beer, activated carbon, etc. Bamboos are good soil binders owing to their particular clump formation and fibrous root system and hence also play an important role in soil conservation.

Bamboo is useful for different things at different ages:

<30 days it is good for eating

6-9 months for baskets

2-3 years for bamboo boards or laminations

3-6 years for construction

>6 years bamboo gradually loses strength up to 12 years old

In the present day context of scarcity of wood raw material due to forest conservation act, bamboo has great potential to serve as substitute for wood in many areas.

DEFORESTATION and increased CO_2 emissions threaten the earth's biodiversity and the very air we breathe. Perhaps the environmental crisis' at hand have not yet touched our life, but the time is shortly to come. Recent NASA reports of a 60% loss of ozone over the arctic provide an explanation for increased severity in the worlds weather patterns which has only begun to affect us whether directly or indirectly. The social, political and economic implications are difficult to imagine as our ozone layer continues to thin, forests disappear and desertization is occurring at an alarming rate.

Bamboo is the fastest growing canopy for the regreening of degraded lands, and its stands release 35% more oxygen than equivalent stands of trees. Some bamboo even sequester up to 12 tons of carbon dioxide from the air per hectare. Bamboo can also lower light intensity and protects against ultraviolet rays. Traditional belief holds that being in a bamboo grove - the favorite dwelling place of Buddha - restores calmness to emotions and stimulates creativity.

Bamboo has an important role to play. The earth desperately needs the attention and action of all of us or else our generation next will surely not have a world fit to live in. There is no one solution but amazingly, the simple bamboo plant can make a dramatic positive impact in many areas.

EROSION CONTROL. A peerless erosion control agent,. it's net like root system create an effective mechanism for watershed protection, stitching the soil together along fragile riverbanks, deforested areas, and in places prone to earthquakes and mud slides. Because of their wide-spreading root system, uniquely shaped leaves, and dense litter on the forest floor, the sum of stem flow rate and canopy intercept of bamboo is 25% which means that bamboo greatly reduces rain run off, preventing massive soil erosion and keeping up to twice as much water in the watershed. Bamboo is a pioneering plant and can be grown in soil damaged by overgrazing and poor agricultural techniques. Unlike with most trees proper harvesting does not kill the bamboo plant so topsoil is held in place.

SAVING RAINFORESTS. Bamboo is one of the strongest building materials. Bamboo's tensile strength is 28,000 pounds per square inch versus 23,000 pounds per square inch for steel. In the tropics it is possible to plant and 'grow your own home;. in Costa Rica, 1000 houses of bamboo are built annually with material coming only from a 60 hectare bamboo plantation. If an equivalent project used timber, it would require 500 hectares of our diminishing tropical rainforests. Using bamboo to replace timber saves the rainforests. With a 10-30% annual increase in biomass versus 2 to 5% for trees, bamboo creates greater yields of raw material for use. One clump can produce 200 poles in the three to five years. Bamboo generates a crop every year.

However, emphasis on bamboo utilisation aspects from a scientific viewpoint is of recent origin in this country.

One of the main obstacles to even more widespread use of bamboo is its susceptibility to degradation. A biological material like wood, bamboo is vulnerable to factors like fire and weathering and to attack by pests and microbes. This vulnerability reduces the lifespan of the bamboo product.

But, like with wood it is possible to safeguard bamboo against deterioration by preserving and protecting it, by adopting certain practices during harvest, storage, processing and use." Effective treatment and handling of bamboo will not only increase the life of the product, but the value of bamboo as well, currently tremendously undervalued as a commodity. **In other words, better post harvest management and proper storage of bamboo culms are the need of the hour for efficient utilization of bamboo and extend its service life.**

Post-harvest operations and technologies

The timing and age of felling are very important. Culms will have less soluble carbohydrates, proteins and moisture as they get older, and they are less active physiologically in winter season and thus more resistant to the timber borers. Hence, harvesting only culms over 3-4 years old and felling at winter season are particularly recommended.

The primary processing of bamboo utilisation includes harvesting, storage, transportation, preservation and seasoning. The secondary processing line includes fabrication of value added products. The aspects of grading (strength / feature / colour / exterior / interior based) and quality control are nonetheless important including the functional tests on products such as furniture joinery and structures.

The main drawback of efficient utilisation of bamboo for quality products lies in its secondary processing, which is done by the age-old tools. The axe, the wedge and the hammer used to open the timber logs have now been replaced by frame saws, band saws, and associated chipper canters using computerised control. The subsequent wood working techniques have replaced the hand tools by portable power tools. Similar approach is required to be adopted for the bamboo owing to the benefits of mechanization. The introduction of mechanised tools is also essential for handicrafts sector to improve the quality of worked surface on which subsequent region based craft skills can be introduced in the final stage. The arbour saws are quite efficient to cross cut the bamboo in green (harvesting, primary processing) and dry condition (secondary processing).

After felling, treating culms physically or chemically can significantly improve their resistance to borers as well as to fungus.

Protection pre and post harvesting. The natural durability of bamboo depends on species, climatic conditions and type of use. The average life of untreated bamboos is less than two years. Bamboos thus fall in class III (non-durable category) with little variation in durability among different species. Variation in durability has also been observed along the length of the culm and the thickness of the wall. The lower portion of the culm is considered more durable, while the inner part of the wall deteriorates faster than the outer harder portion. This is probably related to the anatomical and chemical nature of the woody cells.

In bamboo, soluble sugars form the principal nutrients for degrading organisms. The presence of large amounts of starch makes bamboo highly susceptible to attack by staining fungi and powder-post beetles. Due to lack of any toxic constituents, bamboos form a ready food source for a variety of organisms. bamboo is more prone to both soft rot and white rot attack than to brown rot.

Therefore, if the sugar can be removed from the culms by non-chemical-methods , the risk of decay is significantly reduced. A number of methods for lowering the sugar content have been adopted. Non-chemical methods of preservation, otherwise known as traditional methods are widely used by villagers and can be undertaken without the use of any special or sophisticated plant and equipment or significant increase in costs. Typical traditional methods include:

Felling during low sugar content season. *Felling* of bamboo during low sugar content season in almost all plants varies according to season. In India, for example, it is higher in spring than in winter It is therefore advisable to harvest bamboo during the winter months

Felling of mature bamboo. *Felling of mature* bamboo when sugar content *is* low in bamboo varies with age and is lowest during the first year. However, the usefulness of very young bamboos is limited due to their low strength and yield.

Post-havesting transpiration of bamboo culm . Sugar content in bamboo can also be reduced by keeping culms upright or leaning them against trees for a few days, with the branches and leaves intact. Parenchyma cells in plants continue to live for some time, even after felling. During this period, the stored food materials are utilised and thus the sugar content of the bamboo is lowered.

Water soaking of bamboo. The traditional and most simple method is to immerse felled culms in water. This method may be effective only in preventing damages from bostrychid beetles. It is also suitable only for those bamboos with a low starch content (Sulthoni 1990), takes a long time, and culms treated in this way tend to blacken (Xu Tiansen 1983. The soaking method is commonly used in many Asian and African countries and consists of submerging freshly cut culms for *4-12* weeks in stagnant or running water, or mud (Sulthoni, 1987). Generally, stones are placed on top of the bamboo to keep it submerged during the soaking period.

During the process of soaking, the starch content of the parenchyma cells of the culm is reduced by dilution. As a result it is claimed that the bamboo is more resistant to wood borers. It is important to realise that treatment using this method does not confer added protection to the bamboo. It merely reduces the inherent susceptibil-ity of the material.

Smoking method Traditionally, bamboo culms are placed above fire-places inside the house so that the smoke and heat rises up and both dries and blackens the culms. It is possible that the process produces some toxic agents that provide a degree of protection. Alternatively, the heat generated by the fire could possibly destroy or reduce the starch content of the parenchyma cells by pyrolysis.

Whitewashing method Bamboo culms and bamboo mats for housing construction are often painted with slaked lime. This is carried out mainly to enhance the appearance, but there is also an expectation that the process will prolong the life of the bamboo structure by preventing moisture entering the culms. It is possible that water or moisture absorption is delayed or in some cases prevented which will provide a higher resistance to fungal attack. However, there remains a question as to whether the bamboo can be weakened over time by such an alkaline treatment.

The best likely protection will result from a combination of the above methods, for example harvesting mature culms during the winter months, leaving them upright for a few days after harvesting and then soaking them in water for 4-l 2 weeks.

Undoubtedly traditionally treated bamboo culms show increased resistance to insect and fungal attack when compared to freshly cut bamboo culms. However, because of the low natural resistance of bamboo to biological deterioration, the methods do not provide durability of product or structure in the long term and therefore offer no real cost saving benefits.

Chemical treatment methods Bamboo culms have a number of important chemical and anatomical differences from hardwoods and softwoods. These differences have a significant influence on the efficacy of treatments applied to bamboo. Three major anatomical differences that influence the penetration of preservative solution between bamboo culms and hardwoods and softwoods can be identified.

The ray cells in hardwoods and softwoods are linked to form a radial transport system. These structures are absent from bamboo where there are no cells to facilitate an easy movement of liquids in the radial direction.

The vessels, which run axially between the inter-nodes, are isolated from each other by parenchyma cells. The vessels branch extensively within the node region of the culms. There is a gradation in vessel size - small at the periphery of the culm and larger in the centre.

The outside wall of the culm is lined with epidermal cells. The inner layer of cells is heavily lignified and appears thicker. The outermost cells of the culm have a waxy coating and the inside of the culm is composed of numerous sclerenchyma cells.

This anatomy and structure mean that there is very little opportunity for radial movement of liquids. Therefore, preservative penetration pathways exist only at the cut culm ends and, to a lesser extent, at the scars around the nodes.

The penetration of liquids into the culm takes place through the vessels in the axial direction, from end to end. To ensure a satisfactory treatment process for the bamboo it is necessary for the treatment solution to diffuse from the vessels into the surrounding fibres and parenchyma cells. The vessels only account for about 5-10% of the bamboo cross section. Thus even when the vessels are filled to saturation point, the bamboo can still be vulnerable to fungal or insect attack if the preservative does not diffuse sufficiently into the main tissue of the culm.

When compared to traditional methods, the use of chemicals for the preservative treatment of bamboo is more effective in providing protection against biological deterioration. However, chemical preservatives are invariably toxic and due care and attention should be exercised whenever they are used The following chemical treatment techniques are described below:

Butt treatment The butt ends of freshly cut culms, with the branches and leaves intact, are placed in a drum containing the preservative. The continued transpiration of the leaves draws the chemical solution into the vessels of the culm. The method is used for the treatment of shorter culms with a high moisture content (green or freshly cut). The treatment process is very slow and often the vessels do not take up enough of the liquid to preserve, by diffusion, the surrounding fibres and parenchyma cells. The preservative in the barrel must be replenished regularly in order to maintain the desired level. When the treatment has been completed, care should be taken in the disposal of the contaminated foliage. Butt treatment is usually applied to bamboo posts. Such posts are often used for fruit supporting sticks in banana plantations.

Open tank method for cold soaking The open tank treatment method is economical, simple and provides good effective protection for bamboo. Culms, which have been prepared to size, are submerged in a solution of a water-soluble preservative for a period of several days. The solution enters the culm through the ends and sides by means of diffusion. Immature bamboo culms can be penetrated by preservative solution more easily than mature culms. This is probably largely due to the increased lignifications present in mature culms.

Also, penetration is easier with dried culms than with freshly cut (green) culms. Green culms are difficult to treat because they are likely to have a moisture content in excess of 100%. As a result there will be little or no room for additional liquid within the Culm. Preservative concentration should therefore be higher when green culms are being treated. Following soaking, the culms should be wrapped to enable further diffusion of the preservative.

Since the inner skin of the Culm is slightly more permeable than the outer skin, split culms can be treated more effectively than round culms. Some success in the treatment of bamboo has been obtained by punching the internodes region of the culms. Admittedly, this operation is probably not practicable on a commercial basis. Mechanical scratching of the outer skin of the Culm can help to speed up the penetration, especially where slow diffusing preservatives are used.

The time of treatment can be reduced considerably by using the hot dipping or the hot and cold method (see Hot and cold bath process). A double treatment can also be applied although this technique is fraught with commercial and technical difficulties that effectively prevent its use in practice.

Boucherie method The Boucherie method requires the culms to be in a green condition. The water-transporting part of the culm can be penetrated completely and the treatment itself is applied by an inexpensive installation.

Preservative is fed by gravity from a container placed at a higher level than the culm through pipes into its base end (figure 3). The culms are fastened to the tubes by rubber sheaths and clamps. It is also possible to hang the culm vertically and to scratch the inner wall of the top internode in order to use it as a reservoir for treatment. The treatment is terminated when the solution at the dripping end shows a sufficiently high concentration of chemicals.

The duration and success of the treatment process depends on the type of preservative, its adhesion and precipitation, and the swelling influences on the cell wall. Preservatives with high adhesion can stop flowing through the culm in a relatively short period of time, blocking the vessels and pits. Also, if the moisture content of the culm is too low, water is withdrawn from the preservative solution causing precipitation and blocking the vessels. The best results are therefore obtained during or shortly after the rainy season, using younger culms with a higher moisture content, providing alternative solutions to the problem of disposal.

Allowing the bamboo to dry slowly in the shade for a period of at least two weeks after treatment ensures that the solution diffuses into all of the tissue surrounding the vessels

Modified *Boucherie* method The basic Boucherie method has been improved by the introduction of pneumatic pressure over the preservative fluid in a reservoir, for example by using an air pump or electric pump. The preservative is forced axially through the culm by the air pressure in the reservoir. In this way the time of treatment can be reduced from several days to 3-8 hours. In other respects the process is similar to that for the basic Boucherie method.

Pressure treatment method Pressure treatment, using either creosote or water- borne preservatives, offers the best method of preservation for bamboo culms. The applied pressure ranges from around **0.5-1** .5N/mm 2 (5-15 bar) and as such requires special plant and equipment. Accordingly, costs are high, but a service life of up to 15 years can be expected from adequately treated bamboo when used in the open and in contact with the ground.

In order to achieve sufficient chemical penetration and absorption, the culms must be air dried prior to treatment. Also, since the inner skin of the culm is slightly more permeable than the outer skin, split culms can be treated more effectively than in the round.

Hot and cold bath process When pressure treatment facilities are not available the hot and cold bath process offers an acceptable alternative. The bamboo is submerged in a tank of preservative which is then heated, either directly over a fire or indirectly by means of steel coils in the tank. The bath temperature is raised to about 90°C held at that temperature for about 30 minutes and then allowed to cool.

When using preservatives which can precipitate when heated, it is best to pre-heat the bamboo in a suitable liquid, such as water, and then transfer the hot bamboo into a separate tank containing cold preservative. In order to assist the effectiveness of the treatment, the impermeable diaphragm of the nodes should be cleanly bored through, thus providing uninterrupted access throughout the culm for the preservative.

When the treatment process has been completed, the bamboo should be allowed to dry slowly to allow further diffusion of the preservative to take place.

Glue line treatment Glue line treatment is specific to the manufacture of bamboo mat board and involves adding preservatives to the glue during manufacture. This process is also more economical than using adhesives of a higher solid content. Additives which have been shown to provide effective preservative treatment without impairing the bond strength of the mat board include 1% Chlordane or 1% sodium octaborate tetrahydrate with a 1:2 diluted PF solution containing 17% solid content

Fire retardant treatment Fire presents a potential hazard in any form of construction, but the risk is especially high in bamboo buildings. The combination of bamboo and matting, and the tendency of the internodes to burst causes rapid fire spread. The danger is increased when the joint lashings are destroyed, which can cause catastrophic collapse of the building.

It is, however, possible to treat bamboo with a combination of preservative and fire retardant chemicals. The process is normally carried out by pressure treatment. The cost of fire retardant treatment is generally high and is therefore often considered inappropriate. The importance of finding a suitable and cost effective treatment, which will provide combined protection against bio-degrade and fire, is a necessary area for further research. Boron based retardants offer a possible solution, with the added advantage of being relatively safe to use.

Chemical treatment using various insecticides and preservatives. These have been the most widely used method in controlling post-harvest pests of bamboos. Various preservatives have been recommended and used in different countries: 5% water solution of copper-chrome-arsenic composition (CCA); 5-6% water solution of copper-potassium dichromate-borax (CCB); 5-6% water solution of boric acid-borax-sodium pentachlorophenate in 0.8:1:1 or 1:1:5 ratio (BBP); 2-3% water solution of borax:boric acid in 5:1 ratio; and 10% or 20-25% water solution of copper sulphate. These are mostly applied by soaking under normal temperature, cold or heated conditions, or under high pressure.

Drying of bamboo

Seasoning of bamboo is essential before it is used as seasoning gives it strength and prevents it from fungal discolouration and decay.

Green bamboo can have a moisture content of 100-150%, depending on the species, area of growth and felling season. The chemical composition of bamboo results in a comparatively higher hygroscopic-ity than wood. Additional problems in the drying of bamboo occur because the material lacks an efficient radial transport system and possesses a waxy coating. Therefore, the major pathway for the loss of moisture is from the ends of the culms The liability to biological degradation and to deformation owing to excessive shrinkage (which occurs even above the fibre saturation point) necessitates quick drying of bamboo.

Kiln drying At the present level of drying technology, kiln drying of round bamboo is not feasible. Even mild drying conditions can increase the incidence of cracking and collapse. Split bamboo can, however, be kiln dried.

Air drying Air drying takes 6-12 weeks, depending on the initial moisture content and wall thickness. Collapse can be a major problem in some species, owing to excessive and non-uniform shrinkage of the culm. However, problems are mostly seen in drying of immature culms. It is recommended that only mature culms are used.

Air drying of split bamboo does not pose any problems, even in direct sunlight. Split bamboo standing upright dries faster than when stacked horizontally. Round bamboo can also be dried standing upright or in stacks, using bamboo crossers of appropriate diameter.

Chemical seasoning of round bamboos for making value-added handicraft products

An attempt has been made in this study to minimise cracks and splits during seasoning and subsequent use of round bamboo in order to make it fit to be used in novelty handicraft items such as flower vases, pen stand, ashtray, table lamp post, etc. The value addition was done by chemically bulking the bamboo material before forced-air drying. The process of air or kiln seasoning after treatment with anti-shrink chemicals, chiefly with the object of minimizing seasoning degrades, is known as ‘chemical seasoning’. Chemical seasoning of *Dendrocalamus giganteus* has been tried earlier using poly ethylene glycol-600 (PEG). Urea and common salt have been used in this study and are much cheaper as compared to PEG. Chemical seasoning of green round *Bambusa tulda* has been tried before using urea. In the present study chemical seasoning was carried out for three species, viz., *Bambusa nutans*, *Dendrocalamus membranaceus* and *Dendrocalamus giganteus*.

B. nutans, D. membranaceus and D. giganteus in round form can be seasoned free of drying degrades like cracking and splitting after giving it an anti-shrink treatment in green, freshly felled condition. The treatment makes it possible to air-dry bamboo defect free. A solution of urea as well as NaCl (40 per cent w/v) in water can be used to get satisfactory results. But urea gives better results compared to NaCl. After drying the treated product should be coated by polyurethane finish in order to avoid sweating in prolonged humid atmosphere, as urea is hygroscopic. The treatment offers the possibility for handicraft manufacturers to use these bamboos in round form for novelty items.

The study should prove helpful in treating the round bamboo with urea in order to avoid cracks in seasoning, however, it is suggested that anyone planning to use the treatment commercially should make a series of tests on the species size and shape of specimens to be used, varying the chemical concentration and the treatment time in order to attain an optimum bulking concentration of the chemical.

Storage

There is necessity to store the produce for different periods primarily for commercial reasons.

Harvesting of BAMBOO is seasonal, but consumption is continuous. The market value of the produce - generally low at harvesting time. grower need storage facility to hold a portion of produce to meet the feed Requirements, selling surplus produce when the marketing price is favourable. Traders and Co-operatives at market centres need storage structures to store when the transport facility is inadequate. storage structures to maintain buffer reserves to offset the effects produced by the vagaries of nature.

An ideal storage facility should satisfy the following requirements

It should provide maximum possible protection from ground moisture, rains, insect pests, moulds, rodents, birds, fire, etc.

It should provide the necessary facility for inspection, disinfection, loading, unloading, cleaning and reconditioning.

It should protect bamboo from excessive moisture and temperature favourable to both insect and mould development.

It should be economical and suitable for a particular situation.

For long term storage of bamboo in the open, it is recommended that the stacks are raised on specially prepared ground to prevent termite attack. The stacks should be profusely treated during different stages of stack forming (i.e. at 3, 4, 5 and 6 metres height) and can be covered with treated bamboo mats or grass thatch. However, coverings produced from non-biological materials can offer improved protection as they are less likely to harbour a reservoir of infection.

Conclusion

Bamboo has great potential to substitute wood in housing and industrial sector, provide employment especially for rural people, if proper attention is paid for post harvest management and storage of bamboo culms. It also plays an important role in soil conservation and protects the environment and the air we breathe by releasing more oxygen and absorbing carbon dioxide than the equivalent stand of trees.

Post Harvest Management of Bamboo

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Bamboo is a common name given to a group of tall arboresent grasses. It is the most versatile forest produce and its potential can be tapped for various uses in everyday lives of millions of people. It is a woody grass belonging to the sub family *Bambusoideae* of the family *Poacae.* World wide there are more than 1,250 species, 3which are unevenly distributed in various parts of the humid tropical, subtropical and temperate regions of the earth. Bamboo has versatile uses as building material, paper pulp resources, scaffolding, food and agricultural implements, clothing, fuel etc. The consumption pattern shows that majority of produce is utilized for pulp, housing, rural purposes.

Bamboo has gained renewed importance in the present day context due to shortage of wood. It is a preferred material because of its fast growing nature, abundant supply at cheap price, adequate strength properties and easy workability. All these properties have made its favored building material but wider acceptance of bamboo, however, is often restricted due to its non durable nature. Durability of bamboo against mold, fungus and borer attack is strongly associated with the chemical composition apart from the environment where it is being used. Forest Research Institute, Dehra Dun, India (F.R.I) classified bamboo in class III (non-durable category) with little variation in durability among different species.

Natural durability of Bamboo

The selection of bamboo species for various applications not only depends on the physical and mechanical properties but also on durability. The main constituents of bamboo clumps are holocellulose (60-70%), pentosans (20-25%), hemicelluloses and lignin and minor constituents like waxes, tannins and inorganic salts. Bamboo has high silica content but it is present only in epidermal layer. Natural durability is associated with secondary metabolites and absence of these extractives makes it highly susceptible to biological attack. Absence of minor amounts of secondary metabolites and presence of large amounts of starch makes it a good food material for microorganisms. Natural durability was studied in FRI. It was suggested that under cover, the untreated bamboo may last for 4-7 years but grave yard test concluded that average life of bamboo varies between 3 months to 2 years in ground contact. It is in confirmation with the earlier reports made by different workers in FRI. Seasonal variations also influence natural durability. Forest research Institute has established that there is a positive and significant correlation between moisture content and deterioration. Since the growth starts after rainy season, causing more utilization of starch, it is suggested as best harvesting period.

Protection of Bamboo

A large number of protective procedures, including chemical preservation methods are known, similar to the methods opted for timber in tropical countries but they are rarely because of lack of knowledge of treatment procedures, availability of preservatives, economics of treatment procedures, value addition of material and lack of demand of treated material. It is unfortunate that users are largely unaware that protection of this versatile material with minimum investment may provide longer service life. Protection is also required for sustained supply of raw material. It would not only increase bamboo availability but also help in saving maintenance cost, material cost etc.

Protection of Bamboo in Outside Storage

The requirement of bamboos for pulp is increasing fast with increasing requirements of paper. Many paper mills maintain minimum stocks for a long period. Storage for such long periods in forests and mill deposits results in considerable losses due to biodegradation. Forest Research Institute has carried out limited laboratory studies on outside storage of bamboo at Dehra Dun with and without preservative treatment. *Sodium pentachlorophenate* (NaPCP) and a mixture of boric acid-borax were found quite effective in controlling biological decay. Substantial protection in quality and quantity of bamboo was achieved by prophylactic treatment. In deposits it is given mainly by spraying and is done in two stages. The common practice is that when half of the material is stacked, sprayed is done till solution reaches the bottom layers. Then the stacks are raised to a total height and then the final spraying is done. It is done at the rate of 25 litres of solution per tonne of material. It is also recommended that preservative treatment is repeated after 4-6 months i.e. immediately after the rainy season.

Measures to Enhance Durability

Bamboo is available in green as w3ell as in dry state, so it can be treated in both the stages.

The treatment methods are entirely different from for both types of bamboos. There are a few scientific well known methods of treatment s, besides these methods also in common practice in remote in remote areas.

Traditional Practices for Bamboo Protection:

The possibilities of non-chemical methods for bamboo protection should be considered first to avoid any environmental pollution/problems. In bamboos soluble sugars and starches are the main nutrients for microbes thus by controlling these through non-chemical methods; a substantial loss can be checked.

A number of traditional methods like felling of bamboo during low sugar content season is recommended. Sugar contents are higher in the spring season due to many physiological activities, harvesting between august to December is preferred. The very common practice is culm curing. For clump curing the culms are cut at the base and left as such with the crown for a week. Parenchyma cells in culms continue to live even after felling for some time, during this period the stored food is utilized and moisture content is also reduced, thus providing some resistance against borers. When the culms turn yellow they are transferred to the site. For reducing sugar content a common practice is to soak bamboo in water. Fresh culms are immersed in stagnant water or running water for at least a month whereby, the starch content is mainly reduced by bacteria causing restricted availability of food.

Another common practice at village levels is to plaster the walls with mud. In the mud suitable quantity of treated grass chips are mixed. After the mud plaster is fairly dried it is further plastered with the lime mortar and lime washed. Due to lime the surface becomes alkaline thus delaying fungal attack.

Baking of bamboo after applying oil on the surface is another traditional method to preserve green bamboo. Moderate heating not only seeks swelling of bamboo but also protects bamboo against beetles because of charring of starches. However, the whole process needs controlled heating otherwise severe collapse may occur in bamboo.

Chemical Methods Of Treatment

For most bamboo structures with longer service life a chemical treatment is required. Adequate retention of preservative methods to be assured in treated material. The nature and type of chemical and threshold levels of retentions is decided on the basis of end use of the material. Achievements of required retentions depend upon the moisture content, species, and method of treatment, concentration of preservative and anatomical structure. Due to these reasons, it is always suggested to standardize a method for a particular species which may or may not be applicable for other species of bamboo.

Forest Research Institute has worked on different species, preservatives and treatment methods. Bamboos can be treated in dry as well as in green conditions methods for both types are entirely different.

a)Treatment of Green Bamboo

(1) Stepping: Mainly water-borne preservatives are used in this process where base of a culm of approximately 6 feet length is immersed in a container. The culms are kept along with branches and it is left for 7-12 days. The concentration of preservatives varies from 10-12 %. It is a simple process that operates without special skills requirement.

(2) Sap-displacement or Wick Process: Round bamboos are immersed vertically up to 25cms in 5-10% aqueous solutions of water based preservative. Approximately 2meter long bamboo is placed and these bamboos are inverted after a week. Thus it takes 2 weeks to treat bamboo. High retention levels are achieved by this method.

VAC-FRI: Boucherie and other treatment processes are well known. However, the latest breakthrough was achieved by F.R.I in treatment of bamboo and this approach is faster and efficient while maintaining the economics of the treatment well within the reach to entrepreneurs. Green bamboo culms of 6-8 feet length can be treated by these processes.

b) Treatment of Dry Bamboo

Dry solid bamboo poses problems in the treatment due to the presence of silica and wax on the upper skin. Forest Research Institute has reported creosote: fuel oil CCA and ACA treatment of dry bamboo are given below:

(i) Soaking Treatments: Air dried bamboo are kept in the preservative solution (oil or solvent type) and period of treatment depends on the thickness, species and age of bamboo with water soluble preservative then the same process is called stepping. Treatment with Copper-chrome-arsenic (CCA) and Ammonical copper arsenite (ACA) were done at F.R.I. However, it was observed that treatment with solvent type preservatives is better than stepping in water-borne preservatives.

(ii) Hot and Cold Process: Dry bamboo is dipped in a tank containing hot creosote: fuel oil mixture, temperature is maintained to about 90 degree Celsius for 3-6 hours and then it is cooled and residual oil is drained off. Treatment schedules were developed by F.R.I.

(iii) Pressure Treatment: the pressure treatment of bamboo provides the best long term protection, but it is rarely applied. For treatment a cylinder and preservative tank is required with other accessories. The technical installations and handling makes it costly and often not financially viable. There is a limitation of size also. Bigger size of bamboos cannot be treated as treatment cylinders which are in common practice are of 10-12 feet length. Another limitation of the process is that thin walled bamboos are susceptible to cracks and collapse. However, F.R.I. researchers have suggested that drilling holes or notches between septa can solve the problem of collapse or cracks in round bamboos.

Chemicals commonly used for Bamboo Protection

There are three categories of chemicals. Bamboos can be treated by all types of preservatives. One category is water based preservative. Copper-chrome-arsenic (CCA), Ammonical copper arsenite (ACA) and Copper-chrome-boron (CCB) which are commonly used for long term protection of bamboo. Whereas Borax: Boric Acid is used for interior application. Borax: Boric Acid and Sodium Pentachlorophenate (NaPCP) is recommended for prophylactic treatments for shot durations. Most of the chemicals which are used for bamboo protection are applied at 4-6% concentration.

Service life of Treated Bamboo in Ground: The performance of treated bamboo is evaluated in ground contact under graveyard tests in F.R.I., ACA, CCB, CCA and creosote: fuel oil treated bamboo treated remarkably enhanced the service life of bamboo. Treated bamboo in mud reinforced exhibited more than 53 years of life in F.R.I. which were made in fifties were in sound condition. Bamboos in all the structures are treated and treatment imparted substantial life to the demonstration structures. Recently F.R.I. is constructing low cost huts which are made of treated bamboo. The bamboo installed is treated with ZiBOC, newly developed eco-friendly wood preservative. Demonstration structures establish that the post harvest treatment of bamboo enhances life of structures up to several folds as compared to untreated ones.

Revival of closed plywood factory in the North Eastern Region

A First-Hand Experience

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Chairman, APIL

Abstract

CBTC and Planning Commission inspired APIL to convert its plywood factory to bamboo board manufacturing unit. Having in-house R7D facilities for 70 years in producing panels from natural raw materials, APIL developed flattened bamboo boards. APIL with NMBA, sponsored ancillary has units in remote villages to supply flattened bamboo strips. APIL has a buyback agreement with these ancillary units and will also provide training and technology to produce desired quality of semi-finished products thus creating backward linkages. Product value of each of these units is around 50-70 lakhs per year. The unit ass more than 100 percent value to raw bamboo and earn profit of 15-20 percent. APIL is advocating the ancillary unit owner to grow bamboo in their surplus land to be self-sufficient in getting bamboo on sustainable basis. The model has created employment in remote villages APIL is producing bamboo boards from 3 mm to 24 mm thickness of 2.44 mm into 1.22 mm sizes that is being used for manufacturing pre-fabricated bamboo houses. APIL utilize all species of bamboo by fortifying it with suitable resin. All the panels have been validated by National Testing houses and structural engineers for social activities like schools, pre-medical centers, defence apartments and community halls etc. the project is successfully operating in Namsai, Aruncahal Pradesh. APIL model provides bamboo panels as a substitute to plywood made from timber. It generates employment and income in villages. It has been able to create market for bamboo goods. These structures are not only durable but fire-retardant to withstand all natural parameters like wind, rain, snow and earthquake. These houses can be self-erected-re-erected locally. This technology has been validated and demonstrated throughout the country which offers a unique opportunity for bamboo boards.

I would like to thank Mrs. B. Choudhury, Executive Director, APIL for her suggestions.

Background

In 1996, APIL had two options-either to close down or find an alternative raw material. An easier option was to close its operations, but the management started researching for an alternative raw material that was environment-friendly, available in plenty in the region and easily renewable. During its research it discovered BSMBOO- a grass as recognized by the Honorable Supreme Court.

A seminar on revival of closed plywood factories in the North Eastern Region (shut down due to blanket ban by the Hon'ble Supreme Court) using bamboo as the main raw material was organized by Cane and Bamboo Technology Commission (CBTC), supported by the Planning Commission, Ministry Of Environment & Forests (MOEF), FIPPI, NEC, EXIM Bank, SBI, MIDC and North Eastern State Governments on 27th August 2004. In this conference, Mr M. M. Jalan, representing FIPPI agreed to set an example by converting Arunachal Plywood Industries Ltd (APIL), the first Indian plywood company established in 1919, into a Bamboo Board Industry.

Our journey towards this conversion was not smooth. Producing bamboo board required a number of clearances and clarifications from the High Power Committee, which was constituted by the Hon'ble Supreme Court at the time of the timber ban in the north-east and also from the Arunachal Pradesh State Government. APIL was the first plywood unit to convert into a bamboo- based factory. The process was onerous as procedures and formalities were not yet standardized for bamboo processing. During this process of conversion our factory was closed eighteen times due to different interpretations of the Hon'ble Supreme Court order by different forest officers. It was only in 2006 after the intervention of the Planning Commission that our factory started functioning on a regular basis.

We are grateful to Mr. Kamesh Salem of CBTC for giving us initial support, Dr R K Mandal, Advisor Planning Commission, for giving us logistical support in sorting out matters with the State Government. Thereafter, Mr V S Oberoi, Director NMBA, supported us in setting up 100% pre-fabricated bamboo structures for demonstration in various parts of the country.

APIL was requested by the Planning Commission to demonstrate a pre-fabricated house at the PanelExpo 2004 at Pragati Maidan New Delhi. At that point of time we did not have any specialized machine for bamboo processing, so we had to design and fabricate our own machines for the purpose. Also, after a lot of experimentation and research, suitable resin was formulated for bamboo board. The photograph of the first self-fabricated machine is enclosed.

As far back as in 1972, Government of India had directed different government agencies to substitute timber products with alternative materials. They were unable to find a substitute for timber. It is hearting to know that 5the bamboo industry has been able to convince the CPWD to use bamboo boards in place of plywood for Tsunami reconstruction in Andaman & Nicobar Islands.

Processing of bamboo boards

In processing bamboo boards we adopted similar methods that were followed by us for producing plywood with required modifications. In the first stage, instead of peeling as in the case of timber, the outer knot of the bamboo was removed, then it was split into two pieces, then the inner knots were removed, flattened and planned to required thickness in the planner. Thereafter bamboo splints were treated by boiling with suitable chemicals and glued in the glue spreader and just like plywood.

Feeder units

Having worked for 90 years in the North Eastern Region, APIL had always supported ancillary units in remote villages to produce semi-finished products required for the finished products. Following the same policy, the first ancillary unit for making bamboo splints was established by a local entrepreneur with technical support and buy-back arrangement by APIL. In the initial stages machines were fabricated by APIL and supplied to this unit, free of cost. Subsequently, the designs of these machines were updated and adopted with some modifications by machine manufacturers. At this point of time, NMBA stepped in to finance the entrepreneur by making payments to machine manufacturers. 50% of the cost was given as grant and the remaining 50% was given as loan with 1% interest repayable in 5 years. It was assessed that APIL could support 14 such units. The local state government administration was requested to identify the entrepreneurs APIL and NMBA jointly assessed the potentiality of such people, whether they were genuinely interested in running the unit. Three such units have already been set up and one more is in the pipeline. Financial statement of a splint unit is enclosed (Annexure I).

APIL entered into a buy back agreement with the ancillary units that their entire production would be purchased by them. The condition imposed by APIL was that the local entrepreneur would run the unit himself/herself without handing the unit to an consider and also employ workers from the local village. Bamboo plantation of approved species would be generated in the land owned by him/her. In Nagaland we made an agreement through Nagaland Bamboo Development Agency to purchase the entire mats produced in 38 villages. In the beginning these villagers were supplying only seven hundred mats per month, now they are supplying more than ten thousand mats per month. More villagers are joining to produce mats. Our requirement is one lakh mats per month, which will provide employment to 33,000 persons in the process. 90% of these mat makers are women. From the projections made in Annexure I it would be evident that they are adding more than 100% value-addition.

Comparatively, in Arunachal Pradesh, given that the population is small, each such feeder unit would give direct employment to only about 40 people. However, in its factory, APIL has taken a special imitative to empower women by employing women workers in most of its processing stages. Currently, women workers comprise 80 percent of the total employees. This has inspired women workers in the region, and has also encouraged families to educate their female children.

Market Potential

After undertaking detailed market research, APIL came to the conclusion that it would be difficult to sell bamboo boards as a substitute for plywood boards. This was because plywood boards were already well established amongst the consumers. Considering all these facts, APIL decided to manufacture pre-fabricated houses. Preliminary market research indicated that there was a great demand for such houses. Furthermore, no one had ventured into this field so far.

For example, under the current budget of the Sarva Shikha Avigyan, a large percentage of the allocated Rs.13, 100 crores is for construction of schools. This is a potential area where bamboo houses can be popularised. We have already supplied our structures for SSA schools in both urban and rural remote areas. Our structures have the advantage of easy portability abnd can be erected in the shortest possible time.

It is estimated that around 440 lakhs of *Kutcha* houses exist in rural areas. Under the Indira Awas Yojna under which pre-fabricated bamboo houses produced by APIL can be used to make these structures permanent. The subsidy under Indira Awas Yojna scheme in the current budget has been increased from Rs 25, 000 to Rs 35, 000 in plain areas and from Rs 27500 to Rs 38, 500 in hill/difficult areas. Already in one of the villages in Arunachal Pradesh, an existing *Kutcha* house was replaced by an engineered pre-fabricated bamboo house under the Indira Awas Yojna and MLA fund.

Defence is another potentially large consumer of pre-fabricated houses. We have successfully supplied and erected 50 pre-fabricated bamboo houses for the World Military

Games at Secunderabad within a month. After the games were over, these houses were shifted to a border area in Rajasthan.

In the north-Eastern Region a number of power projects are coming up and they also require pre-fabricated houses for accommodation of their officers and staff. We have already supplied a few houses at a power project at Mopani, a remote place in Arunachal Pradesh.

Other areas where we have supplied pre-fabricated structures include premedical centers at Amethi, and Kargil, Islamic University in Jammu & Kashmir, structures in Uri and Khandar, after the earthquake in Jammu & Kashmir. Finally, we have also received many enquires, especially from foreign sources to keep at least 1000 houses ready for natural disasters.

Technology Transfer

APIL provided technical support to the local feeder units. It also transferred technology and helped decide on suitable equipments for manufacturing flattened bamboo boards by Kerala State Bamboo Corporation Ltd. We are also preparing a detailed project report for conversion of closed plywood unit of Banderdewa Saw mill & plywood Industries, owned by Arunachal Pradesh Forest Corporation into a bamboo board unit. A number of entrepreneurs have visited our plant at Namsai, Arunachal Pradesh and have already taken necessary steps in establishing flattened bamboo board units.

Why Bamboo?

It is on record that forest cover has been shrinking all over the country as per the latest Forest Survey report of India. Moreover, no amount of policing can save the forests unless demand and supply of timber is matched. With increased building activity, the demand for quality timber has increased manifold. Though part of it is met by importing timber, there is still a large gap between demand and supply. (The quantity imported in 1997/98 was 1, 362, 258 cum valuing Rs 1436.92 crores. This has increased in 2006-2007 to 3, 491, 872 cum valuing Rs 4113.98 crores). Engineered Bamboo products are the only substitute to timber. Bamboo converted into boards can substantially reduce the pressure on forest.

The attributes of bamboo board prefabricated structures are as follows:

- Durable (30 years life) and weather resistant.
- Withstands high winds (150 kmph) 7 earthquake resistant.
- Aesthetic, functional and fire retardant (IS-55089/IS-476).

- Easy to construct requiring minimum skilled labor.
- Light weight, modular and inter changeable.
- Eco-friendly, energy saving manufacturing/usage.
- Good thermal and acoustic properties.
- Raw material bamboo renewable resources.
- Cost effective Rs. 450/sq ft plains Rs 9000/sq ft high altitude :puff
- Modules 100-1000 sq ft, width 20ft.
- Can be re-erected with minimal effort.
- 1000 sq ft in one 24' truck.
- Designed as per BIS-4990-1981 read with IS-13958
- In direction parallel to grain; 318 kn/ m2
- At right angles to the grain: at least 588 kn/ m2
- Total tensile strength in both direction: at least 588 kn/ m2
- Bamboo boards are stronger in every respect than plywood

Changing Perception

Bamboo is no longer a poor man's timber. In 1988 China started changing this concept by utilizing bamboo as raw material for value added products, like replacing timber with bamboo products for industrial use and exporting bamboo shoots, bamboo yarn and floor boards etc which has great demand in the international market. Their present bamboo trade domestically and exports is around Rs 26000 crore. In the same way with the right awareness, we can easily adopt bamboo products as a substitute for timber. I feel it is our moral duty to bring awareness in the user of timber to replace it with bamboo product to safeguard the future of the earth.

Conclusion

- Converting closed plywood units to bamboo manufacturing units will create local and rural employment, converts low value bamboo usage into a high value engineered product with assured returns.
- Saving of fuel and transportation cost of hollow bamboo since most of the manufacturing units would be located in close vicinity to the primary and secondary processing units.

- Would provide income generation and steady source of employment, creating from bamboo plantations.
- Most markets of prefabricated shelters outside the north-east would generate wealth even at the grass root level.
- We would be enabling creation of real time assets in a very short time period.
- Replacement of steel, timber and cement by engineered bamboo structures creates a low energy consumption regime which is not only eco friendly but also minimizes use of renewable material used in manufacture of steel, cement, bricks etc.
- At the national level it would result in win-win situation for the north east and act as brand north east product given preferential treatment in establishing social infrastructure facilities in the whole country.

APIL is prepared to share its experience with any one prepared to revive closed plywood units and guide them in selecting equipment and proper technology. We are capable in marching ahead of China if timely support is given to the bamboo industry by government agencies and financial institutions. You will be happy to note that China has adopted our design for structures.

We feel that if bamboo industry has to flourish, then the forest department has to change its outlook regarding harvesting of bamboo in forest areas. Unlike timber, bamboo if not harvested within a period of six years, rots and yields reduce due to congestion of culms or dies due to flowering. In the case of Arunachal Pradesh, 81.945 of land is forest area. This provides potential catchments to harvest bamboo. However, harvesting of bamboo is not done in a systematic manner as the required working plan for bamboo has not been finalized. This is even though working plan for timber has been prepared and approved.

Annexure I
Financial Statement of Splint Manufacturing Unit (in Indian Rupees)

	1st Year	2nd Year	3rd Year	4th Year
SALES TURNOVER	9, 000, 000	9, 000, 000	9, 000, 000	9, 000, 000
Expenses				
1 Raw Materials	3, 600, 000	3, 600, 000	3, 600, 000	3, 600, 000
2 Salaries & Wages	1, 166, 220	1, 166, 220	1, 166, 220	1, 166, 220
3 Electricity	480, 000	480, 000	480, 000	480, 000
4 Consumable Stores & Spares	60, 000	60, 000	60, 000	60, 000
5 Repairs & Maintenance	36, 000	36, 000	36, 000	36, 000
6 Insurance	24, 000	24, 000	24, 000	24, 000
7 Packing & Forwarding Expense	1, 260, 000	1, 260, 000	1, 260, 000	1, 260, 000
8 Office Salary	36, 000	36, 000	36, 000	36, 000
9 Office Expense	12, 000	12, 000	12, 000	12, 000
10 Depreciation	232, 760	232, 760	232, 760	232, 760
11 Interest @ 12.50%	180, 798	180, 798	68, 923	42, 721
	7, 087, 778	7, 087, 778	6, 975, 903	6, 949, 701
Net Profit	**1, 912, 222**	**1, 912, 222**	**2, 024, 097**	**2, 050, 299**

The above estimates are based on bamboo rate being Rs. 12 per piece, on 100 percent utilization of capacity & requirement of 3 lakhs bamboo pieces (30 feet in length) per annum

Tools and small Technologies for spread of design innovations in bamboo of craft at grass root level.

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Abstract:

A new phase of activities in bamboo craft started in India with the launch of UNDP project in 1999-2000 onwards. A new tool kit was designed and developed by Industrial Design Centre of IIT Bombay, Mumbai through Development Commissioner (Handicrafts). The tool kit was introduced along with training conducted by D.C (Handicrafts), C.B.T.C and K.V.I.C in North East as well as other states of the Country. Concept of Micro Common Facility Centres and Mini Bamboo Clusters was promoted by IDC's Bambu Studio. Coil Technique in bamboo which was new to the Country was introduced in the training programmes.

Many new product designs in Coil technique were developed by IDC students and faculty members. Craftpersons at grass root level also came out with new designs in North Eastern states like Manipur, Assam(Barapeta), Nagaland and Tripura. But craftsmen needed structural support for design refinement and to use jigs and fixtures to become competitive in the Global Markets. The present scenario is that, large orders for goods of various designs are received by the entrepreneurs and artisans. But these could not be fulfilled due to lack of production capabilities with required design and product quality. A sustained interaction between the designers, Design development institutes and artisan groups over prolonged periods is necessary to develop these capabilities. Current design assistance schemes have a limitation of being one time with particular group of Artisans. The training schemes should include, 'design and use of jigs and fixtures' and 'working in groups with division of Labor' in addition to design and skill inputs to produce collectively.

The paper discusses various issues involved and possible new Govt. schemes to support such indigenous efforts. Development of 'Tool kit for Bamboo Craft' under UNDP

programme in the year2000 onwards at IDC(Industrial design Centre at IIT Bombay) has been an important input in the bamboo craft sector of India. The background was significant. IDC started serious intervention into bamboo craft in 1992 with a project assignment by MHRD (Ministry of Human Resources and Development) on 'Design inputs into Craft Areas'. A week- long national seminar cum Workshop in bamboo craft design 'Jagruti' was organized at IDC in 1993.with 15 designers,15 craft-persons and 30 students participating in it. Seminar proceedings were brought out in a book form titled 'Bamboo Craft Design' as a IDC-publication. Participation in the world bamboo congresses organized by INBAR and 'Bamboo Link' a project assigned by INBAR to IDC, gave many insights to the nature of problems at the grass root level.

1. The organizational structures for bamboo craft at grass root level were weak.
2. There was no knowledge base in Design, Tools, Technologies and Marketing suitable to small SHGs at grass root level.
3. A large demand for contemporary craft products exist.

These realizations lead to year long sabbatical leave of prof.Rao in 1997 to study the craft potentials of North East.

Tool kit project was initiated by shri.P.Mathur, DC(H) (Development Commissioner, Handicrafts) who had met prof.Rao in BCDI(Bamboo Cane Development Institute) Agartala, during his sabbatical leave. A UNDP project was assigned to IDC to develop Tools, small technologies and Finishes by DC (H). As a result a tool kit with 33 items was designed and developed at IDC. It is currently produced and sold by Lamicraft Enterprises under an agreement with IIT Bombay.More than 1000 toolkits have marketed so far. It has reached many craft-persons at grass root level in North East and other states of India. Bambu Studio keeps a constant check on the quality aspect of the tool kit. It has been well accepted by craft-persons. The price is on the higher side for individual purchase, when it is not subsidised.

The tools in the tool kit cover all the operations starting from splitting, slivering, to measuring , sizing, shaping and finishing. Special tools for sharpening and fine weaving as well as a board for coil technique and a mat to sit on are also provided in the tool kit. Training in the use of tool kit to make new designs was introduced through MCFCs (Micro Common Facilities Centres) conceived by prof.Rao. IDC took up 7 MCFCs under UNDP programme through DC(H) and KVIC (Khadi Village Industries commission) . The experience gained in MCFCs lead to the introduction of 'Mini Tool Kit' in the KVIC sponsored Mini Bamboo Cluster project. Under this project 30 craft-persons in 12 clusters were trained in the use of tool kits and small machines. Each of them was given a mini tool kit. Mini tool kit has 10 tools out of which 6 to7 of them are newly introduced by IDC.

Currently Mini tool kits are being manufactured by, AG Bambu Style' a company under Incubation at SINE(Society for Innovation and Entrepreneurship) IIT Bombay.

Tool kit project at IDC lead to creation of 'Bambu Studio' at IDC. Continuous product development became part of the studio commitment. Development of Training material and Inputs into small technologies like use of hand operated machines, use of Moulds, jigs and fixtures, production planning, treatments for insects and fungus, Colouring with Natural dyes. use of other finishes like Smoking and spray painting etc have been going on for last 7years at the Studio.

Bambu Studio has nurtured 2 expert craft persons and a mould maker who have been the craft trainers as well as core support to designers in developing new craft based products at IDC. A technology assistance package was developed and given to the craft groups in the training programmes. A holistic approach was taken in the Mini Bamboo Cluster Project. Each area was studied for its skills and availability and types of bamboo. Few new designs were developed specific to the area. Moulds were designed. Moulds were prepared in numbers of 5 for Training and technology assistance. A week long workshops were conducted with detailed schedules prepared before hand. Talks and Powerpoint presentations were made using laptop computer. Films on Toolkit and design were also shown. Team of two designer and three craft trainers ensured intensive training of 30 persons. Sukumar Haobam acted as additional design consultant for North East.

The experience gained in the MBC project has been varied. Many groups continued to develop further especially where they were linked to other assistance on bamboo. TAMBAC (Tamenglong Bamboo and Cane Development unit) at Tamenglong in Manipur is a good example. Due to the continued support of CIBART conceived by INBAR, craftgroups that were able to produce the products introduced in the training and market them in Delhi and other places. New designs were also brought out which were exported. But for most of the craft groups it was difficult to continue product development and productionising with design of moulds and jigs.

With this experience we need to put some basic questions.

Is bamboo craft sustainable for the future?

What policies will lead to self sustainance of the groups?

What could be the Govt supports in the long run?

The craft in the country is already facing global competition. Bamboo products fronm Vietnam, China are being sold in Indian Markets at cheaper prices. Due to mechanization and better organization products have better features and getup.

A possible strategy for India would be to use its design strength. India has well developed Institutional structures in Design. Some of the products designed as M.Des projects at IDC shows the new potentials for bamboo craft. Products like table lamps,clocks lamp shade , furniture, hand bags are some of them. They all need to be protected for their intellectual property, developed for production by craft groups with design of Moulds, jigs fixtures etc. There is also need for appropriate marketing channels.

There is need for new Govt. schemes. The existing schemes only provide design assistance through free lance designers. Infrastructure required for new Product development and producing tools, moulds, special tools etc, have not been taken into account in these design assistance schemes. Linking up of free lance designers with nstitutional structure to avail of the infra-structure facility will be essential in these government Schemes. It is also important to nurture selected craft groups or a cluster till they become self sufficient and models for others to emulate as experienced with a SHG called “Chaitanya” at Mumbai. One can conclude that initiatives in introduction of tools, moulds and new designs is significant as no fresh inputs in this direction was provided for decades. Field experience of how the tool kits and technologies were absorbed in North-East were further elaborated in part 2 of the presentation.

New Generation Value Added Products of Bamboo

By Suneel Pandey

Abstract

India is home to more than 125 species of bamboo spread across 18 genera. Bamboo resource base extends over 11.36 million ha under forests and private land, with a total productivity of around 13.50 million tones. There is immense potential to increase the productivity of bamboo resources ,enhance the quality of extracted bamboo and utilize the resource for new generation value added products based on bamboo in segments wood substitutes and composites, utility and craft products,charcoal,activated carbon and gasification for rural and decentralized energy needs, edible bamboo shoot for dietary requirements, other industrial products, and earthquake resistant bamboo based structures for cost effective, rural and disaster response requirements.

Bamboo - A Grass

Bamboo is a woody grass and has always been known as an enduring, versatile and a renewable resourse4. There are more than 125 species of bamboo in India, spread across 18 genera. These grow naturally at heights ranging from sea level to over 3,500 metres in varied habitats. In fact bamboo can be cultivated in almost all parts of India except deserts of Rajasthan and some areas of Kashmir.

Bamboo, after planting, reaches its maturity in 4th year. From fourth year onward, all four year old culms in the bamboo clump should be harvested on annual basis to ensure proper space in the clump for new clumps to grow and also to ensure proper productivity of plants. This makes bamboo as highly renewable and sustainably managed plant. If bamboo clumps are not harvested on annual basis, the clump becomes congested and its productivity goes down, making the available bamboo brittle.

Bamboo Resource Base

In India, bamboo grows in about 9.60 million ha of forestland. Average productivity of bamboo in forests is less than 1 tonne per ha, against a potential productivity of more than 20 tonnes, if properly harvested and managed. In addition, substantial bamboo resources are cultivated on homestead land, private plantations and groves. Sixty six per cent of the country's bamboo resources exist in the northeastern regions in terms of quantum and 28 percent in terms of area.

According to FAO (2006) the total area under bamboo is 10,711 thousand hectares in 1990, which increased to 11,361 thousand hectares in 2005. Of these, around

1,754 hectares is under private ownership, and the rest in the forests, which are under state owernership. This is given in Table 2 below.

Table 2: Bamboo in India according to owernership of land

	Area in '000 hectares		
Ownership of Bamboos	1990	2000	2005
Bamboo under State Ownership	8,957	9,109	9,607
Bamboo under Private Owernership	1,754	1,754	1,754
Total	**10,711**	**10,863**	**11361**

Source: FAO (2006)

*Former Mission Coordinator, National Mission on Bamboo Applications (NMBA), Government of India.

Total estimated stock of bamboo resource in the country is130 million tones. The estimated annual harvest of bamboo in India is around 13.50 million tones as against the current domestic demand of 26.69 million tones .Four fifths of the growing stocks of bamboo in India comprises of three species : *Dendrocalamus strictus* (53 per cent), *Bambusa bambos* (15 per cent) and *Melocanna baccifera* (15 per cent). Species suitable for commercial products in different application segments are D. asper (for shoot and timber), D. hamiltonii(for shoot), and D. stocksii (for crafts, structural and household applications) and B. tulda, B.nutans, B. bambos, D. strictus(for wood substitutes).

Potential of Bamboo Sector

There is a growing realization that the potential of bamboo in the country has not been tapped to its fullest. Bamboo is being 'rediscovered' in India as its attributes and potential are increasingly recognized. Some of the advantages of bamboo are :

1. There is immense potential to develop bamboo based economic activities in India to

Rs.26000 crore (USD 6 billion) by 2015 (Planning Commission, India, 2003) from existing level of Rs.3500 crore (USD 0.8 billion) (NMBAestimate, 2007),based on value added products and application in segments of wood substitutes and composites , utility and craft products, charcoal, activated carbon , gasification for rural and decentralized energy needs, edible bamboo shoot for dietary requirements, other industrial products, and earthquake resistant bamboo based structures for cost effective , rural and disaster response requirements etc.

2. Income and employment generation (more than 8.6 million new jobs) for farmers, rural people and workers in small towns through main and ancillary economic activities.
3. Unique root and rhizome structures of bamboo act as binders for soil and control erosion.
4. Bamboo plantations enhance food quality by improving physical and chemical composition of soil.
5. Bamboo plantation increases the water retention capacity of soil by creating a natural water reservoir.
6. Bamboo produces more oxygen and leads to increased carbon sequestration.

New Generation Value Added Products of Bamboo-status, Potential and Commercial Viability

1. Composites and Wood Substitutes

The decline in timber availability and the emergence of new technologies and product options has spurred interest in bamboo based composities and wood substitutes. Many bamboo based composite products provide promising linkages between the organized and unorganized sectors, for istannce resin bonded boards made from hand woven mats.This highlights the potential for employment , especially in areas that are relatively disadvantaged.The highest priority , because of the employment intensity , and the linkages between industrial scale units and the cottage sector, needs to be accorded to mat based composites, including flattened bamboo boards , bamboo-jute composites , corrugated roofing , shuttering material and mat-glass fibre composites. The econd set of composites is the solid wood segment – laminated flooring, furniture sections and other high value products. Two additional focus areas are : a) non-woven bamboo based composites , based on strips, and b) lower value products – MDF< HDF and particle board, which can utilize bamboo as well as bamboo processing waste. Different types of bamboo based composites and wood substitutes available at commercial stage manufacturing are —

I. Bamboo Mat Board : This is made from layers of woven bamboo mats that has been impregnated with resin and together in a hot press. It is normally manufactured with three to fifteen layers to nine layers of woven mats, depending on thickness of mat board required. It can be produced in a range of standard sizes and thickness. For thicker laminated boards, wood veneers are interleaved with the bamboo boards to produce bamboo mat-veneer composte boards. Bamboo mat boards are stronger, more durable and stable than the wood-based plywood and are resistant to surface abrasion , pest attack, extreme climatic conditions and fire. There are more than seven units manufacturing bamboo mat board in the country.

II. Bamboo Mat Corrugated Sheets : This is an extended technology for Bamboo mat boards to produce Bamboo Mat Corrugated Sheets as a substitute for Asbestos corrugated sheets which are considered to be health hazard and environment unfriendly. Bamboo Mat Corrugated Sheets (BMCS) roofing sheets confirm to the requirements prescribed for asbestos cement roofing sheets with enhanced characteristics like toughness, resilience and ductility. Apart from this Bamboo Mat Corrugated Sheets is environment friendly, energy efficient and possesses good fire resistance. There are more than three units manufacturing BMCS.

III. Flattened Bamboo Boards : In core, these boards utilize planed flattened bamboo, produced after cross cutting, splitting, flattening and planning the strips. Flats are glued, put in core with either glued surface veneer or surface mat bonded together in a hot press. These can be used for panel, partition as well as in shuttering ply. There are five units manufacturing flattened bamboo board in the country.

IV.Bamboo Jute Composites : Resin-bonded Bamboo-Jute Composite, with jute content of 35% to 40% (Bamboo and jute ratio being 75:25), also provides an excellent wood substituye. The products is very similar to resin-bonded Bamboo Mat boards and plywood, but has more strength and resin content, reducing its susceptibility to moisture absorption, to enhance its resistance for exterior applications. One manufacturing unit in West Bengal is manufacturing this composite.

V. Bamboo Flooring : Laminated bamboo flooring or laminated bamboo parquet (block flooring) is a unique flooring material. It has many advantages, such as its smoothness, stability, resistance to wear and tear, sound insulation, resistance to dampness, pressure resistance and flexibility. It is produced by splitting quality bamboo sections culm (with minimum wall thickness of 12-15mm and minimum diameter of 10cm) into thick sections, planning, bleaching (treated for antifungal properties) single layers (either at sheet or at individual section level) are glued and bonded together. The bonded material is then sized to about 900mmx90mmx15mm size and finished coated with lacquer coating and heat treated/stabilized.

All bamboo based wood substitutes have extremely high viability with Internal Return (IRR) varying from 27%-30% (depending upon scale of manufacturing and cost of raw material).

Replacing wood based panels and hard wood with bamboo mat boards/flattened bamboo boards and flooring tiles, is now a fairly well documented, demonstrated and commercialized technology. The bamboo based ply is fairly competitive in its pricing and removal of bottlenecks on the supply side will only create further downward pressure on the prices.

According to the association ASSOCHAM, in India, Defence, Railways, Central and State's Public Works Departments can cumulatively save nearly Rupees 7,000 crore annually on purchases of wood and wooden products if these are replaced by articles made of Bamboo. Bamboo is enduring natural resourse which also provides income and housing to millions of Indians. Cummulatively the governmental organizations buy Rupees 10,000 crore of wood and wooden products per annum. Such iteams can easily be replaced by products made out of Bamboo and Jute wastes, forming a composite technology and this would save about Rupees 7,000 crore per annum as their material costs would not exceed beyond Rupees 3,000 crore for the various government department departments.

Presently there are three wood based panels manufactured in India, namely plywood, particleboard, and fiberboard (hardboard and medium density fiberboard).

Plywood : Plywood has a wide variety of use in the form of tea chests, shuttering, packaging, flush doors, block boards, moulded furniture, laminated pick sticks for cotton and jute textile industry, compreg wood veneers. In all these, bamboo boards have the potential and structural strength to replace plywood.

Table-7 : Plywood Production in the 50 years since Independence

Years	Plywood Production in Million Metric Tonnes
1951	6.59
1961	15.36
1971	27.54
1981	50.15
1991	62.52
2001	14.61

Source: Federation of Indian Plywood and Panel Industry1

As indicated in Table-7, the consumption of plywood in India has increased tremendously over the years. On account of Supreme Court Order dated 12/12/1996, the plywood manufacturing in the country was totally suspended in medium/ large scale units particularly in the North Eastern region. This resulted in drastic reduction in production from 1997.On one hand there has been significant and increasing trend of demand for plywood, the existing plywood industries are unable to meet this demand due to the Court order. Under such circumstances bamboo based plywood boards offer an excellent opportunity.

Particleboard : Particle board is reconstituted construction panel particularly developed as a aubstitute for natural construction wood and is made from low grade waste woods or from certain agricultural wastes. Ulike the world trend, growth of particleboard in India has been sluggish, due to high production cost, for low scale of manufacturing as well as high cost of resin adhesives. However in the end nineties, the demand and production drastically inmproved and in the four years between 1997 and 200 production increased seven fold. However following the implementation of the Supreme Court Order dated 12/12/1996, production of particleboards, like that of plywood,was also affected.

Table-8 : Particle board Production 1997-2001

Years	Particle board Production (tones)
1997	13,489
1998	34,634
1999	63,684
2000	92,728
2001	50,050

Source : Federation of Indian Plywood and Panel Industry, ibid

Particle production has largely, for its raw material sources, remained wood based (92%), even though a variety of non wood raw materials were available. Bamboo waste can be utilized as a raw material for particleboards. Presently, only a few units, are manufacturing bamboo based particleboards and more such units need to come up to fill the potential demand gap.

Fiber board : Fiberboard is board comprising range of sheet materials of varied nature from refined or partially refined wood fibres or other vegetable fibres. Bonding agents and other materials may be incorporated in the manufacture to increase strength, resistance to moisture, fire or decay.

Table-9 : Fiber board (hardboard and MDF) Production 1997-2001

Years	**Particleboard Production (metric tones)**
1997	77,388
1998	75,758
1999	120,375
2000	121.981
2001	118,450

Source : Federation of Indian Plywood and Panel Industry, ibid

Although first unit in India in fiber board was established in the early fifties, by the mid nineties, there were only b5 units. These units can be categorized into hardboard and medium density fiberboard.

Estimated Demand for Panels

From various studies carried out and available during nineties, the demand demand for panels and wood raw material requirement to produce the same, was worked out by Ganapathy (1997). Table below gives the estimated requirement of wood raw material for plywood, particleboard and fiberboard.

Year	**Plywood (million cu.m)**	**Particle board (million cu.m)**	**Fiber board (million Tonnes)**		**Wood raw material requirement (million cu.m)**
			Hardboard	**MDF**	
2000	0.73	0.13	0.089	0.20	2.41
2005	0.85	0.18	0.13	0.34	3.17
2010	0.96	0.25	0.17	0.47	3.93

Source: Ganapathy, P M, (1997)

The estimate of Ganapathy (1997) of the requirement of wood material for plywood and decorative veneer industries, as well as for particleboards and fibreboards was assuming 80% capacity utilization. The estimate of wood raw material requirement (in million cubic metres) by 2010 for plywood was 1.92 million cubic metres and at 50% yield the plywood volume would be 0.96 million cubic metres. For particleboard, it has been estimated that 1.2 tonnes of air dry wood chips required to obtain 1 tonne of dry chips, making requirement of wood at 2.64 cubic metres for a tonne of board. For fibreboard, the projected raw material requirement used the conversion factor at 2.5 cubic metres round wood with bark at 70% moisture content for a tonne of fibreboard.

These estimates were based on the projected and reported consumption in 1995. However, with growing housing and construction industry, the demand will easily outstrip 2 million cubic metres of engineered wood by 2010. Even taking 30% market penetration by bamboo based wood substitutes by 2010, there is going to be the requirement of around 300 manufacturing units, of 200 board (8'x4'x12mm) per day.

2. Incense Stick and Base Utility Products

Incense sticks made from bamboo is an input/raw material for the increase stick manufacturing industry, which is well developed, with a turnover of Rs.2000 crore and has the presence of large industrial houses. Moreover, such manufacturing of Agarbatti/ incense sticks involves creation of livelihood, especially for a large number of women, who would otherwise have been kept out of the economic sector, working in their time (conversion of slivers into agarbatti stick can be home-based).

The biggest advantage with the agarbatti stick making activity is that start up cost of capital is very small as non-mechanised process or small machine tools can be used.For example, the bamboo poles are first cross-cut into 8-inch and 9-inch cylinders. These are then made into slats using a locally made hand tool, which costs less than Rupees 500.The slats are converted to sticks using another hand tool that cost half the price. However, if the process of conversion of the raw bamboo into slats can be mechanized, this would immensely increase the scale of manufacturing and related income at the household level.

The slats can be distributed to the rural communities, especially women in bundles of 4 kilograms (kg).It is estimated that a 4kg bundle of slats can produce back 3 kg of agarbatti sticks, with 1 kg as the estimated wastage.It is estimated that one person is able to produce 12 kg of agarbatti sticks per day if one is engaged in this activity all day and even the women are able to produce an average of 6 kg agarbatti sticks per day after attending to their routine household activities.The resource procurement of the finished product can either be managed by the local communities themselves (like after forming a co-operative) or such procurement facilitation can be made by an agency (like NGOs) to the incense stick industry.

One kg of agarbatti sticks would fetch about Rupees six (for the minimum length) and therefore one person can earn at least about Rupees 70-75 per day. The waste generated in the process can also be used for charcoal production providing additional income or can be sold to the paper mills.

In Andhra Pradesh, under the Andhra Pradesh Community Forest Management (APCFM) project (which was with the help of the World Bank), value addition to bamboo in the form of agarbatti stick making was taken up in Adilabad and Vizianagaram districts. Marketing of these sticks was being done locally as well as to ITC, Chennai. The production capacity was 10 tonnes per month in 2005, which was upgraded to 100 tonnes per month by mid-2006. This activity was fetching revenue of rupees 18,000 per tonne as against rupees 500 per tonne realized from pulp and paper mills.

With NMBA support, community level manufacturing facilities including bamboo stick making, rolling, adding fragrance packaging/branding have been developed at Imphal (Manipur), Agartala (Tripura), Jagdalpur (Chattisgarh), Joypur (Orissa), which provide an annual turnover of more than rupees 16 crore with employment of more 1 million man days per annum. The initiative has resulted in larger value addition in for stick making areas / regions in terms of rolling and adding fragnance (as detailed in Table 5.10) as well as value addition in terms of stick making in areas where bamboo was grown without any value addition.

The NMBA has initiated a large scale programme to convert stick making rural regions in to higher value addition through rolling, adding fragnance, packaging/ branding support. Details of extent of value addition of different level of incense stick making is mentioned below in Table-10.

Table-11 : Level of value addition of bamboo at different stages in the Agarbatti (Incense) Industry

Process	Ingredients	Cost of Ingredients	Labour Cost	Final product	Market value of final product
Bamboo stick manufacturing	Bamboo (2.5 kg)	Bamboo (Rs.2.50)	Rs.5/	Bamboo stick (1 kg)	Rs.10/-
Bamboo stick rolling	Bamboo stick (300 gm), Jigget (350 gm), Charcoal (400 gm)	Bamboo stick (Rs.3), Jigget (6.30), Charcoal (Rs.4.00)	Rs.15/	Rolled stick (1 kg)	Rs.45/-
Fragrance and packaging	Rolled stick (1000 gm), DEP (160 gm),	Rolled stick (Rs.45), DEP (Rs.25.6),	Rs.17/	Packaged stick (ready market) -1 kg	Rs.240/

	Fragrance (40 gm), packaging material	Fragrance (Rs.30), packaging material (Rs.34)			
Marketing	Marke chain			1kg (packaged in 204 packets of 8 sticks)	Rs.408/

Source : NMBA/ IDF calculations

The incense stick or agarbatti industry in India is estimated to be worth Rs.2000 crore (US$400 million) (Kumar and Sastry,1999), with expected annual growth of more than 30%. Bamboo can emerge as a major driver for growth of incense stick industry, with concomitant creation of employment and livelihood in remote areas of the country. Apart from incense sticks, there are also huge potential for stick based Venetian blinds and other utility products.

3. Bamboo Charcoal/Activated Carbon

All available species of bamboo are available for charcoal production. As charcoal is a biomass based product, bamboo with 3-4 years maturity, when it attains maximum biomass, should be used for charcoal production. To get maximum yield in charcoal production, moisture content of bamboo should be around 20-25%, accordingly freshly cut bamboo should be stored for 15-20 days to lower down the moisture content.

All bamboo-processing units waste to the extent of more than 50% of bamboo used in the processing. The waste bamboo (in round form) can also be used for charcoal production. Moisture content in waste bamboo is also lowered to a large extent during processing and it can directly be used for charcoal production without waiting for further drying.

Charcoal is produced by heating bamboo with a controlled supply of air. This is done in brick kilns and it can also be done by the pit method, in metal kilns and in drums. Heating can be direct by igniting the biomass itself or it can be indirect. The conversion can be done in batches or in continuous flow depending on end use, capacity requirement and investment.

Carbonisation in a brick produces uniform quality charcoal with a good yield and with minimum investment. The process is efficient, non-hazardous and reliable production, operated in batteries of 5-6 kilnsat the village level. Bamboo Vineger is the bye-products of bamboo charcoal production. The volatiles coming out from bamboo charcoal production is condensed to produce bamboo vinegar. Bamboo vinegar is used as organic fertilizer, preservative, for relief of pains etc.

Apart from being used as a solid fuel by hotels, bamboo charcoal is suitable for use in dhabas (road side eatery), dhobis (laundry) and for cooking in rural areas. Produced charcoal can be further value added by pulverizing (for use in incense stick making) and briquette forming (for space heating). It also finds use in space heating and in forging and metal works as fuel.Depending upon the properties and availability, the price of charcoal varies from rupees 5-12 per kg, and it is extremely viable activity with value addition of bamboo going up to 2.0.

Charcoal manufacturing is an extremely viable activity, if market linkages are established, due to its low required investment and potential for employment generation at village level/bamboo growing region. If cost of bamboo/bamboo waste is taken at rupees 1/kg, cost of manufacturing of charcoal including labour cost would be rupees 4/kg market value of charcoal being around rupees 7/kg and with investment requirement for a battery of five kilns (capacity 1 tonne charcoal a day) being rupees 75,000, payback period is just one month.

Bamboo charcoal manufacturing units/kilns have been established and are operational at twelve locations in the country, with a annual production capacity of 5,000 tonnes of charcoal. Present requirement of charcoal in the country is more than 2 million tones (FAO report). With 30% penetration by bamboo based charcoal by 2010, we require 120 fold increase in manufacturing of bamboo charcoal, and about 3 million tones of bamboo/ bamboo waste as raw material.

Bamboo charcoal can also be used as a raw material for activated carbon manufacturing. Activated carbon is a black solid substance resembling granular or powdered charcoal. It is extremely porous with a very large surface area. Raw bamboo charcoal is steam activated under temperature conditions of 900-1200 Centigrade, to derive a highly porous final product. Typically for the activated material, surface areas range from 500-1400 m2/gram.

Activated carbon is high valued fine chemical used for its absorption, filtration, decolourisation, deodorization, reduction and catalysis functionalities in gas or liquid streams, and is used in air purification, water treatment and purification as well as in sugar, beverage, edible oil, solvent extraction and pharmaceutical industries. An activated carbon manufacturing unit of 600 TPA would cost rupees 2.20 crore and with cost of bamboo being rupees 1/kg and ex-factory price of activated carbon taken as rupees 40/kg, pay back period would be three years. First manufacturing unit of 600 capacity of activated carbon is slated to come up in Bongaigaon, Assam. With present estimated demand of more than 40,000 tonnes of activated carbon (NMBA estimates) in the country, there is potential for more than 20 manufacturing units of bamboo based activated carbon at 30% market penetration.

4) Bamboo Gasification for Power/Thermal Applications

Gasification ios a process by which any biomass wood chips, dead leaves, twigs, etc- is burnt at very highj temperatures, between 700 degrees and 900 degrees celcius, in the presence of a gasification agent such as air. Bamboo chips have an advantage over other biomass as they have a higher calorific or heating value, low ash content and alkali index. In addition, about five percent of the input is converted into charcoal.

With electricity supply being erratic in India's north eastern states and the hills of Uttaranchal, bamboo-based power plants might soon become the answer. Gasification of bamboo from bamboo waste for electricity/thermal applications can have significant impact in the rural economies. The requirements for the gasification uniots are a small proportion of the total availability. A 100 Kw Gasifier would require only about 1,000 tonnes per annum of bamboo, the equivalent of a truckload every three days on the average. An added advantage of gasification of bamboo is that 15% of the biomass would also be available as a by-product in the form of high grade charcoal. In the case of a 100 Kwe gasifier, around 135 tonnes of charcoal would be available each year to meet local needs of fuel. It is clean, cheap and renewable source of energy. It does not depend on quality, species, and maturity of bamboo. The NMBA has demonstrated commercial viability of bamboo based gasification system through units at HPC jagi Road and Silchar (1 MWe thermal), Agartala (4 units of 25 KWe), Kolashib (80 KWe), Arunachal (25 KWe), Madhubani (25 KWe).

For power generation, if cost of bamboo is rupees 1/kg, cost of power generation would be rupees 2.5/unit, which is extremely viable at remote, off-grid location where DG set (cost of power-rupees 7/unit) is being used to drive economic activities/operate an industrial activity. Cost of investment for 1 MWe capacity is rupees 4.5 crore and pay back period would be around 3 years. For bamboo based gasification for thermal applications, of 1 MWe thermal, cost of investment is rupees 2.50 crore and pay back period vis-à-vis replacement of furnace oil is just one year.

5) Bamboo Fiber Reinforced Thermoplastics

This product segment includes bamboo reinforced PP (polypropylene) and bamboo mat-acrylic based products for utility and automobile products. Bamboo waste and dust of appropriate mesh size along with coupling agent provides reinforcement to the PP to enable required PP/raw material characteristic for manufacturing different utility, and automobile products. It improves viability of the product and adds vale to the bamboo and bamboo processing waste. Bamboo mat-acrylic moulded product provides an oppurtinity to link mat weaving communities with industrial units bamboo mat-acrylic sheet manufacturing, which supply raw material/sheets for different utility product moulding units.

Bamboo mat acrylic product manufacturing unit is operational at Kudal (Maharashtra) and first Bamboo fibre reinforced thermoplastic granule manufacturing unit is coming up at Mangalore, with technical and financial support of the NMBA. Cost of bamboo mat acrylic product manufacturing unit is rupees 90 lakhs, with production capacity of 7.5 lakh square feet per annum, with a pay back period of 2 years. Cost of Setting up a project for manufacture of Bamboo fibre reinforced thermoplasts is around rupees 6 crore (for a capacity of 15000 Tone per annum) with IRR of 27%. Both these products have immense potential for value addition of bamboo, as well as potential for limited substitution of thermoplastics with biodegradable bamboo material.

6) Edible Bamboo Shoot

A bamboo shoot is a young culm harvested at the time, or shortly after it appears above the soil surface. When the shoot pierces the ground, critical bio-chemical processes start. These lead to rapid growth, as well as concurrent hardening, as the shoot elongates and turns into a woody culm.

Most bamboo species produce edible shoots. The edible content of a newly harvested shoot is typically around 30%; the balance is made up of the sheath, and the extreme portions of the shoot. Bamboo shoots have high nutritional value and low fat, and are a good source of fibre. Bamboo shoots are rich in vitamins, cellulose and amino acids. At harvesting, a shoot may contain as much as 90% water. The International Network for Bamboo and Rattan (INBAR) has selected 6 species which are most suited for development of bamboo shoot industry in India. These are *Bamboosa balcooa, Dendrocalamus giganteus, Dendrocalamus hamiltonii, Dendrocalamus strictus* and *Melocanna baccifera.*

In the North East India and in some other areas, bamboo shoots have formed a part of traditional cuisine – fresh, dried, shredded or pickled. There is however also a growing market for processed and packaged shoots, representing an opportunity for the establishment of commercially administered processing units. Modern processing and packaging technologies have developed new dimensions and markets for bamboo shoot. It is now possible, even at the scale of tiny and village level enterprise to prepare and pack shoots for the market, through processes that allow bamboo shoot to retain its freshness for a period of time.

There are presently three large scale processing units at Dimapur (900 tonnes per annum), Jorhat (200 tonnes per annum), and Bongaigaon (300 tonnes per annum). With cluster level processing technologies being developed and demonstrated, and also branding and marketing support taking place, the bamboo shoot industry does hold the promise to grow in future.

Bamboo shoots carry the potential of value added economic activity and provisioning of income at the rural community level through cultivation and processing. A processing unit (canning) costs about Rs.1.20 crore (for 900 TPA capacity) with IRR estimated to be 31%. It has been estimated by the Planning Commission that the bamboo shoots market was around rupees 5 crores in 2001. The Planning Commission has also estimated that the Indian bamboo shoots industry has the potential to grow at the rate of 25% per annum and capture a market worth rupees 300 crores. A large potential export market exists for shoots in Japan, Hong Kong, Singapore and Thailand. For this, development of cultivation-supply chain-enterprise-market models of activity at the cluster and community level addition in the bamboo shoot segment is therefore crucial for this sector.

6) Construction and Structural Applications

Bamboo has traditionally been used in India for structural applications. In house construction its predominant use is for walls, framework, floors, doors, window and doorframes and roofing. Bamboo mat boards are much more flexible than wood-based plywood and can be used in structural applications such as stressed skin panels, wall bracings and web beams for which plywood is not suitable.

Bamboo based housing can cater to different economic class of people and can also be of the pre-fabricated type.Rural housing can be constructed for the low end consumers and can be made of engineered bamboo composite roofing, flooring and bamboo composite boards; cladding can be bamboo mat board. With a cost of roughly rupees 300 to 400 per square meter, an area range of 120 to 180 square feet would cost within rupees eight thousand per dwelling unit.

Venu-gram is a low cost, bamboo based cluster housing project, implemented by Acharya Shrimannarayan Polytechnic Wardha, and Sampoorna Bamboo Kendra, Amravati and situated on the Nagpur- Bombay highway at Salod near Wardha (Maharashtra).

Housing at the mid-level are primarily for urban areas where access to manufactured building components and modern practices of construction is there and wherever substitution of building components is possible by bamboo based material, is done. Housing at the high end are mostly public utility structures where whole bamboo are used for structures and this highlights the aesthetic characteristics of bamboo.

Bamboo composite based prefab structure is a temporary structure with characteristic of easy to erect and easy to transport. It takes a short time for construction, modular and has use for public as well as private places. Its life-cycle is of 15 years. The structures are strong, durable, low in maintenance, fire retardant, and have thermal insulation. Under the NMBA supported programmes, these have been structurally tested and erected at kargil, Leh (Jammu and Kashmir), Port Blair, car Nicobar (Andmans), Khamman (Andra Pradesh), Guwahati, Tezpur, Dinjan, Bodoland (Assam), Ruskin, Pasighat, Lumla (Arunachal Pradesh), Patna (Bihar), Dantewada (Chattishgarh), Delhi, Chamba (Himachal Pradesh), Agartala (Tripura), Amethi (UP), Haldwani, Joshimath, Ranikhet, Dehradun (Uttaranchal), kalimpong, Dinhatta (West Bengal) Kisama, Dimapur (Nagaland).

Over 12,000 bamboos based pre-fabricated structures for schools, hospitals, sanitation and housing in the areas where construction is difficult and which are earth quake prone and Tsunami affected, have been installed in last two years. These structures are fire retardant, disaster proof and easy to install. There has been widespread acceptability of the structures by the local communities.

Bamboo prefabs are reaching standardization in product design and in the manufacturing processes. The advantages lie in the speed of erection (2 per day of size 12 ft x 10 ft by a single team), bamboo roofing, flooring and cladding provide natural insulation-strong and fire resistant, shelters are easily removable and relocated, they are light-weight and easy to transport by road, or demand for these are likely to grow as earthquake resistant as well as emergency times disaster relief shelters.

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Development of Bamboo Utilization Tool (BuT) in Ghana: A needed strategy for sustainable utilization of sympodial Bamboo

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Abstract

Empirically, the sustainable development of any resource in a given geographical location entails the sound interaction of many factors and the prioritization of its potential uses. Thus, the pursuit of developing neglected resources such as sympodial bamboo which abound in the forests of Ghana, many factors and their interactions are considered. In this present study, the major parameters that influences bamboo utilization were identified and used to develop model-Bamboo utilization tool (BuT). Based on a preliminary study of technological properties and socio-cultural parameters which varies significantly with sites in Ghana, four major parameters were identified: Accessibility and availability Index (AAi) Technological property Index (TPi) and; Socio-Cultural index (SCi) and integration module. The preliminary use of BuT proves accurate and easy decision making tool. It is recommended that stakeholders in the bamboo sector in Ghana and other countries adopt it for sustainable utilization of bamboo.

Key words: Resources, Bamboo Utilization Tools, interaction. Sympodial bamboo

1.0 Introduction

Bamboo has been identified as a useful resource that has improved livelihood in many parts of the world (INBAR, 2006). Its demand for internal and external market is growing very rapidly with an increasing non sustainable extraction of bamboo especially from their natural habitats. And with recent research revealing over 1500 documented use and increasing trade values in bamboo products and service, the desire to develop and use bamboo is ever growing among stakeholders.

Bamboo utilization, however, varies from country to country and continent to continent depending on the distribution, knowledge and awareness of its uses. In Ghana, for instance, the utilization of bamboo is relatively low in comparison to China and India a situation that is closely linked, partly, to low species diversity and lack of knowledge of the potentials of native bamboo species. Bamboo resource is thus underutilized in most regions or over-extracted in other regions. The sustainable utilization of bamboo resources has, therefore, been at the heart of discussions around the world in recent times especially in the wake of global climate changes which threaten human survival. Its industrial use can either be by promoting a better mix of components industries, maximizing the amount of premium and medium value processing but also balancing this with bulk and lower value processing to ensure good utilization rates of the raw material. Another important option will be to develop more efficient industry structures that allow waste rates to be reduced and different parts of the raw material to be easily used in the most productive way. (Xialo wang, 2006; Smith et al 2006).

Suffice it to say that the utilization and development of bamboo in a locality is a function of many minor and major parameters. Literature indicates a tool that allows sound judgment on the most appropriate method to utilize bamboo in a specific area and a particular in its development is missing especially in West Africa. This paper introduces the Bamboo Utilization Tool for determining the Bamboo priority areas and the niche as part of the roadmap to sustainability. BuT has been formulated as a planning tool and a methodology to provide country-wise synoptic views of local Bamboo quality and quantity patterns.

2.0 The BuT approach

BuT is intended as a strategic planning tool deserving urgent attention to identify these critical areas or hot spots, relevant interaction over a set of socio-economic and environmental variables, directly or indirectly related to Bamboo are analyzed. The approach identified through literature search, earlier research work on bamboo major parameters technological properties and Socio-cultural survey in Ghana (Tekpetey et al, 2008, Ebanyenly and Oteng Amaoke, 2007; Tekpetey S.L. 2006, These interactions were grouped into four steps. BuT is based on the integration of geographical , technological and socio-cultural data and information onh bamboo, which offers new possibilities on for combining, or integrating statistical information about the quality and quantity and the consumption of Bamboo. This accessible, user friendly tool makes itpossible to display the results of analysis ion easily understandable ways to public officials and private officials as well as to the scientific community.

2.1 BuT Methodology

Conducting a BuT analysis involves four main steps: these are (1) Availability and Accessibility Index (2) Technological property Index, (3) Socio-Cultural Index and (4) development of integration module

Mathematically, BuT can be identified as:

BuT=AAi + TPi + Sci

Where

AA i= Availability and accessibility index

TP i= Technological properties index

SCi= Socio-cultural Index

The components of each of the parameters as follows:

- Availability and Accessibility Index (AAi): This index is the numerical summation of the ranking of the extent and quality of bamboo resources in a geographical location at a specific time. It considers the Natural stands of bamboo species, plantation, bamboo species diversity and accessibility to the resources. The ranking is high (1,2) middle (3,4) and low (5).
- Technological Property index (TPi): This is the second component of the bamboo utilization tool. It measures the quality of the bamboo stands empirically. It encompasses the evaluation of anatomical properties, type of bamboo extractive content cellulose content and photochemical results of the extractives. Other components of the index include physical properties of interest. The ranking is similar to the AAi described above.
- Social-Cultural Index (Sci): The human factor cannot be over looked in the issue of sustainability in this millennium. The interest, level of awareness, belief system, and land ensure issues surrounding bamboo use. Others include skilled labour and experts and availability in the region of interst.

2.2 Integration Module

The main scope of the integration module is to analyze relevant interactions among the major components of Bu T identified which reveal the quality and quantity of bamboo resources in a selected region. One of the main challenges for this module is achieving a consistent intergration of databases, therefore given different scenarios several variables or indicators can be designed to analyze the combined impact of Bamboo quality and quantity in particular region of the world. The Integaration module can be represented diagrammatically as shown in Fig 1.

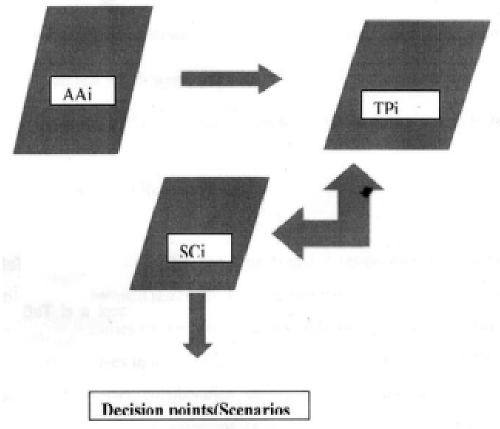

Fig 1- Integration modules of bamboo utilization Tool (BuT).

The BuT use these parameter to give the most appropriate strategy for bamboo use in agiven location.

Four main decision points can be reached using the integration modules Scenariors/options are available are:

A) Industrial processing which could farther divided into be

- Premium processing (flooring)
- Medium processing (chopsticks, mats) and
- Low value and bulk processing – (Charcoal, crates, pulp and paper)

B) Marketing strategy could be the issue of branding, advertisement

C) Conservation and Ecotourism: there are a number of animals including the giant panda (Ailuropoda melanoleuca), and Red panda ? (Ailurusfulgens ploceus cucullatti (village weaver) and others whose survival depand on largely on the bamboo. Not surprisingly then, some species of anim,als are closely associated with bamboos and dependent on them for survival. This could be developed base on the outcomes from the integration modules.

D) Plantation and Resouce management: The last option is the plantation of bamboo which seems to be the missing link in most countries in Africa where majority of the resources is extracted from the natural stand in forest zones.

3.0 Conclusion and Recommendation

BuT is a location specific and time bound decision making tool foe substantial utilization of bamboo resources. Like the compass it will lead stakeholders in Ghana and other countries of the world to the right direction to turn efforts and scarce financial resources in an effort to find use for bamboo species in different regions of the world. Further collaboration among bamboo growing countries and related governmental and non governmental organizations is recommende for upgrading and adoption of the BuT for wider use as efforts are made towards sustainable utilization of natural resources in this millennium.

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Indian Bamboo Industry Market Overview & Outlook

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Introduction

Used for housing, pulp, paper, panels, boards, veneer, flooring, roofing, fabrics, crafts, oil, gas and charcoal, bamboo today is a major non-wood forest product and wood substitute. Important from a socioeconomic and cultural standpoint, its usage as a healthy vegetable (the bamboo shoot) has also been growing over the years.

Always an important resource in Asia, bamboo is gaining importance in other regions with increase in higher value uses

Quickly changing its image from the "poor man's tree" to a high-tech, industrial raw material and substitute for wood, bamboo is globally recognised now as an *increasingly important economic asset in poverty eradication and economic and environmental development*. Bamboo has always played an important economic and cultural role across Asia and its usage is growing rapidly in Latin America and Africa as well.

In spite of its extensive usage, data on this resource is scarce and unreliable

In spite of bamboo's importance worldwide the global statistics pertaining to its resources, production and trade remain rather scarce and inconsistent. The lack of reliable and comprehensive data on bamboo resources and utilisation has been a cause of concern hampering its sustainable development and limiting its potential to contribute to poverty reduction.

Bamboo plant

Member of the Gramineae family, bamboo is extremely diverse and can survive severe calamities

Bamboo belongs to the *Gramineae* family and has about 90 genera with over 1200 species. It flowers rarely and in irregular cycles which are not yet clearly understood. Bamboo is an extremely diverse and hardy plant which can easily adapt to varied climatic and soil conditions. While dwarf bamboo species may reach only a few centimetres (cm), medium-sized bamboo species may reach a few metres (m) and giant bamboo species grow to about 30 m, with a diameter of up to 30 cm. Bamboo stems are generally hard and vigorous, and the plant can survive and recover after severe calamities, catastrophes and damage.

Global bamboo scenario

Distribution

Though it can grow in the all tropical and sub-tropical regions, two-thirds of the current acerage is in Asia

Bamboo is naturally distributed in the tropical and subtropical belt between approximately 46^0 north and 47^0 south latitude, and is commonly found in Africa, Asia and Central and South America. Some species may also grow successfully in mild temperate zones in Europe and North America.

Bamboo acreage	Area (million ha)	% of forest cover
Worldwide	36	3.2
Asia	24	4.4
*Africa	2.7	-
*Latin America	10	-

Source: FAO, YES BANK analysis

The available data on bamboo is scare and even the reported data is not uniform mainly due to different methodological approach in calculation in different countries and also in many countries it is considered of low economic value and regional level mapping is not carried out.

India & China account for 45% of the world total bamboo resources

Asia remains the richest continent in bamboo resources with about 65 percent of total world bamboo resources falling in the continent. Three of the top six producing countries are from Asia. India and China together account to approximately 45 per cent of the world bamboo resources with an individual share of 30 and 15 percent respectively.

Ownership of bamboo resources

While majority of the bamboo acreage is under government control between 1990 and 2000 private ownership has increased from 19 per cent to 27 per cent

The ownership structure and tenure system are important in formulating effective bamboo resource policies. Forest ownership is in transition in many countries. FAO (2006) conducted a regional survey on ownership of forests and trees in over 20 countries in Asia. Preliminary results of the study indicated that over 80 percent of Asian forests are public. Most forest areas are under the formal jurisdiction of governments, and forest management is mostly a governmental issue. In the last 20 years, a gradual shift has been noticed towards decentralization. Ownership and control over natural resources is increasingly shifting from the state to local communities and the private sector – and to individual households in many countries (Scherr, White and Kaimowitz, 2003). In Asia the area under private ownership has increased from 19 per cent in 1990 to 27 per cent in 2000.

Bamboo products and global trade

With forest resources being under severe pressure, bamboo has emerged as an exceptional substitute for wood

Forest resources are experiencing increasing pressure due to the growing world population and improving loving standards. During the last 15-20 years, bamboo has developed as an exceptionally valuable and often superior substitute for wood. Bamboo-based panels and boards are hard and durable and may successfully substitute for hardwood products. Bamboo may soon replace wood in many industrial applications and thereby contribute to the saving and restoration of the world's forests.

Engineered bamboo can replace wood, steel and concrete in many uses

The main commercial uses of bamboo have been summarized as under:

1. Raw material: Bamboo is a non-durable resource and is used for exposed conditions with or without treatment. Bamboo can be processed into modern products (Engineered bamboo) that may successfully compete with wood products in price and performance. Use of bamboo in composite panels and boards overcomes differences in quality related to the culms and allows the production of homogeneous products. Engineered bamboo may well replace wood, steel and concrete in many uses.
2. Bamboo charcoal: Bamboo charcoal is traditionally used as a substitute for wood charcoal or mineral coal. It can serve as a fuel, absorbent and conductor.
3. Housing.
4. Pulp, paper and cloth.
5. Bamboo panels and flooring.

6. Weaving products and crafts.
7. Furniture.
8. Fuel.
9. Edible bamboo shoots: Fresh bamboo shoots are delicious and healthy with high fibre content. Cooked bamboo shoots can be stored in containers and shipped worldwide.

It is estimated that worldwide, about *2.5 billion people trade in or use bamboo* of which about 1 billion use it for housing.

Bamboo industry which supports 2.5 billion people today is expected to grow from current $12 billion to about $20 billion by 2015

The world market for bamboo is large and growing. Recent estimates place the global market for bamboo at about *$12 billion* and market growth to *$20 billion* or more is foreseen by the year 2015. However, reliable statistics are still lacking and most of the economic activities related to bamboo are not recorded officially.

Bamboo scenario in India

India while have 17 per cent if the global acreage, has only 4 percent of global market due to low yields compared to countries like Japan, China & Malaysia which contribute 80 per cent

India has the largest area and the second largest reserve of bamboo in the world today. A very large standing resource of bamboo is found mostly in moist and deciduous forests in all the states expect Jammu & Kashmir. Of India's total forest area of 67.7 million hectares, bamboo (both natural and planted) occupies around 11.4 million hectares. This represents 16.7 per cent of the total forest area of the country and 3.4 per cent of the total geographical area (329 million hectares) of India. But despite having the largest area under bamboo in the world comprising more than 100 different species, India contributes to only 4 per cent share of the global market. This is mainly attributed to the low productivity of around 0.4 tonnes per hectare which is much lower compared to other countries such as Japan, China and Malaysia which contribute about 80 per cent to the world's bamboo market.

Distribution

North Eastern region account for 54 per cent of India's bamboo resources

The NER (North Eastern Region) has the largest bamboo stock in the country and accounts for 54 per cent of the bamboo resources in India. The other most abundant bamboo growing areas are the Andaman and Nicobar Islands, the Himalayan foothills, Madhya Pradesh and Western Ghats.

Bamboo market of India: Present and future opportunities

The market size, both domestic as well as share of international trade is expected to increase to 5 times by 2015

The size of the domestic bamboo economy has been estimated at around 2000 crore by the Planning Commission. The market potential however, is estimated at around Rs. 4500 crore, which could grow to Rs. 26,000 crore by 2015. India's share in the global market is estimated to be $1 billion (around Rs. 4000 crore) and is expected to increase to $5.7 billion (around Rs. 22800 crore) by 2015.

Consumption pattern of bamboo in India

Uses	**Percentage consumption (%)**
Pulp	35.0
Housing	20.0
Non-residential	5.0
Rural uses	20.0
Fuel	8.5
Packing, including basket	5.0
Transport	1.5
Furniture	1.0
Others, wood working industries	1.0
Others, including ladders, mats etc.	3.0

Source: Planning Commission, YES BANK analysis

The current and expected size of the market for some of the bamboo products has been summarized in the table below:

Product/Application	**Current Market (Crore Rupees)**	**Expected by 2015 (Crore Rupees)**
Bamboo Shoot	5	300
Bamboo as wood substitute	10,000 (import value)	30,000 (in 20 years)
Bamboo Plyboard	200	500
Bamboo Plyboard (for trucks & railways)	1000	3400

Bamboo Flooring	100 (Domestic) 100 (Export)	1950
Bamboo pulp	100	2088
Bamboo Furniture	380	3265
Building and Construction Material		
Scaffolding	-	861
Housing	-	1163
Roads	-	274
Bamboo grids for Tiny/ cottage sector (e.g. Agarbatti)	-	1000
Misc. Uses (ice creams, fireworks, pencils, matches etc)	394	600

Source: planning Commission: National Mission on Bamboo Technology and trade Development.

Challenges in developing domestic bamboo economy

The challenges in developing the domestic bamboo economy from production to consumption can be broadly classified under the following heads:

Production

Availability of quality inputs severely limits productivity leading to over exploitation of existing forests

- The major hurdle in cultivation of bamboo from seeds has been the poor availability of planting material. Most of economically important bamboo species bear seeds only 2 to 3 times in a century and seed viability is only for a short period.
- Existing use of rhizome as planting, material. This is not only insufficient and costly but in most of the clump forming bamboos, is leading to relocation rather than development of the resource.
- Over-exploitation of the existing forests. This is threatening the very existence of important genetic resources of economically important species.
- Low awareness of conservation practices which is gradually leading to the decrease in production and supply of bamboo.

Harvesting/Storage

Manual harvesting and lack of storage infrastructure hinders efficient cultivation

- Adhoc and unsustainable harvesting based on seasonal dictates of market demand which can be largely attributed to the patterns of intermediation in marketing channels.
- Lack of mechanization in harvesting making it a cumbersome and inefficient practice and often leading to losses being incurred.
- Lack of appropriate storage and warehousing infrastructure. After harvest bamboo is required to be transported safely and stored properly in warehouses near the villages. This is mostly lacking at present.

Processing

- Scarcity of quality raw material aggravated by the gross inefficiency in management, harvesting and storage.
- Processing machinery and equipment available in India often found to be expensive and not satisfactory in terms of performance and handling capacity.
- The imported machinery are not always suitable for handling the sympodial bamboo which grows in our country. This often results in rapid wearing and poor quality of product.
- Non-availability of genuine machinery spare parts and poor after sales service due to unorganised nature of the industry.

Marketing

- No accurate assessment of the demand and supply position of the resources which is resulting in considerable uncertainty in the industrial and business operations.
- Bamboo still not widely recognised as a substitute for wood and not used in mainstream construction industry.
- Most Bamboo product manufacturing still considered as a source of livelihood for artisans and not as a remunerative and lucrative industry.

Way forward

Shift from wild bamboo to farmed bamboo needed to ensure consistent quality

- Major policy shift towards farm based supplies from forest based bamboo resources, which do not exist at present. The industry requires bamboo that is consistent in quality and this can only be provided by planting stocks that are intensively managed so that the desired quality is selectively bred into the crop by good practices that are embedded into the cultivation and harvesting of the natural resource.

Strong industry linkages essential commercial success at the farmer level

- Commercialization of bamboo as an enterprise at farmer's level. Bamboo should be put into the industrial pedestal with appropriate tie-up arrangements with bamboo based industries viz. paper, handicrafts and the new emerging areas of eco-friendly products e.g. housing, tiles, flooring, bamboo shoots etc.

Research & Development is essential for development of the product as well as productivity

- Boost research and development activities for genetic improvement in bamboo, development of efficient methods for mass production of superior quality planting stock and conservation of the genetic resources. Since a limited number of species produce most of the products, basic research should be directed towards the minor but potentially useful species.
- Increasing availability of planting material to the farmers through development of improved storage facility for bamboo seeds, vegetative propagules and establishment of a network of suppliers of plant material.

Investment required across infrastructure across the board covering all areas from availability of quality planting material, farming & harvesting technologies, storage facilities to strong linkages with the user industries in order to make the industry grow in size and profitability

- Selection of high yielding clones and agro techniques for raising bamboo plantation for higher productivity.
- Installation of a grading system for classifying bamboo according to its age, height and thickness to ensure better prices and provide an incentive to grow and supply bamboo of the required maturity, quality and species.
- Development of processing machinery, suitable for Indian bamboo species, producing quality product at a competitive price.
- Proper linkages between private growers, cottage industries/artisans and marketing agencies need to be established by envisaging a holistic developmental plan for the bamboo industry.

Bamboo Trade – from local to global

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Summary

The market for bamboo products in the world is expanding, in size and from local to global. This potentially offers highly needed opportunities for rural communities to generate income, which can be done in combination with protection of the environment. Fair and transparent national and global trading systems are a prerequisite for this. Product development, capacity building, international standardization and networking are needed to realize the potential. We describe how INBAR and its partners are developing a global public private partnership to realize the potential of bamboo as a pro-poor timber of the future.

Introduction

It is estimated that 0.5 to 1 billion people depend on bamboo, because they live in bamboo houses, they use bamboo utensils, they eat bamboo, they work in bamboo processing industry, or they sell mambo and bamboo articles. Most of these people live in the sub-tropical and tropical parts of the world, in Asia, Africa and Latin America. Bamboo is found in the forest, and in the back yard of farms, providing an easy accessible and very important non-timber forest product to forest dwellers and farmers. Due to its capacity to hold soil together, it not only provides income generation throughout the year, but also environmental services to rural communities. Presently bamboo products are used mainly locally, but there is a growing interest in bamboo products in many countries, and the trade is developing rapidly from local to the global level. The global interest is strongly related to the green image of bamboo. The developing global market offers both opportunities and threats to rural populations. It is important that the market develops fair systems that allow meaningful participation of rural communities in the value chain. Furthermore it is needed that the value chains are globally standardized both from a product quality point of view and ecological requirements, to allow the trade to develop in size without backlashes from inferior quality and sustainability issues. As the

International Commodity Body (ICB) for bamboo and rattan, the International Network for Bamboo and Rattan has undertaken several initiatives with stakeholders at all levels to provide the framework for the establishment of a global market network for bamboo products.

Trade

From 1990 onwards INBAR has been able to follow the international trade in bamboo and rattan products, by observing the trends in relevant product categories as provided by the World Custom Organization. The analysis is based on the UN COMTRADE Statistics (ref 1). The data have their limitation, but provide a valuable estimate of the trade and the trends. Figure 1a shows that the total export of Bamboo and Rattan products has risen by 100% in the recent 15 years, to a recorded level of 3.6 bln us dollar in 2004. This is thought to be an underestimation, because the data do not include e.g. paper, bamboo shoots, and flooring. Figure 1b shows that the increase in export value is mainly located in furniture and other processed products, while there is very little market growth in the export of basically unprocessed raw materials. Figure 1c shows that the major markets for export are the countries of the European Union, the United States and Japan. The main exporters are China, the countries of the European Union (probably reselling and/or further processing of imported products), Vietnam and the Philippines (Figure 1d).

While it is clear that there is a lot of internal bamboo and rattan trade going on in India, the country does not figure significantly in any of these world statistics. Imports increased from 1 mln US$ in 1990 to 14 mln US$ in 2004, with export growing from 4 to 10 mln US$ in the same time frame. The most probable explanations for this fact are firstly that since the internal demand for bamboo and rattan products is thought to be very high in India, there has been very little attention for international trade development up till now. Furthermore, it is thought that because the internal market is predominant, the production systems used in India may not put priority on conforming with international trade requirements and standards, which restricts the entry of Indian products on the International market.

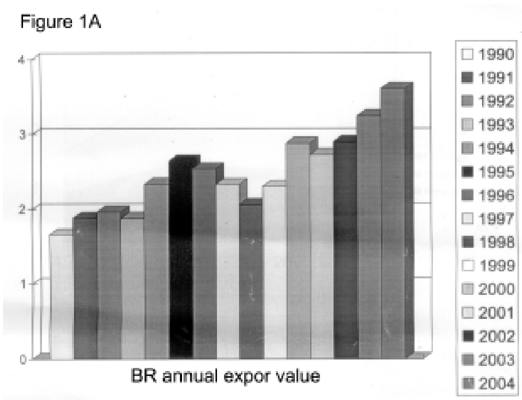

Figure 1A Recorded exports of bamboo and rattan products from 1990 to 2004 (bln US$)

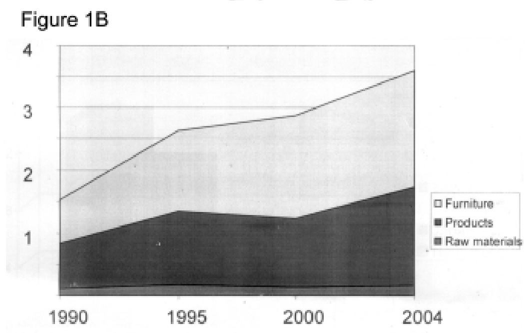

Figure 1B Recorded Market development of major products made out of bamboo and rattan from 1990 to 2004 (bln US$)

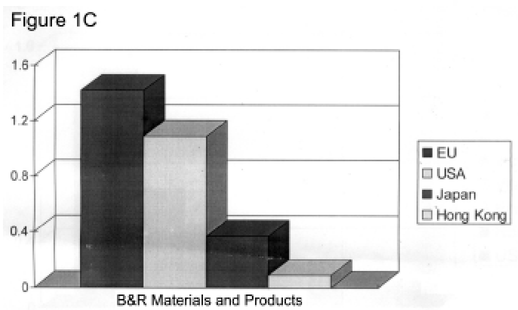

Figure 1C Major importing countries of bamboo and rattan products as recorded in 2004 (bln US$)

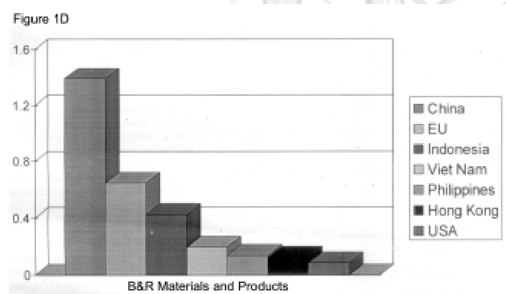

Figure 1D Major exporting countries of bamboo and rattan products as recorded in 2004 (bln US$)

World Custom Organization bamboo codes

In 2003 the World Custom Organization approved a proposal from INBAR and other stakeholders to introduce a 6-digit code for bamboo (and rattan) products. These new codes will very much facilitate the international trade in bamboo products, remove some tax barriers and improve the collection and analysis of trade statistics. The document provides for the deletion of one code and 14 new codes as part of the so-called 'Harmonized System' (HS) (ref 2), which now has total of 22 codes for bamboo and rattan. The codes provide more clarity about products and for the first time will make it possible to include data on flooring, pulp and paper, panels and boards, charcoal as well as bamboo shoots. The set of 22 codes became official in 2007, as shown in table 1, and there effect on the trade will become clear in the next couple of years. Furthermore it is hoped that the international codes will be used nationally as well, allowing for greater transparency and improved trade inside countries as well. For example, both China and India use the HS codes internally by adding an additional 2 digits to the 6 digit HS codes.

Table 1. Overview of codes of the Harmonized System 2007 for bamboo and rattan products. * - already existing codes before 2007.

Code	**Description**
140110*	Bamboos used primarily for plaiting
140120*	Rattan used primarily for plaiting
140190*	Vegetable materials not elsewhere specified, used primarily for plaiting
460120*	Mats, matting and screens, vegetable plaiting material
460110*	Plaits and products of plaiting materials
460191*	Plaited vegetable material articles not mats or screen
460210*	Basketwork, wickerwork products of vegetable material
940150*	Seats of cane, osier, bamboo-or similar materials
200591	Veg, mixes, prepared/preserved, not frozen/vinegar, of bamboo shoots
440210	Bamboo charcoal (including shell or nut charcoal) whether or not agglomerated
440930	Bamboo continuously shaped products other than flooring
441210	Bamboo veneered panels and similar laminated bamboo
442213	Bamboo strips and friezes for parquet flooring
460121	Bamboo plaits and similar products of plaiting materials
460192	Other vegetable materials, of bamboo
460193	Other vegetable materials, of rattan
460211	Basketwork, wickerwork and other articles, of bamboo
460212	Basketwork, wickerwork and other articles, of rattan
470630	Pulps of fibers of bamboo
482361	Other paper, paper board, cellulose wadding and webs of cellulose fibers of bamboo
940151	Seats of bamboo and rattan
940381	Furniture of bamboo and rattan

Products standards

One of the major factors needed for the development of a global trade is a system of reliable standards and specifications, to allow buyers to know what they are trading in, and to give consumers around the world confidence in the products. This is particularly relevant for parts for further manufacturing or construction, e.g. panels and flooring, which are used in the housing industry, and which need to comply with size specifications as well as safety requirements, such as glues and fire resistance. An interesting case is the use of bamboo for scaffolding. While extremely common in South and East Asia, where both residential properties and tall skyscrapers under construction are surrounded by bamboo scaffolding, which is put together very skillfully by the workers of the construction company, the use of such scaffolding in Africa is not even allowed for low rise buildings, because of lack of experience and the fact that the bamboo scaffolding does not comply with the standards that were drawn up for wood and/or metal. INBAR is developing international standards for scaffolding together with the Polytechnic University of Hong Kong, which were submitted to the International Standard Organization (ISO) in 2003.

There is a clear need for many more standards to stimulate the trade of bamboo products. Therefore INBAR has started to collect the available standards from its member countries, to see what is already available. Good national standards are invaluable starting material for the development of international standards, although of course for international standards the production circumstances and local species of different countries have to be taken into account. A special case is formed by ecological standards. Bamboo is rightly considered a green material by many, and it is important to protect that image in the international market. To be able to do so, two issues stand out. Presently bamboo cultivation is very environmental friendly, using little in the form of pesticides and fertilizers, and due to the selective harvesting of the culms bamboo can be considered a resource which prevents land degradation and erosion. However, the increased interest in bamboo for industrial purposes is leading in some places to intensive agricultural production with also the arrival of diseases and destructive harvesting. The industry has to develop self regulation to ascertain that the cultural practices will stay within recognized green limits. At the other side of the production chain, bamboo can be used to replace timber, thereby preventing deforestation, but the hollow stems of most bamboos require pre-processing such as splitting, planning and glueing, processes which carry environmental hazards (van der Lugt et all, 2003 (ref 3). The systems the sector will be using should comply right from the start with those currently accepted for wood processing, in order to ascertain that bamboo will continue to be recognized as a safe and environmental friendly replacement of timber.

Databases

One of the most important tasks of INBAR is to facilitate the international trade in bamboo and bamboo products. To be able to do this INBAR needs access to information about trade. INBAR has developed 2 databases, available on INBAR's website, which can help to get a better understanding of trade and trade developments.

The bamboo and rattan trade database allows viewers to check trade volumes in tons and dollars, and prices between countries. It is a direct product of cooperation between INBAR, the International Tropical Organization (ITTO) and the European Forest Institute (EFI). It is based on the UN Statistical Division COMTRADE data, utilizing the Harmonized Commodity Description and Coding System (HS) used by World Customs Organization (WCO) (see also above). The searchable database is only an initial step on the way of establishing of a comprehensive International Database on B&R Trade and Production. Up till 2006 it only includes nine B&R commodities, those which were explicitly identified in the international custom codes. The represented aggregates may imply besides B&R also willow, osier and the other specified materials. On the other hand the B&R database does NOT yet incorporate many B&R based products that are not easily identified in national or international statistics, such as bamboo pulp, paper, flooring, roofing, panels, boards, composite materials, charcoal etc. a recent INBAR study in China showed that the original 9 HS codes identified only 35% of the total trade. Nor does the database embrace production, trade and consumption of B&R inside the countries. Introduction of the new HS codes as described above at the start of 2007 will contribute greatly to the strengthening of the database. INBAR will continue working and cooperating with the interested agencies on improving B&R statistics (ref 4).

The bamboo and rattan yellow pages provide an entry to look for companies trading in bamboo and rattan. Although the yellow pages are still very much a list of companies in China, due to the fact that they started of as a project to list all companies active in China, more and more non-Chinese companies are being listed as well. The yellow pages are divided in bamboo products, rattan products and services, and presently contain about 1050 listings, of which 950 in China and 100 from outside China (ref 5).

Global Marketing Initiative

Fair trading systems require in particular support for small producers to facilitate their participation in global trade. INBAR's Global Marketing Initiative (GMI) aims to fill that gap, and aims to help poor bamboo producers in Asia, Africa and Latin America access information and technical support in line with larger markets towards bridging the infrastructural gap between the rural producer and the urban buyer. Linking these bamboo producers to networks of experts such as designers, architects, engineers, marketing professionals, process flow experts, institutions, producers, consumers and buyers situated around the globe is a step towards making rural communities reliable and dependable producers of quality goods in quantity in line with markets. The GMI aims to offer people around the world the opportunity to choose innovative, sustainable and environmentally friendly products and lifestyle options made from bamboo which will help ensure the income sustainability of poor bamboo producer communities. The GMI is based on a networked model comprised of Design and Marketing Units. Currently these exist in India, the Philippines, Italy and Ecuador, with coordination provided from India.

Future trends

The market for bamboo products seems healthy and growing. There is room for more volume, and there is room for new products. This offers exiting possibilities for the sector. Bamboo can replace wood, an ever diminishing resource. Bamboo is rural-farmer-friendly, both for cultivation and (pre-) processing. And bamboo fits very well in sustainable approaches to natural resource management, providing the consumers with a 'green' product. Most recently discussions about bamboo for biofuels and bamboo for CDM purposes have started seriously. However, the key to being able to make use of these exiting opportunities lies in standardization and transparency. The sector needs reliable product standards, to be developed in close collaboration with international organizations such as ISO. It needs standardized production, from the village level to the big scale factories (ISO norms), and it needs a strong and reliable eco-image, based on certified production both as part of sustainable forest management and chain-of-custody. At this moment the sector still has the time to develop its own standards and transparency measures – if the industry waits much longer it is likely that it will be done by others, and the sector would be confronted with rules and regulations that might not be a very good fit. INBAR therefore calls for a pro-active global public-private partnership to take the bamboo trade successfully from local to global for consumers and producers alike.

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Investment opportunities for Banks in channelising Credit for raising Bamboo Plantations on Non-Forest Lands

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Abstract

Bamboo cultivation is an important activity in rural areas and NABARD (National Bank for Agriculture and Rural Development) has promoted several credit linked projects, besides providing training to Bamboo artisans. Bamboos grow fast and are eco-friendly, fitting neatly into the bank's lending systems. Annual income flows after a short gestation period of 4-5 years and production continues for many years, thus making Bamboo a commercially viable crop. In North Eastern States, besides the paper mills, a number of Bamboo-based new generation industries have been set up. Although, there is a good market for bamboos, the price offered by paper mills on weight basis is low. On the other hand, the industries offer better price on per piece basis. All these industries are facing problems in sourcing quality raw materials hence requested NABARD to initiate programmes for planting quality bamboo under commercial farm forestry. Accordingly, NABARD undertook a series of techno-economic studies and formulated a rhizome based bankable scheme of Jati Bamboo (*Bambusa tulda*), which is most favoured both by the farmers and the industries. As land availability is a serious problem, NABARD prepared a one bigha (1/3 acre) model in 2005 for intensive bamboo cultivation, which is being implemented by the Assam Grameen Vikas Bank.

In the meantime, government of India launched a centrally sponsored scheme of National Bamboo Mission (NBM) in December 2006 with an outlay of Rs. 568.23 crore for holistic development of the Bamboo sector in the country, under which during the Eleventh Five Year Plan 88,000 ha each of forest and non-forest land will be utilised for raising bamboo plantations. While the cost considered for raising bamboo plantation on forest land is

Rs. 25,000 per ha with 100% support from NBM, the same is Rs 16,000 per ha on farmers' non-forest lands with Rs 8,000 as subsidy and balance Rs 8,000 through bank credit. NABARD considers that Rs 16,000 for raisisng one ha Bamboo plantation is inadequate, hence prepared a credit based model with unit cost of Rs 25,500 for the benefit of farmers and bankers, so that the schemes are not underfinanced. As a large number of small/ marginal farmers will have access to bank credit, financial inclusion of RBI will also get a big boost through the scheme.

Introduction

Bamboo is a versatile group of plants yielding strong, renewable and environment-friendly material which can be put to different uses. It is the fastest growing plant and can be grown quickly and sustainably harvested every alternate year after attaining growth for 3 to 5 years. It grows on marginal and degraded land, along field bunds and river banks. It adapts to most climatic conditions and soil types, acting as a soil stabiliser, an effective carbon sink and helps to counter the greenhouse effect. However, in many areas bamboo resources have dwindled due to over exploitation and poor management. The Bamboo is in short supply and most of the industrial needs are being met from the Bamboo forests of North Eastern Region. There is a strong demand for concerted efforts to promote bamboo plantation in different areas as per species/ site suitability.

Recognising the potential of Bamboo and its contribution to socio-economic conditions and economic growth in the rural areas, the Government of India launched an ambitious scheme viz. the National Bamboo Mission (NBM) in December 2006 with an outlay of Rs 568.23 crore for holistic development of the bamboo sector in the country, under which during the Eleventh Plan 88,000 ha each of forest and non-forest lands will be utilised for raising plantations. The National Bamboo Mission is a centrally sponsored scheme, in which the contribution of the Central Government will be 100%, however, in case of non-forest wasteland development; it is proposed to involve bank loans. The Scheme is being implemented by the Division of Horticulture under the department of Agriculture and Cooperation in the Ministry of Agriculture and Cooperation, New Delhi. NBM has three Mini Missions viz. R & D, Plantation and Handicrafts Development, and Marketing & Export.

NABARD's initiatives

In consonance with the policy of the Government of India, NABARD has identified the Bamboo sector as a major thrust area and has taken initiatives to accelerate the pace of development through involvement of institutional credit. Various efforts include preparation of a policy document highlighting the interventions to be undertaken, the National Consultative Meet on Bamboo held in May 2005, advocacy for State specific Bamboo Policies, assessment of district-wise potential for bamboo farming in states and its credit needs and conduct of various sensitisation programmes in various states, etc. NABARD aims at developing Bamboo farming, processing and marketing as a mainstream activity by changing 'forestry mindset' into 'farm mindset.'

In North Eastern States, besides the paper mills, a number of Bamboo based new generation industries have been set up. Although there is a good market for Bamboos, the price paid by paper mills on weight basis is low. On the other hand, the new industries viz. Koson's Forest Products offer better price on per piece basis. All these industries are facing problems in sourcing quality raw materials and hence have requested NABARD to initiate programmes for planting quality Bamboo under commercial farm forestry. Accordingly, NABARD formulated a rhizome based bankable scheme of Jati Bamboo, *Bambusa tulda*, which most favoured both by the farmers and the industries. As land availability is a serious problem, NABARD prepared a one bigha (1/3 acre) model, which is being implemented by Assam Gramin Vikas bank in several districts of Assam. These schemes can however be implemented in all the states in India.

Potential for Bamboo Plantation

Bamboos grow fast and are eco-friendly, fitting neatly into banks' lending systems. Annual income flows after a short gestation period of 4 to 5 years and continue production for many years, thus making Bamboo a commercially viable crop for financing by the bankers. It is expected that the country's bamboo economy will grow by over 15% to touch Rs 260 billion by 2015. Therefore, if proper policies are put in place and implementation procedures are streamlined, India's Bamboo based industries are likely to achieve a quantum jump in production of wood substitute products. The National Mission on Bamboo Technology and Trade Development under the Planning Commission, has estimated that if proper encouragement is given to Bamboo cultivation and its use, it can replace the projected import of timber to the tune of Rs 300 billion by 2025. By then, the market size for Bamboo Plywood is to grow to Rs 5 billion. It has been estimated that the total market size of Bamboo Flooring materials will rise to Rs 19.5 billion by 2015. The demand for Bamboo pulp is expected to grow to Rs 20.88 billion by 2015 from Rs 3.8 billion in 2001. The demand for road construction will rise to Rs 2.74 billion and for bamboo grids the demand will be Rs 1.0 billion. By 2015, bamboo Scaffolding requirement will rise to Rs 8.61 billion and for housing purposes, the demand will rise to Rs 11.63 billion.

Promoting Bamboo plantation is one of the major components in the Bamboo Mission. This component comprises Bamboo Nursery, tissue culture units and area expansion under Bamboo plantation both in forest and non-forest areas. The Bamboo Mission aims to cover 1.76 lakh hectare area (covering forest and non-forest lands) under Bamboo Plantation activities over a period of five years (2006-07 to 2010-11). Out of this, 88,000 ha cover non-forest area or private wastelands. This provides a huge potential for investment in the Bamboo Sector by the banks. The successful investment in promotion of Bamboo plantation will also lead to investment opportunities in the bamboo based industries specially by setting up of the new generation bamboo based industries. As a large number of rural farmers will have access to bank credit, financial inclusion will also get a big boost through the Scheme.

Need for specific scheme/ Models for Bamboo Plantation

As per the operational guidelines of NBM, while the cost of creation on forest lands is estimated at Rs 25,000 per ha, the same for farmers' non-forest lands is estimated at Rs 16,000 per ha with Rs 8,000 as subsidy to be released in two instalments and for the remaining Rs 8,000, is proposed to be disbursed by banks. NABARD is of the opinion that Rs 16,000 as cost for raising one ha bamboo plantation is inadequate. However, the guidelines for taking up the plantation through bank credit and utilising subsidy have not been laid down in the operational guidelines of National Bamboo Mission. Hence, NABARD has proposed a credit linked subsidy scheme to the Directorate of NBM in order to dovetail the efforts for promoting Bamboo on non-forest areas through institutional credit as well as utilising the incentives available under National Bamboo Mission.

Objectives of the Scheme

- The objectives of the Scheme are to:
- Encourage Bamboo Plantation on non-forest waste lands through people's participation
- Provide institutional credit for Bamboo Plantation on private lands as envisaged by National Bamboo Mission
- Establish convergence of resources and synergy among stakeholders for achieving the goals of National Bamboo Mission
- Encourage bank finance for the hitherto neglected but potential forestry sector in the country

- Augment raw material supply for Bamboo-based industries and promote new generation Bamboo based industries

Plantation Models for Bamboo

One of the major problems in promoting Bamboo Plantations both on forest or non-forest lands is the lack of availability of quality planting material as Bamboo seeds are not readily and regularly available due to cyclic flowering. Therefore, in order to achieve the target of area coverage fixed in the NBM, it will be imperative to utilise all available propagation methods for producing quality planting stock. Keeping this in view, three plantation models are proposed based on the type of planting materials available to the farmers. These are: (a) Seedling based model, (b) Tissue culture plants based model, and (c) Rhizome based model. The species selected are *Bambusa tulda*, *Dendrocalamus strictus* and *D. Hamiltoni*.

Seedling based model

This model has been suggested for plains areas where sufficient seed material is available and nursery seedlings can be easily produced by forest and horticulture department. These plantations are to be taken up in degraded and unculturable wastelands or where the farmers are not interested in cultivating on agricultural crops as in case of absentee landlords. The recommended spacing for this model is 5 m x 6 m with a plant density of 333 plants per ha. The unit cost up to fifth year for this model has been worked out at Rs 25,500 per ha. The details of cost estimates along with technical and financial parameters are given in Table I.

Table 1 : Cost estimates for raising 1 ha Bamboo Plantation through seedlings

Sl No	Particulars of works	Unit	Rate	Cost (Rs) per year					
				1	2	3	4	5	Total
1	Site preparation, clearing of shrubs, bushes, etc	Manday (MD)	12	840	-	-	-	-	840
2	Alignment & staking	MD	4	280					280
3	Digging of pits (60 cm 3) @ 12 pits/ MD and refilling of pits after mixing FYM, fertilisers & insecticides @ 40 pits/ Manday	MD	36	2520	504	-	-	-	3024

Sl No	Particulars of works	Unit	Rate	Cost (Rs) per year					
				1	2	3	4	5	Total
4	Cost of FYM @ 4 kg/ pit	Rs/kg	0.5	666	666	666	666	666	3330
5	Cost of insecticides @ 5 gm/ pit	Rs/kg	100	167	167	-	-	-	334
6	Cost of plants including transport (333,66)	Rs/plant	4	1332	264	-	-	-	1596
7	Planting @ 30 plants per Manday	MD	11	770	155	-	-	-	925
8	Soil working & weeding (3,2,1)	MD/ weeding	12	2520	1680	840	-	-	5040
9	Life saving irrigation (5 times per yr) in dry months only	Rs/ irrigation	600	3000	3000	-	-	-	6000
10	Pruning/tending/cleaning/ burning	MD	10	-	-	700	700	700	2100
11	Bio-fencing/Live hedge fencing	Rs	LS	1000	-	-	-	-	1000
12	Inter cropping	Rs	LS	1000	-	-	-	-	1000
	Total			14095	6436	206	1366	1366	25469
		Say Rs 25,500							

Spacing (m x m): 5 x 6, number of Bamboo planted/ Ha: 333, survival @ 80%: 266, wage rate/ Manday: Rs 70, casualty replacement: 20%.

NB: some shade loving field crops like colocassia, ginger, turmeric etc can be taken up as intercrop.

Yield and income from one hectare seedling based bamboo Plantation

Sale price per culm	Rs 20
Surviving clumps per Ha (No.)	266
Number of clumps available for harvesting per year	133

Year	Number of culms available for harvesting per clump every year in a harvesting cycle of 2 years	No. of culms per ha per year	Total Income (Rs)
6	4	532	10640
7	7	931	18620
8	10	1330	26600
9	12	1596	31920
10 onwards	12	1596	31920

IRR	31.68%
Repayment Period	10 years
Grace Period	5 years

Tissue Culture Plants (TCP) based model

This model has been suggested for areas where seedling stock is not readily available due to non-availability of bamboo seeds. Although the cost of raising tissue cultured plants will be high as compared to seedling plants, the same will be offset by the quality produce and earlier production as compared to seedling model. The recommended spacing for this model is 5 m x 6 m with a plant density of 333 plants per ha. The unit cost up to fourth year for this model has been worked out to be Rs 35,000 per ha. The details of cost estimates along with technical and financial parameters are given in Table 2.

Table 2: Cost estimates for raising 1 ha plantation through tissue culture plant

Sl No.	Particulars of works	Unit	Rate		Cost (Rs) per year			
				1	2	3	4	Total
1	Site Preparation, clearing of shrubs, bushes etc	Manday (MD)	12	840	-	-	-	840
2	Alignment & staking	MD	4	280	-	-	-	280
3	Digging of pits (60cm3) @ 12 pits/MD and refilling of pits after mixing FYM, fertilisers & insecticides @ 40 pits/MD	MD	36	2520	504	-	-	3024
4	Cost of FYM @ 8 kg/pit	Rs/kg	0.5	1332	1332	1332	1332	5328

Sl No.	Particulars of works	Unit	Rate		Cost (Rs) per year			
5	Cost of fertiliser @ 100 gm/pit	Rs/kg	10	500	499	-	-	999
6	Cost of insecticide @ 5 gm/pit	Rs/kg	100	167	167	-	-	334
7	Cost of plants including transport (333,66)	Rs/Plant	12	3996	792	-	-	4788
8	Planting @ 30 plants per Manday	MD	11	770	155	-	-	925
9	Soil working & weeding (3,2,1)	MD/ weeding	12	2520	1680	840	-	5040
10	Life saving irrigation 8 times per yr in dry months only	Rs/ irrigation	600	4800	4800	-	-	9600
11	Pruning/tending/cleaning /burning	MD	10,10	-	-	700	700	1400
12	Bio-fencing/ live hedge fencing	Rs	LS	1500	-	0	0	1500
13	Inter cropping	Rs	LS	1000	0	0	0	1000
	Total			20225	9939	2872	2032	35058
		Say Rs 35,000						

Spacing (m x m): 5 x 6, No. of bamboo planted/ ha: 333, survival @ 75%: 250, wage rate/ Manday: Rs 70.00, casualty replacement: 20%.

NB: Some shade loving field crops like colocassia, ginger, turmeric etc can be taken up as intercrop.

Yield and income from one hectare TCP based bamboo plantation

Sale price per culm	Rs 20
Surviving clumps per Ha (No.)	250
Number of clumps available for harvesting per year	125

Year	Number of culms available for harvesting per clump every year in a harvesting cycle of 2 years	No. of culms per ha per year	Total Income (Rs)
5	4	500	10000
6	7	875	17500
7	10	1250	25000
8	12	1500	30000
9	12	1500	30000
10 onwards	12	1500	30000

IRR	28.93%
Repayment Period	10 years
Grace Period	4 years

Rhizome based model

This model has been suggested for areas where neither seedling stock nor tissue cultured plants are available especially in remote areas. Besides, farmers prefer only rhizomes as planting materials. The recommended spacing for this model is 5 m x 6 m with a plant density of 333 plants per ha. The unit cost up to fourth year for this model has been worked out to be Rs. 30000/- per ha. The details of cost estimates along with technical and financial parameters are given in Table – 3.

Table-3: Cost Estimates for raising 1 ha Bamboo Plantation through Rhizomes.

Sl No	**Particulars of works**	**Unit**	**Rate**	**Cost (Rs) per year**			
				1	2	3	Total
1	Site preparation, clearing of shrubs, bushes, etc	Manday (MD)	12	840	-	-	840
2	Alignment & staking	MD	4	280			280
3	Digging of pits (60 cm^3) @ 12 pits/ MD and refilling of pits after mixing FYM, fertilisers & insecticides 40 pits/ Manday	MD	36	2520	378	-	2898
4	Cost of FYM @ 5 kg/ pit	Rs/kg	0.5	833	833	833	2499

Sl No	Particulars of works	Unit	Rate	Cost (Rs) per year			
5	Cost of insecticides @ 5 gm/ pit	Rs/kg	100	167	167	-	334
6	Cost of Rhizome including transport i(333,50)	Rs/plant	20	6660	1000	-	7660
7	Planting @ 25 plants per manday	MD	13	910	140	-	1050
8	Soil working & weeding (3,2,1)	MD/ weeding	12	2520	1680	840	5040
9	Life saving irrigation (5 times per year) in dry months only	Rs/ irrigation	600	3000	3000	0	6000
10	Pruning/tending/cleaning/ burning	MD	10	-	700	700	1400
11	Bio-fencing/live hedge fencing	Rs	LS	1000	-	-	1000
12	Inter cropping	Rs	LS	1000	-	-	1000
	Total			19730	7898	2373	30001
		Say Rs 30000					

Spacing (m x m): 5 x6, No of bamboo planted/ ha: 333, Survival @ 85%: 283, wage rate/ Manday: Rs 70.00, casualty replacement: 20%

NB: Some shade loving field crops like Colocassia, ginger, turmeric, etc can be taken up as intercrop.

CBTC

Yield and income from one hectare rhizome based bamboo plantation

Sale price per culm	Rs 20
Surviving clumps per ha (No.)	283
Number of clumps available for harvesting per year	142

Year	Number of culms available for harvesting per clump every year in a harvesting cycle of 2 years	No. of culms per ha per year	Total income (Rs.)
4	4	566	11320
5	7	991	19820
6	10	1415	28300
7	12	1698	33960
8	12	1698	33960
9	12	1698	33960
10 onwards	12	1698	33960

IRR	42.62%
Repayment Period	7 years
Grace Period	3 years

A comparative overview of the three plantation models are also provided in Table – 4.

Table-4: A comparative cost estimate and other parameters of three models.

Models	Unit Cost	Gestation Period/ Grace Period (years)	Surviving Clump per ha (No.)	Annual Income after yield stabilisa-tion (Rs/ha)	IRR (%)	Repay-ment Period (years)
Seedling Model	25,500	5	266	31920	31.68	10
Tissue Culture Plants Model	35,000	4	250	30000	28.93	10
Rhizome Model	30,000	3	283	33960	42.62	7

Harvesting

The plantations raised through seedlings start yielding culms during the fifth year whereas in the plantations raised through tissue cultured plants and rhizomes, the culms can be harvested during the fourth year. To maximise shoot output, some shoots must be left each year to develop into leafy young culms. Thus, it is better to harvest the culms from the available clumps following a felling cycle of two years in such a way that the harvestable culms can be removed from half of the surviving clumps every year, ensuring regular annual income.

Yield, Income and Financial Viability

Yield

The annual yield of a bamboo clump depends on the number of new culms produced each year which in turn depends upon the production of young rhizomes. Generally, culms become mature after two years. Based on two year felling cycle, the number of culms per clump which can be harvested in the first, second and third year of harvest are assumed at 4,7 and 10 respectively in all the three models.

Sale Price/ Income

The sale price of bamboo depends upon ultimate purpose for which it is being utilised. The paper industries buy bamboo for pulp and hence buy on tonnage basis and the price offered is not very remunerative whereas some of the new generation bamboo based industries requiring bamboo with standardised specifications buy on piece basis and thus offering attractive prices. The sale price also varies depending upon its origin, species, its dimensions and mode of transportation. Keeping this in view a conservative price of Rs. 20 per culm has been considered for all the three models.

Financial Viability

All the three plantation models viz. Seedling Model, Tissue Cultured plants model and Rhizome based Model are found to be viable. The detailed financial parameters are given in Tables 1 to 3.

Repayment Period

Based on the yield and income generated, the repayment period has been worked out. The bank loans would be repaid in annual graded instalments with a grace period of 3 to 5 years with a repayment period of 7 to 10 years depending upon the plantation model. The repayment so considered is without taking into consideration the subsidy part. Therefore, subsidy will definitely improve the net surplus available to the farmers ensuring earlier loan payback period.

Discussion and Conclusion

A comparative analysis of three models indicated that the Rhizome based plantations will give maximum financial returns with IRR of 42.62 per cent and repayment period of 7 years. The next best model is seedling based plantation, which will give an IRR of 31.62 per cent with repayment period of 10 years and the returns from the former is quite early as compared to the latter. The tissue culture plant based model will give a financial return of IRR 28.93 per cent with a repayment period of 10 years. These variations in yield, returns and repayment period can best be explained based on the cost of planting materials, cultural operations required and comparative advantages of propagules used for plantation. As for example, in case of seedling based plantations, planting material cost is Rs. 4.00 per plant whereas it is Rs. 12.00 in case of tissue culture plants and Rs. 20.00 in case of rhizomes. Although it is very easy to raise seedling based plantations, there are problems in non-availability of seeds of desired bamboo species. Its gestation period is also long. In case of tissue culture plants, cost of planting material is much higher in comparison to seedlings thus giving less returns. To make these plantations more viable, cost of tissue cultured plants needs to be reduced through mass production. In case of rhizomes, the cost is much higher, although the survival in field conditions is high and returns are quick. But there are several disadvantages of such plantations viz. large plantations cannot be raised through rhizomes and also there are injuries in the clumps while excavating the rhizome. Such plantations, however, can be raised to a little extent on farmers' land under homestead farming.

Because of their very fast growth bamboo fits well in the banks' lending system. Returns on investments are comparable with any other methods of farming systems. Annual income from bamboos after a short period of establishment makes them suited for farm/ agro forestry on small land holdings of small and marginal farmers. Within such bamboo plantations, intercrops like soya bean, ginger, turmeric, mustard and various medicinal plants can be successfully cultivated for several years, which also give substantial income to the farmers. In fact, with *Bambusa vulgaris*, a family continues to get a steady annual income for several decades (Chaturvedi 1986). With little planning and efforts these can be converted into several bamboo products fetching good price thus assisting the poor families in improving their economic status.

Bamboo in India is not under any organised sector, sometimes farmers face difficulty in marketing, on the other hand, the artisans face problems in procuring bamboo easily. Overall, there is a good scope of raising bamboo through institutional credit in India (Haque 1997, 2002, Karmakar and Haque, 2004). The bamboo plantation technology is now well established, therefore, the introduction and cultivation of desired bamboo species in the pattern of agro forestry is the need of the hour. Bamboos – the poor man's timber has the capacity to improve the economic condition of vast rural poor of India (Haque, 2004). As the supply diminishes, there is a need for a major thrust to restore and enlarge the production base (Karki *et al*., 1997). During the past 60 years of India's independence, bamboo received little attention compared to other timber yielding trees (Biswas, 1997). The recently launched National Bamboo Mission will fill this gap.

Hopefully, the potential of bamboo is being reassessed and it s cultivation and proper utilisation can make rural communities of India and the country self sufficient and economically strong in wood front, as it has achieved in the food front with the Green Revolution. It has been observed that bamboo based agro forestry models provide economic returns much faster and higher than Poplar (*Populus sp*.) and *Eucalyptus sp.* (Rawat *et al*., 2002). In addition, it provides ancillary benefits in the form of improvement of environment, flood control, soil and water conservation etc.

Planning Commission (2001) had identified bamboo as one of the 6 species for agro forestry plantations. It advocated the use of Clonally Propagated Cutting (CPC) of *D. Strictus, B. Tulda and B. Vulgaris* besides those of *B. nutans* for cultivation. It also recommended the research work for selection of plus culms for quality pulp, early and every year flowering, good height and diameter growth including high biomass production per unit basis. National Mission on Bamboo Technology and Trade Development (2002) had also recommended identification of potential bamboo for plantation in different agro ecological regions, technology up gradation including mass production by tissue culture, plantation technology standardisation for afforestation of wastelands, and establishment of primary and secondary processing units of bamboo for value addition, employment generation and poverty alleviation.

NABARD will support any bamboo based activities that will improve the economic condition of vast rural masses of India (Haque, 2004). The North East has a special significance with respect to bamboo, since about 60% of the bamboo resources of India and 20% of the world are available in the region (Salam, 2006). Victor Brias (2005) had recommended that since North East has the highest concentration of bamboo in the world, by blending modern technology and by cutting across boundaries, bamboo can be used as a universal asset. Bachpai *et.al* (2005) undertook growth studies on 15 clones of *B. tulda* selected from Assam and Meghalaya states. It indicated that there were significant differences among genotypes for all the parameters viz. height, dbh and age. The authors concluded that there is an opportunity to select the best plus clumps for further production of improved planting stocks for afforestation and other plantation programmes.

Green markets are growing and offer new opportunities for the promotion of bamboo as an alternative wood. Thus investing in bamboo plantation will definitely help the farmers on one hand and provide investment opportunity to banks on the other hand. The income from the produce of bamboo plantation would add to the livelihoods of the rural people and will help in meeting the demand of raw material of existing bamboo based industries. Furthermore, the produce from these plantation will open various investment and employment opportunities in terms of setting up of new generation bamboo based industries. There are emerging industrial and large-scale applications too in the manufacture of wood substitutes and composites, energy, charcoal and activated carbon. Building and structural components represent vast possibility for enterprise, value addition, income and employment.

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Investment Potential and Marketing in Bamboo Sector

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Introduction

Bamboo is known as poor man's timber. It is a giant woody grass. A single bamboo clump can produce up to 15 kilometres of usable pole (up to 30 cm in diameter) in its lifetime. Bamboo is the most diverse group of plants in the grass family, and the most primitive sub-family.

The traits that characterize bamboo make it an ideal solution for environment and social consequences of tropical deforestation. Moreover, technology in the recent years has made bamboo based entrepreneurial activity a distinct and viable opportunity that has the promise of vastly improving rural livelihood and alleviating poverty. Industrialization of this sector can contribute substantially to the gross domestic product of the nation especially in light of the inclusive growth that we now seek.

Properties and Uses of Bamboo

The characteristics/properties of bamboo make it an enduring, versatile and highly renewable resource. Bamboo has more than 1,500 documented uses, ranging from fire wood to light bulbs, medicine, poison and toys to aircraft manufacturing. Over 1,000 million people live in houses made of bamboo or with bamboo as the key structural, cladding or roofing element.

- Its biological characteristics make it a perfect tool for reducing carbon dioxide levels in the atmosphere. It generates more oxygen than equivalent strands of trees, lowers light intensity, protects against ultraviolet rays and is an atmospheric and soil purifier.
- Bamboo is a versatile natural resource. The great diversity of species makes bamboo adaptable to many environments. It tolerates extreme precipitation from 30 to 250

inches of annual rainfall. A dense bamboo cover also offers stakes to trees, folder to animals and food to humans.

- Bamboo grows very fast and has a short growth cycle. Bamboo grows much faster than wood, and needs relatively little water. It is the fastest growing plant, growing three times faster than most eucalyptus species. Commercially important species usually mature in four to five years (versus 10 to 25 years for most soft woods). It can be harvested/cut annually.
- Bamboo prevents soil erosion. Its anti-erosion properties create an effective watershed, stitching the soil together along fragile river banks, deforested areas, and in places prone to earthquakes and mud slides. Thus, bamboos help control landslides, keep flooded rivers along their natural course and slow the speed of the water flow.
- Bamboo is foremost in biomass production, with up to 40 tonnes per hectare per years in terms of culms only in managed stands. An estimated one-quarter of the biomass in tropical regions and one-fifty in subtropical regions comes from bamboo.
- Bamboo has been used in ancient medicine. Bamboo has for centuries been used in Ayurveda (for example, Chawanprash) and Chinese acupuncture. The powered hardened secretion from bamboo is used internally to treat asthma, coughs and can be used an aphrodisiac. In China, ingredients from the root of the black bamboo help treat kidney disease.
- Bamboo is one of the world's best natural engineering materials. Due to its high tensile strength, it is an essential structural material in earthquake architecture and is one of the strongest building materials. Its strength-to-weight ratio is better than that of teak wood and mild steel. This makes bamboo wood a potential alternative, at least in some applications, to steel which requires more energy for manufacturing/production. Its strength and flexibility make it a viable material for building shelters that offer protection against hurricanes and earthquakes. In Bangladesh, 73% of the population lives in bamboo houses. Bamboo based pre-fabricated houses can be constructed quickly with new and emerging techniques and is thus an important post-disaster relief material. It is extensively being used in Tsunami rehabilitation in India. Bamboo reinforcement in concrete piles is used by the Indian Railways.
- As a food source, bamboo shoots have provided nutrition for million of people worldwide. In Japan, the antioxidant properties of pulverized bamboo bark prevents bacterial growth and it is used a natural food preservative. Taiwan alone consumes 80,000 tons of bamboo shoots annually constituting a $50 million industry.

- Bamboo is a viable replacement for wood. Its qualities of strength, light weight and flexibility make it a viable alternative to tropical timber that is used in the furniture and building material industries.
- It is a critical element of the economy. Bamboo and its related industries provide income, food and housing to over 2.2 billion people worldwide.
- Bamboo is a high-yield renewal natural resource. Bamboo is now being used for wall paneling, floor tiles, for paper making, briquettes for fuel, raw material for housing construction, and rebar for reinforced concrete beams. It can be used to produce many items of daily use that are currently made out of plastic or other less eco-friendly materials.
- Bamboo is being used as an input or raw material in certain industries. It has been primarily been used in the paper industry in bulk quantities as a raw material for paper pulp. Bamboo is also used in manufacturing wood substitutes, composites, utility products including Venetian blind and Agarbatti (incense sticks).
- Bamboo is also a source of energy. Gasifier can produce electricity using bamboo as fuel. These can also be used for thermal applications replacing furnace and diesel oil. Charcoal and its processed form in powder and briquettes can also be manufactured. It is superior to other sources of charcoal in terms of calorific value. Bamboo charcoal can also be used as a raw material for activated carbon manufacturing which is used as adsorbent in different industries like genetable oil beverage, pharmaceuticals etc. goldsmiths prefer bamboo charcoal in making jewels.

Bamboo based Products

The products that can be made from Bamboo can broadly be categorized into:

1. Wood Substitute and Composites,
2. Industrial Use and Products,
3. Food Products,
4. Construction and Structural Applications.

Apart from this broad classification various handicraft and cottage industry products are made from bamboo.

Wood Substitutes and Composites

This category of products essentially comprises of boards of varying descriptions and uses, and which can further be used to manufacture finished products like wooden floors, shuttering ply, furniture etc.

Bamboo Based Panels: China started producing bamboo panels in the early 19th century. At present more than 20 different types of panels are produced in Asia. The panels are widely used in modern construction as structural elements. They are also used for flooring, roofing, partitions, doors and window frames. Bamboo panels have some advantages over wooden board due to their rigidity and durability. Various types of bamboo veneers, panels and boards can be broadly classified as follows: veneers, strips boards, mat boards, fibreboards, particle boards, medium density boards, combinations of these and combinations of these with wood and other lingo-cellulose materials and inorganic substances. Composite of bamboo and jute are also possible to make panels.

Bamboo Furniture: Traditional bamboo furniture used natural round of split bamboo. Unlike the traditional design, the composite bamboo furniture be shipped in compact flat packs to be assembled on the spot.

Industrial Products

Traditionally the industrial use of bamboo has been in the paper and pulp industry. Apart from this, the industrial products from bamboo essentially comprise of converting into fuel or electricity through gasification. Through pyrolysis, bamboo can be converted into three valuable products – bamboo charcoal, oil and gas. Changing the pyrolysis parameters can change the product mix depending on the purpose and market conditions. Bamboo based producer gases can be used as a substitute for petroleum. Bamboo charcoal is in excellent fuel for cooking and barbequing. There can also be use of activated charcoal. This is used as a deodorant, purifier, disinfectant, medicine, agricultural chemical and absorbent of pollution and excessive moisture. The industrial use is using bamboo waste for gasification and thereby producing electricity.

Bamboo for Paper and Pulp: Several bamboo-producing countries, such as China and India, use bamboo in paper and pulp. Bamboo paper has practically the same quality as paper made from wood. Its brightness and optical properties remain stable, while those of paper made from wood may deteriorate over time. The morphological characteristics of bamboo fibres yield paper with a high tear index, similar to that of hardwood paper. The tensile stiffness is somewhat lower compared with softwood papers. The quality of paper may be improved by refining the pulp.

Bamboo Charcoal for Fuel: Bamboo charcoal is traditionally used as a substitute for wood charcoal. It can serve as a fuel, absorbent and conductor. The calorific value of bamboo charcoal is almost half that of oil of the same weight. Activated bamboo charcoal can be used for cleaning the environment, absorbing excess moisture and producing medicines.

Bamboo Based Gasifier for Electricity: Gasification of bamboo can produce energy both thermal or electrical. It utilizes waste generated by processing operations; substitute the use of fossil fuels and lower operating costs.

Bamboo based fibre and fabric: The most recent advancement in bamboo is the manufacturing of fibre for making yarn and into various fabrics. Bamboo fabrics are naturally anti-microbial and due to the presence of micro pores in the fabric absorb, they three times more moisture than cotton, making it a superior product.

Apart from the ones outlined above, bamboo extracts contain valuable elements that can also used an input in several industrial products. For example, bamboo can be used in pharmaceuticals, creams and beverages. Traditional medicines like *Chawanprash* use bamboo extracts.

Food Products

Under this category, it is essentially bamboo shoots that are consumed after being cooked. About 200 species of bamboo can provide edible and palatable bamboo shoots. Fresh bamboo shoots are delicious and healthy, with high fibre content.

Construction and Structural Applications

Advances in structural engineering and the development of bamboo composites have opened new vistas for lightweight, durable and aesthetic construction for a variety of applications, enabling informed choices for housing, community and functional structures.

Bamboo housing: there are three main types of bamboo housing, a) traditional houses which use bamboo culms as a primary building material; b0 traditional bahareque bamboo houses, in which a bamboo frame is plastered with cement or clay; and c0 modern prefabricated houses made of bamboo laminated boards, veneers and panels. These buildings are usually cheaper than wooden houses, light, strong and earthquake resistant, unlie brick or cement constructions. New types of prefabricated houses made of engineered bamboo have distinct advantages. They can be packed flat and transported at a reasonable cost. They are better designed and environmentally friendly.

The properties and uses of bamboo vary at different stages of growth and its appropriateness at different stages of growth is s follows:

Up to 30 days	-	Bamboo shoots to be used as food
Between 6-9 months	-	for basketry
Between 2-3 years	-	for laminates and boards
Between 3-6 years	-	for construction

Initiatives

National Mission on Bamboo Applications (NMBA) which is an initiative of Govt. of India under the aegisis of Department of Science and Technology, Govt. of India for the development of bamboo sector by developing new range of value added products and applications.

In the first two years, the NMBA created base for economic activities worth Rupees 1,300 crore (worked out over a ten year period of estimated life of commercial projects). It has generated employment for 25.2 million man days for 1.70 lacs persons, in extraction, processing and value addition in bamboo growing areas, across the country.

Government of India under Ministry of Agriculture has launched a Centrally Sponsored Scheme of National Bamboo Mission in December 2006, with Focus areas of activities being plantation related research, bamboo cultivation and propagation and handicrafts marketing and exports. The Scheme targets 176,000 hectares of fresh plantation, with 88,0000 hectares each in forest and non-forest areas. In addition, there are 36,000hectares of re-establishment/improvement of existing plantations. It also targets improvement of productivity of bamboo plantations from existing level to average level of 18 tonnes/ha. The initiative is likely to result in availability of additional around 3.02 million tones of bamboo/year after four years. An area of around 30,000 hectares of bamboo plantations has been covered under the scheme.

It has also been decided by the Government that to ensure synergy of plantation and resource development activities with value addition, the NMBA will provide required technical and financial support to post harvest processing, technology development and commercialization, setting up of processing and product manufacturing units, processing zones, technology parks, industrial applications and subsequent value addition.

Success Story of Konbac

Sanjev S.Karpe

(Director-Konbac)

Sindhudhudurg district of Maharashtra has a geographical area of 5087 sq. km with a forest area of around 910 sq. km. The forest lands are largely owned by the government (to the tune of 94 sq. km.) with about 50 sq. km under the ownership of private persons. The main aspects of bamboo found here are *Oxytenanthera stocksii*, *Oxytenanthera monostigma, Bambusa arundinacea* and *Dendrocalamus strictus.*

With the objective of using the local resources, for employment generation in the Konkan region youths in Sindhudurg district joined hands to form a local NGO called – *Konkan Nisarg Manch* in the year 2000. With able guidance of Mr. Suresh Prabhu , the local member of the Parliament, the organization decided to focus on Bamboo.

In June 2001, *KOnkan Nisarg Manch* published a report on Investment Opportunity in Bamboo. With the involvement of Forest Research Institute – Dehradun a survey was carried out of the inventory of Bamboo in the district.

With the sponsorship from NABARD, INBAR was invited to the district for evaluation and guidance and possibilities in Bamboo which could be activated in the region. During the subsequent conference held in it was decided to form an NGO which would be a Section 25company with equal partnership between INBAR and the local community.

The strategic region for setting up the office in Kudal was availability of abundant bamboo in Sindhudurg and adjacent area. The proximity to Goa (Tourist destination) and Mumbai, the business hub, was an added advantage for the market of the outputs.

The *Konkan Bamboo and Cane Development Centre* [KONBAC] was established in Kudal of Sindhudurg district and was registered in June 2004.

KONBAC decided to work with the civil society, government and community to make bamboo-based sustainable development a reality by building networks and partnership. The aim of KONBAC is to achieve environmental security and economic development of the community through sustainable use bamboo. Given Sindhudurg 's rich bamboo resources and the people's natural affinity to this grass there were immense opportunities and KONBAC aims to actualize this untapped potential by guiding and training traditional bamboo working communities to set up bamboo based enterprises.

On commencing links with the local communities KONBAC realized that the youths of the traditional bamboo workers was not interested in getting involved with the project because they had come to the conclusion that working in the bamboo industry was not economically viable as the traditional products were replaced with cheap plastic which rendered bamboo work as an endeavor less respectable than other trades.

This reflected the general image of bamboo from the artisans' point of view which closely mirrored the buyers in the high end markets which stated that "Bamboo is a poor man's timber and is basically a cheap and inferior raw material" ultimately producing cheap products. The quality and durability was also suspect. This is the prime reason of very low income in the bamboo sector for the traditional artisans.

These were the hard hitting feedbacks and image that KONBAC carried back from the community to our offices for lengthy brainstorming sessions amongst our team. We started of with finding a GOAL in which would bring about a major turnaround for bamboo to be taken up seriously by the communities and the potential markets at close quarters in GOA and other places. After many hits and misses and seemingly wild ideas we concluded looking upon the opposite of LOW COST. It was decided that the goal would be high quality, with design intervention to make the best use of local available species of bamboo and traditional craftsmanship to produce products which would reposition bamboo as an Exotic material for high value products.

Within a span of two and half years KONBAC has initiated several steps. Awareness raising and training programs is ongoing features of KONBAC activities. KONBAC through activities intends to provide technology support to these groups in the area of design, development and market linkages that would promote eco-income general activity.

The product focus was:

1. Bamboo Furniture.
2. Bamboo Crafts.
3. Light Structures.
4. Turn key bamboo construction projects.

Bamboo Furniture

KONBAC worked with a methodical approach covering areas such as designing, prototyping, test marketing, tr4aining production, branding market promotion and sales. The continuous efforts of the first 21 months helped sell bamboo furniture worth Rs. Lacs in the ensuing 15 months and counting.

Bamboo Crafts

A major thrust in assessing the existing skill levels of traditional bamboo artisans helped us in creating programs for upgrading their skills with introductions of new methods in crafting exquisite products. Training in natural dying methods, preservative treatments, use of modern tools and machinery with moulds and jigs brought about the necessary results. The In-House design cell developed which were prototyped, developed and test marketed. These products were transferred to various Self Help Groups formed by KONBAC for production. The following tie ups with the Handicrafts Department of Government of Goa created a platform for sale in the retail outlets of the department in Goa.

The acceptance of the quality and finish of the end product presently fetches prices which were once thought of as impossible for a bamboo product.

Light Structures

Thorough design development with trained man power and treated and graded bamboo with aesthetically designed and structurally stable and durable structures were developed for varied private and public spaces. From a Roof Top Restaurant to a High Stall foe DRDA, Passenger Shelter for Konkan Railway and an exotic Gazebo for the Tourism Department, all the structures were well received by the owners and the subsequent users.

Konkan Bamboo and Cane Development Centre [KONBAC] is an independent non-profit organisation to promote the bamboo sector in western India. KONBAC aims at establishing backward linkages into the villages and forward linkages into technical and with other development agencies in the regional, national and international level.

Turnkey bamboo construction projects

The most challenging assignment till date which converted KONBAC's small step in the bamboo sector to a giant leap in Bamboo construction a turnkey project worth more than 1 Crore was awarded by the dynamic Maharashtra Maharashtra tourism Development Corporation [MTDC]. The challenges were endless and at its extremes spanning – Complete structural skeleton in Bamboo, Ground plus one structure including 4 rooms which are fully equipped with air conditioning and bath tubs, Implementation on sand at a location facing high wind velocities up to 200 kms per hour, all this covering an area of 3000sq.ft.

The use of a lower diameter of bamboo has given a very sleek and chic look to the Resort. The resultant feedbacks confirmed a complete acceptance from the target group and the focus of KONBAC's GOAL.A repeat assignment from the same client for a still higher end Bamboo Resort endorsed it. A small but steady flow of potential customers are interacting with KONBAC for similar projects to the tune of more than 3 crores to be implemented in the near future.

1. Infrastructure with KONBAC
2. Bamboo Common Facility Centre.
3. Pressure Treatment Plant.
4. Furniture Manufacturing Unit.
5. Crafts Manufacturing Centre.
6. Training Centre.
7. Design Cell.
8. Community Based crafts Production Centre.
9. Bamboo Structure Prefabrication Unit.
10. Bamboo based Hygiene product manufacturing unit.
11. Bamboo construction unit.

KONBAC's Research Partners

- Technical University Delft, Netherlands
- Indian Institute of Technology Bombay (IIT), Powai, Mumbai.
- National Mission of Bamboo Applications (NMBA) DST, Gol.
- National Institute of Design (NID), Ahmedabad, India.
- University of Turin, Italy.
- University of Bombay, India.
- Shreeram Institute of Industrial Research, New Delhi, India.
- Agricultural University, Ratnagiri, Maharashtra, India.
- Dutch Design in Development, Netherlands.

KONBAC's Partners in Development

- District Rural Development Agency, (DRDA), GoM.
- National Agriculture Bank for Rural Development (NABARD).
- Maharashtra Industrial & Technical Consultancy Organization, (MITCON).
- Department of Forest, GoM.
- Department of Social Forestry, GoM.
- Konkan Agriculture University, Dapoli, Ratnagiri.
- Municipal Corporation Sawantwadi & Kankawali.
- OBC Corporation, u/t Govt. of Maharashtra.
- District Urban Development Agency, (DUDA).
- Janshikshan Sansthan, GoI.
- Joint Forest Managemant Committee Dist. Sindhudurg.
- Architecture & Development (A & D), Paris, France.
- Goa Handicrafts Rural and Small Scale Industries Development Corp (GHRSIDC) Govt. of Goa.
- Bamboo Development Agency, N.B.M – Govt. of Maharashtra.

Bamboo Based Livelihoods: The Maharashtra Model

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Part I. Why Bamboo

1. Introduction

The history of genus *Bambusa,* or bamboo, is not only rich, but also warrants a promising future for humanity. It has benefited human societies since times immemorial, and continues to be a tremendous asset to billions of people around the world. Bamboo is a fast-growing, widespread, renewable, versatile, low- or no-cost, environment-enhancing resource with the potential to improve life in the years to come, in both the rural and urban areas of the developed and developing world. As global population grows and resources stretch, bamboo holds the potential to benefit the poor, with its vast spectrum of utilization, ranging from providing shelter and piping, to agricultural tools and furniture. Furthermore, apart from its traditional usage, bamboo has various new applications as an alternative to rapidly depleting wood resources, and as an option to more expensive materials.

India has abundant bamboo resource, which amounts to almost 20% of the global bamboo resources. 1250 species of bamboo in 75 genera are available in the world. Next to China, India has the richest bamboo genetic resources in 136 species including eleven exotic species. According to the Forest Survey of India Report the total forest area under bamboo is 8.96 million ha, which is about 12.8% of total forest area. The estimated annual harvest of bamboo in India, which is being put to different uses, is about 13.47 million tonnes against the demand estimated at 26.69 million tonnes. There is a huge gap between the present and potential yield. Even the current supply is largely used for subsistence purpose in food, shelter, footbridges, fencings and industrials activities. Hence, the need for new bamboo plantation, which will be in the nature of 'Industrial Plantation' to raise special purpose/species needed by the industry of crafts as, may be identified. Appropriate selection of site, choice of species, protection and silviculture tending, sound management practices, proper harvest, post harvest treatments and usages are essential steps for value added products and can raise productivity substantially.

2. Indian bamboo: Economy and potential for rural development

According to United nation's Industrial Development Organization (UNIDO), the bamboo business in Indian region would be worth Rs.5, 000 crore in the next 10 years. National Mission on Bamboo Technology and Trade Development envisages expansion of the India's bamboo market to US $5.5 billion by 2015. This is an achievable objective as the bamboo economy is largely unorganized and therefore will respond quickly to systematic improvement as envisaged under the mission. These will create economy growth with stronger thrust on employment generation. The mission aims to implement an action program with the objective of placing bamboo as a key component in the National effort to generate employment and mitigate environmental degradation and strengthen the process of bamboo base industrial development including handicrafts.

WHY BAMBOO?

- **Bamboo is 17% stronger in tensile strength than steel.**
- **Bamboo is 27% stronger than red oak.**
- **Bamboo is 13% harder than hard maple.**
- **Bamboo is as good as (or better than) timber in strength, compression and flexion.**
- **Bamboo is resistant to moisture and coloration.**
- **Everything in wood can be produced from bamboo.**

WHY BAMBOO?

- **Contributes to subsistence and housing needs of over a billion people globally – traditionally a part of the rural economy.**
- **Managing and processing one ton bamboo produces 350 days employment for the poor; in a paper mill the equivalent is 12 workdays; replacing ¼ India's annual plywood requirement can save >8000 ha of forests & generate 66 m workdays employment.**
- **Net profit from well-managed bamboo plantation better than from sugarcane and rice.**
- **It is a strategic economic wood and fiber material.**
- **Only real natural alternative to wood – yet eco-friendly.**
- **Has close equation with women, the rural poor and other marginalized groups.**

According to Technology Information, Forecasting and Assessment Council (TIFAC), a Leader of the Government of India in bamboo technology and bamboo project implementation, there are nearly two thousand recorded uses of bamboo now as fuel, fodder, food, firewood, laminates, furniture, mates, construction material, chop stick, tooth pick, musical instruments, vinegar, beer, activated carbon, steel and cement.

The potential of bamboo as an economic resource capable of generating employment for the rural poor and the skilled and semi-skilled labor in plantation and others in various value addition activities has remained largely untapped due to lack of an appropriate policy and institutional framework, covering plantation with community involvement, technology upgradation, product and market development. In the bamboo Development Strategy envisaged under the Missiom, the growing and primary processing of bamboo will be a function of the community while all value addition and commercial activities such as processing, manufacturing and trading can be taken up by entrepreneurs in the private sectors.

2.1. Bamboo as building material

Wood has been used for centuries as a common material in construction of buildings and other structures. Similarly, bamboo has also a long and well established tradition for being used as a construction material throughout the tropical and sub-tropical regions of the world. With the rising global concern, bamboo is a critical resource as it is very efficient in sequestering carbon and helps in reduction of Green House gas emissions.

The Government of India has declared the goal of 'Housing for All by 2010' and it is required that at least 2 million houses are put up every year by the public sector agencies in addition to the ongoing housing construction in the private and informal sectors. Despite the Supply: Demand ratio of 1:3, funds to the tune of Rs.52, 000 crore were available from the formal sector for rural and urban housing during the IX Five Year Plan (1997-2002).

Bamboo can substitute not only wood, but also plastics, steel, cement & other materials in structural and product applications through improvements in processing technologies, product innovation with the application of scientific and engineering skills. The sector has vast potential for generating income and employment, especially in the rural areas. Towards promoting the usage of bamboo into value-added products, the National Mission on Bamboo Applications has been a major initiative by the Govt. of India under the X Five Year Plan.

The National Housing and Habitat Policy recognizes housing sector as a medium to generate more employment by strengthening production activities of environment friendly and cost-effective building materials. As the housing and building construction industry is one of the largest consumers for natural mineral resources and forests, it is increasingly realized that innovative building materials and construction technologies which offer potential for environmental protection, employment generation, economy in construction and energy conservation, need to be encouraged as best options to meet the rising demand of housing in different regions of the country. Nearly 60 percent of the country's area being prone to natural disasters like earthquakes, cyclones, floods etc. the Policy also lays emphasis on promoting design and construction of disaster resistant technologies for housing. Construction techniques using bamboo as main material have been found very suitable for earthquake resistant housing.

Building materials accounts for nearly 60 to 65% of the cost of house construction. With the constant rise in the cost of traditional building materials and with the poor affordability of large segments of our population the cost of an adequate house is increasingly going beyond the affordable limits of more than 30-35% of our population lying in the lower income segments. This calls for wide spread technology dissemination and availability at decentralized locations of cost-effective building materials and construction techniques.

3. Economising housing Sector using Bamboo structures: some considerations

With millions of poor and homeless people in the world and the presence of extensive bamboo resources in many regions, the need for low-cost bamboo houses is extensive. Such houses are an adequate and necessary solution for rural and urban dwellers in need for an affordable, efficient and fast shelter, and particularly in cases of natural disasters and other emergencies. The potential to increase the manufacturing of low-cost bamboo houses is enoromous in countries that have bamboo resources while their homeless live plastic or hardboard huts

Low-cost bamboo houses are a basic contribution to poor peoples' livelihood development. A safe home is an important starting point for a family for further socio-economic development through social organization, education and employment. The manufacturing and distribution of low-cost bamboo houses itself will provide employment to a range of people and there will be extra employment generation in its forward and backward linkages, such as cultivation and harvesting of bamboos, primary processing, transport, marketing and retailing. A unit producing 50 houses a day will require a total workforce of over 150 people. The need for a sustainable supply of raw materials will encourage the proper management of bamboo stands, and the establishment of new plantations, with their associated environmental benefits.

According to the research conducted by International Network for Bamboo and Rattan (INBAR) in various countries, low-cost bamboo-based houses are a cheap and safe alternative to the shelters of plastic, wood and stone that are currently used by many homeless people. They are produced from natural materials that are abundant in tropical and sub-tropical regions and are safe in adverse weather conditions and earthquake prone areas they can be produced in a range of standard sizes and can be adapted to different types of terrain the production costs of the bamboo houses make them available too resource poor people for less than Rs. 30,000.00 and a good and efficient option for governmental and non-governmental NGOs concerned with social housing programmes.

The low-cost houses of VHC are prefabricated in the form of bamboo panels made of wooden frames, flattened bamboo mats and bamboo laths. The bamboo panels, the wooden frame and the corrugated roofing parts are sold to the owner as a kit of parts and transported to their plot of land. With the help of friends and family the house can be assembled in a single day using simple hand tools and materials.

Part II. Bamboo And Sustainable Livelihoods

1. Bamboo and livelihoods

To assess impact of Non-timber Forest Produce such as bamboo and Rattan (cane) on various aspects of livelihoods, sustainable livelihood framework approach can be for understanding how bamboo and rattan as key NTFPs impact on various aspects of livelihood. The framework depicts livelihood as being determined by a range of resources that lend support to a household using this framework, livelihood can be defined at first instance according to several broad categories:

1.1. Human capital: The skills, knowledge, ability to work and good health that together enable people to pursue different livelihood strategies. Human capital acts both as a building block towards livelihood outcomes, or as an end in itself.

1.2. Social capital: The social resources upon which people draw as they pursue their livelihood objectives. These resources may include social networks, formal groups and other types of relationships. Social capital may not always be positive since it may also facilitate exclusion of non-members and also group membership may limit the mobility or rights of members.

1.3. Natural capital: The natural resource stocks useful for livelihood generation. These are particularly important for those who derive all or part of their livelihood from such resources (e.g., fishermen, farmers, gatherers), but they also have a wider importance. Natural capital may also include land, forests, woodlands and water sources (and the quality of each).

1.4. Physical capital: The basic infrastructure necessary to support livelihoods, and the producer goods (tools and equipment) used by people to function productively. This type of capital is likely to include transport, water supply, sanitation, energy and communication networks.

1.5. Financial capital: The financial resources people use to sustain their livelihoods, including stocks (savings, liquid assets, access to credit) and regular in-flows (including remittances, pensions or other government grants). This form of capital is probably the one most easily exchanged for other forms of capital.

1.6. External factors: External factors to the household can exert significant influence on livelihood, however. One category of external factors is processes and structures. These include the legal environment, culture and institutions that have an effect on how people utilize their assets and how they accumulate those assets. Another category of external factors is vulnerability. This refers to the ways external shocks and trends may affect assets levels and household resilience (in essence, the level of exposure to external factors of the categories of capital defined above). Models used to better understand systems of livelihoods are often based on the assumption that households build their livelihoods according to their assets and available opportunities. These assumptions argue that livelihood assets can be augmented through locally available resources and that households within the same locality have diverse levels of assets that can be better utilized if only the households could see the potential.

Bamboo is a unique natural resource. It is fast-growing and yields annually. Bamboo is a versatile material and has the advantage of creating large-scale employment by nature, bamboo processing activities are labour-intensive. Bamboo lends itself easily to processing. It can be easily spilt and slivered with hand tools unlike wood. Processing silvers in to incense sticks, mats, craft products etc is relatively simple. Bamboo has the ability to replace wood and it is proven that it can enter the market of a range of wood products ranging from furniture, flooring, and housing to infrastructure application. Further, bamboo is food, paper and medicine.

Bamboo has a strong relationship with rural communities, allowing them to participate in a larger proportion of value addition compared with other industrial processes. Requiring intensive management, it needs many more hands to contribute to cultivation, harvesting, preservation and value addition. Thus, it provides livelihood options in various areas to a larger number of rural workers. Benefits of bamboo can be capitalized upon to promote poverty alleviation, create employment, increase income and protect the environment.

The handicrafts sector, which provides employment to 23 million, stands as the second largest source of employment after agriculture in India, which is bamboo-based. Many of the crafts reflect the mystic relationship of bamboo, people and culture. Ingenious skills revolve around silvering, weaving, stitching, splitting, layering, inserting, winding, stringing and pinning and create products for a thousand applications. Rural communities employ bamboo extensively for their day-to-day uses like fencing, energy, housing and household utilitarian and agricultural implements.

2. Bamboo in Konkan

The traditional bamboo working communities of Konkan belong to scheduled castes, and they largely produce utilitarian products to cater to the local market. However, wide use of plastic material, which is cheaper, has reduced the use of bamboo products thereby decreasing demand for bamboo-based products. As a result, bamboo workers are forced to take up new occupations alongside their traditional occupation. An unfortunate impact of the above can be seen among the young generations of these communities, who are not interested in traditional art and are looking for petty jobs, which could eventually lead loss of indigenous knowledge and skills.

Because of the vital role that bamboo could play in providing a viable livelihood option to those bamboo working communities, there was a necessity to initiate a people-centred programme in Konkan region. This initiative is aimed at uplifting the livelihoods of traditional bamboo crafts communities while training new craftsperson and identifying crafts clusters for promoting value-added bamboo products.

Bamboo is one of the most abundant and environment-friendly and sustainable resources available in the Konkan region, which is not being used to its full potential. The agro-climatic conditions of he Konkan area, especially the districts of Sindhudurg and Ratnagiri, are ideally suited for bamboo. The main species of bamboo found here are:

- *Oxytenanthera stocksit;*
- *Pseudoxytenanthera monostigma;*
- *Bambusa bambus; and*
- *Dendrocalamus strictus*.

At present, the bamboo resources available in the Konkan area are harvested and used for low-value applications while there are sufficient bamboo resources available and suitable varieties for handicrafts, furniture and also for other industrial applications. Value addition of bamboo products therefore could create large-scale employment and income generation for the community.

Bamboo is one of the means by which SME, large-scale enterprises and the community can be integrated profitably. In addition, there would be large-scale rural employment in the management of bamboo forests and in bamboo harvesting, collection, transport, storage, etc.

The basic bamboo processing skills are already available in the region due to the prevalence of a traditional bamboo working community. However, there is a need to expand and consolidate the bamboo sector in Konkan by forward and backward linkages, and the development of support facilities – such as vocational programmes, technical facilities and marketing support – which will help in furthering employment and income generation. The bamboo sector also needs to undergo restructuring through technology upgrading and modernization to improve productivity, quality, cost-effectiveness and consumer satisfaction fpr competing on the marketplace.

The government of Maharashtra encourages and supports the cottage and tiny industrial sector, which employs a large number of persons with low capital investment, and contributes significantly to the state's industrial produce, and also promotes industrialization in a manner that ensures large-scale employment generation and environmental protection.

The development of bamboo-based craft and industry requires relatively low capital, raw material, tools and machinery investments in comparison with other handicrafts activities. Because of this, it would be possible to address all related issues – economic, cultural, social and ecological – in bamboo development through sustainable approaches.

With proper design inputs, a adequate training, appropriate production methods and a facilitating environment, bamboo sector development could be attempted at the community level. This would facilitate the community to venture into non-traditional but value-added activities that provide alternative employment opportunities. Currently, most of the artisans remain at the traditional skill levels and are unable to produce according to the market demands or are not linked to appropriate markets

Part III. Bamboo Based Development

1. The Sindhudurg Model

The wood-based handicraft items of Konkan region, particularly the Sindhudurg District of Maharashtra are well appreciated all over and have earned a special recognition for the super craftsmanship of the artisans. The skills of the artisans are basically traditional and have enough scope for its development. But lack of proper guidance and assistance the total sector is now on the way to lose its credential. On the contrary, the handicrafts sector is also playing major role in State Revenue Collection but appropriate action towards promotion of this sector has not been considered on priority basis. The sector has enough scope to generate sufficient employment opportunities, not only in the area of wood based but also in case of bamboo-based crafts.

The poverty does not allow the family members of the poor artisan to go for education as well as to continue the trade. Some of the poor, who are lucky to be able to complete their primary/secondary education, also look for alternative source of livelihoods, the reason being lack of suitable crunch of working capital.

It is in this context, that the handicrafts sector of Konkan requires a special attention towards its Promotion and Development. Konkan Bamboo and Cane Development Centre (KONBAC) along with the University Department of Life Sciences (UDLSc), University of Mumbai, has initiated community based bamboo development programme. KONBAC has been closely working with rural communities on poverty alleviation and environmental rehabilitation and protection by (a) community based development of bamboo forests,

(b) developing bamboo-based industry for poor communities by encouraging farmers' participation via adopting the PRA approaches.

In view of the lack of bamboo technical personnel in region, it was necessary to invite experienced bamboo experts to provide training on the technology of bamboo plantation, management and utilization. Expertise of UDLSc in the area of bamboo development, as also from other institutions such as Indian Institute of Technology (IIT - Bombay), Mumbai, National Institute of Design (NID), Ahmedabad and International Network of Bamboo and Rattan (INBAR), China, in accordance with the practical needs of the Project, provided the much needed short-term and regular consultations to the Project, and helped develop the community based bamboo development strategy and guidance for the bamboo Program in the region. Some of the comprehensively demonstrated work in the project is highlighted below:

2. Demonstrated work of the Project

2.1. Establishment and demonstration of one community-based bamboo treatment plant: In the procedure of evaluating product need, marketing issue, the technical assistant plan and implementation, the PRA approaches were used for determining the selection of the acceptable products, machines and technologies for the establishment of a 'Demonstration Factory' in Kudal Tehsil of Sindhudurg District. This led to commissioning of a Pressurised Treatment Plant.

With the help of financial assistance from the National Mission for Bamboo Application (NMBA) of the Department of Science and Technology Government of India, a Pressurised Treatment Plant (PTP) was set up at Kudal (see **Photo 01**). Approximately 20 feet long and 350 numbers of local bamboos (particularly Oxitenanthera stocksii) can be treated at a time. Each cycle runs for about 5 hrs. the CCB (Copper-Chrome-Boric) Chemical Used in treatment of bamboo in which Copper Sulphate ($CuSO_4$) protects interior part (Tissue structure) and Boric Acid protects the surface layer. Sodium Dichromate acts as fixative agent for both. Due to the establishment of the PTP, a reliable preservation treatment for bamboo is available for the first time in Konkan, at low cost.

2.2. Bamboo Furniture Manufacturing Unit: Further to the establishment of PTP, a Bamboo Furniture Manufacturing Unit (BAFMU, see **Photo 02**) was set by

KONBAC at Kudal MIDC (Maharastra State Industrial Development Corporation). Expert Artisans from Tripura were invited to provide "Hands-on training" to the local "Burud" community (a tribe known traditionally for its expertise in bamboo craft-making) in addition to local bamboo artisans.

The "Bamboo Tool-kit" developed by the Industrial Design Centre of IIT-Bombay including the treated material of bamboo is supplied to the trained artisans to make components of furniture in their respective villages/homes. Emphasis is also placed to provide training to women, who constitute 75 per cent of the trainees. Final assembling and finishing is carried out at the BAFMU. The product is then marketed at both, local level as well as within the surrounding Tehsils. Some of the recently developed products are also in much demand by the hotel industry mainly from Goa, which is one of the Hotspot tourist destinations in the Country.

2.3. Establishment of Bamboo-based Marketing Hubs (BAMHU) involving SHGs of Women: looking at the progress that the Project has made in Kudal, the DRDA (District Rural Development Agency DRDA) of Maharashtra Govt. has encouraged KONBAC build a retail outlet shop along the Mumbai Goa National Highway. The stall is run by 'Women Self Help Groups' belonging to 'Below Poverty Line' families to sell local produces **(Photo 2)**.

The eco-friendly Highway Stalls or the bamboo-based Marketing hubs (BAMHU, as seen from **Photo 03**) are implementing by KONBAC (Konkan Bamboo and Cane Development Centre) using treated bamboo. NMBA (National Mission for Bamboo Application) of Department of Science and Technology, Govt. of India has appreciated this design and agreed to provide 50% subsidy for the construction of 5 stalls in Sindhudurg district.

2.3.1. Technical description of BAMHU

- Treated Bamboo structure (treated in pressurized treatment plant treated with CCB) with retention level of 10 kg per cubic metre.
- Ground contact (bamboo which are embedded) treated with hot and cold creosote (mixture of coal tar and diesel, which makes bamboo water resistant, and doesn't shrink) treatment.
- Bamboo mat board used in the Stall is Phenol bonded
- Weaving of bamboos is done (which are also treated) and used to provide finish.
- The roof of Highway Stalls is made up of Saturated Bituminous Fibre imported from Germany
- Size: Floor area: 100 sq feet
- Time of commissioning: 8 days

2.4. Reaching larger masses: Passenger Resting Shade at Ratnagiri Railway Station:

Taking encouragement from the above experiments, KONBAC ventured in to reaching larger masses by promoting construction of a Passenger Resting Shade (PRS) for the Konkan Railway Corporation. A shade (see Photo 04) of 300 sq ft. was commissioned at Ratnagiri railway Station (Platform). Since Ratnagiri being a prominent railway station the structure received wide publicity and appreciation from the Konkan Railway authorities.

2.4.1. Technical description:

- Area is 300 sq feet.
- Treated Bamboo Structure (treated in pressurized treatment plant treated with CCB) with retention level of 10 kg per cubic metre.
- Ground contact (bamboo which are embedded) treated with hot and cold creosote (mixture of coal tar and diesel, which makes bamboo water resistant, and doesn't shrink) treatment.
- The wall is made up of overlapping Bamboo splits (used after treatment).
- Weaving of bamboos is done (which are also treated) and used to provide finish.
- Size: 300 sq feet.
- Time of commissioning: 45 days

2.5. Catering needs of Tourists: the first ever All-bamboo Resort at Tarkarli, Sindhudurg District

Based on the field level execution of various bamboo-based structures and the positive responses from various strata of Society, the Maharashtra Tourism Development Corporation of Government of Maharashtra assigned KONBAC in 2006, the responsibility of construction of an All-bamboo Resort in the coastal village of Tarkarli in Sindhudurg District (the first Tourism District declared by ITDC, Govt. of India). This is the first ever bamboo-based resort being developed by the Government anywhere in the Country.

2.5.1. Technical description:

- Area is 2200 sq feet
- Foundation (RCC) 4 feet deep (below ground level)
- Treated Bamboo structure (treated in pressurized treatment plant treated with CCB) with retention level of 10 kg per cubic metre.

- Ground contact (bamboo which are embedded) treated with hot and cold creosote (mixture of coal tar and diesel, which makes bamboo water resistant, and doesn't shrink) treatment
- The wall is made up of overlapping Bamboo splits (used after treatment).
- Weaving of bamboos is done (which are also treated) and used to provide finish
- Size: 2200 sq feet (CARPET)
- Time of commissioning: 90 days

3. Challenges to Bamboo-based entrepreneurship

Despite bamboo's economic potential, its ecological benefits, and its relevance for poverty alleviation, the resource base has been under-managed and is commonly overexploited, especially in Asia. This results in the harvesting of mediocre material, inadequate efforts to regenerate depleted areas, and the generally unsustainable management of natural stands. A first step to correct this situation would be to undertake an inventory of the extent and distribution of existing bamboo resources (at the national, regional and global level) to allow for sound planning in bamboo dependent industries. A second challenge to the realization of bamboo's socioeconomic potential is the developmental imbalance that exists in the industrial use of this resource. The fast-growing bamboo trade in both domestic and export markets, creates heavy competition among bamboo producing countries.

Bamboo is not a staple commodity like rice or sugar, nor does it have a guaranteed market like electricity. This means that changes in market demand can greatly affect processors and suppliers, and cause undue pressure on natural resources, resulting in unsustainable harvesting. This is one of reasons for the degradation of the bamboo resource. Both higher and lower prices for bamboo products may lead to increased harvesting in the short term with subsequent depletion of the resource in the future. Higher prices increase harvesting because people want to capitalise on the increased prices but is tempered by the quality that the market demands, and lower prices increase harvesting because people need to make up for loss of income. Effective steps for developing local manufacturing are therefore important for encouraging local demand and increasing prices for raw materials and helping stabilise the demand for them. Emphasis on supply-driven solutions such as establishing plantations would not have any effect until this is addressed.

While some nations (and provinces) have achieved remarkable results, other resource-rich countries are lagging behind in bamboo development. In addition, standards and quality control need to be developed, while certain technologies require major refinements; such as, improved processing techniques with an emphasis on creating greater durability and a better finish. There is an urgent need to modernize both the design of bamboo products and their use. Where bamboo was once favoured, plastics and metals are often being substituted because they are uniform, cheap, durable and readily available. The challenge is to analyze customer needs and to identify commercial opportunities (i.e. market segments, end users, product types such as 'ply-boo'). At the national level, there is clear need for coordination and organization among the various sub-sectors, so that action plans can be created for development of the bamboo industry: in other words, bamboo must be put on the development agenda.

Yet another major challenge is the need for public education campaigns, as well as training at different levels, to correct the popular perception of bamboo as an antiquated material, unable to compete with more 'modern' alternatives. With new technical inputs and innovative marketing, renewed interest can be generated; bamboo's image can be changed from that of the 'poor-man's timber' into achieving its appropriate status as a material of the future.

4. Conclusion

The bamboo is an important resource in the Indian socio-economic-cultural-ecological-climatic-functional context with 1500 recorded uses. It is a fast growing, wide spread, renewable, versatile, low-or-no cost, environment- enhancing resource with potential to improve livelihood security in the years to come, in both rural and urban areas. Apart from its traditional uses bamboo has various new applications as an alternative to rapidly depleting wood resources and as an option to more expensive materials.

Recognizing the potential of bamboo and the fact that it has been subjected to neglect, and thus remain disorganised with poor market linkage and sub optimal level technology application for manufacture of value added products in the industrial and artisanal sector, the National Mission on Bamboo Technology & Trade Development has formulated an Action Plan to upgrade the bamboo economy by according bamboo development a strategic role in rural development, poverty alleviation and bamboo based handicrafts and industrial development.

As the market for environment friendly "green" products is growing, India must try to secure her due share in the world bamboo market which is expected to grow from the present size of US$10 Billion to over US$20 Billion by 2015, if we could expand the bamboo economy steadily to the level of Rs. 26,000 crore by the 2015, from the level of about Rs. 2,000 crore, as envisioned by the Building Materials and Technology Promotion Council (BMTPC), Govt. of India.

Mautam-Melocanna baccifera flowering-Ecological characteristics and influence to the juhm agriculture

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Abstract

Melocanna baccifera is one of the most important resources in India and naturally distributes through the limited area including North-east India. The flowering of this species has been recorded on every 48 years at least since these 200 years. According to these records we could predict its next flowering from 2004 to 2007. In the field of bamboo ecology to trace all process of flowering from the pre-flowering stage to post-flowering stage perfectly had not been realized because of the uncertainty to predict the flowering timing. In this mean the predicted flowering of *M. baccifera* was very rare chance in a million. Just as we expected *M. baccifera* started to flower from small scale in 2003 on some places like in Manipur to gregarious flowering in many places in Mizoram and so on in 2006 and 2007. Even in Mizoram, flowering year was separated to three years may be according to the regions, namely eastern part in 2005-06, central part in 2006-07 and western part in 2007-08. We could also understand the particular ecological and biological characteristics of *M. baccifera* flowering. This flowering is making severe influence to the local and traditional agricultural system (juhm). *M. baccifera*vegetation is dominating by juhm because of high capacity of regeneration after burning. Addition to this many local farmers regards that

bamboo-dominated vegetation is suitable for high-production yield for juhm. At present the situation of *M. baccifera* – dominate area the recovery of its vegetation by seedling is starting. The influence of bamboo flowering to the juhm agriculture will be estimated hereafter.

Introduction

For the bamboo researchers in the world bamboo flowering is a very inviting event. Because many species aren't known their flowering periods it is very difficult to forecast the flowering time. Jantzen (1976) collected many bamboo flowering records and inspected them. Although this paper can't distinguish the gregarious flowering and sporadic flowering collected records are very useful. On the other hands, in Japan, some researchers started very long-term research project from 1890's, which is to collect bamboo seedlings derived from sporadic flowering and to wait the next flowering. By this kind of research flowering cycle of 67 years of *phyllostachys pubescens* was recorded twice in 1979 and 1997 (Watanabe et al. 1982, Shibata 2002).

As we understand through these records to wait for the bamboo flowering in advance is difficult. But we knew that *Melocanna baccifera* was recorded its 48-years flowering cycle at least four times in past. This means it is possible to trace all the process of flowering. As the result we couldf start a minute survey of bamboo forest from one year before flowering and observe all the process of flowering from formation of flower bud to fruiting.

The distribution area of *M. baccifera* in north-east India is an active area of slush-and-burn agriculture called 'Juhm'. By juhm the bamboo forest vegetation becomes dominant vegetation in this area. Bamboo is regarded as excellent vegetation for juhm production. The influence of bamboo flowering in this area to the juhm production is also important concern.

Here we report the *M. baccifera* flowering process ecologically and its adaptation to the juhm agriculture.

What is Melocanna baccifera?

M. baccifera is very unique bamboo in the world because of a particular subterranean style pf pachymorph with mixture of short-necked type and long-necked type (Fig. 1). Long culm neck is thought to have the possibility of evolution to leptomorph bamboo species mainly dominant in temperate Asia.

Concerning to the flowering period *M. baccifera* has marvel records. Jantzen (1976) collected flowering records of this species, in which there are many flowering records in 1863-1866, 1892-1893, 1900-1902, 1960 even only in Mizoram. In these records it is presumed that gregarious flowering and sporadic flowering are mixed, so this species is estimated some flowering periods like 30 years, 35 years, 45 years and so on. However when we tried to estimate the gregarious flowering through the flowering records in north east India in broad area, *M. baccifera* seems to flower gregariously every 48 years in 1860-1863, 1908-1911 and 1956-1959. Through this estimation it was believed that the next gregarious *M. baccifera* flowering will occur in 2004-2007.

In addition by the interview to the farmers in Mizoram it was estimated that most gregarious flowering will be found from thre end of 2006to the spring of 2007. This estimation makes possible to trace all the flowering process of bamboo flowering from the condition of bamboo forest before flowering to recovery of vegetation by seedlings including the process of formation of flower bud, pollination, fruiting and seed dispersal. For example many bamboo flowering records say the number of new culms extremely decreases one year before flowering but we don't have ecological data concretely. This chance expect that this kind of ecological data would be observed.

Through the preliminary survey and interview flowering phenology of *M. baccifera* in Mizoram was grasped like followings:

1. Formation of flower bud: August to November
2. Elongation of inflorescence: October to December
3. Flowering (Fig. 2): November to February
4. Fruiting (Fig. 3): January to May
5. Drop of fruit and germination: after May (by the start of rain season)

According to this information, research project was planned.

Research site and method

Research was carried out in Mizoram, north east India (Fig. 4) where is the area one of the highest density of *M. baccifera* can be seen in its distribution area. To understand the ecological characteristics of *M. baccifera* flowering one survey quadrat (16mx 20m in 2005 and 20mx 20m in 2006) was made in Sairang village. Research site has been kept in natural condition at least for more than 15 years. Research quadrat was made in 2005 and the location, diameter at breast height, age and the condition of bud of all culms were recorded. In the autumn of 2005 some leaves from all culms were sampled and DNA analysis was done to make clone map of research site. Same research was continued also in 2006. In the autumn of 2006 after the start of gregarious flowering the change of all culms was traced every two weeks till the spring of 2007. Addition to these researchers, four culms were cut in the neighboring bamboo forest in every two weeks to check the process of inflorescence formation.

Another research sites to understand the behavior of *M. baccifera* in juhm (slush-and-burn agriculture) area were made in Mamit area. In 2005 and 2006 we made vegetation survey in some juhm site, which has different fallow years; 1 year, 3 years, 7 years and 8 years.

Addition to these two main research sites we went around the Mizoram every visiting tie to grasp the broad scale information of flowering.

Result

Broad area survey in Mizoram

Through the broad area survey it was cleared that in Mizoram there were at least three flowering genealogy. In the eastern part the gregarious flowering occurred from the end of 2005 to the spring of 2006, in central part where bamboo flowering was observed in broadcast area from 2006 to 2007 and in western part from 2007 to 2008. As Sairan and Mamit are included in central part we could encounter to flowering as we expected.

Ecological research

Through the survey in Sairang we got many important ecological information and many of them are through to be the first knowledge concerning to the bamboo flowering in the world.

Before flowering

We stared the ecological research from one year before the expected flowering. Through this one year the change of new culm number was dynamic. In 2005 the culm number of more than 3years old, 3 years old, 2 years old, 1 year old and current year per hectare was 11100, 2850, 5660, 4500 and 4310, respectively. Culm density was estimated about 30000 per hectare. In this tear the diameter of current culms appeared evenly in every diameter size (from 5mm to 45mm) (Fig. 5a). In 2006 the number of new culms including culms without leaves decreased to 3000 per hectare and all of them were very thin (<15mm) (Fig. 5b). From these results it is said the new culm occurred in flowering year was small.

Flowering process

Formation of flower buds mainly started on June, 2006 and most of the buds appeared before October. Following to the bud formation, the elongation of inflorescence started gradually from September, 2006 to January, 2007. Main flowering period was November, 2006 to February, 2007 (Fig. 6). By the observation it was identified that there were three types of inflorescence. They were found on different part of culm that is at the top of branches, from the middle of branches and from culm nodes directly. Each inflorescence type have characteristic role, namely the inflorescence on the top of branches mainly keeps male function and there is difficult to find the mature pistil and ovary. On the other hand the inflorescence directly from culm appeared slowly but there were many female flowers with ovary.

Existence of flowering culms in 2005 and 2007

In Sairang we found flowering culms even in 2005 at first. The percentage of these culms was low but they produced fruits and in 2006 some seedlings were observed. Although the light condition is not enough for the growth of seedlings many seedlings were growing in the autumn of 2006. After the gregarious flowering in 2006, there were about 100 non-flowering culms (2500/ha) in the quadrat. They flowered in 2007-2008 and produced fruits. The survival of the seedling should be traced this year. Through these results it was considered that flowering behavior continues at least three years even in small scale.

Response of *M. baccifera* to the juhm agriculture and its influence

M. baccifera expands its dominant area by the juhm agriculture because of its subterranean system which doesn't die out by burning. This bamboo has been expanding its vegetation with human behavior of juhm. And farmers also understand that bamboo vegetation has brings high productivity. Usually bamboo vegetation gives farmers high productivity but they need to wait at least more than 7 years for next juhm. By this rotation farmers gain rich production mainly by silica supplied from bamboo ash. Through the research it was shown that *M. baccifera* recovers about three years later after the *Miscanthus*-dominant stage. The bamboo biomass recovered seven years later to the similar level to Sairang bamboo forest (fig. 7).

These results give us the presumption that juhm culture on bamboo flowering year brings severe low productivity. But the true influence is not clear at present. Synchronizing to the bamboo flowering it is also estimated the catastrophic increase of rodent population. This is also another concern.

Discussion

As known *M. baccifera* produces very big fruits but the number of fruits on each culm is very small. To produce such a big fruits *M. baccifera* is thought to get very unique regeneration system. Through the research three types of inflorescence were observed and each type seems to differentiate its reproductive function. The inflorescence on the branch top produce the male function and that from the lower part of culm directly have heterosexual flowers. *M. baccifera* is concluded as the hermaphrodite plant. Addition to this flower of *M. baccifera* is regarded ashomothallism. It means that pollination on the same inflorescence occurs easily and a lot of fruits will be derived to self pollination.

It is also important to accept the fact that a part of them flowered one year before the gregarious flowering and another part of them one year after the gregarious flowering. We already understand that this species flowered in different years in broad scale in Mizoram. This let us imagine that *M. baccifera* staggers the flowering timing on various scales to avoid the species extinction risk only one flowering in its evolution.

In juhm area burning influences severely to the bamboo regeneration. Especially the burning one year before flowering is thought to make the formation of flower buds slow and to give severe damage to reproduction o9f bamboo because of the insufficient recovery before flowering time. If farmers hope to continue high crop productivity from bamboo vegetation, they need to consider the juhm culture on the year before bamboo flowering.

Fig. 1. Pachmorph rhizome pattern of M. baccifera

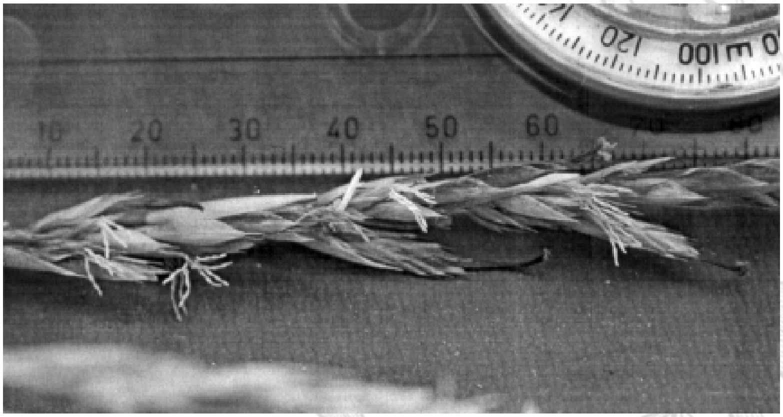

Fig. 2. Inflorescence of M. baccifera

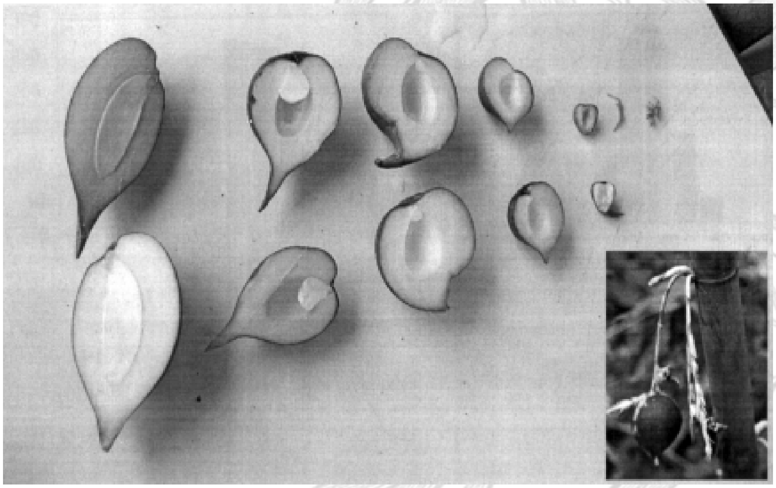

Fig. 3. Fruits of M. baccifera Maturing from right to left

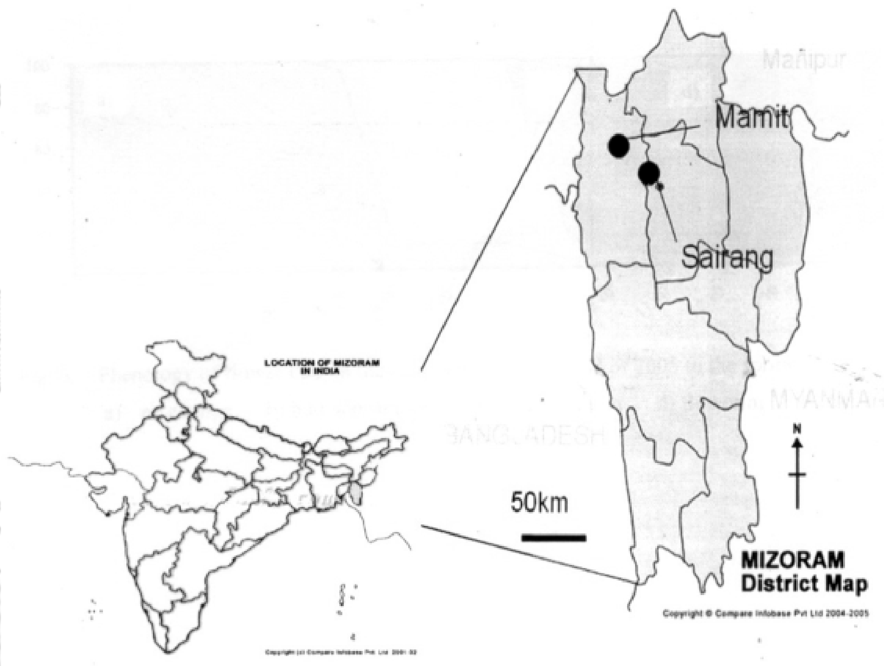

Fig. 4. Research sites

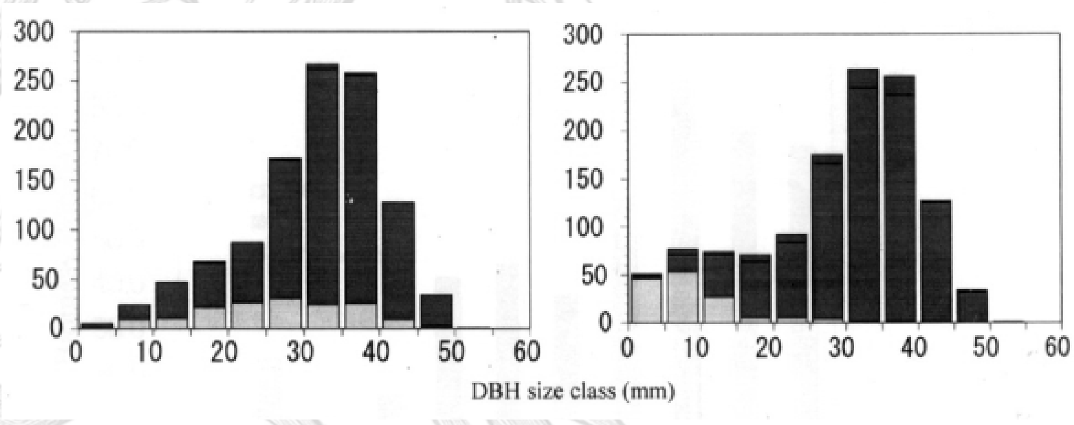

Fig.5. Distribution of culm diameter of Sirang bamboo forest
Left: 2005 right: 2006
White: current year culms light grey: other culms dark grey: dead culm

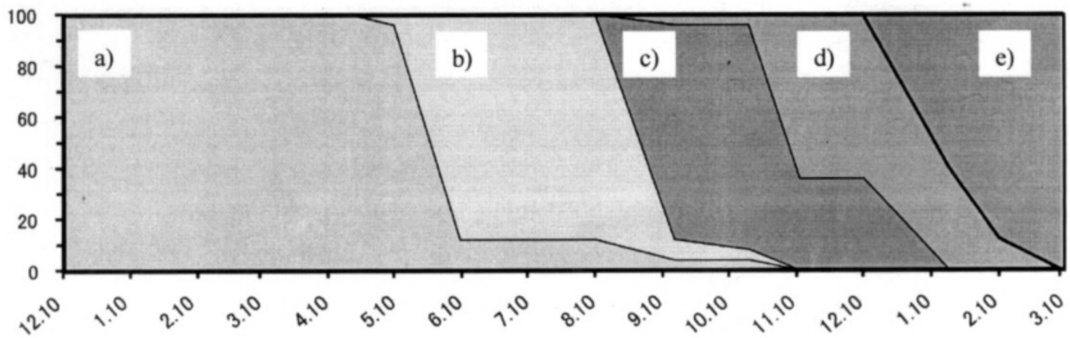

Fig.6. Phenology of flower bud on the culm node from the end of 2005 to the spring of 2007
a) no change b) bud appearance c) bud elongation d) flowering e) fruiting

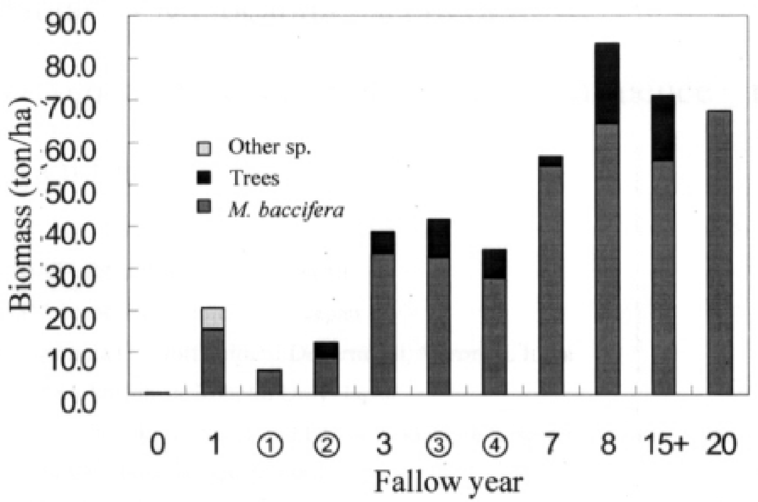

Fig.7. Vegetation biomass change in juhm farmland in Mamit according to the fallow year

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Bamboo Cultivation in Homegardens of Kerala, India

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Introduction

Bamboo is considered as one of the oldest building materials used in different parts of India. By virtue of its availability and versatility, it is closed associated with the life of people of India since time immemorial. Available literature indicates the fact that during the first century to third century AD, villagers were collecting bamboo from the wild along with many other non-timber forest products (Sastri and Srinivasachari, 1970). However, cultivation of bamboo became common by the sixth century AD. For example, Khana (505 to 587 AD) indicated to the farmers that better crops might be obtained from bamboo, amorphophallus and coconut if the soils were enriched with paddy husk, ash and salt respectively (Raychaudhuri, 1941). Misra Chakrapani, in his book entitled Vishva Vallabha, written in the sixth century AD, classified lands into three categories namely, dry, moderately dry and wet types. According to him, bamboo can be cultivated in dry lands while in Vrikshayurveda (a traditional book on trees and perennial crop cultivation), possibilities of bamboo cultivation in wet soil are discussed (Gangopadhyaya, 1932). In this paper, bamboo cultivation in agro forestry system with special reference to homegardens of Kerala in the light of ecological, social and economic context is discussed.

Homegarden Agroforestry System

A homegarden represents an operational farm unit which integrates trees with field crops and sometime domestic animals, around the homestead. This farming system has attained international popularity due to the fact that the basic objective of the system is ensuring the sustained availability of multiple products besides generating employment and cash income. Homegardens exemplify many agroforestry characteristics like the intimate mix of diversified agriculture crops and multipurpose trees. They fulfill most of the basic needs of the social populations. The multi-storeyed configuration and high species diversity of the home gardens help to reduce the environmental deterioration commonly associated with monoculture production systems. Multi-tired and multi-species structure is essentially the major feature identified for home gardens' socio-economic adaptability and stability, biological balance and resilience, and sustained productivity at a low-level equilibrium (Peyre et al., 2006). Homegardens are often comparable, in terms of species diversity, with wet evergreen and semi-evergreen forests. They also represent a 'genetic back stop', preserving species and varieties that are not economic in field production and are planted in small scale for the reasons of taste, preference, tradition or availability of planting material. The average size of a home garden, in several tropical and subtropical regions, is much less than a hectare.

The tropical homegardens constitute a principal source of natural resources such as timber, bio-fuels and bamboo. Occurrence of bamboo as one of the plant components in homegerdens is documented in Kerala (Krisnankutty, 1998), Bangladesh (Khaleque, 1987), Ethiopia (Zemede and Ayele, 1995), Java (Kappelle and Jurej, 1995) and Tanzania (Ruglema et al., 1994). According to Randhawa (1983), homestead bamboo cultivation in India existed even during the sixth century AD. Based on the survey of ancient Indian literature related to agriculture, he pointed out that in Assam, during this period, the houses were usually concealed in dense groves of bamboo, plantain and jack-fruit trees. Similarly, the villagers of Bengal lived, more or less in secluded homesteads, surrounded by a belt of fruit trees or bamboo thickets. During this period, villages of Orissa were characterized by the linear cluster of houses with clums of jack trees, mangoes, bananas, bamboos and plantains. Detailed information on contribution of bamboo to the total crop species diversity in homegardens of north-eastern States of India such as Meghalaya and Arunachal Pradesh (Gangawar and Ramakrishnan, 1989: Singh, 1993) is also available.

Bamboo species in Kerala homesteads

In Kerala homesteads, Bambusa bambos (Bambusa Arundinacea), Bambusa vulgaris and Dendrocalamus strictus are the most common species. However, cultivation of Bambusa bambos is more common, particularly in the low rain, dry agro climatic zone of the Sate, due to the fact that farmers need thorny branches for fencing their homesteads and agricultural lands. It is also found that only Bambusa bambos from homesteads is traded in the wholesale depots.

Generally, in a homegarden, distinct horizontal zones can be recognized. Size, location and plant species composition of these zones may be different. Some crop species may be scattered throughout the homesteads or seen in different management zones of homesteads. However, in Kerala homesteads, bamboos are planted on farm boundaries regardless of landholding size. Cultivation of bamboo in corners of homegarden is a strategy to minimize competition between bamboo and other crops and to facilitate freedom of movement for farmers within the garden.

Number of bamboo clumps in the homesteads depends primarily on the size of the homesteads. For instance, in small homegardens (<0.4 ha) one bamboo clump is more common whereas in medium (0.41 to 1.2 ha) and large (>1.2 ha) homegardens, mean number of bamboo clumps is 2 and 6 respectively. However, number of clumps in the homegerdens is also decided by the farmers' crop preference (Chandrashekara et al., 1997), with less number of clumps in homesteads dominated by commercial crops than in mixed species homesteads.

Management of homegarden bamboos

Compare to several other crop species in homegardens, bamboo is getting generally a less importance by the farmers in terms of its management. However, a few farmers dig trench which is about 1 to 1.5 meter deep and about 0.75 meter wide around the clump in order to restrict horizontal spread of bamboo roots, thereby reducing competition with other crops. Soil from the trench along with ash, paddy husk and partially decomposed leaf litter, spread around the clump improve soil fertility and culm production. In order to reduce shading of other crops, detopping of new culms is another traditional practice observed in homegardens of Kerala (Chandrashekara et al., 1996). The culm tip removal also leads to the production of lengthy branches from remaining part of the culm (Chandrashekara et al., 1997). Therefore, by cutting culm tip farmers also get more branches which they require for fencing needs.

One of the myths which has become accepted as fact is that 'nothing can be grown near bamboo'. Intercropping with shade tolerant and short duration crops such as ginger (Zingiber officinale), turmeric (Curcuma longa) and mango ginger (Curcuma amada) has been noticed in some homegardens (Chandrashekara, 1996). A study was conducted to understand the scientific validity of this traditional practice of intercropping of bamboo and rhizomatous short duration crops. The study also revealed the fact that there is less impact of bamboo on yield of intercrops as the crops can be harvested prior to bamboo cutting season so avoiding the risks of damage caused in this process. Crops like ginger, turmeric, mango ginger etc. are also suitable for cultivation on raised beds, so reducing root competition with bamboo (Chandrashekara et al., 1997).

Benefit-cost ratio analysis of bamboo in homegarden system

Compared to mo0st of the seasonal, annual and cash crops, a bamboo crop does not require intensive labour inputs. Thus, a financial cost-benefit analysis of bamboo crop in relation to other crops in mixed cropping homegardens assumes special significance. Krishnankutty (1998) estimated the benefit-cost ratios for different components within a mixed cropping homegardens with bamboo in tow villages namely, Peringandur and kuthannur, which represent the villages in the central and low rainfall dry agroclimatic zones of Kerala, respectively. The average annual cost of different crop components in homegardens of Peringandur village and that of Kuthannur village was estimated as Rs. 5,500 and Rs. 2,000 respectively. In both villages, the average annual cost of the bamboo components was found to be negligible (Rs. 0.83 to 0.86/ha/year). The average annual benefit from all crops per hectare in Peringandur village was around Rs. 30,000 while that in Kuthannur village it was around Rs. 20,000. The return from bamboo (Rs. 4,430/ha/year in Peringandur and Rs. 3,430/ha/year in Kuthannur village) was almost equal to that from seasonal-annual crop component for which a high annual cost was incurred compared to bamboo. Moreover although the annual cost incurred for bamboo component was negligible, the potential benefit, which is the mean annual value of the growing stock, was found to be substantial. The estimated benefit-cost ratio for different crops at various rates of land rents (6, 12 and 18% of land value as land rent) was estimated in both the villages. At all rates of land rent, bamboo has the highest benefit-cost ratio (Peringandur: 8.89, 4.44 and 2.96, respectively at 6, 12 and 18% land rent; Kuthannur: 6.49, 3.25 and 2.16, respectively at 6, 12 and 18% land rent) followed by perennial cash crops, seasonal and annual crops and trees components. Comparatively higher benefit-cost ratio for bamboo in Peringandur village located in the central agroclimatic zone has been attributed to the fact that bamboos in this village have better growth and larger size than that in Kuthannur, a village in the low rainfall dry agroclimatic zone. Apart from agroclimatic differences, intensive cultivation of perennial cash crops with inorganic fertilizes and irrigation in Peringandur village has its effects on bamboo, which is grown in the homestead margins.

Additional benefits of homegarden bamboo

As already indicated, bamboo branches are an essential fencing material in homesteads of some parts of Kerala. In areas where large landholdings are available, farmers prefer thorny bamboo (*Bambusa bambos).* Bamboo branches are generally cut during the months of December-January when they are about 4-5 months old. A study was conducted to analyze the qualitative and anatomical features of bamboo branches of different ages

(Chandrashekara et al., 1997). Month-wise comparison of cell wall thickness from September to June showed a steep increase from 4.92 mμ during October to 8.58 mμ from during January, with no clear trend in subsequent months. This steep increase in cell wall thickness in samples collected in the month of January may be an indication of bamboo branch maturity. During this month, even the moisture content in bamboo branches was between 33 and 37 per cent as against 40 and 68 per cent in the previous months. The month of January, being off-season of paddy cultivation for both farmers and labourers, is ideal for the farmers to cut bamboo branches and fence their homesteads and other farmlands. Farmers also link new fencing in January-February with occasions such as festivals and marriages which are common during these months.

Homestead bamboo has a significant place even in the rural sociological context. For instance, bamboo and bamboo products are generally shared within the local communities. Homegardeners allow local bamboo weavers to collect bamboo from their homesteads. In return, weavers offer some of the products made by them to the homegardeners, which are required for agriculture related activities. Home gardeners also offer bamboo branches, when they are in excess, to their relatives and neighbours to use for fencing their farmlands. These kinds of sharing of bamboo and its products are significant in a social milieu and thus homestead bamboo is one of the major components in a complex system of rural relationships where human beings are the main actors.

Marketing of bamboo from homegardens

Bamboo *(Bambusa bambos)* is one of the crop components in the mixed cropping homegardens in Kerela State, India. Bamboo culms are sold through both the primary bamboo depots located in most of the districts in the state and wholesale bamboo depots clustered around certain places only in Palakkad district. In primary depots, bamboo is purchased in small lots and sold in smaller quantities to cater the local demand, whereas in wholesale depots bamboo is purchased in large lots and sod in bulk mostly to different consuming centers in the neighboring State of Tamil Nadu. The wholesale depots have been operating as a wholesale bamboo market since 1960, whereas the primary depots have only started since the year 2000. the total quantity of green bamboo marketed through the depots during the year 2005 was 74,000 metric tones of which the primary depots accounted for 48% and the wholesale depots the remaining 52%. Market analysis showed that the farm price of bamboo, the net income received by an average grower, accounted for 40% of the wholesale price of Rs 2,878 per metric tonne green weight during 2005. this indicates relatively fair returns to the grower from a crop for which no expenditure was incurred. Bamboo harvesting in home gardens is not sustainable and enough quantity of bamboo is not available to meet the demand. It is evident that export of bamboo to Tamil Nadu has been declining mainly due to the shortage. The factors suggest that bamboo resource in the home gardens needs to be developed through better management techniques. This can be achieved by disseminating market infoemation among growers which will encourage them to improve the resource through better clump management. Better management of bamboo by popularizing the package of practices would yield significant benefits to the farmers who supply bamboo to the depots.

Conclusion

Although a wide spectrum of goods and services are obtained from bamboo, there is yet incomplete understanding about the value. Despite the fact that bamboo as one of the plant components has the potential to improve the productivity of the land and economic conditions of the farmers, cultivation, proper management and sustainable use of homestead bamboo are being neglected. Non-availability of propagules of different bamboo species, lack of knowledge about scientific cultivation, difficulty in managing, cutting and selling culms, lack of knowledge about quality, importance and benefits of bamboo, lack of knowledge on the marketing possibility of bamboo and difficulties in getting cutting permit and pass for transportation are some of the reasons for the disinterest shown by the farmers in developing bamboo resources in homesteads of Kerela.

It may be pointed out here that success of agriculture depends on a range of support services such as research, extension, credit and marketing. In general, such services are developed in relation to specific crops rather than overall farming systems. In Kerela, for homestead bamboo such support services are almost non-existent. With relatively more technical inputs and judicious selection of species, homestead bamboo can be made viable and sustainable to meet the requirement of household uses and for the market in the present day socio-economic context. The significant potential of homestead bamboo for carbon sequestration needs to be assessed by systematic qualitative study and research. Such research supported information together with policies is expected to help bamboo growers to get due recognition and rewards for their efforts in carbon sequestration.

It is hoped that the homestead bamboo will be understood in the context of overall farming systems and in not in isolation from them. It is also hoped that homestead bamboo will be understood from a range of perspectives; not just that of producers but also from that of other groups such as traders, processors and consumers. The National Bamboo Mission has a major role to play in this.

Summary

Bamboo is one of the plant components in homegarden agroforestry system of Kerela. *Bambusa bambos* , *B.vulgaris* and *Dendrocalamus strictus* are the common bamboo species cultivated in a homestead boundary. Clumps are managed by traditional methods like mounding of soil and organic manure around the clump, detopping culms to reduce shading of other crops and trenching around the clump to restrict the horizontal spread of bamboo roots to the remaining parts of homestead. Even for a minimal average annual cost, the estimated benefit-cost ratio for bamboo is significantly higher than for perennial cash crops, seasonal and annual crops and tree components in homegardens of the state. Homegarden bamboos also provide several other tangible and intangible benefits to the homegardens and can be regarded as one of the major components with high social value in a complex system of rural relationship. However, in recent years, homestead bamboo cultivation, management and sustainable utilization are neglected. Bamboo wealth in the homegarden system may be developed with more research back-up, policy support, technical inputs and judicious selection of species to meet the demand of the growers and consumers. In this context, the Indian Government establishing the National Bamboo Mission and implementing its programmes through State Bamboo Missions is commendable. This will promote homestead bamboo cultivation in Kerela once again.

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The Systematic Analysis on the Fast Successful Development of Bamboo Industry in Zhejiang Province, China

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Abstract: Zhejiang is most development bamboo province in China. Main reasons are: 1. A strong back-up for bamboo industry growth by updating technology. 2. Balanced bamboo development promoted by government. 3. Harmony between bamboo cultivation and processing. 4. Special soci-economic and humanitarian advantages for bamboo development. 5. Quick international and domestic bamboo market expanding.

Kew words: Bamboo, Industry development, Experience, Zhejiang

Being fastest growing, short harvest, renewable, sustainable and versatile use, bamboo is worldwide recognized as one of 2 top Non-timber Forestry Products, and has unique harmony of economic, social and ecological benefits. It is highly linked to human being's livelihood, plays increasingly important roles in rural social-economy development and ecological environment protection.

China is globally acknowledged as "Kingdom of Bamboo" for its bamboo excellent achievements. It has rich bamboo resources, i.e. 500 species, 39 genera and an area of 5 million ha. or about 1/3 of the world total respectively. After 4-decade painstaking efforts, China's bamboo sector has been growing into a booming and sun rising industry streamlined from cultivation, integrate processing into export, and becoming a pillar of agricultural economy. In 2006, China's total bamboo production value is over US$ 6 billion with an export value of US$ 600 million.

Bamboo is widely grown in Asia, Africa, Latin America and the Pacific Regions; it has 1250 species, 150 genera, and an area of 17 million ha. But those treasonable and rich resources have not explored well. Author has investigated many countries of 5 continents on bamboo, and also in charge of conducting 21 international bamboo technology training workshops in China as funded by the Chinese government and international organizations, in which over 600 trainees of 62 countries are well trained. Through those activities, author is deeply impressed how firm their determination is to explore bamboo, and how strongly they expect to know the China's successful experience and secret of bamboo development so that they can learn more from China to help their bamboo development, but they usually attribute China's bamboo achievements to technology role, however neglect other more important factors which hinders them from deep and right understanding on China's bamboo.

This article is the case study of Zhejiang bamboo development, and makes the all-sided and detailed analysis on its successful development experience so as to provide significant references and instructions for bamboo development of other countries.

1. Outline of bamboo industry development of Zhejiang

Zhejiang province is also well recognized as the first Bamboo Province in China. "If you want to know world bamboo, please look at China's bamboo; if you want to know China's bamboo, please look at Zhejiang bamboo", which is a vivid and precise description of Zhejiang bamboo. Zhejiang has a bamboo forest area of 0.78 million ha., in which Moso bamboo (Phyllostachys pubescens) forest is 0.6 million ha., or around 1/6 of the China's total one, but it produces an annual bamboo production value of USD 2.3 billion in 2006, or around 1/3 of the China's total one (Fig. 1), in which USD 300 million from export. It has 4838 bamboo processing enterprises, in which 4 enterprises with an annual production value of over USD 13 million, 17 ones over USD 6.5 million. It produces over 3000 varieties of 10 line products. Bamboo resources are expanding quickly from 1989 to 2004, bamboo plantation area increases by 22.5%, 19.7% and 4.7% each 5 years respectively, and Moso culm stock by 41.18%, 25.32% and 45.32% respectively (Fig 2). The primary, secondary and tertiary industry is developing harmoniously (Fig 3) Bamboo industry has been becoming one of main farmer's income resources and agricultural pillars. In Zhejiang, 34 countries have an annual bamboo production value of over USD 12.8 million, in which Anji County is over USD 641 million.

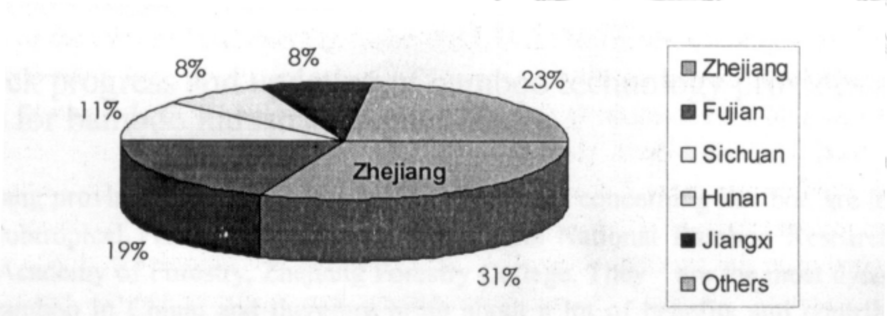

Fig. 1

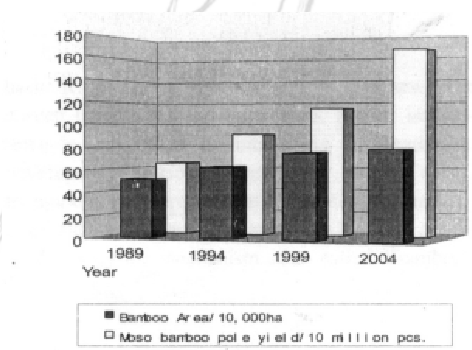

Fig. 2

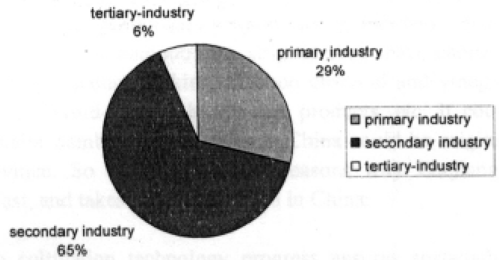

Fig. 3

2. Main reason analysis to drive quick development of Zhejiang bamboo industry

It is acknowledge that the below factors make main contributions to the great success of Zhejiang bamboo industry:

2.1. Quick progress and updating of bamboo technology provides a strong back-up for bamboo industry development

It is Zhejiang province that the famous research institutes concerning bamboo are located in, e.g. the Subtropical Forestry Institute of CAF, China National Bamboo Research Centre, Zhejiang Academy of Forestry, Zhejiang Forestry College. They are the most dynamic in R & D of bamboo in China, and therefore bring about a lot of benefits and contributions to Zhejiang bamboo development. The wide application of the following advanced cultivation technologies increases markedly productivity and quality of bamboo forest: Classification management technology of bamboo forest, Improvement technology of low-yield and low-benefit bamboo forest, and high-yield, high-value directional cultivation technology of bamboo forest, water irrigation and balance fertilization, counter-season cultivation of "early bamboo" (Phyllostachys praecox) by mulching which produces amazing economic benefits as high as USD 77,000 /ha. Directional and high-yield cultivation for 3 kinds of shoot (spring shoot, summer shoot and winter shoot) greatly increases production, quality and output value of fresh shoot.

Primary and basic R. & D. of new technology and new product is done by concerted cooperation between institutions and enterprises, further improvement of new product and market acceptance is undertaken by interaction cooperation between manufacturers and importers of developed countries. Therefore by such a cycle from research institution, manufacturer to market, new products are accepted by market, and new technologies are matured, and more such art-of-the-state technologies are quickly disseminating among all the bamboo enterprises by the mechanism of so called "Bamboo Industry Zone", so that the whole bamboo processing industry is simultaneously promoted. In recent 2 decades, the following technologies have played key role in making the bamboo industrialization shifting from the traditional way featured with simple, cottage handicraft-level and low value addition to the modern one with complicate, modern industry-level and high value addition. Bamboo culm harvesting method, bamboo timber bleaching, preservation and drying, bamboo timber carbonization, manufacturing technologies of bamboo floor (incl. solid bamboo floor, bamboo and wood composite floor, reinforced bamboo floor), bamboo veneer, bamboo building plywood, bamboo mats (square bamboo mat, strip bamboo mat), bamboo shuttle and carpet, sliced bamboo shoot by vacuum packing, bamboo charcoal and vinegar, bamboo fiber and fabric, bamboo leave flavoid-derived health-care products, etc. it could be concluded the majority of those major bamboo technologies in China could be originated from, or related with Zhejiang province. So that is major of reasons why Zhejiang's bamboo industry development is so fast, and takes the first position in China.

Therefore, bamboo cultivation technology progress ensures sustainable provision of raw bamboo material in a high yield and high quality, and bamboo processing technology advance guarantees production of high value-added and high quality products so as to enhance its economic benefits, on another hand, greatly drive bamboo cultivation since high demands for raw materials are resulted in increasing of its purchase price, as a result, the whole bamboo sector is promoted initiated from bamboo technology progress.

2.2. Various governmental supports promote the orderly and harmonious development of bamboo sector

2.2.1 Favorable policies ensuring sound development of bamboo industry

Government intervention to promote bamboo sector development could be generally classified into 3 steps in the development sequence. From later 1970's to early 1980's, China makes rural system reform, the rural production system is shifted from the unified collective management to Household Responsibility System (HRS) which greatly promotes farmer's bamboo production. Meanwhile, bamboo product marketing system is also shifted from the state monopoly which does not allow farmers to sell their bamboo, to the free market which farmers can sell their bamboo in market at their own will. More township and village enterprises are booming, and some of them start bamboo processing. As a result, preliminary and simple bamboo processing industry is started and developed. In middle 1990's, "3-stabilization policy which is "Stabilization of mountain and forest property", "Stabilization of self-processed mountain property", and "Stabilization of household responsibility system" is issued by the central government, which has further strengthen farmer's determination of developing bamboo plantation since they would have not enough confidence with long-term investment for bamboo plantation considering possible change of properties of mountain and forest. By this, quantity and quality of bamboo forest resources are greatly improved. In 2006, China's government make another far-reaching forestry system reforming, that is forest property reforming, of course, it includes bamboo, it renders farmers with not only the right of management in which farmers have been empowered in the previous HRS, but also the right of ownership which allows farmers to transfer, transact or circulate as a property, so that the huge fixed assets of bamboo resources are activated, therefore, more and more people show much bigger enthusiasm for developing bamboo plantation since it is indeed a very profitable investment. Therefore bamboo plantation has got another big momentum and opportunity to fly.

Sundry kinds of taxi and fee imposed to bamboo farmers as a fund-pooling means for developing bamboo before have been exempted since 2001, they are: Agriculture specialty product taxi of 6-16%, a forestation fund of around 0.5 Yuan/bamboo pole, Forest construction fee and Forest resource compensation fee, which makes farmers more incomes from bamboo planting, therefore they are highly motivated to develop bamboo plantation and supply more bamboo poles to factories for high-valued processing. Different provisions of incentive subsidiary of fund, fertilizer are also made by government to encourage farmers to establish new bamboo plantation and improve existed low-yield and low value bamboo plantation.

In order to encourage export, government promulgates a set of export tax refunding system for bamboo products, the principle is "the more the tax is refunding, the higher product value addition is", e.g. only 5% for raw bamboo pole, and 12% for bamboo floor. It is to spur up bamboo enterprise to make much more intensive processing of bamboo resource to produce much higher value addition, and also limited bamboo resources are ushered to development of high value-added products.

2.2.2 Strengthen bamboo plantation base construction and expand bamboo resources for sustainable supply of raw bamboo material for processing

In the 9th Fiver Year, special fund are earmarked by provincial government to support the implementation of 3 big construction projects of bamboo plantation bases, i.e. 1 million mu (Mu is a Chinese area unit, 1 ha. is 15 mu) of high-yield Moso bamboo plantation, 1 million mu of Moso plantation for shoot and timber, and 1 million mu of the improvement of low-yield bamboo forest. In the 10th Fiver Year, construction and improvement of bamboo forest bases is listed as one of priority workings in agricultural planting structure adjustment of province, bamboo forest management level is raised to a great degree by extending new cultivation technology, water irrigation, what should be stressed is that more investment has been earmarked for better developing bamboo road networks in several key bamboo production countries/cities by provincial government in order to reduce harvesting and transportation costs of bamboo timber and reduce production, which makes farmers more benefits. Therefore areas, productivity and quality of bamboo forest have been increasing very much to meet high demand of bamboo processing for raw bamboo material. It is said that "Bamboo Spring" is approaching in Zhejiang.

2.2.3 Facilitate the formation and development of "dragon-head" bamboo enterprises to play much more important role in example-setting and promotion.

Dragon-head bamboo processing enterprises are always connected both markets as up-stream and thousands of hundreds farmers as down-stream, therefore, it plays a key role in promoting bamboo industry development. 18 bamboo enterprises which represent different field of bamboo processing and different areas have been selected out as provincial-class "dragon-head enterprise", therefore they can get favorable and special support and assistance by government in fund, loan and land purchase, etc in order to enhance their capacity, technology and export for play much bigger driving role in the whole bamboo industry of Zhejiang.

2.3 Good bamboo management models between bamboo cultivation and processing and sale to ensure balanced development of the whole bamboo sector.

At present, Zhejiang Provincial Bamboo Industry Association is set up with 5 chapters, i.e. Bamboo plywood chapter, Bamboo floor chapter, Bamboo shoot chapter, Bamboo charcoal chapter, and Bamboo article chapter. Meanwhile, there are 70 bamboo industry associations with 5834 members, 52 bamboo cooperatives with 6145 members in Zhejiang. Each main bamboo county has set up such association and cooperative. Regarding cooperative, it has 3 kinds of organization form: "Dragon-head enterprise + cooperative + farmer", "market + farmer", e.g. Northern Zhejiang Moso Bamboo Market has 402 "bamboo management households", and connects 62,000 farmer households, spurs on development of bamboo plantation "Cooperative farmer", "Dragon-head enterprise + bamboo processing farmers", e.g. Deqin M Bamboo Plywood Factory places purchase orders of semi-finished bamboo products to farmers to meet their finished product production needs, which connects 22,000 bamboo farmers, absorbs over 5000 farmers, consumers over 11 millions bamboo poles per year, drives development of 80.

Association is a good bridge among government, enterprise, farmer and plays an important role in protecting rational benefits of bamboo farmers and production initiatives, ensuring enterprise purchase costs of raw material low and stable supply and promoting sound development of bamboo industry as a whole. A share-holding Finance which provides a financial loan service for bamboo enterprise with help of Zhejiang Provincial Bamboo Industry Association.

2.4. Special socio-economic and humanitarian advantages and conditions

2.4.1 Developed and convenient transportation facilitates bamboo export business located in China's eastern costal areas, Zhejiang is one of the most economic development provinces in China and ranks the 3rd of export value in China. Its transportation network is very developed: wherever you can be over there by driving within 4 h, a 2 h driving way to Shanghai which is the biggest commercial city in China; Nangbo sea port of Zhejiang ranks the 3rd in China. All those unique geographical location and good infrastructure condition plays a firm physical foundation for bamboo export, and promotes bamboo industry development since bamboo export takes a leading role in driving the development of the whole bamboo industry.

2.4.2 Export and private-enterprise culture promotes quick growth of bamboo processing industry

Zhejiang is scarce in natural resources, and small in land areas, therefore it has to take a road of developing "export-oriented and value-added industry invigorated by more dynamic and flexible economic policy and system. For 3-decade efforts, now most of the enterprises in Zhejiang are highly connected with import/export business, and the total export value is ranked the 3rd in China. It has formed an "export culture" which makes a deep impact on Zhejiang entrepreneurs. The private economy is extremely booming, and ranks the first in China; its economic contribution is over "half a sky", or over 50% of the provincial total GDP. Therefore Zhejiang is growing one of the most economic development provinces in China.

Composition of bamboo enterprises of Zhejiang is nearly 100% private, weather from inside China or outside China as a joint-venture or sole-funded, but none from government which is a key base for dynamic development.

As cultivated and effected by "export culture", bamboo entrepreneurs know how big importantly the export will bring about, and know how to better engaging in export business; meanwhile, they can get a quick enhancement of business management by absorbing and updating their advanced management technology as they do transaction and interaction with the developed countries e.g. USA, EU, Japan etc., to which they export bamboo products, but importers of developed countries usually have a very serious quality and service requirement for exporters. For example, now the general level of China's bamboo flooring manufacture and quality could approach to the highest level of world wood floor one in many aspects after 2-decade efforts; it is an excellent result of exposure and export of China's bamboo floor to the developed countries.

2.4.3 "Bamboo Industry Zone" and "Bamboo Economy Block"

There are 4838 bamboo timber processing factories in Zhejiang, but their distraction is mainly restricted in the western and northern, and they produce 10 lines of products which are very similar, i.e. bamboo floor, bamboo plywood, bamboo curtain/carpet, bamboo shoot, etc., so they look like a big "Bamboo Industry Zone", in which it has formed a whole chain from bamboo plantation, transportation, semi-finished processing by farmers, finished processing by factories, supply of subsidiary materials to export. Indeed, it creates a "Bamboo Economy Block" which is consisted of the primary industry —bamboo plantation for supply bamboo poles, the secondary industry——production of different semi-finished and finished bamboo products, manufacture of bamboo machines, processing of subsidiary material, and the tertiary industry—financial, technical and trade service, bamboo ecological tourism. Inside the zone, there are several saline advantages: (a) Production enterprise could share technologies by learning from each other, or even by "stealing", therefore technologies are updating and progressing very quickly as a whole. (b) Price of products are reduced since all the purchase price of raw and subsidiary materials, service, etc is lower as a "wholesale price", not a "retail price". (c) Quality of products is much higher. Each enterprises faces a very serious competition from many similar enterprises nearby, so has to take painstaking efforts to enhance its product quality, reduce its price, otherwise, it should not be survived further. (d) More business opportunities are occurred. More customers come to the Zone for doing business for its much better price and quality, more selecton of suppliers, and much easier to explore new products. All the above-mentioned advantages are hard to be found outside the Zone where bamboo enterprises are quiet less.

2.4.4 Excellent talents of bamboo grown up under unique humanitarian environments.

Bamboo in Zhejiang has a history of over 5000 years, people has accumulated very rich experiences of bamboo cultivation and processing, bamboo is already rooted deeply in people's mind, that is a good working foundation of bamboo. People are very famous for its "Clever, Diligent, and Able" in China, "the richer people are, the harder they work" has a fashion which is called as "A Spirit of Zhejiang". At present, bamboo industry is still a combination of handicrafts and semi-mechanization, so it needs such labors who should be not only quiet intelligent, but also hard and diligent. Therefore, it is Zhejiang where people are extremely excellent and qualified for bamboo development. In fact, the majority of bamboo's entrepreneurs are grown up from those people who have been "farmers", and but very motivated to start up township and village enterprises once China opening up to the outside world in 1980's. It is the unique social and cultural foundation that bamboo is developed so quickly in Zhejiang.

2.5. Quick expanding of international and domestic bamboo market stimulates and drives the development of bamboo industry

In recent two decades, international and domestic markets of bamboo products are expanding very quickly, especially since 2000. On international market, over 90% of bamboo flooring made in Zhejiang is for export, and more with an annual increase of 20% thanks to its excellent and unique quality and environment-protection. Over 80% of bamboo curtain and carpet are also for export to USA, EU, Japan, etc. for it fine designing, unique function. Bamboo shoot market is expanded not only in Japan which is a traditional main importer, but also in USA, EU which do not eat bamboo shoot, but now start to enjoy it for its rich nutrient and slimming function. Bamboo fiber and fabric, bamboo charcoal, bamboo build plywood which have very high value addition are showing a strong tendency of export. On domestic market, bamboo mat is amazingly growing, e.g. on average, if each household in China should have one bamboo mat, how much big it is. Bamboo shoot market is traditionally restricted in the Southern China, but now comes across the Long River to the Northern China.

The justification why bamboo product market can be developed quickly is as below: world supply of wood product is decreasing due to serious depletion of wood resources, and needs of wood products are increasing since people prefer natural and environment-harmonious commodities than artificial synthetic ones, like plastic , therefore the gap between supply and need is widening, it is bamboo that well fills up this gap because bamboo can replace wood in many use, and bamboo can exceed wood in some use for its unique characteristics.

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Figure. 1. Bamboo industry value distribution of different provinces in China

Figure. 2 Quick increasing of bamboo forest area and Moso bamboo culm yield from 1989 to 2004 in Zhejiang province, China

Figure. 3 Zhejiang bamboo industry composition of the total bamboo industry value of USD 2.15 billion in 2006

Forest Policy and Laws Governing Cultivation, Harvesting, Transport and Trade of Bamboo in Kerala

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Kerala is a narrow strip of land between Arabian Sea and the Western Ghats, with a geographical area of 38863 sq.km. The population of the State is 3.18 crores with a density of 819 persons/sq.km. The per capita land is only 0.122 ha. It receives an average annual rain fall of 3000 mm and 44 rivers drain the water. Western Ghats constitute the chief mountain system in the State with the highest elevation of 2694 meters in the Anamudi peak. The state is known for its luxuriant vegetation. In the homesteads multi-tier cropping system is practiced. The economy of Kerala is mainly based on cash crops.

The total area of the Forests in Kerala is 11271 sq.km forming 29% of the geographical area of the State. The diverse climatic edaphic and physiographic factors led to the formation of different types of forests ranging from temperate rain forests to dry, scrub jungles. The per capita forest area in the State is 0.035 ha. The major portion of the forest area in Kerala is covered by the tropical evergreen, semi evergreen and moist deciduous forests. The State is having 15 Wildlife Sanctuaries and 5 National Parks covering an area of 2382 sq.km (6.1% of the geographical area). A total of 2.1 lakh hectare area is covered by plantations of different forest species and teak is the main plantation crop with an area of 75000 ha. The State earns an annual revenue of nearly Rs.200 crores from the forest sector.

Main species of Bamboo and their Abundance

Bamboo is one of the important species of Kerala forests. In Kerala 25 species of bamboos have been recorded under 7 genera. Bambusa arundinacea, Dendrocalamus strictus, Ochlandra travancorica and Ochlandra rheedii are the main species of bamboo in Kerala. While the distribution of Dendrocalamus strictus is limited to the drier localities, Bambusa arundinacea is widely distributed throughout the State. It is abundant in Wayanad, Nilambur, Palakkad regions.

Ochlandra travancorica is more abundant in south Kerala in Trivandrum, Munnar, Malayattoor, Ranni, Vazhachal regions and widely occurs as an undergrowth in low level evergreen and semi evergreen forests. Bambusa arundanacea is the most common bamboo species among the homesteads of Kerala. Occasionally Bambusa vulgaris is raised as an ornamental bamboo in the homesteads. It is estimated that annually 1.5 lakhs MT of bamboos and 1.25 lakhs MT of reed bamboos are available for extraction from the forests of Kerala. A study conducted by Dr.C.N.Krishnankutty, KFRI in 1987 indicated that the area occupied by bamboo in the homesteads of Kerala is 581 ha containing 39 million culms.

Bamboo Plantations in Kerala

Bamboo is one of the plantation species in Kerala. During the eighties, 3500 ha of bamboo plantations were raised by under planting bamboos in the finally thinned teak plantations. Though Bamboo has flourished under Teak plantations, the growth and yield of Teak is affected because of under planting and the programme was therefore stopped. Bamboo is one of the species eminently suited for the restoration of degraded moist deciduous forests. During 1998-2004, the department planted bamboo, reeds and rattans in 7200 ha degraded forest area. Bamboo is one of the preferred species for planting in the degraded forests by the Vana Samrakshana Samithies also.

Management

Bamboos and Reeds are managed with the objective of ensuring their sustained supply to the industries and to the local people for their bonafide use. Bamboos and reeds are worked on a three-year felling cycle in Kerala. The felling rules prescribe that (a) bamboos and Reeds adjacent to the stream banks and located on slopes above 30^{o} gradient are not worked; (b) culms of age more than two years are only felled; (c) while extracting the mature bamboos, the culms are cleaned; (d) the felling of culms is done on a horse-shoe pattern; (e) no felling is done during the regeneration period of June, July, August and (f) all dead, malformed culms are removed irrespective of age.

Utilisation of Bamboo in Kerala

Bamboo is one of the most important renewable bio-resources. It is a poor man's timber and has a variety of applications. In addition to its use as a raw material for paper and pulp industries, bamboo is also used for making handicrafts, baskets, mats, flutes, agricultural implements, spears, bows and arrows and walking sticks. Cultivation of edible and decorative bamboos is yet to take of in the State.

The main consumers of Bamboo in Kerala are the paper and pulp industries. Bamboos and reeds are also being used by the traditional basketing and match weaving community.

Bamboo is one of the ideal species for the purpose of agro-forestry, because of its ability to grow on marginal and wastelands, rapid growth, low cost of extraction, low cost of processing etc. Bamboos conserve soil and moisture, restore the degraded lands, provide livelihood and nutritional security, apart from generating employment both in the organized and unorganized sectors. Bamboo could provide shelter to the homeless and inexpensive buildings for schools and hospitals.

Bamboo Based Industries in Kerala

a. ***Kerala State Bamboo Corporation*** – This is a public sector undertaking, established in 1984 at Angamali near Ernakulam. The Government is supplying 30,000 MT of reeds annually free of cost to the Company and the company produces mainly bamboo ply, which has got vide acceptance in the market.

b. ***Hindustan News Print Limited*** - Hindustan News Print Ltd, Veloor, Kottayam is a subsidiary of Hindustan Paper Corporation. The State Government had entered into an agreement in 1982-83 to supply 1.89 lakhs of reeds and other raw materials annually to M/s.HNL at subsidized rates. They have been collecting annually about a lakh of tones of bamboos & reeds. From 2004 onwards the subsidized supply is stopped and the department agreed to supply 1.5 lakh tonnes the bamboos and reeds at market rates.

c. ***Gwaliyor Rayons*** - The Gwaliyor Rayon Pulpwood Plant was established at Mavoor, Calicult in 1961 with a production capacity of 72,000 tonnes/annum. Government of Kerala entered into an agreement with M/s.Gwaliyor Rayons in 1953 to supply 2 lakh MT of bamboos at the subsidies rate of Rs.1.67/MT. The company was closed during 1999 due to shortage of raw materials, labour and pollution problems. Since then the utilization of bamboo in Malabar forest areas low.

d. ***Punalur Paper Mills*** – Punalur Paper mills is one of the oldest paper mills in India with a capacity of 50,000 tonnes. The department was supplying annually 85,000 tonnes of reeds to the factory. The factory was closed during 1987 due to financial mismanagement, fire occurrence, raw material shortage, poor productivity.

e. ***Travancore Rayons*** – This is another private sector rayon factory which was closed down due to shortage of raw materials etc.

Employment Potential

The bamboo based industries have great employment potential both in the organized and unorganized sectors. The Kerala State Bamboo Corporation provides employment directly to 30,000 traditional bamboo workers and to directly to 3 lakh workers. The Hindustan News Print Limited provides employment to 1000 persons directly and around 20,000 workers indirectly. The Gwaliyor Rayons used to provide employment to 6000 people. Lakhs of workers get employment as labourers in bamboo extraction and various other cottage industries such as basket making, mat making and handicrafts.

Policies affecting Bamboo Cultivation

(a) National Forest Policy, 1988

As per the National Forest Policy, as far as possible, a forest based industry should raise the raw material needed for meeting its requirements preferably by establishing of a direct relationship between the factory and the individuals who can grow the raw material by supporting the individuals with inputs including credit, constant technical advice and finally harvesting and transport services. No forest based enterprise except at the village or cottage level should be permitted in future unless it has been cleared after a careful scrutiny with regard to the assured availability of raw material. Forest based industries must involve themselves fully in raising trees and raw materials. Natural forests will not be made available to the industries for undertaking plantation and for any other activities. Farmers, particularly small and marginal farmers will be encouraged to grow on marginal/ degraded lands available with them, wood species required for industries. The practice of supply of forest produce to industry at concessional prices should cease. Import of wood and wood products should be liberalized.

(b) Draft Kerala Forest Policy

The Draft Forest Policy of Kerala also support the above principle. The State Government had stopped the supply of raw materials to industries at subsidized rates from 2004 onwards. The State Government recognizes the need to popularize cultivation of bamboo and bamboo based handicrafts and small scale industries across the State to utilize the abundant bamboo resources available in the State. The Draft Forest Policy of Kerala also recognizes the need to plant bamboo along the river banks with people's participation to stabilize them. The Draft Forest Policy of Kerala also recognizes the need to encourage bamboo and reed based industries and to supply bamboos and reeds to the traditional bamboo workers at concessional rates. The Government of Kerala accordingly issued orders during 2007 to supply bamboo and reeds to the traditional bamboo works and to the SC/ST Communities at ¼ of the seigniorage rate.

In Kerala, the Hindustan News Print Limited which is major bamboo consuming industry is distributing seedlings to the public on a large scale and buying back raw materials produced by them at attractive prices. They are also managing around 4000 ha of captive plantations to meet their requirements partly.

(c) Draft Kerala Bamboo Policy

The Kerala Bamboo Mission has prepared a draft Bamboo Policy. The main objectives are

- Enhancement of bamboo resources through promotion of bamboo plantation in forests and private lands
- Improvement of productivity by use of quality planting stock
- Revival of traditional bamboo sector and diversification
- Development of bamboo based industries
- Conservation of bio-diversity of bamboos

Impediments for the Cultivation of Bamboo in the Private Sector

Bambusa arundanacea, the common bamboo in Kerala is thorny and difficult to extract its cultivation in homesteads encourages rodents. Raising and distributing the seedlings of thornless bamboos will attract more people to plant them in their homesteads. Availability of sufficient quantity of seeds of different thornless bamboo species is a problem in this area. We may utilize the tissue culture and the vegetative propagation techniques to overcome this problem. There is no mechanism for regulating remunerative prices for bamboos. Similarly there is no net work of bamboos and reed collection centres to purchase them from the farmers. There is also dearth of sufficient training personnel in the State for imparting skills to produce handicrafts and other bamboo products. There is also no mechanism to issue soft loans to the enterprenuing bamboo cultivators on a commercial scale. There are also legal impediments in the form of the Forest (Conservation) Act, 1980, The Plantation Labour Act, etc.

Legal Framework

The various legal aspects that affect the cultivation, sale and transport of Bamboos are discussed below.

Kerala Land Reforms Act, 1963

As per the Kerala Land Reforms Act, 1963, the plantation crops are exempted from the provisions of land ceiling. Plantation is defined under the Act as any land used principally for the cultivation of coffee, cocoa, rubber, cardamom or cinnamom. In order to encourage bamboo cultivation across the state, it is suggested that bamboo may be included as one of the crops in the definition of Plantation Crops under the KLR Act.

Kerala Forest Act, 1961 & Kerala Forest Produce Transit Rules

Kerala Forest Act, Section 2(f) defines 'forest produce'. As, "Forest Produce includes (1) the following whether found in, or brought from a forest or not, that is to say

Timber, Charcoal ……………………"

As per the above definition, all the bamboos grown in private lands also will be classified as forest produce and therefore, the Kerala Forest Produce Transit Rules will be attracted. It is therefore suggested that the definition of forest produce may be amended by deleting the word 'or not' from the present definition.

Forest Conservation Act, 1980

As per the liberalized definition given by the Hon'ble Supreme Court, the word 'forests' is to be understood according to the dictionary meaning. There are apprehensions in the minds of the people whether a private area cultivated with forest species also attracts the above provision. It is therefore necessary to clearly define 'forests' so as to exclude all private plantations of forest species including bamboos, to encourage private plantations of bamboo.

Kerala Land Utilization Order, 1967

Rule 6 of the Kerala Land Utilization Order, 1967, restricts conversion of any land cultivated with food crops into other crops. Many of the food crops like rice have become uneconomical and many of the cultivated areas are being utilized for growing cash crops etc. The relevance of the above Order needs to be reviewed in the present day context and needs to be suitably modified to encourage bamboo cultivation in the State.

The Kerala Forest Produce (Fixation of Selling Price Act), 1978

As per the Kerala Forest Produce (Fixation of Selling Price) Act 1978, the Government shall, before the end of every financial year by notification published in the Gazette, fix the selling price of certain species of forest produce for the following financial year and no such forest produce shall be sold by Government or any forest officer at a price less than the notified selling price. Bamboo is one of the species covered under the above Act and the price of the standing Bamboo is being notified by the Government year after the year. This Act only gives the minimum price at which bamboo is to be sold by Government.

However, by this notification, Government cannot ensure a support price for the bamboo grown on private lands. There shall be a mechanism to ensure minimum support price for bamboo so that the farmers can be assured of a minimum return and there by can be attracted towards cultivation of bamboos.

The Kerala Forest (Preservation, Re-production, Disposal of Trees and Timber belonging to Government but grown on lands in the occupation of private persons) Rules 1975

As per the above rules framed under section 76 of the Kerala Forest Act, the pattayam holders do not get any right over the trees reserved or grown by them as the land assigned by Government to them has not been dis-reserved. This discourages people from planting more trees/bamboos on such lands. The conditions attached to the assignment deeds make the assignee responsible to take care of the trees standing at the time of assignment on the assigned land and those which may come into existence subsequent to it. The right of all such trees vests in the Government and Government may remove them at any time. Therefore, the assignees has no interest in cultivating or preserving trees in such lands. This rule needs review and amendment under the Act.

Proactive Steps Taken by Government

The Kerala Promotion of Tree Growth on Non Forest Areas Act, 2005 (as amended in 2007)

The Government of Kerala has liberalized the felling and transport regime of the forest species through the above legislation. No permission for felling or transport of bamboos on lands grown on non forest areas except in certain notified sensitive areas is required in Kerala as per the above Act.

Essential Commodities Order

As per G.O.(MS) No.179/81/Forest(1) dated 20..06..1981 certain species such as rubberwood were declared as essential commodities and the export of those species is restricted. However, bamboo is not included in the above list. Therefore, there is no restriction on the export of bamboo outside the State.

Scope for expansion of Bamboo Cultivation

In Kerala, fresh bamboo planting can be undertaken in (a) degraded forest areas (b) private lands and (c) along the river and canal banks. Planting in degraded forests can be undertaken with the help of Vana Samrakshna Samithies/Eco-development Committees/ Forest Development Agencies. An area of 1,000 ha/annum can tackled utilizing funds from National Afforestation Programme or Bamboo Mission. The planting in private areas can be undertaken with the help of self-help groups, cooperatives, etc. Non Governmental Organisations and Local Self Governments shall play a major role in planting along the banks of the 44 rivers. The State Bamboo Mission can play the role of Nodal Agency by arranging quality planting materials, market survey, training and extension as well as research interventions. To encourage planting on private lands arranging micro finance, minimum support price for bamboo and establishing a network of marketing centres are quite essential.

Recommendations

A) To encourage cultivation of bamboo on private lands the following steps are essential.

1. The State Bamboo Mission shall facilitate the following.

- Quality planting materials shall be produced through tissue culture and vegetative propagation techniques and large number of seedlings, preferably of thronless varieties of bamboos shall be made available.
- A network for collection and marketing centres shall be developed in the rural areas across the State so that the farmers can sell their bamboo produce without difficulty.
- Micro finance to small farmers shall be arranged by organizing them into self help groups. NABARD may consider giving soft loans for the cultivation of bamboos and tree crops. The present systems of NABARD loans are not helpful for the cultivation of tree crops.
- Arrange training to tribals & other artisans for value addition to exploit potential in tourism.

2. The bamboo-based industries should encourage tree farming by entering into buy back arrangements with the farmers and assuring remunerative prices.

3. The taxes and duties on production and sale of bamboo based handicrafts, furniture and other products may be completely removed to encourage the bamboo based industries.
4. There shall be a mechanism to ensure a minimum support price for the bamboos cultivated in the private lands and homesteads.
5. Large scale extension activities are needed to educate the public on the economic potential of bamboos and as to how to exploit the same profitably.
6. The Government shall provide a package for cultivation of decorative and edible bamboos for high end commercial market.
7. The legal system has to be suitably modified as detailed below to encourage cultivation of bamboos.
   - Necessary amendment may be made in the Kerala Forest Act in such a way that bamboo is a 'forest produce' only when found in or brought from forests.
   - The Kerala Land Reforms Act may be suitably modified to exempt the bamboo cultivated areas from the land ceiling provisions.
   - The Kerala Forest (Preservation Re-production, Disposal of trees and Timber belonging to Government but grown on lands in the occupation of private persons) Rules 1975 may be amended to facilitate cultivation and harvested of bamboo by owners.
   - The legislations so far has been regulatory in nature and there is no proactive legislation to encourage cultivation of forest tree crops on private lands. It is suggested that a comprehensive legislation for promoting tree farming on private lands on a commercial basis shall be undertaken. Even though the Kerala Promotion of Tree Growth on Non-forest Areas Act 2005 liberalised the felling and transport regulations, it does not contain any provision to encourage the cultivation of tree crops and bamboos. A subsidy for the cultivation of bamboos and forest tree crops on the lines of the subsidy given to rubber cultivation is suggested.

B) To promote planting of bamboo and utilization of bamboo from the forest areas, the following steps are suggested.

1. Make available quality seeds and tissue culture planting materials of desired species.

2. Make available high end technology to utilize surplus bamboo in the forests
3. Encourage VSSs/EDCs to cultivate bamboo in degraded forest areas with an attractive benefit-sharing package.
4. Provide adequate funds for planting and entry point activities.
5. The Hon'ble Supreme Court may be approached with a request to allow extraction of flowered bamboos within the Protected Areas.

Kerala State Bamboo Corporation

Sl. No.	Year of allotment	Allotted quantity in MT	Collected quantity in MT
1	1994-95	30000	22003
2	1995-96	30000	22132
3	1996-97	30000	20599
4	1997-98	30000	22615
5	1998-99	30000	22078
6	1999-00	30000	18253
7	2000-01	30000	19258
8	2001-02	30000	16100
9	2002-03	20000	13204
10	2003-04	20000	11169
11	2004-05	15000	9235
12	2005-06	10000	5493

Allotment and extraction of Bamboos by M/s.Gwaliyor Rayons, Kozhikkode

Sl. No.	Year	Total allotment (lakh tonnes)	Quantity collected by the Company (lakh tonnes)
1	1988-89	1.00	0.49
2	1989-90	2.00	2.11
3	1990-91	2.17	1.10
4	1991-92	2.14	1.94
5	1992-93	2.41	1.78
6	1993-94	2.38	0.97

7	1994-95	1.69	1.02
8	1995-96	1.90	1.07
9	1996-97	1.80	1.40
10	1997-98	2.70	1.23
11	1998-99	1.50	1.11

Allotment and extraction of Bamboos by M/s. HNL

Sl. No.	Year	Total allotment	Quantity collected by the Company (Net)
1	1988-89		
2	1989-90		
3	1990-91		
4	1991-92	185000	65193
5	1992-93	210628	74294
6	1993-94	189000	69910
7	1994-95	189000	76142
8	1995-96	186500	60313
9	1996-97	135850	59476
10	1997-98	191050	73574
11	1998-99	156385	85453
12	1999-00	117057	82640
13	2000-01	155586	122775
14	2001-02	89535	112238
15	2002-03	178876	66992
16	2003-04	65198	46678
17	2004-05	72206	26869

Bamboos are arborescent perennial grasses distributed widely from tropical to subtropical and temperate regions of the world. Taxonomically bamboos belong to the subfamily Bambusae of family Poaceae, consisting of about 1,250 species. There are 75 genera and 136 species of bamboo in India. In Kerala around 30 species of bamboos are found.

Forest Policy and Laws Governing Cultivation, Harvesting, Transport and Trade of Bamboo in Nagaland

I Panger Jamir

1. Introduction

Bamboo, the fast growing and highest yielding renewable natural resources constitute one of the most important resources of Nagaland. It is found extensively all over the State, and has been put to use in the present day context for the benefit, growth and development of the people.

Bamboo has been integral part of the Nagas and will continue to play a predominant role in the life of the people. It ranges from Agricultural implements and tools to shelter, food and livelihood

Denudation of Forest, degration of environment and deterioration of ecological balance threaten the very existence of man and animal. The development of natural bamboo resources of Nagaland will greatly prevent the consequences and impact of the environment and ecological imbalance.

A planned, scientific and holistic approach to the cultivation and management of bamboo on a sustainable manner can serve as the inexhaustible source of goods and services to the people can also playa significant role in the restoration and rejuvenation of rural economy and the overall economic development of the State.

With increasing demand of timber, which is becoming scarce commodity in the world, bamboo can serve as an alternative to the many forest products and Nagaland can be powerhouse for development and resources of bamboo for the future generation.

2. Rationale

2.1 Bamboo being the basic natural resource and in abundant helps in survival and progress for the Nagas and will continue to play dominant role in the near future to come. Its use has been grown over the centuries and the study of bamboo has currently identified over 1500 uses of bamboo.

2.2 Overuse and mismanagement of natural forest resources with first rise of human and animal population leads to the degradation soil and ecological adversely affecting the quality of life of the rural people who constitute more than 80 percent of the total population of the state.

2.3 Bamboo is the fastest growing canopy for greening of degraded areas and is reported to be generating more oxygen than equivalent stand of other tree species. It lowers light intensity and protects against ultra violet rays and is an atmospheric and soil purifier.

2.4 Bamboo is a hardy and versatile species, which is adaptable to a wide range soil and climate. It responds well to high inputs like irrigation and fertilizers for higher productivity.

2.5 Mass propagation of bamboo for massive plantations on private and public wasteland is feasible as the plantation, management and harvesting technique of bamboo is well known to the people.

2.6Bamboo is a viable alternative of wood as timber Technology inputs to the qualities and resilience has given it a totally wider scope of uses in the form of pulping ,ply ,furniture ,handicraft and many other uses including energy alternative in the form of bamboo charcoal and biomass electric generating resources .

2.7 bamboo shoot has been identified as food with large commercial market all over the world while the leaves can be promoted various form of medicine apart from being rich fodder for animals.

2.8 Bamboo is therefore, one of the most important forest resources in Nagaland. Its multiple use will help in develop in and rejuvenate the rural economy, if manage on sustained basis, alleviating the rural poor.

3. Bamboo as resource of Nagaland

3.1 Bamboos are found extensively all over the State. It occurs as a predominant species in the District of Dimapur, Peren, Mokokchung, Mon and foothills of Wokha .It is also found readily mixed with other forest timber species in all other district of the State .It is estimated that bamboo covers an area of 16,579.00 sq.km. of the State.

3.2 There are more than 40 species of bamboo recorded in the State. Amongst the bamboo species few important commercially important species found in Nagaland:

1. Bambus balcooa
2. Bambusa Palliada
3. Bambusa tulda
4. Dendrocalamus hamiltonii
5. Dendrocalamus giganteus
6. Dendrocalamus calostachys
7. Dendrocalamus hookeri
8. Schizostachyum duiioa
   (Teinostachyum dulloa)

9. Melocana bambusoides

(M.baccifera)

4. Aims & objective of the policy

1. Protection and conservation of rich bio-diversity associated with bamboo forest and bamboo growing rate of the state.

2. Sustainable development and utilization of bamboo resources through scientific management.

3. Promote bamboo plantation as one of the key thrust area for future economy of the State.

4. Promote bamboo based industries for utilizing the available resources for generating income.

5. Promote traditional bamboo craft and art for export to outside the state.

6. Promote bamboo as wood substitute in order to reduce pressure on forest.

7. Promote awareness and understanding of bamboo and its applicability in the diverse range field.

5. The Strategy

The bamboo policy will have to approaches namely:

a. Development of bamboo as a resource

B. Development of bamboo as an enterprise

6. Development as a resource

i) Inventorization of the bamboo resources, including identification, documentation and resource mapping.

ii) Bamboo plantation and regeneration both in government and community/private land.

Iii) Evolve scientific management practices for natural as well as plantation improves productivity.

iv) Create awareness of the value of bamboo among the people, specially the stake holders.

v) Evolve suitable policy to tackle the gregarious bamboo flowering in the state.

vi) Evolve techniques of multiplication and develop infrastructure for mass production of planting materials for commercial plantation.

vii) Introduce desirable and commercially important bamboo species.

viii) Establish bamboo setum for different agro-climatic zones for ex-situ conservation of the germ plasm.

ix) Development network for development of bamboo as an industry in the state.

6.1 Action Plan for development of Bamboo resources:

A) Development of Natural Bamboo Forest:

i) Identify and demarcate the natural bamboo bearing areas.

ii) Increase natural bamboo bearing areas through aided natural regeneration.

iii) Improve communication network to access the existing bamboos for harvesting and transportation

b) Development of bamboo Plantation:

i) Promote bamboo cultivation in the community and private land by involving the joint forest Management Committee (JFMCs), village Development Board (VDBS) Village Council (VCs). 88.80%ofd the total Forest area belongs to the private / Community owned.

ii) Introduce commercially viable bamboo species for better economic return.

iii) Develop bamboo nurseries and distribution networks for adequate supply of high quality planting materials.

iv) Synchronizing bamboo plantation with the farming practices (Jhumming) for maximum interim benefit.

7. Regulation of Bamboo harvest and transportation

There is no organize cooperate body who surprise the bamboo harvesting. However, the villagers or the private communities cut the bamboos in their land sell in the market. There are some middle men who take advantage of this system, which requires check.

Bamboo is forest produce and it requires Transit Pass and payment royalty (Tax) on transportation. However this levying of royalty has been exempted for the time being to harvest and transport excess gregarious mulli bamboo (Melocana bambusoides) flowering.

The development of bamboo as an economy requires substantial infrastructure especially road communication and power to cut the cost extraction and maximize profit. It shall endeavor to initiate special infrastructure development for bamboo roads and strengthening the rural power to develop bamboo industries in the rural areas.

There is no ban on transportation of bamboo from the Nagaland to other States either by road or railways.

8. Protection from Forest Fire

Forest fire occurs almost every year during dry season – (March –April). It greatly reduces the bamboo productivity, specially in the natural bamboo bearing areas. Advantage will be taken the existing institution like JFMCs,VDBsand VCs to prevent forest fire . Awareness and enforcement of preventive measures is being done at the local level to prevent forest fire with active participation of these institutions.

9. Bamboo Trade

With the policy of reform in management, harvesting, utilization of natural bamboo resources and promoting plantation, it is expected to increase the volume of bamboo and its products. Trace in bamboo and bamboo products within and outside the State shall grow. The bamboo traders shall be organized into trade associations with linkage with bamboo exports to rationalize the bamboo trade practices.

The various dynamics and the location of activities such as collecting points, marketing points, auction points, etc is required to work out properly. A study will be undertaken with an aim to promoting the bamboo products and to ensure that the bamboo products of Nagaland become commercially viable with competitive price.

10. Development of bamboo as a Trade

The following broad areas are identified for promoting various bamboo based industries

a)Finished industrial bamboo products in the form of bamboo ply ,bamboo timber, flooring tiles ,shuttering, curtain making.

b) Semi finished products for production of chopsticks, toothpicks, skewers, incense sticks.

c) Bamboo crafts, handicrafts and art.

d) Bamboo charcoal and industrials bamboo charcoal filter filter products.

e) Bamboo food products –raw Bamboo shoot as well as finished bamboo shoot food products.

f) Bamboo medicine and alcohol beverages.

11. Task Force for Development of Bamboo

There are two task forces to implement the bamboo policy and function in the State for development of the bamboo sector:

1. Task force development of bamboo as resources headed by principal Secretary (Forest & Environment) GON and principal chief conservator of Forest is member Secretary, and related departments are members.

2. Task force for Development of bamboo as Enterprise headed by Principal Secretary (Industry & Commerce) GON and Director (Industry & Commerce) is member Secretary, and related departments are members.

12. The bamboo development policy comes under an apex Governing Body headed by

1. Chief Minister
2. Minister Forests & Environment
3. Minister Agriculture

4. Minister Horticulture
5. Minister Industry & Commerce
6. Minister Rural Development
7. Chief Secretary
8. Development Commissioner
9. Financial Commissioner
10. Principal Secretary Forest
11. Principal Secretary Agriculture
12. Principal Secretary Industry
13. Representative of the Concerned Ministry, GOI
14. Representative of Donnor
15. Representative of NEC
16. Representative of CBTC /UNIDO
17. Representative of TIFAC
18. Representative of NABARD
19. DGM SBI (LEAD BANK)
20. Agriculture production Commissioner: Member Secretary

Co-opted Members

1. Nagaland University
2. SASARD
3. ICAR
4. SARS
5. RFRI, Jorhat
6. RRL, Jorhat

Bamboo for Economic Prosperity and Ecological Security with Special Reference to North-East India

Shri Kamesh Salam

Director, CBTC

and

Member, Apex Committee on National Bamboo Mission, Ministry of Agriculture and Co op, Govt. of India

"……….The programme envisages the cultivation of bamboo over two million hectares and promotion of technology and networking for enhancing trade. Economic and social benefits from these activities will lead to creation of 8.6 million jobs and market opportunities worth over Rs. 6500 Crore with investment of Rs. 2,600 Crore. This will be useful for additional development of the North Eastern Region…………."

- Excerpt from the speech of Dr. A.P.J. Abdul Kalam, former President of India, on the eve of country's 56th Republic Day address to the nation highlighting the importance given by him to National Bamboo Mission.

Commonly known as "Poor man's timber", bamboo played a significant role in human society since time immemorial and today it contributes to the subsistence needs of over a billion people worldwide. It has been traditionally used as fuel, food, rural housing and shelter, fencing, tools and various other purposes. In modern days, it is being used as industrial raw materials for pulp and paper, construction and engineering materials, panel products etc. Bamboo, which can be grown easily, much faster in growth than any known tree, eco-friendly and adaptable to various locality factors, is now becoming the most promising wood substitute. It has more than 1500 documents applications, ranging from medicine to nutrition and from toys to aircraft.

The north eastern region, a landmass of eight states, spread over an area of 262179 Km^2 representing around 8% of the total geographical area of the country with a population of about 39.04 million is a region which is abundant in bamboo resources. The region houses about two-thirds of the bamboo resources of the country spreading over an area of about 3.10 million hectares where 89 species of bamboos are available. This invaluable gift of nature to the region is integral to life and culture of all the ethnic groups of North Eastern India. Its multipurpose uses have made it an indispensable resource for the rural people. Being interwoven with daily life of ethnic groups, it has been incorporated in their cultural and social occasions also. Efforts backed by a surge in people oriented policies by the State Governments of the Region have begun to bear fruits. Bamboo being principal natural resources, the people of the region in particular will be better served by this God given bounty, if we all get down to the task of economic taming of this resource. A look at the facts reveal that sustainable and economic utilization of bamboo will throw open a plethora of opportunities, especially for the rural poor. Continued technological advancement and research have put bamboo into more and more uses and as raw materials of several industries. A priority requirement for harnessing its economic potential would be to draw up a well coordinated multilateral approach. The raw stock of bamboo in the region is conservatively valued at Rs. 5,000 crores. Even with a modest target of two-fold value addition to the stock through suitable methodologies, an annual turnover of approximately Rs. 10,000 Crore can easily be generated in the Region.

The first bamboo based panel was developed in China in the 1940s. Since then, over 30 panel products have been developed. For instance in China, over 10,00,000 cubic meters of panels of various types are produced annually in some 200 Mills, whereas in India, industrial scale production of panels is confined to bamboo mat board with about 2000 cubic metres board produced by just seven mills. There are also enormous environmental and socio-economic implications and benefits. For example in India, it is estimated that if Bamboo mat boards replace 1/4th of plywood, it can save 4,00,000 cubic metres of round wood, thereby preventing the disturbance to 30,000 hectares of forests per year. Further more, it will generate 16.7 million workdays of employment per year.

A large section of the society depends on bamboo for livelihood. Although the people of rural area cultivate a few species of bamboos in homestead land to cater to their domestic needs, most of the tribal people depend on the wild bamboos occurring in forests. Large resource of bamboo in the Region is mainly utilized for domestic, handicrafts and in paper industries. Many of the species which are available in the region have great farming potential. Apart from wastelands and degraded lands, bamboo can be grown in marginal farm and underutilized lands. There is also great scope of increasing the yield and productivity of the bamboo bearing forest areas through scientific management and by introducing quality planting stock of selected commercially important species. Farming is obviously related to utility, gap between demand and supply of raw materials, economic returns etc. Therefore, setting up of industries for high value bamboo products, which require bamboo of uniform age, dimensions, quality and colour will enable the utilization of the resources in bulk and in turn generate further opportunity for farming.

The details of forest cover of the tribal district of N.E. Region and that of all India in the year 2003 are as under:

Name of the State	Total Geographical Area in Sq. Km	No. of Tribal district	Geographical area of tribal /Hill district (Sq.Km)	Area of Forest cover	Percentage of Forest cover (Sq. Km)
Arunachal Pradesh	83743	13	8374	68019	81.22
Assam (1)	78438	16	50137	12052	24.04
Assam (2)*		3	19153	13158	68.70
Manipur	22327	9	22327	17219	77.12
Meghalaya	22429	7	22429	16839	75.08
Mizoram	21081	8	21081	18430	87.42
Nagaland	16579	8	16579	13609	82.09
Sikkim	7096	4	7096	3262	45.97
Tripura	10486	3	10486	8093	77.18
NER Total:	262179	71	253031	170681	67.45
All India	3287263	187	1103463	407298	36.91

*Data on 3 hill districts of Assam namely Karbi Anglong, North Cachar Hills and Nagaon covering an area of 19153 Sq.Km.

Mass plantation of bamboos in forest areas and private land will go a long way in mitigating the situation of the depleting forest cover of the country in general and for the North Eastern Region in particular. Bamboo can conserve soil and water in catchments areas, minimize soil erosion and control flash floods in the valleys and plains. It is most effective in controlling landslides and can protect road sides, riverbanks, canal banks and dam sites. In recent time, bamboo is seen as the '*Wonder Plant'* of 21st Century and as substitute of wood, it can mitigate the pressure on natural forests and contribute to conservation of biodiversity. Bamboo is the best plant for carbon sequestration to retard pace of climate change.

The Government of India has launched the "*National Bamboo Mission*", a 100% centrally sponsored scheme through the Department of Agriculture and Co-operation under the Ministry of Agriculture, to promote holistic growth of the bamboo sector through area based regionally differentiated strategies. Similarly, the North Eastern Regional Bamboo Mission (NERBaM) under North Eastern Council, has also taken up implementation of a comprehensive Short Term, Medium Term and Long Term Plan for development of Bamboo for poverty alleviation and saving forests, specially for North Eastern Region.

Interest in bamboo increasing the world over

Many nutritious and active minerals such as vitamins, amino acids, flavine, phenolic acid, polysaccharide, trace elements and steroid can be extracted from bamboo culm, shoot and leaf. And all these have anti-oxidation, anti-aging, anti-bacterial and anti-viral functions. These are valuable in health care, and can be processed into beverage, medicines, pesticides, or other household items like toothpaste, soaps etc. At present, quite a few products have found their way into markets:

- Bamboo leaf contains 2% to 5% flavine and phenolic compound that have the power to remove active oxy-free-radicals, stopping sub-nitrification and abating blood fat. Flavine beverage and beer have been widely accepted particularly in east Asian countries like China, Korea and Japan mainly because of their value in health care.
- Some materials extracted from bamboo can be used in fresh flavour preservation or food storage application.
- Some additives obtained from bamboo are used in food such as bamboo juice, beverage, bamboo flavoured rice etc.
- Bamboo shoot is one kind of ideal vegetables being free in pollution, low in fat, high in edible fiber and rich in mineral. It is cold in properties, functions well in removing sputum, enhance digestion, relieve toxicity, improves diuresis and often used for healing swollen state of tissues or edema and abdominal disease in which watery fluid collects in cavities or body tissues called ascites. Shoot also contains saccharine which can resist against little white mouse tumour and tumour – 180 and also has anti aging elements.

For all these chemical properties of bamboo and its capacity to set right various global problems such as the pollution of air and water resources, the aging of population and increasing prevalence of old age diseases have aroused unprecedented interest in bamboo the world over. Of late, research have shown that *bamboo charcoal* is one of the base material for human health right from water treatment to its uses as shield from electro magnetic radiation. With the increasing demand for returning to the nature, there is an increasing preference for products processed or extracted from plants. With its high growth rate, wide range of applications and high renewability, the bamboo resources have taken significant position in the 21st century.

Considering all the above aspects, the North-East region of India may be considered as the powerhouse of bamboo based value added products and if harnessed properly, bamboo may act as the engine of growth especially for the rural poor.

Climate Change Mitigation Opportunities in Bamboo and Bamboo applications

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ABSTRACT

Financial mechanisms have evolved to mitigate the adverse impacts of Climate Change in recent past. These mechanisms are project based and allowance based. Under the compliance structure of international carbon market, Clean Development Mechanism of the Kyoto Protocol is attractive option for overcoming financial and other barriers of Climate Change mitigation project implementation in the developing countries. A comparatively small market is also evolving under the voluntary structure driven by the corporate social responsibility to offset emission footprints of activities, products and services of individuals and companies.

Having large Bamboo resource and potential of enhancing its cultivation and utilization, India has promising opportunities for Climate Change mitigation. These include- Sequestration in Bamboo plantation and energy generation from Bamboo biomass, gas and Charcoal.

Eligibility of these options has been assessed in the paper under the CDM and VCM (Voluntary carbon market) from the methodological aspects.

Based on the assumptions from past studies it was estimated that the Bamboo and Bamboo application can generate 18 to 26 carbon credits per ha per year, offering the revenue of Rs. 5,578 to 10,078 per ha per year and even more in certain cases.

The economic models for the same have been discussed in the paper.

Key words: Bamboo, Gasification, Charcoal, CDM, VCM, Emission Reductions, Climate Change.

International Carbon Market: Structure and Function

In response to alarming evidences of global Climate Change, world governments reached to a consensus to reduce their green house gas emissions. The response materialized in form of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. In the year 1997, Kyoto Protocol (KP) was adopted under the framework convention on Climate Change as a legally binding instrument for the parties who ratify it. The protocol set individual targets for developed country parties listed in the Annex I of the UNFCCC to reduce their GHG emissions collectively by 5% of the base year emissions between the commitment period of 2008-2012. The protocol gives flexibility to these parties to reduce their emissions *ex-situ* also, on comparatively lower costs. A developed country party can reduce its emissions by assisting implementing of emission reduction/ net removal projects in developing nations through the procedures set for Clean Development Mechanism (CDM), a project based financial mechanism of flexibility provided by the Kyoto Protocol. Climate Change mitigation projects typically face certain financial, technological, social and other barriers to their implementation in the developing nations and thus require inflow of additional financial benefits from the sale of carbon credits to overcome these barriers. Other financial mechanisms of flexibility provided by Kyoto Protocol include Joint Implementation (JI) and Emission Trade (ET). The carbon credits generated by these three mechanisms *i.e.* Certified Emission Reductions (CERs) from CDM, Emission Reduction Units (ERUs) from JI and Assigned Amount Units (AAUs) from ET collectively shape the 'Kyoto Type' Compliance Market. Compliance/ Regulatory Market is named so because the carbon credits under this structure are used to meet compliance of governments/ private bodies under certain international (like KP) or national/ sub-national regulations. 'Non Kyoto Type' compliance market includes the national or sub-national legislations that mandate emitters achieving emission reduction.

In recent years a new structure has emerged as Voluntary Carbon Market (VCM). The aim of voluntary carbon market is to reduce or completely offset the emission footprints of activities, products and services of a company or organization. Companies disclose their carbon footprints and offset emissions by purchasing Verified/Voluntary Emission Reductions (VERs) to achieve Carbon Neutrality (CN). Offset market is chiefly driven by the sense of Corporate Social Responsibility (CSR). Making events or individuals carbon neutral is an emergent venture these days. Events like conferences and seminars, summits etc. are being made carbon neutral or 'green' by the sale and purchase of VERs. The VCM projects are developed and implemented in developing nations based on certain standards approved by the international bodies like VCS (Voluntary Carbon Standards), CCBA

(Climate Community and Biodiversity Alliance) and VERplus etc. There are a number of whole-sellers, retailers and intermediaries like brokers and aggregators are also involved in addition to the credit generator (end seller) and credit user (end buyer).

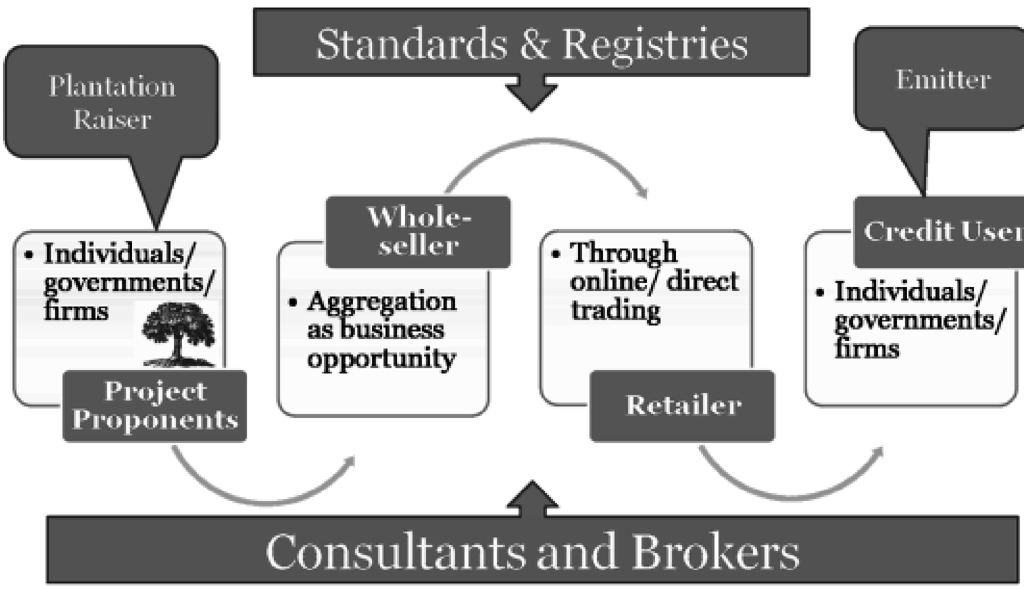

Figure 1: Structure of the voluntary carbon market, *Source: Author*

Bamboo Resource of India

India possesses one of the largest Bamboo resources in the world spread over an area of 10.03 million ha (Ganapathy, 1997). Bamboos are perennial grasses of extremely gregarious habits, in which woody aboveground stems (called culms) arise from woody underground stem (called rhizomes). Full size culms are produced after 4-12 years depending on the species and conditions. Most Bamboos have hollow culms. While fixing the felling cycle the age of culms is an important factor to be considered. It varies from 4 to 14 years. General tendency is to fix a 3 year felling cycle. A rotation cycle of three years has been used for assessments throughout this paper.

Climate Change Mitigation Opportunities

There exist a number of Climate Change mitigation options based on Bamboo. Climate Change mitigation opportunities from Bamboo sector can be categorized into:

1. Bamboo plantations

2. Bamboo as energy source
3. Bamboo products

Bamboo plantations

Bamboo plantations serve as carbon stock due to their sink action. Carbon sequestration in Bamboo plantations can give carbon credit benefits under voluntary structure of carbon market. Bamboo plantations are eligible under 'revegetation' category of Voluntary Carbon Standards 2007. Co- benefits of these plantations can lead to accruals of benefits under 'Climate Community and Biodiversity Alliance's Standards. As of now, there is no methodology approved under CDM and VCM for assessing baseline and monitoring of net removals by sinks from such plantation. Eligibility of Bamboo plantations under A/R CDM project activities was unclear as Bamboo does not fall in definition of tree. In its 19th meeting the A/R Working group of UNFCCC agreed that, the environmental integrity of the CDM activities is not affected by considering bamboos as being equivalent to trees in the context of A/R CDM project activities. Bamboos may be treated in the same way as trees in the context of A/R CDM project activities.

In Chittagong Hills Tracts in Bangladesh, figures of 1,200 to 3,600 culms per acre (3,000 to 9,000 per hectare), and in another stand an average of 6,000 culms per acre (15,000 per hectare), have been reported on a three-year rotation (Ahmed, 1954). Experimental weight determinations of *Melocanna bambusoides* in this region indicate that 1,000 culms (entire) weighed 4.4 tons (4.5 metric tons) green or 2.5 tons (2.6 metric tons) air dry. This would mean air-dry weights of 3 to 9 tons (3 to 9.5 metric tons) and 15 tons per acre (38 metric tons per hectare) for the three year rotation, on the basis of the above-mentioned counts (Huberman, 1959). Assuming 50% carbon content, we arrive at a sequestration level of 70 t CO_2/ha/rotation of three years. Net Removals of carbon dioxide from atmosphere would be around 35 t CO_2/ha/rotation, assuming leakage and project activity emissions to be 10% and buffer credits (non tradable account under VCS 2007) to be 40% of removals. This estimation is valid for degraded and degrading lands only. Conservatively taking VER price at the rate of \$4/tCO_2, Bamboo plantations in India can generate revenue of 140 US\$/ha/rotation corresponding to Rs. 5,600 per hectare per rotation of three years.

Bamboo as energy source

Bamboo can be used as a source of bio-energy. Bio-energy is considered to be GHG neutral and its use poses hardly any net radiative forcing to the atmosphere. Given the large amounts of biomass that Bamboo can produce it provides a very interesting source of bio-energy in the tropics (Fielden, 1999). When grown as an agricultural crop the biomass produced by Bamboo can be considered as a renewable source of energy. Bamboo as an energy source can be utilized by:

1. Direct biomass burning

Like any other biomass Bamboo can also be directly burnt for heat and/or power generation.

a. Thermal application by direct burning: Bamboo biomass can replace coal in thermal applications. Considering Net Calorific Value of Bamboo to be 16 GJ/t dry matter (Ganesh, 2003) and CO_2 emission factor of sub bituminous coal to be 96.1 t CO2/TJ (IPCC, 2006), and 75% thermal conversion efficiency, emission reduction of 44 t CO_2/ ha/rotation can be arrived. This would generate carbon credit revenue of around 440 Euros/ha/rotation corresponding to Rs. 24,500. Such applications are eligible under CDM and VCM both. Small scale CDM methodology 'AMS I.E- Switch from Non-Renewable Biomass for Thermal Applications by the User' can be used. This is a potential activity under programmatic CDM also.

b. Power generation by direct burning: Biomass from each hectare of Bamboo plantation contains 608 GJ energy at each rotation (calculated based on above assumptions). This will generate 56 MWh power assuming 33% efficiency of power generation. Taking Grid Emission Factor (combined margin) for India 0.85 t CO_2/ MWh (CEA, 2007), Emission Reductions come out to be 47 t CO_2 per rotation. This would generate carbon credit revenue of around 474 Euros *i.e.* Rs. 26,500 from each ha of plantation harvested for power generation over a rotation of three years. Approved CDM methodologies 'AM0042- Grid-connected electricity generation using biomass from newly developed dedicated plantations', 'ACM 0006- Consolidated methodology for grid-connected electricity generation from biomass residues' and 'AMS ID- Grid connected renewable electricity generation' would be applicable for such project activities.

2. Bamboo Gasification

Bamboo Gasification is one of the manufacturing methods which make Bamboo heated to form products under the condition of isolating air or in limited supply of air. The methods can be categorized as below:

a. Bamboo carbonization: Bamboo is heated in brick kilns or mechanical kilns with little air by means of the beat energy generated by burning firewood to pyrolyze Bamboo and produce Bamboo Charcoal.

b. Bamboo destructive distillation: Bamboo is heated in a pyrolyzing kettle isolating air to produce Bamboo Charcoal and Bamboo vinegar and so on.

c. Bamboo activated carbon: the Bamboo material is heated in a brick kiln and activated kiln to get Bamboo activated carbon.

d. Bamboo Gasification: Bamboo or Bamboo residues resulting from the processing are heated to get Bamboo gas in a Gasification kiln (Huang 1996).

There are three groups of pyrolysis products: they are solid (Bamboo Charcoal), liquid (Bamboo vinegar) and gas (Bamboo gas).

The contents of products of oven dried Bamboo pyrolyzed at the terminal temperature of 500°C are as given below: (Shenxue, 2004)

Bamboo Charcoal	30%
Bamboo vinegar	51%
Bamboo gas	18%
Loss	1%

Bamboo gas can be used for heat and power

a. Bamboo gas for heat: Based on above assumption it can be calculated that 7.6 t Bamboo gas can be produced from 38 tonnes of dry Bamboo biomass gasified. Taking density of producer gas 1 kg/ nm^3 it would be around 7,600 Nm^3 gas. NCV of Bamboo gas is taken to be 4.52 MJ/nm^3 (Ganesh, 2003). Total energy content of the gas produced thus comes out to be around 34,000 MJ. Taking thermal efficiency of gas combustion to be 85% and emission factor of coal 96.1 t CO_2/TJ, Emission Reductions come out to be about 2.8 tonnes CO_2/ha/rotation offering revenue of 28 Euros or ~Rs. 1,500. This is a potential activity under programmatic CDM.

b. Bamboo gas for power generation: At 45% power generation efficiency, 4 MWh power can be generated from 7,600 nm^3 Bamboo gas derived from each rotation. This may generate 3 carbon credits and would create carbon credit revenue of 30 Euros or Rs. 1,900.

3. Bamboo Charcoal

Bamboo Charcoal is a product of Bamboo pyrolysis. It has a number of uses. Bamboo Charcoal can be used to replace coal for thermal applications. 38 tonnes of dry Bamboo biomass pyrolysed would generate 9.5 t Charcoal (conservatively taking Charcoal yield

25%). NCV of Bamboo Charcoal is taken to be 25,000 MJ/t (Ganesh, 2003). Replacing coal by this Charcoal would generate 17 carbon credits per rotation creating a value of 170 Euros (Rs. 9,500). IPCC default values have been used for estimations.

Harvested Bamboo Products

Bamboo can be used for almost all parts of houses, including posts, roofs, walls, floors, beams, and fences. People also use Bamboo to produce mats, baskets, tools, handles, hats, traditional toys, musical instruments and furniture.

Thus Bamboo can be used as a replacement of building materials, and might reduce emissions associated with the production of baseline building material (*e.g.* concrete). Other products like furniture and household instruments/ composites can replace conventional energy intensive products. These options theoretically fall under the scope of Climate Change mitigation, but being complexities in monitoring and unavailability of methodology for estimation of Emission Reductions, it would be difficult to actually create carbon credit revenue out of these products. Studies are required to benchmark the baseline and project activity emissions in this sector.

Conclusion

Bamboo can be used for Climate Change mitigation in India. Options and potentials on based on above analysis for the same have been listed as below:

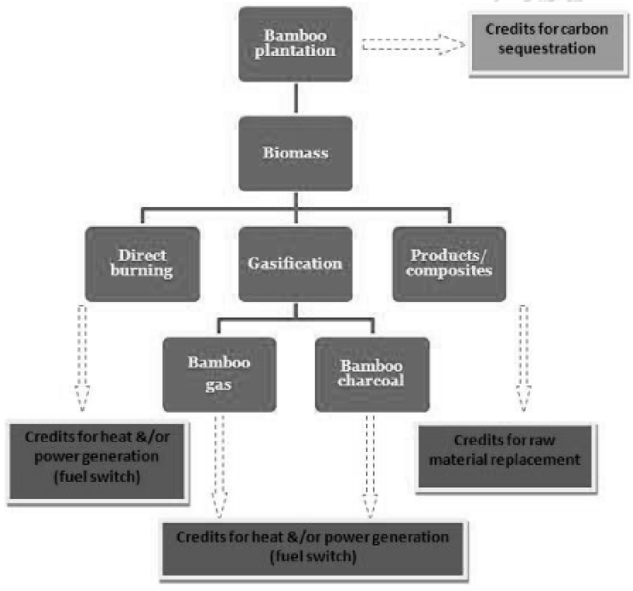

Figure 2: Climate Change mitigation option from Bamboo

The matrix below gives results of theoretical assessment of carbon credit potential in bamboo sector. It should be noted that these are approximate values obtained from calculations based on literature and observation; actual credit/ revenue generation will depend on specific project conditions and may vary in time and space. A project activity should be additional over and above the baseline for obtaining CC benefits.

Table 1: Mitigation Potential

S. No.	Measure	ER/ha/year	CC Revenue Rs / ha / year
Option 1	Plantation + Power generation-direct biomass burning	26	10,700
Option 2	Plantation + Power generation-Gasification + Charcoal	18	5,600
Option 3	Plantation + Thermal use- direct biomass burning	26	10,000
Option 4	Plantation + Thermal use- Gasification + Charcoal	18	5,500

Above matrix shows that there exists an annual abatement potential of 18 to 26 tCO_2 by simple and feasible options that may generate revenue of Rs. 5,500 to 10,700.

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Economic of Bamboo Production in Maharashtra State

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Abstract

Bamboo has the potential of providing ecological and livelihood security to millions of poor in the world. For taping the vast economic potential for bamboo, it has become necessary to study the production of bamboo on forest as well as non-forest lands. Hence, the study attempts to estimate the costs and returns from bamboo production in Maharastra State and evaluate the economic feasibility of bamboo production. Eight forest circles are available in the state, out of that Nagpur circle of Maharastra State was selected purposively based on availability of input-output data for complete crop cycle of Bamboo production for 35 years. In the present study for the selection of sample, multi-stage sampling design was adopted. The data were collected by cost accounting method from seven forest ranges in four divisions of Nagpur forest circle. The data pertains to the year 2004-2005. The data were analysed by employing simple statistical tools for testing economic viability. The sensitivity analysis was also performed by simulating situations in respect of costs and returns assuming (i) 40 per cent increase in cost with constant returns, (ii) 30 percent decrease in returns with constant cost and (iii) 40 per cent increase in cost and 30 per cent decrease in benefits.

The study revealed that at constant prices, the per hectare cost of bamboo production worked out to be Rs.70063, while gross and net returns were estimated at Rs. 10,57347 and Rs. 987283 respectively. The per hectare production of bamboo was Rs. 2, 22,222. The benefit- cost (B.C) ratio, net present value (NPV), profitability index (PI), pay back period (PBP) and internal rate of return (IRR) at 12 per cent discount rate was 5.77, Rs. 102275,

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9.49, 9 years and 34.88 percent, respectively. While at 15 percent discount rate was 5.77, Rs. 102275, 9.49, 9 years and 34.88 percent, respectively. This indicated that, all the parameters of economic feasibility test turned out to be favourable, thereby justifying investment in bamboo production which was found to be economically a viable production.

This sensitivity analysis revealed that, at 40 per cent increase in cost with 12 per cent discount rate PI was more sensitive followed by B-C ratio and NPV. However, at 15 percent discount rate B-C ratio was more sensitive, followed by PI and NPV. IRR was less sensitive to increase in cost under the situation of 30 per cent decrease in benefit a 12 per cent discount rate. NPV was more volatile, followed by PI and B-C ratio. Erosion in value of IRR was more as compared to increase in cost. At 40 per cent increase in cost and 30 per cent decrease in benefit, sensitive of NPV was higher at both the discount rate, followed by B-C ratio and PI. IRR value fell by 28.97 per cent which was higher as compared to the other two situations. All the indicators favoured bamboo production and substantiate that even under cost overrun decrease in benefits simultaneously, investment

made in bamboo production is economically viable even under hypothetically changed or simulated situation. Hence, bamboo production need to be encouraged on degraded Government forest land, community owned wasteland and private land also. This will solve the problem of ever increasing demand for bamboo by different sectors. These will also indirect help in soil and water conservation, ecological and environmental balance.

Introduction

Bamboo is a versatile multipurpose forest produce which plays a vital role in the world's industrial and domestics economics. It has been used, especially by the natural people, for their shelter and for every day utilities. It is described as the "word of the poor", green gold of the forest and friend of the people. Bamboo grows over wide areas of Africa, Asia, the Caribbean and Latin America. Being closely interwoven with the life of the people in several ways, bamboo occupies an important place in upliftment of rural economy. In many parts of the world it is used as a food, fodder, the primary construction material and for making great variety of useful objects from kitchen tools, to appear to dinnerware. It can also be woven into baskets and mats. To make such products, bulks of the supplies of bamboo are derived from the forest freely harvested for trade and economic gains.

However, with population increase and over exploitation, it is now being realized, that the bamboo stocks in the forests are getting depleted at a faster rate than expected, reaching the levels of extinction of certain species in some areas. The plant is deteriorating all around as affecting the lives of rural people who depend on bamboo for their earning.

Now, it is being realized that development based on bamboo is an effective way to improve the livelihoods of rural poor people in bamboo growing areas because they generally have adequate access to these crops and bamboo can be grown or harvested in forest margins or agro – forestry situation requiring a modest capital investment to generate farm income. With these ideas, the present work has been undertaken to study the economics of bamboo production with the following specific objectives.

1. To workout costs and return from bamboo production in Nagpur forest circle.
2. To evaluate economic financial viability of bamboo production.

Methodology

In the present study for the selection of sample, multistage samplings design was adopted. The first unit of sampling was the selection of forest circle, the secondly forest division, the third unit was selection of forest ranges and final or ultimate unit of sample was the bamboo production coups. In the state of Maharastra in all there are eight forest circles. Of these, Nagpur forest circle was selected purposively based on availability input-output data for complete crop cycle of plantation for the 35 years right from the clearing of field to clear felling. All the four divisions (Nagpur Bhandra, Gondia, and Wardha in Nagpur forest circle were selected for the present study.

The input output data of bamboo were maintained by the cost accounting method in the concerned forest offices, the same was made use of in this study.

For an analysis of the data simple statistical tools viz. means, frequencies ratio, percentage etc. were employed to arrive at meaningful conclusion.

Economic Evaluation of Investment of Bamboo

To test economic financial viability of bamboo production, project evolution techniques were used, which comprised Net present value (NPV), Pay back period (PBP), Benefit cost ratio (BCR), Profitability index (PI) and Internal rate of return (IRR). The definitions of these parameters / indicators are given below.

Net Present value

The discount rate/compound rate which reflects the price of the investment funds is used to arrive at costs and returns to a common point of time. These costs are subtracted from returns to get the net present value of the project. It can be computed as:

$$\text{Net Present value} = \sum_{t=1}^{T} \frac{Rt-CT}{(1+i)^t}$$

Where,

Rt = return in period 't',

Ct = cost in period 't'

i = discount/compound rate

T = project life

The decision criteria are to check the profitability,

If NPV>0, investment is worthwhile, NPV<0, investment is not worthwhile

NPV=0, indifference case.

Pay back period

It is the number of years an investment project takes to recover its cost from its returns.

Symbolically, the pay back period equals t*, where t* is the lowest value of 't' for which the following inequality holds.

$$\sum_{t=0}^{t^*} Ct < \sum_{t=0}^{t^*} Rt$$

Benefit cost ratio

It is the ratio of the discounted value of all cash inflows to the discounted value of cash outflows during the life of the project. It can be computed as:

$$BCR = \sum_{t=0}^{T} \frac{Rt}{(1+i)t} \left(\sum_{t=0}^{T} \frac{Ct}{(1+i)^t}\right)^{-1}$$

The decision criteria are uses for profitability

If, B-C> 1, investment is worthwhile, B-C< 1, investment is not worthwhile

B-C = 1, indifference case.

Profitability index

It is a ratio of net present value of the project to the total capital expenditure.

$$PI= \frac{NPV}{Co} \quad \frac{1}{Co} \quad \sum_{t=0}^{T} \quad \frac{Rt\text{-}Ct}{(1+i)^{t}}$$

Where,

Co - Initial capital investment

Internal rate of return

The internal rate of return (r) is that discounted rate at which the NPV is zero. Accordingly the derived discount rate (IRR-r) is compared with the price of the investment funds to know the worthiness of the project.

$$IRR= \sum_{t=0}^{T} \frac{Rt\text{-}Ct}{(1+r)^{t}} = 0$$

Solve this equation to find the value of IRR-r for used the profitability.

If, $r>i$, investment is worthwhile

$r<i$, investment is not worthwhile

$r = i$, indifference case

To bring parity between investment cost and benefits, the input outputs were evaluated at 2004-05 prices as accordingly cash out flows. (cost) and cash inflows (returns) series were generated foe discounting cash inflow and outflow streams two rates of discounting i.e. @ 12 and 15 per cent were considered farmer was deposit interest rate accured for owned saving or opportunity cost of equity or capital. While, latter was lending rate charged by financial institutions.

Sensitivities Analysis (treatment of Uncertainity)

In the present study, in order to test the financial economic efficiency of the investment in bamboo plantation under different adverse situations viz. cost over run, yield retention price fluctions etc. based on co-efficient of variation (CV) the sensitivity tests were carried out for simulated situations viz. i) at 40% increase costs with constant returns from plantation ii) at 30% decreased benefits with constant costs of plantation iii) at 40% increased costs and 30% decreased benefits from plantation. For discounting cash in flow and outflow streams two rates i.e. 12 and 15% were considered.

Results and Discussion

Cost of production (complete crop cycle)

The per hectare cost of production of bamboo at constant prices is presented in Table-1.

Table – 1: Average per hectare cost of bamboo production in Nagpur Circle

(Figures in Rs.)

	Item	**Forest Division**				
		Nagpur	**Bhandara**	**Gondia**	**Wardha**	**Overall**
	Cost A:					
a.	Human Labour	73832.63 (51.96)	66862.12 (49.98)	73923.47 (51.75)	60005.42 (47.80)	69469.42 (50.76)
b.	Contingencies	724.58 (0.51)	693.67 (0.52)	681.08 (0.48)	633.73 (0.50)	687.54 (0.50)
c.	Labour Welfare @ 4%	966.11 (0.68)	924.88 (0.69)	908.16 (0.64)	844.98 (0.67)	916.74 (0.67)
d.	Planting material	865.00 (0.60)	865.00 (0.65)	865.00 (0.61)	865.00 (0.69)	865.00 (0.63)
e.	Manure's and fertilizers	255.00 (0.18)	255.00 (0.19)	255.00 (0.18)	255.00 (0.20)	255.00 (0.19)
f.	Plant protection	135.00 (0.10)	135.00 (0.10)	135.00 (0.10)	135.00 (0.11)	135.00 (0.10)
g.	Transport of planting material, fertilizers and pesticides	110.0 (0.08)	110.0 (0.08)	110.0 (0.08)	110.0 (0.10)	110.0 (0.08)
h.	Depreciation	555.00 (0.39)	555.00 (0.41)	555.00 (0.40)	555.00 (0.44)	555.00 (0.41)

	Item	Forest Division				
		Nagpur	Bhandara	Gondia	Wardha	Overall
i.	Interest on working capital	6195.47 (4.36)	5632.06 (4.21)	6114.61 (4.34)	5072.33 (4.04)	5839.49 (4.27)
	Total Cost (A)	**83638.79 (58.86)**	**76032.73 (56.83)**	**82547.32 (58.58)**	**68476.46 (54.55)**	**78833.19 (57.61)**
	Cost B:					
a.	Rental value of land	50400.00 (35.47)	50400.00 (37.67)	50400.00 (35.77)	50400.00 (40.15)	50400.00 (36.83)
b.	Interest on fixed capital	370.00 (0.26)	370.00 (0.28)	370.00 (0.26)	370.00 (0.29)	370.00 (0.27)
	Total cost (B)	**50770.00 (35.73)**	**50770.00 (37.95)**	**50770.00 (36.03)**	**50770.00 (40.44)**	**50770.00 (37.10)**
	Cost C					
a.	Supervision charges	7688.83 (5.41)	6984.67 (5.22)	7587.77 (5.29)	6284.91 (5.01)	7243.87 (5.29)
	Total C	**7688.83 (5.41)**	**6987.57 (5.22)**	**7587.77 (5.39)**	**6284.91 (5.01)**	**7243.87 (5.29)**
	Grand Total (A+B+C)	**142097.62 (100.00)**	**133787.30 (100.00)**	**140905.03 (100.00)**	**125531.37 (100.00)**	**136847.06 (100.00)**

(Figures in parentheses are the percentages to the total)

The Table-1 observed that, at an overall level, per hectare total cost of production of bamboo at constant prices was worked out to be Rs. 136847.06. In this share of conventional cost components viz; cost 'A','B' and 'C' was 57.61, 31.10 and 5.29 per cent, respectively. This indicated that, contribution of direct and indirect cost toward the total cost of bamboo production was approximately equal. However, indirect costs had an edge over direct cost.

An interdivisional comparison of the per hectare cost was the highest in Nagpur division (Rs. 142097.62) followed by Gondia division (Rs. 140905.03), Bhandara (Rs. 133787.30) and Wardha division (Rs. 125531.37), respectively. This showed that higher cost of production was incurred in Nagpur Forest division. The higher cost in this division attributed to higher wage rates as per minimum wages act policy of the State Government. Besides this higher prices of inputs in Nagpur division as compared to other divisions (Pathak P.S. – 1989, Chaturvedi A. N.- 1988).

Forgoing analysis lead to concluded that, bamboo production under public sector is a labour intensive enterprise, without much emphasis on critical inputs.

Economics of Bamboo Production

The per hectare felling wise average yield and returns from bamboo at constant prices are presented in Table – 2.

Table – 2: Per hectare average yield and returns from bamboo in Nagpur circle

Age of felling (years)	Forest division									
	Nagpur		Bhandara		Gondia		Wardha		Overall	
	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)
9th year (First felling)	9200 (3.70)	413.08 (3.70)	10800 (3.70)	47952 (3.70)	12400 (3.70)	54560 (3.70)	7200 (3.70)	3060 (3.70)	9900 (3.70)	43605 (3.70)
13th year (Second felling)	28316 (11.40)	127139 (11.40)	31984 (10.97)	142009 (10.97)	36814 (11.00)	161982 (11.00)	21136 (10.88)	89828 (10.88)	29563 (11.06)	130240 (11.06)
17th year (Third felling)	32822 (13.21)	147371 (13.21)	36516 (12.52)	162131 (12.52)	39368 (11.76)	173219 (11.76)	25566 (13.15)	108656 (13.15)	33568 (12.56)	147844 (12.56)
21st year (Fourth felling)	35548 (14.32)	159611 (14.32)	39750 (13.63)	176490 (13.63)	47636 (14.22)	209598 (14.22)	28748 (14.79)	122179 (14.79)	37921 (14.19)	166970 (14.19)
25th year (Fifth felling)	38436 (15.47)	172578 (15.47)	44810 (15.37)	198956 (15.37)	52348 (15.64)	230331 (15.64)	30344 (15.61)	128962 (15.61)	41485 (15.52)	182707 (15.52)

Age of felling (years)	Forest division									
	Nagpur		Bhandara		Gondia		Wardha		Overall	
	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)	Quantity	Total Amt. (Rs.)
29th year (Sixth felling)	41958 (16.89)	188391 (16.89)	49976 (17.14)	221893 (14.17)	56688 (16.93)	249427 (16.93)	34510 (17.75)	146668 (17.75)	45783 (17.13)	201595 (17.13)
35th year (Final felling)	62120 (25.01)	278919 (25.01)	77764 (26.67)	345272 (26.67)	89546 (26.75)	394002 (26.75)	46896 (24.12)	199308 (24.12)	69082 (25.84)	304375 (25.84)
Total	248400 (100.00)	1115317 (100.00)	291600 (100.00)	1294703 (100.00)	334800 (100.00)	1473119 (100.00)	194400 (100.00)	826101 (100.00)	167302 (100.00)	1177336 (100.00)
Total Cost	142097.62		133787.30		140905.03		125531.37		136847.06	
Net Returns	973219.38		1166915.70		1332214.97		700668.63		1040488.94	
BC Ratio	7.85		9.68		10.45		5.58		7.60	

(Figures in parenthesis are percentages to the total)

The Table-2 reveals that, at an overall level, the per hectare production of bamboo was 2, 67,302. In monetary terms the per hectare gross returns from bamboo for complete crop cycle of 35 year were worked out to be Rs. 11,77,336. A felling wise production of bamboo showed that, there was increasing trend at every successive felling in all the forest divisions. At an overall level, production of bamboo increased from 9,900 (3.70 per cent) in the first felling at an age of a 9 year to 69,082 (25.84 per cent) in the seventh felling at an age of 35 year.

An interdivisional comparison of productivity/yield of bamboo revealed that, the per hectare highest yield level was recorded in Gondia Forest Division (3, 34,800) and it was the lowest in Wardha division (1, 94,400). It is also observed that, the per hectare highest gross returns were fetched in Gondia division (Rs. 14, 73,119) followed by Bhandara (Rs. 12, 94,703), Nagpur (11, 15,317) and Wardha (Rs. 8, 26,201), respectively. Thus, it is concluded that, higher gross returns in Gondia division were realized on account of higher productivity level attained in this division. While, reverse situation was noticed in Wardha division.

It is also seen that, at an overall level of per hectare total cost of bamboo production in Nagpur Forest circle was worked out to be Rs. 136847.06. As against this, the per hectare gross returns and net returns fetched through sale of bamboo were Rs. 177336.00, Rs. 1040488.94, respectively. This implied that, bamboo production enterprises were economically profitable proposition.

Further, division-wise per hectare total cost of production revealed that, the highest cost was incurred in Nagpur division (Rs.142097.62) followed by Gondia division (Rs. 140905.03), Bhandara (Rs.133787.30) and Wardha (Rs.125531.37), respectively. Whereas, the per hectare gross returns obtained from bamboo production were the highest in Gondia division (Rs.1473119.00) followed by Bhandara division (Rs. 1294703.00), Nagpur (Rs.1115317.00) and Wardha division (Rs. 826201.00), respectively. The net returns realized were the highest in Gondia division (Rs. 1332214.97) followed by Bhandara division (Rs. 1160915.70), Nagpur (Rs. 973219.38) and Wardha (Rs. 700668.63), respectively. This showed that, Gondia Forest Division had an edge overall the forest divisions in the Nagpur Forest Circle in respect of both gross as well as net returns. The higher returns realized in Gondia division were due to higher productivity of bamboo in Gondia as compared to rest of divisions in Nagpur circle. This implied that, agro-physiographical situation prevailing in Gondia division was more favourable than that of its counter part in Nagpur circle. In view of this bamboo plantation in Gondia Forest Division need to be encouraged on large scale to encash its comparative advantage over rest of the forest division in Nagpur circle.

The benefit-cost ratio of bamboo plantation was the highest in Gondia division i.e. 10.45 followed by Bhandara (9.68). Nagpur (7.85) and Wardha (5.58). Whereas, for the Nagpur Forest Circle as a whole BCR worked out to be 7.60. Thus, study brought out that, bamboo production was found to be economically viable venture as it is substantiated that BCR was greater than unity in all the divisions of Nagpur circle. The BCR indicated that, at an overall level a rupee spent on production of bamboo in Nagpur circle as a whole generated an additional return to the tune of Rs. 6.60. This shows that investment in bamboo plantation was highly paying proposition (Agrawal S. K. and et al. 1994).

Economic feasibility of Bamboo production

The results of economics feasibility of bamboo production are given Table-3.

Table - 3: Indicators of economic feasibility evaluation of bamboo production

Parameters	Forest Division									
	Nagpur		Bhandara		Gondia		Wardha		Overall	
	Discount rate		Discount rate		Discount rate		Discount rate		Discount rate	
	12%	15%	12%	15%	12%	15%	12%	15%	12%	15%
I. Benefit Cost Ratio	4.05	3.48	4.33	3.80	3.87	3.52	3.38	2.89	3.93	3.41
II. Net Present Value (Rs.)	77389	46466	88265	54252	97730	59643	53256	31281	79457	47731
III. Profit-ability Index	18.13	11.81	20.95	13.81	24.40	15.85	14.80	9.62	19.49	12.67
IV. Pay Back Period (years)	9	9	9	9	9	9	9	9	9	9
V. Internal Rate of Returns (%)	33.98		36.23		38.48		31.26		34.68	

The Table-3 reveals that, at an overall level at both the discount rates (i.e. @ 12% and 15%) BCR was greater than unity thereby indicated that, investment in bamboo plantation in Nagpur Forest Circle was found to be economically profitable venture. In all the divisions BCR was greater than one at both the rates of discount. At both the discount rates BCR was the highest for plantation done in Bhandra Division (4.33 and 3.80) of Nagpur circle and it was the lowest in Wardha division (3.38 and 2.89).

For the Nagpur circle as a whole the NPV was worked out to be Rs.79457 at 12 per cent discount rate and Rs.47731 at 15 per cent discount rate. This substantiate that, investment in bamboo plantation was worth while as NPV is grater than zero or positive at the discount rates chosen for the study. The highest NPV at 12 per cent and 15 per cent was recorded in Gondia division and it was Rs. 97730 and Rs. 59,643, respectively. The lowest NPV was observed in Wardha division i.e. Rs. 53256 and Rs. 31281 at 21 per cent and 15 per cent, respectively. The similar situation was noticed in respect of PI, it was the highest in Gondia (24.40 and 15.85) and the lowest in Wardha (14.80 and 9.62) at both the rates.

As regards to PBP it was uniformly 9 year for all the divisions. It would have been less than 9 year also. But scientifically bamboo attains physiological maturity at an age of 9 year. Hence, the first felling is due at this age. An initial investment made on establishment of bamboo grove and cost incurred on maintenance of bamboo was record in the first felling at an age of 9 year. So that PBP of bamboo plantation was worked out to be 9 year.

The IRR at an overall level was 34.68 per cent. It was higher than the present rate of interest charged by the financial institutions in the country. IRR was higher than bank interest rate in all the divisions of forest in Nagpur circle. The highest IRR was worked out to be for bamboo plantation in Gondia division (38.48 per cent) and it was the lowest in Wardha division (31.26 per cent).

The foregoing analysis revealed that, all the parameters selected for an assessment of economic viability lent support for decision making about acceptance of investment made in bamboo plantation in Nagpur Forest Circle was worthwhile and financially as well as economically viable venture.

Sensitivity analysis (Treatment of uncertainity)

In present study in order to test the financial efficiency of the investment under different adverse situations, the sensitivity tests were carried out based on Co-efficient of variation for the situation viz., (i) At 40 per cent increased costs and constant returns from bamboo, (ii) At 30 per cent decreased benefits and constant cost of production for bamboo and (iii) At 40 per cent increased costs and 30 per cent decreased benefits from bamboo production. The results of sensitivity analysis at 12 and 15% discount rate from bamboo production are presented in Table – 4.

Table – 4: Sensitivity Analysis test for Bamboo Production in Nagpur Forest Circle

Parameters	Increased in cost an Constant in returns		Constant in cost and decreasing in returns		Increasing in cost and decreasing in returns	
	Discount rate		Discount rate		Discount rate	
	12%	15%	12%	15%	12%	15%
I. Benefit Cost Ratio	2.81	2.44	2.67	2.34	1.91	1.67
II. Net Present value (Rs.)	68645	39822	45245	26425	34403	18676
III. Profitability Index	13.42	9.02	13.23	8.67	9.45	6.19
IV. Pay Back Period (Years)	9	9	9	9	9	9
V. Internal Rate of Returns (%)	29.66		29.31		24.28	

It is observed from the Table – 4 that, at both the discount rates even under simulated situation in pre para, BCR is greater than unity, PI is also greater than one, NPV is positive, PBP is shorter and IRR is greater than rate of interest or opportunity cost of capital i.e. higher than the prevailing bank rates. All these indicator turned out in favour of bamboo production, and substantiate that, even under cost over run or escalation in cost and decreased in benefits simultaneously investment made in bamboo plantation is economically viable proposition even under hypothetically changed or simulated situation.

The study revealed that, an investment project face on adverse situation on account of increase in cost at lower discount rate (i.e. 12%) PI was more sensitive followed by BCR and NPV. However, at higher discount rate (i.e. 15%) BCR was found to be more sensitive followed by PI and NPV. The IIR was less sensitive to increased cost of investment.

Under the situation of decreased benefits, at both lower as well as higher discount rate NPV was found to be comparatively more volatile followed by PI and BCR at 12 % discount rate, while, at 15% discount rate NPV was more susceptible followed by BCR and PI. However, erosion in value of IRR under decreased benefits situation was more as compared to increased cost.

In increased cost and decreased benefits situation at both the discount rate sensitivity of NPV was higher followed by BCR and PI. However, under the situation of increased cost and decreased benefits IRR value fell 29.99 per cent, which was higher than rest two types of situations wherein rise in cost and fall in benefit, took place independently.

The finding of present study suggested that bamboo production need to be encouraged on degraded barren govt., forest land, community owned waste land and private land also. This will solve problem of ever increasing demand for bamboo by different sectors. Besides this bamboo plantation will also help indirectly to arrest soil erosion due to interception of tree canopy to slash of rain whish check rain water velocity and reduce run off rate of rain water. This help in soil and water conservation. Further more afforestation also help in maintaining ecological and environmental balance. This is at present at state due to indiscriminate denudation of forest by felling of massive trees. (Shammugharvel P. 1994 and Varmha J. C. and et al. 1981).

Conclusion

1) Per hectare total cost of bamboo production (complete crop cycle i.e. 35 years) in Nagpur circle was worked out to be Rs. 136847.06 at constant price. While gross return and net returns received were Rs. 1177335 and Rs. 1040487.90, respectively.

2) The per hectare total cost of bamboo production in Nagpur division was highest (Rs. 142097.62) while it was lowest in Wardha division (Rs. 125531.37 at constant price. Gross returns of net returns were highest in Gondia division (Rs. 1473120 and Rs. 1332214.97, respectively as lowest in Wardha division (Rs. 826200 and Rs. 700668.63, respectively).

3) For the Nagpur circle, as a while, the BCR, NPV, PI, PBP and IRR were worked out to be 3.93, Rs. 79457, 19.48, 9 years and 34.68 per cent, respectively. The results revealed that, all the parameters selected for an assessment of economic viability lent support for decision making about acceptance of investment made in bamboo plantation in Nagpur forest ircle was worth while and financially as well as economically viable venture.

4) The results of the sensitivity analysis show that, if 40% discount in cost and 30 % increased in benefits were presumed and minimum critical cost of production and maximum benefit opportunity were fixed where PBP was unaffected. This indicated that even under hypothetically simulated discount, bamboo proposition should economically viability.

In view of this, it needs to be encouraged bamboo plantation on waste lands as well as agricultural lands for economic upliftment of the private stake holders.

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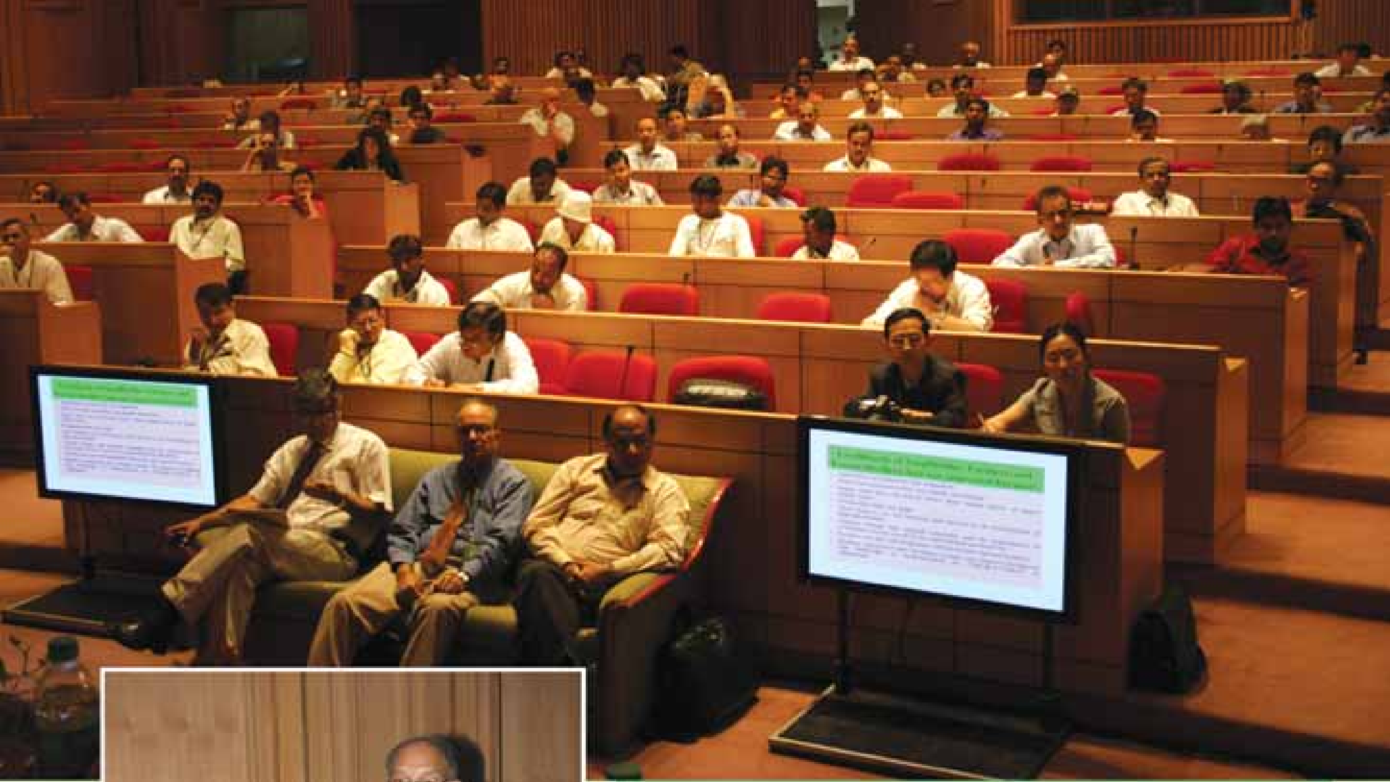


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Bamboo in relation to Horticulture in Arunachal Pradesh

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Abstract

Bamboo is an integral part of horticultural development in Arunachal Pradesh. Bamboo is used in various ways right from nursery preparation to harvesting and transportation of various horticultural produces. Among fruit crops, citrus, banana, pineapple, kiwi fruits are some of the major fruit crops in Arunachal Pradesh. Bamboo is mostly used for preparation of fencing for nursery, as it is a locally available material. Besides nursery, various kinds of baskets are used for harvesting of these fruits and for transportation to even long distance markets. Unlike conventional method of using CFB boxes or plastic crate citrus growers generally used bamboo basket of various designs, sizes etc for carrying citrus. It is observed that bamboo baskets are effective packaging material as these are less costly, disposable, decomposable and easily available. Without bamboo basket a farmer could not think of sending his fruits to even local market and this way marketing of citrus is possible only by the use of bamboo basket. Besides basket, for harvesting purpose also they are using some ladder which is made up of bamboo. In case of kiwi fruit, a farmer generally uses bamboo for training. Bamboo internodes are also sometimes used for life saving irrigation during dry season. Vegetable nursery as well as protection of crops is generally done by bamboo fences. Farmers are also using different kinds of bamboo strands for climbers like sweet gourd, ridge gourd, bitter gourd, bottle gourd, pumpkin etc. Different kinds of bamboo baskets are used for carrying vegetables from top-hills as well as to local markets. The benefits of bamboo hedges are that they acquire useful density and do not require annual pruning. As root system of bamboo hedge is not extensive it is not exhausting the soil nutrient and moisture from nearby beds. Potentialities of bamboo as garden plant are by virtue of its evergreen nature and luxuriant growth. A wide range

of species with cane colour and shape, and variation in foliages can be chosen for various ornamental purposes.

In this paper various usages of bamboo in horticulture as well as species suitability with special reference to Arunachal Pradesh are discussed.

Key words: bamboo, horticulture, Arunachal Pradesh.

Introduction

Arunachal Pradesh has been blessed by nature with one of the richest flora and fauna on the earth. It is a centre of origin of a number of cultivated plants and many plants species and germplasms have still to be collected, identified and assayed for their possible use. Bamboo is depicted as one of the noble plants. The bamboo is symbolic of wise man who shaken violently by the storm bends but never breaks. The bamboo is amazingly adaptable for a multitude of purpose. Environmental condition of Arunachal Pradesh is suitable for growing an array of horticultural crops besides bamboo. The State forests provide suitable niches for cultivation of fruits, flower, vegetable, spices, medicinal and aromatic plants. The State has comparative advantages in relation to these plants. The land use under horticulture in the State can be increased to a large extent from the economic point of view. The paper describes some of the use of bamboo in horticulture production in Arunachal Pradesh. Bamboo is a non timber forest produce that threads together ecological, economic and social development. Bamboo appears as an ideal material on which a labour intensive development can be based. It has commercial application and offers development opportunity for marginal farmers and provides oft-needed income and equitable distribution of income. Bamboo has the ability to grow in marginal land and making them important for subsistence and income needs of rural communities especially those with few alternative resources.

Bamboo in relation to horticulture in Arunachal Pradesh

In Arunachal Pradesh, bamboo is an integral part of life of people. The people of Arunachal Pradesh use bamboo in various ways for their livelihood. They use bamboo in their every day activities right from construction of houses to edible shoots. Various uses of bamboo in horticulture production in Arunachal Pradesh are as follows:

1. Fence: Bamboo is commonly used fence material in most of the families in Arunachal Pradesh. Every farm family of Arunachal Pradesh uses bamboo as fence material for protecting their nursery or crop field. As bamboo is one of the readily available materials and due to inaccessibility of other alternatives in the hills, it is a good fencing material. So far as durability of bamboo fencing is concerned, it depends on its use i.e. if splitted bamboo is used it generally lasts for 2 to 3 years, whereas in case of whole bamboo it may last for up to 5 years.

2. **Hedge**: Some bamboo species are used as hedge. Suitable species for hedge are *Arundinaria fastuosa, A. japonica, A. nitida, Bambusa arundinaria, B. atra, B. nana, B. vulgaris, B. polymorpha, B. multiplex, B. variegate, B. khasiana, Cepalostachys pergracile, Phyllostachys aurea, P. henonis, P. mitis, P. viridis var. galucenscens, Pseudosasa japonica, Schizostychum brahycladum* and *S. zollengeri* (Sharma, 1980; Kochhar et al. 1990).

3. **Ornamental Plant**: a wide range of species is used as ornamental plants by virtue of its evergreen nature, can colour and shape. Plants pecies like *Bambusa variegate* (variegated yellow and green strips), *B. vulgaris var. wamin* (pitcher shaped internode of the culm), *B. vulgaris var. vitata* (yellow culm with green strip), *Chimonobambusa armata* (single stemmed spreading rhizomatous) are used for the purpose.

4. **Carrying Basket**: In Arunachal Pradesh, most of the farmers use bamboo basket for carrying their harvested fruits and vegetables from the field to the house. Generally, they carry it on the back loaded with the harvested products.

5. **Transport Basket**: Bamboo baskets are suitable for transporting fruits and vegetables to the distant market. In Arunachal Pradesh, citrus particularly Khasi Mandarin, kinnow, Valencia are most grown and they are transported to the markets. Plastic crates or CFB boxes are costly items for the farmers to use as transport baskets. As bamboo is locally and easily available as a less costly material, they prefer it and prepare different kinds of transport boxes and send their fruits to distant markets.

6. **Bamboo ladder**: Bamboo is also used for manufacturing some climbing ladders for harvesting of fruits in case of tall trees. The species suitable for manufacture of bamboo ladder is available abundantly in Arunachal Pradesh.

7. **Bamboo vegetable farming and agro forestry**: Bamboo is basically a house plant species grown around houses, compounds and homesteads, on farmlands and other available places on farm holdings. It is grown in homesteads as every part of the bamboo finds one use or another in daily life of the farmer. Jaysankar and Muralidharan (2000) found that advantage of bamboo over perennial cash crops as low gestation period, fast growth, diversified uses and easier marketability, all ensuring its potential as an excellent agro forestry crop. The scope for bamboo, as a component of agro forestry systems is very much there under uncertain weather conditions, increasing cost of labour involved in

agriculture and large areas of unculturable lands with every farmer in this region. Traditionally, one to five clumps of bamboo in homesteads are existing with every household in this region. They are also being used for edible shoot harvest. It gives regular return after three years of planting. It has soil erosion control capacity and ameliorates immediate environment in the humid tropical and sub tropical conditions.

8. Bamboo can be grown as a farm crop:

a) exclusively for their edible shoots

b) dual purpose – they can be grown for mature culm and for edible young shoots

c) they can be grown exclusively for mature culms

9. Edible bamboo shoot: Sharma (1980) listed 26 bamboo species traditionally used for edible purposes in NEH Region. This accounted 16 species of genus *Bambusa*, 12 species of *Dendrocalamus*, 9 species of *Arundinaria*, 4 species of *Cephalostashyum*, 2 species each of *melocanna* and *Teinostachyum* and one species each of *Chimonobambusa, Phyllostachys, Pseudostashyum, Melocalamus, Neohouzeaus, Sinobambusa* and one introduced species in Arunachal Pradesh, *Gigantochloa*. The constituent of bamboo vegetables are presented in a table at the end of the paper.

10. As standard for horticulture crops: In Arunachal Pradesh bamboo is mostly used as strands for climbing type of vegetables and as support for training of fruit crops like kiwi fruit.

Conclusion: Bamboo has a tremendous potential to create jobs at the rural areas of the State. It has a capacity to provide employment and income to a fairly large number of people in the State. Therefore, harvest of bamboo from environment should be in equilibrium with the capacity for regeneration.

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Table: Constituent of Bamboo Vegetable

Constituent	**Bamboo Shoot**	
	B. tulda	*D. giganteus*
Proteins	2.76	2.56
Free amino acids	0.18	0.24
Starch	0.34	0.28
Total soluble sugars	1.67	1.34
Reducing sugars	1.09	1.17
Non reducing sugars	0.58	0.17
pH	5.07	4.91
Lactic Acid	0.01	0.02
Volatile acid	0.01	0.03
Diacetyl	0.02	0.04
Acetoin	0.00	0.00
2-3 butanediol	0.02	0.03
Esters	0.01	0.01
Citric acid	0.04	0.05
Free phosphate	0.61	0.56
Total phenolic compounds	0.03	0.05
Volatile phenolic compounds	0.00	0.00
Ethanol	0.01	0.00
Glycerol	0.00	0.01

Source: Singh and Singh (1995)

The need of Planned Plantation for Sustainable utilization of bamboo - a natural bioresource of North - Eastern Region

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Abstract

Manipur is one of the north-eastern states of India. The state is geographically isolated from the rest of the country. The valley portion of the state is surrounded by nine (9) different hills. Plenty of bamboo species are growing in the hills and valleys. A total of 60 species are found to grow luxuriantly stretching in the hilly terrains as one of the diversity of forest and in the valleys. Mostly monopodial varieties of bamboos are found to grow in hills and sympodial varieties in the plains. The growth pattern of bamboos is very specific. It shows a beautiful picture of plant association i.e. co-existence and mutual survival in nature. Bamboos are the flowering plants and seed propagated also. But propagation by seed is insignificant as the flowering cycle of bamboos takes years mostly 2 - 100 yrs. Vegetative propagation in bamboos is very fast and most favourable form of multiplication in natural condition. The caespitose growth form of bamboos always seems to favour co-existence. When such bamboos grow together, there seems no question of suppression. Instead, competition becomes higher and observed full luxariant growth of each species or variety. A case study has been made since last 4 - 5 yrs to study and observe such association in a piece of land of area less than 2 acres. The study area has the traditional way of plantation of bamboos. Nine (9) different species belonging to 4 different genera are planted in about 5 ft wide area all along the length. The enterior portion has been developed into a floriculture park keeping the bamboos all around the park. It increases the science beauty of the lanscape and creates a natural and scenic ecofriendly establishment of different vegetations. So the present study takes the opportunity to highlight the need of planned plantation of bamboo on an available area. There are always

prospects and scopes of ecoplanning or mixed farming. Cultivation and harvesting of good number of plants can pratice according to the need of man. Such establishment should help much in creating a bioresource for sustainable utilization.

Introduction

Bamboos, the fast growing woody grasses, are widely grown in Manipur. Many genera of bamboos grew abundantly both in the valley and hilly areas of the state. They used to grew wild in the hills covering the long hills tracts because of their naturally favoured mode of propagation. In the valley, people used to cultivate species of economic importance in the plots and in homesteads. It was considered compulsory and legendary to plant certain species in the courtyards. It helps much in the biodiversity conservation and germplasm collection. Nowadays due to the incresing deforestation, many species that grew in the hilly areas are distroyed to a large extent. The species that are found in the hilly areas are very important as they take the key-role in shaping the topography and acts also as wind breaker and prevent soil-erosion.

Bamboo are divided into two classes according to their growth habits- Monopodial and Sympodial. Monopodial species have widely spaced culms. Every culm has long rhizome which develops buds at each of its joints every year and grow into new culms. Such types of rhizomes are known as leptomorph rhizomes. Sympodial species have short rhizomes and new culms grow close to the parent bamboo, rarely flower and seed. This type of rhizome is called pachymorph rhizome. Cultivation is generally carried out by taking cuttings of either rhizomes or culms, depending on the species. For monopodial species, cuttings are taken from rhizomes with or without sections of culms attached. And for sympodial species, cuttings are taken from sections of culm with or without rhizomes.

Bamboos are flowering plants and seed propagated also. But they produce flower after a long period in their lifecycle and hardly seeded. The mode of seed propagation hence becomes unpredicable and distinctly insignificatn except some species like *Melocanna baccifera*. Both the two rhizome types i.e. leptomorph and pachymorph are highly successful in nature for vegetative propagation. Hence the bamboo diversity is so rich in north-east without any question of planned plantation and cultivation. Bamboos have tremendous contribution on the socio-economy of people. People depend on these plants party or totally for livelihood and as income source of the family by doing bamboo crafts. In fact, bamboo is the nature gifted bioresource for the poor.

After all assessing the economic potential of bamboo, it is now important for doing planned plantation and cultivation of some varieties which are of high economic importance in the society. It will help in the development of social and cultural status of the north-east. The present study focusses to the traditional ways of cultivation, plantation and harvesting of bamboos and how it helps in the long run for germplasm collection and species conservation. Not only the study also targets to point out the role of bamboos in establishment of plant association and co-existence related to mixed farming.

Results

A case study was made specifically in one locality of Imphal West District since 2003. This particular plot is having an area of less than 2 acres. Along the whole length of boundaries, nine (9) different species belonging to four (4) different genera are cultivated at random. These nine species includes seven large sized bamboos and two medium sized bamboos. All the species grow luxuriountly attaining the full vegetative growth and observing the mutual co-existence. Table No. 1 shows the information regarding the density of clump growth and biomass characteristics. Bamboos are harvested from time to time for marketing the cu lms as income source. Very recently the interior portion of the plot after keeping a drain of 2 - 3 feet wide from the clump growing portion, a floriculture farming has been set up which flourishes succesfully (Photographs Plate No. 1-4). The Garvested bamboos are used in making rest houses, nursery houses, working sheds etc. for farming.

The different species planted are the followings —

Sl. No.	Scientific Name	Local Name
1.	*Bambusa kingiana*	Watangkhoi
2.	*Bambusa nana*	Khok-wa
3.	*Bambusa nutans*	Utang-wa
4.	*B. tulda*	Saneibi
5.	*Dendrocalamus flagellifer*	Longa
6.	*D. Sericeous*	Ooci
7.	*D. Strictus*	Unam
8.	*Melocanna baccifera*	Moubi
9.	*Neohouzeaua dullooa*	Tollu/Nat

The study on the clump growth revealed that *Bambusa nana* has the highest number of culms in a clump (58-67 culms/clump) while *Dendrocalamus flagellifer* has the lowest number (28-39 culms/clump). Bambusa tulda and Dendrocalamus flagellifer has the highest fresh weight biomass weighing above 40 kg per culm white *Bambusa nana, Melocanna baccifera* and *Nevhorezeana* dullooa are having *Neohouzeaua dullooa* less than 10 kg/culm (Sobita and Brojendro, 2007). It is clearly noted that there is mutual co-existence among the species. At the bases and nearby the clumps, there are plenty of herbs, shurbs and trees. This shows plant association at the best. Bamboo can be now considered as the ecofriendly plant.

Discussion

Bamboos are long-lived monocarpic plants having the nature of 'Century Plants' and as unusual characteristics of perennial bamboos is their habit of flowering at long intervals, drying back and then regenerating from seeds or rhizomes. But their vegetative propagation is very fast and maturity also attain within 6 - 8 months. They can grow in a very restricted space. As they grow in tufts, when different species grow together, do not mixed up. And when one species flowers, the other do not produce flowers. This adaptability nature help much in conservation of genetic diversities of bamboos.

Different species of bamboos have different utility. Based on the needs, on an available spot, one can cultivate together different species. Bamboo can substitute mechanised wall-fencing as they have thick growths with branches. As they do not disturb the growth of other plants, mixed farming can be made possible. Bamboo plantation in a special design will increase the landscape designing. Farming like Floriculture, Pisciculture, Bee-keeping. Vermicomposting etc. can be done on the bamboo plantation site.

Bamboo gives immense utilization to mankind. It is a renewable resource of forest, raw-material for industry, timber for the poor, asset for income source for rural development. Plants can be rejenerated successfully by modern micropropagation methods. In the hilly states of India's North East bamboos are the green gold. Many people are skilled in bamboo crafts thus helping in the socio-economy of the states. It is the only natural bioresource which has very wide applications in many sectors.

So planned plantation and cultivation of efficient and highly potential bamboo species will surely be able to upgrade the economy of North-East and directly or indirectly the national economy. Bamboo has endowed with all the quality and power of long-term utilization to make the very existence of man on this planet.

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TABLE - 1 : Density and biomass characteristics of bamboo growing habitats in Study Area (After Sobita & Brojendro, 2007)

Species	No. of culms per clump	Average no. of clump per clump	Fresh weight biomass ranges (kg/culm)	Average fresh weight biomass (kg/culm)
Bambusa kingiana	34 - 50	40	22 - 48	35
B. nana	58 - 67	61	4 - 12	7
B. nutans	18 - 42	30	32 - 48	35
B. tulda	40 - 58	52	32 - 50	40
Dendrocalamus flagellifer	28 - 39	35	32 - 48	40
D. sericeus	33 - 48	36	12 - 31	20
D. strictus	41 - 60	*52*	*3 - 6*	*4*
Neohouzeaua dullooa	*38 - 68*	*53*	*4 - 6*	*5*

Green Gold in Archery

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Abstract

Manipur, one of the north-eastern states of India is well known for its sports talented youths. This hilly state is inhabited by 33 different ethnic groups. Each group has their own pattern of cultural and traditional methodes of game and sports. Ancient forefathers used various defensive methods to protect themselves as they passed their hardship lives in the thick forest areas, people used simple tools like swords bows and arrows. spears etc. made out of bamboos and woods. Archery is one of the traditional sports of Manipuries. Arrow shooting has been a part of Manipur Cuture since the time immemorial. Peoples of various groups inhabiting in this state make different designs of bows and arrows from the locally available natural resource i.e., the bamboos. Three spices of bamboos are specially used for bow and arrow making viz. *Dendrocalamus flagellifer, Bambusa balcooa* and *Arundinaria rolloana.* The first two are used in making the bows and the third one for making the arrows. A case study has been made on a local indigenous bamboo - bow production centre named 'Angela Archery Centre'. Among the production, the 'take down' titled archery product is the new and best which can give good results in both the National and International arena of Archery. The sportsperson practiced with this bamboo-bow won gold medals in the Archery Events held upto the International level. Till date, any kind of technological application has far not been made by the skilled craftsperson working in this manufacturing unit. So technical input and training for the application of modern technological appliances are necessary to keep the ongoing production to be more sophisticated and standardized. The present study highlights the attention and importances of authorities at all levels to encourage the local skilled artisans in this field of bow and arrow making. Not only it provides the improvement in technical skill and resource mobilization but will help in establishing and enriching the traditional and cultural games and sports.

Introduction

Bamboo has enormous potential. It can be regarded as the only bioresource that has manifold utility. The whole plant parts can be used for various applications. Manipur state has a high diversity of bamboo and the number has countable more than 60 (Sobita and Brojendro,2007). These species grow luxuriantly in both hilly and valley areas. Many legends of this region are associated with bamboo and it is traditional to cultivate and maintain certain species of bamboos in the homestead. Bamboo also plays an important role in the socio-economy of the people. People largely depends on bamboo and bamboo products for their livelihood and economy. The ethnicity of the enhabitants also reflects a lot on the development of various bamboo crafts and designing.

People uses, various bamboo species in different ways. From household constructions to simple defensive weapons are made out of bamboos. Bamboos that have caespitose growth are tall, highly rigid, strong, durable and if properly seasoned are highly resistant to insects. Both monopodial and sympodial types of bamboos are used in making tools and weapons like handles of knifes, spades and specially for arrow and bow making.

Arrow shooting is a very fond traditional game and sports. Mainly large sized and tall bamboos are seasoned and used for making bows. And small sized, monopodial bamboos are mostly used for making the sharp arrows. Bows made are of different sizes, designs and speeds. Particularly two species of bamboos *Dendrocalamus flagellifer* (LN-Longa) and *Bambusa balcooa* (LN - Leewa) are used in making indigenous bamboo - bows. The first one is reported to be more suitable for the purpose than the second one. *Arundinaria rolloana* (LN -Tenwa) which are growing in the high altitudes and used for making arrows.

Study Report — A Case Study

Arrow and bow - making is hardsome tasks of a dedicated and skilled artisan. Bamboo crafts and designing needs the knowledge of science, mathematics and practical application of laws and principles and also devotion to job. The present case study has been made on one production unit of Archery namely 'Angela Archery Centre' which is located in Imphal. The designer and maker of bamboo arrow and bamboo - bow is a known National Archer. The following are the datas collected during the study period —

Raw Material used for bamboo - bow	:	Dendrocalamus flagellifer Munro, (LN - Longa)
Availability	:	Very common, growing in the hills and plains.

Altitude	: 782 - above (m asl).
Naturally favoured habitat	: Foot Hill.
Straightness	: More when grow together with tall trees.
Height	: Can grow up to 100 ft.
Part of the culm utilized	: Upto 50 ft from the base.
Size of the Outer Circumference	: 12 to 16 inches.
Seasoning period	: 1 - 4 yrs. (after postharvest)
Insect resistance	: Very high.
Fibre content	: High
Durability of the product	: More than 10 years.
Thrust Impact	: High
Cost of Production	: Less and Reasonable.
Application	: Wide; In all levels - State, National and International.
Speed	: Sub-junior - 20 - 30 m/sec. Junior - 30 - 40 m/sec. Senior - 30 - 50 m/sec.
Production Rate	: 5 - 10 Nos/day. > 1000 /yr.
Standard	: Approved World - Wide (Approved by IFITA - Federation of International Target Archery).
Supply & Demand	: Agreeable/Approximate.

(Source : President, B. Achoubi Sharma, Angela Archery Centre, Manipur)

Result and Discussion

Dendrocalamus flagellifer Munro, is widely used in many othe rpurposes viz in house construction, fencing, in making basket of different design and sizes etc. This bamboo is locally known for its size, hight, strength, durability and binding properties (Sobita, 2007).

It is found to be comparatively better than other species regarding its flexibility, fibre content, non infecticusness and thurst impact regarding the archery. This bamboo is also one of the rich diversity and naturally availabled bioresource. Nowadays, advance technical applications could increasingly assess the wide utility of bamboos. In fact, bamboos are the best and perfect raw material for industrialization. To fully harness the resource, bamboo based industrial sectors can be set up in the region. This will surely help in uplifting the socio-economic condition of the inhabitants. The locally designed and made bamboo arrow and bow has successful applications. Many Archers who represented the State or the country were awarded with gold in Archery Events. Archery played an important role in popularising sports movement in Maniur. The lady archer, B. Basanti Devi became the first senior archer from Manipur to represent India at any International Archery Championship. She participated in the 9th Asian Games 1982, at New Delhi and many are there in list. In the present scenario of games and sports, people want to popularize the traditional and cultural sports. The players can be trained in traditional ways using the locally available materials. The North East people need to revive and exhibit their skill in bamboo based sporting technique to the outside world. It will surely create the place — a destination for ethnic tourism or Ecotourism. The idea of sustainable utilization of natural bioresources will also enhance the economic development of society. The creativity and innovative works of our skilled artisans will be supported from all possible angles by the related Government Departments and relevant Government and Non-Government Organisations. More educated youths can be trained in the line to give employment in the field. New technological applications and appliances are needed to provide to increase the production. To standardize the product is impotant to get the market far and wide at the global level.

Special consideration, if made, to improve the present position of production, then it will surely help in the upliftment of socio-economy status of the state which will directly or indirectly relate to the per capita income of the country. To utilize the available natural resources will provide the livelihood of the people thereby helping in alleviation of poverty and also will offer opportunity to the educated youths for self-employment.

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Bamboo Marketing in Maharashtra State

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Abstract

In Gondia Division of Nagpur Forest Circle in Maharashtra State, the highest sale of Bamboo has been carried out. Therefore, an attempt has been made to study the marketing of bamboo in Gondia Division with specific objectives i.e. to identify different channels in marketing of bamboo and to study the marketing margin, price spread and marketing efficiency.

In the study area, bamboo was sold by auction sale methods. The required data for the present study was collected purposively from 2 forest depot i.e. Navegaonbandh and Dongargaon, 6 wholesaler and 50 retailers by survey method with the help of special designed pre-tested scheduled separately for the marketing functionaries viz., the forest depot, wholesalers and retailers. The analysis of data by simple tabular method with meaningful conclusions. The data pertains to the year 2004-2005.

The study revealed that bamboo was sold by three channels viz., I) Forest Depot -> Consumer, II) Forest Depot -> Wholesaler / Saw Miller -> Retailer -> Consumer and III) Forest Depot -> Wholesaler / Saw Miller-> Consumer.

On an average per bamboo price fetched by the producer seller was Rs. 4.30/Culm. The producer seller i.e. forest depot fetched common price in all the three channels, because method of sale adopted by the forest depot for bamboo was open auction sale. Hence, there was no question of price discrimination both the wholesaler and ultimate consumers participated in auction bid together. On the average per buyer number of bamboo culm purchased by the buyers from channel – I, II and III was 813, 152560 and 14856, respectively.

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The producer share in consumer price was the highest in channel –I (95.12 per cent) followed by channel –III) 39.52 per cent) and channel-II (25.09 per cent). This showed that, slightly more than one fourth of consumer price was percolated down in channel- II and rest was absorbed by marketing cost and margin of marketing functionaries intervening between producer seller and ultimate consumer.

It was also observed that, the per unit cost of marketing of bamboo was highest in Channel-II followed by Channel-III and I. Through Channel-II, gross marketing margin was higher in sale of bamboo (74.91 per cent). The producer share in consumer rupee was highest in Channel – I (95.00 per cent) followed by Channel –II and III, which implied that Channel –I was most profitable channel due to elimination of middle mean. The marketing efficiency was also highest in Channel-I. This indicated positive relationship between value of produce sold and efficiency of marketing channel.

Introduction

Bamboo is a vernacular term for members of sub family Bambusoideae of family Poaceae of about 1250 species of bamboo's belonging to 75 genera nearly 136 species occur in India. Green bamboo is used for basket weaving and mat making etc. Bamboo is an important produce and is rightly called "Poor man's timber. It can be used wherever timber is used as in cradles, hutments, toys, art pieces and furniture. Bamboo has long fibers and they give a homogeneous. It is therefore, a very important raw material in paper and Rayon Manufacture. The bulk of dry bamboo is supplied to paper mills in the country. In the study area of Gondia Forest Division, auction sale method is being adopted for the sale of bamboo. The marketing system for assembling and distribution of bamboo consist of forest depot, wholesaler, retailer and consumer. The commodity passed through the three channel of trade namely, producer-> consumer i.e. direct sale to consumer (Channel-1), Producer-> Wholesaler -> Retailer-> Consumer i.e. sale through wholesaler (Channel-II) and Producer -> Wholesaler -> Consumer (Channel-III). In Gondia Division of Nagpur Forest Circle in Maharashtra State, the highest sale of Bamboo has been carried out. In view of the above an attempt has been made to study the marketing of bamboo with following specific objectives.

1) To identify different channels in Bamboo.

2) To study the marketing margin, price spread and marketing efficiency.

Methodology

In Nagpur forest circle, the highest turn over of the forest products was reported in Gondia forest division. Hence, for studying marketing of bamboo, Gondia division was selected purposively for the present study. Further, from Gondia forest division both Navegaonband and Dongargaon forest sale depot were selected for the present study. The forest depot of Gondia division assumed the place as producer seller in the present study. From an operational area of Gondia division for marketing of bamboo 6 wholesalers and 50 retailers dealing with bamboo was selected randomly. The data on marketing was collected by survey method with the help of specially designed pre-tested schedule separately for each marketing functionary viz., the forest depot, wholesalers and retailer. The simple tabular approach was used in the present study. The data pertains to the year 2004-2005.

Results and Discussion

The marketing system for assembling and distribution of bamboo consist of forest depot, wholesaler, retailer and consumer. The commodity passed through the three channel of trade namely, producer-> consumer i.e. direct sale to consumer (Channel-I), Producer-> Wholesaler-> Retailer-> Consumer i.e. sale through wholesaler (Channel-II) and Producer -> Wholesaler-> Consumer (Channel-III).

Channels of Sale

The information regarding channel – wise distribution of bamboo sale in Gondia forest division is presented in Table-1

Table -1 : Channel-wise sale of Bamboo in Gondia forest division.

Sr No.	Channels of Sale	Distribution of Bamboo Buyer	Quantity Sold of Bamboo		
			Quantity (No)	Average Price per bamboo	Average quantity per buyer
I	Direct Sale	11 (47.82)	8943 (0.88)	4.30	813
II	Wholesaler/ Retailer/ Consumer	6 (26.09)	915362 (90.32)	10.35	152560
III	Wholesaler/ Consumer	6 (26.09)	89136 (8.80)	10.35	14856
Overall		23 (100.00)	1013441 (100.00)		

(Figures in parentheses are indicates the percentages to total)

It is observed from the Table-1 that, at an overall level, there were 23 buyer of bamboo from forest depot in Gondia forest division. Out of this, 11 (47.82 per cent) were ultimate consumers, who directly bought from the producer seller i.e. forest depot in open auction sale organized by the forest depots. The total quantity of bamboo purchased by them was 8943 (0.88 per cent). This shows that, the number of ultimate consumers was higher but quantity bought by them was lower. This is quite obvious that, consumers purchased bamboos for their own use. As against this the number of middlemen in channels –I and II was 6 each (26.09 per cent) which was seller than final ultimate consumers. However, as far as quantity of bamboo purchased by the wholesalers operating in channels-II and III was concerned it was 9, 15362 (90.32 per cent) and 89,136 (8.80 per cent), respectively. This revealed that, smaller number of wholesalers purchased large quantity of bamboo from produce seller i.e. forest depot. This was quite natural because the wholesalers from both the channels purchased bamboo for resale or business purpose. Thus, intention of the wholesalers behind larger purchases was to earn profit from marketing bamboos.

On an average per bamboo price fetched by the producer seller was Rs. 4.30/Culm. The producer seller i.e. forest depot fetched common price in all the three channels, because method of sale adopted by the forest depot for bamboo was open auction sale. Hence, there was no question of price discrimination both the wholesaler and ultimate consumers participated in auction bid together. On an average per buyer number of bamboo culm purchased by the buyers from channel –I, II and III was 813,152560 and 14856 respectively.

Function wise Marketing Cost

The function wise cost of marketing incurred by the marketing functionaries in different channels of sale for bamboo was worked out and the results are given in Table-2.

The Table-2 shows that, the per culm cost of marketing of bamboo in Gondia forest division was highest in channel-II (4.12/ culm) followed by channel-III (Rs.2.62/ culm) and channel-I (Rs.0.21/ culm). The highest cost of marketing in channel-II attributed to involvement of wholesalers and retailers in distribution of bamboos, to do so, wholesaler and retailers incurred expenses in performing marketing functions. As against this in channel-I, marketing functionaries were absent and hence there was saving in cost of marketing in channel-I.

Table-2: Item-wise per unit cost of marketing incurred in different channels of sale for bamboo.

(Figures in Rs.)

Sr. No	Particulars	Channels		
		I	II	III
1	Felling of Trees and Trimming	0.10 (47.62)	0.43 (10.44)	0.25 (9.54)
2	Handling	—	0.33 (8.01)	0.12 (4.58)
3	Transportation	0.10 (47.62)	0.38 (9.22)	0.23 (8.78)
4	Processing	—	0.16 (3.88)	0.07 (2.67)
5	Storage	0.01 (4.76)	0.04 (0.97)	0.02 (0.76)
6	Sale tax	—	0.96 (23.31)	0.96 (36.64)
7	Income tax	—	0.60 (14.56)	0.60 (22.91)
8	Interest in capital	—	1.22 (29.61)	0.37 (14.12)
	Total Cost	0.21 (100.00)	4.12 (100.00)	2.62 (100.00)

(Figures in parentheses are percentages to total)

An item-wise distribution of the total cost of marketing revealed that in channel-I felling of bamboos and trimming and transport were an important marketing functions. The contribution of these items in to the total cost of marketing worked out to 47.62 per cent each and rest 4.76 per cent was shared by the storage operation. The storage cost in channel-I comprises ground rent for stacking of bamboos. In channel-II, major items of the cost of marketing were sale tax, income tax and interest on capital. All these items together had share 67.48 per cent in the total cost. The rest 32.52 per cent cost was shared by felling of bamboo, trimming, handling, transportation, processing and storage. The similar trend was observed in channel-III also. In channel-III, sale tax, income tax and interest on capital accounted for 73.67 per cent of the total cost of marketing.

The foregoing analysis revealed that, the total cost of marketing for bamboo and numbers of marketing intermediaries involved were positively related. To keep down the cost of marketing, it is necessary to trim out marketing intermediaries. However, total elimination of marketing intermediaries is also not desired, because, they create different utilities to the goods. To restrict the number of marketing functionaries is possible.

Marketing Margin, Price Spread and Marketing Efficiency of Bamboo

The per culm marketing margin, price spread and marketing efficiency of bamboo is presented in Table-3.

Table-3: Channel wise Marketing Margin, Price Spread and Marketing Efficiency of Bamboo.

(Figures in Rs./Culm)

Sr. No	Items	Channels		
		I	II	III
1	Net Price realized by Forest Depot	4.09 (95.12)	4.09 (25.09)	4.09 (39.52)
2	Net Margin of Wholesalers	—	3.64 (22.33)	3.64 (35.17)
3	Net Margin of Retailers	—	4.45 (27.30)	—
4	Cost of Marketing (I)	0.21 (4.88)	4.12 (25.28)	2.62 (25.31)
5	Consumers Price (v)	4.30 (100.00)	16.30 (100.00)	10.35 (100.00)
6	Gross Marketing Margin	0.21 (4.88)	12.21 (74.91)	6.29 (60.48)
7	Marketing Efficiency (ME)	19.48	2.96	2.95

(Figures in parentheses are percentages to total)

From the Table-3 observed that, the highest gross margin in marketing of bamboo was in channel-II (71.91 per cent) followed by channel-III (60.48 per cent) and channel-I (4.88 per cent). The higher margin in marketing of bamboo through channel-II attributed to intervention by wholesaler and retailer between producer seller and ultimate consumer. The marketing cost incurred by the wholesaler and retailer plus their margin increased the gross marketing margin in channel-II. As against this, in channel-I, marketing intermediaries were eliminated and ultimate consumers directly purchased the bamboos from producer seller i.e. forest depot. This caused in saving of marketing cost and margins in channel-I. Hence, the marketing margin was on lower side in channel-I. This revealed that, there was positive relationship between number of marketing intermediaries intervening and marketing margin.

The producer share in consumer price was the highest in channel-I (95.12 per cent) followed by channel-III) 39.52 per cent) and channel-II (25.09 per cent). This showed that, slightly more than one fourth of consumer price was percolated down in channel-II and rest was absorbed by marketing cost and margin of marketing functionaries intervening between producer seller and ultimate consumer. In channel-II also there was no much difference only two fifth consumer prices was fetched by the producer seller and rest was swallod by the marketing cost and margin of retailer. However, in channel-I producer seller was better placed with more than 95 per cent share in consumer price. But, it would be difficult to all ultimate consumers to make direct purchase from the forest depot. This is limitation for channel-I.

As usual net margin of retailer (27.30 per cent) was higher than that of wholesaler (22.33 per cent) in channel-II wherein, there was involvement of both wholesaler and retailer. The retailers had kept higher margin as compared to wholesaler on account of lower total turn over of retailers. As against this wholesaler increased their total profit margin by keeping lower rate of margin with increase in the total turn over. It is interesting to note that, net share of retailer in consumer's price was higher than that of producers net share in consumers rupee in channel-II. Similarly, in channel-III also there was no much difference between producers and wholesalers share in consumers price paid.

Thus the results of present study confirmed an established relationship in marketing literature i.e. of decline in producers share with the increase in the length of marketing chain. The results of present study are in conformity with earlier studies findings of Jayasankar and Muraleedharan (1993 and 1995).

It is also observed that, the marketing efficiency of bamboo was the highest in the sale through channel-I and the lowest in channel-II. Further, it was seen that, value of the produce sold and efficiency of marketing were positively correlated. The higher efficiency in channel-I attributed to the lower cost of marketing due to absence of marketing intermediaries in between producer seller i.e. forest department and ultimate consumer. As against this, in channel-II of all the bamboo there was intervention of wholesaler and retailers in between producer seller and ultimate consumer had increased the cost of marketing and thereby reduction in efficiency of marketing.

Thus, foregoing analysis revealed that, there was positive relationship between value of produce sold and efficiency of marketing channel. Further, it was revealed that, the number of marketing intermediaries intervening between producer sellers and ultimate consumers had negative correlation with efficiency of marketing.

Conclusions

The following conclusions were made from the foregoing analysis

- The commodity passed through the three channel of trade namely, producer-> consumer i.e. direct sale to consumer (Channel-I), Producer-> Wholesaler-> Retailer-> Consumer i.e. sale through wholesaler (Channel-II) and Producer-> Wholesaler-> Consumer (Channel-III).
- The distribution of bamboo buyer through Channel-I, II and III was worked out to 11, 26.09 and 26.09 per cent, respectively. It was also concluded that, bamboo sale through Channel-II was most prominent. But from consumer point of view Channel-I was reasonable due to lower purchase price.
- In all channels, income tax, sale tax and interest in capital were major items of cost of marketing. The remaining cost of marketing was shared by felling of trees and trimming, handling, transportation and storage.
- The cost of marketing in channel-II was higher than that of channel-I and III due to longer chain of marketing intermediaries in channel-II.
- The per unit cost of marketing for bamboo was the higher in channel-II followed by channel-III and I. through channel-II, gross marketing margin was higher in sale of bamboo (74.91 per cent).
- The marketing efficiency of bamboo was the highest in the sale through channel-I and the lowest in channel-II. Thus, Channel-I proved to be efficient channel as it minimized the marketing cost and increase the producer share in consumer rupee.

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Farmers Friendly Cost Effective Propagation Techniques of Bamboo

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Abstracts

Bamboo is a wonderful gift of nature. The people of Asia, Africa and South America are dependent it for their housing and agricultural implements. It is extensively used for making pulp and paper, domestic commodities and in cottage industries. Bamboo shoots are eaten as vegetables, especially in Southeast and East Asia. The plant is also known as "green gold" for its fast growth rate. In addition, it conserves soil, regreens eroded slopes and provides short-term income and employment in small cottage industries. Many cultural traditions in the rural areas of Asia are intimately connected with bamboo. With a conservative estimate, it is pointed out that 2.5 billion people depend on or use bamboo materials at a value of 7 billion US $ per annum.

Bamboo propagation is always be a problem due to unavailability of seeds every year as bamboo flowers once in its life time and that too after many years. Secondly, the seeds has very low viability (2-4 months), hence can not be stored/kept viable for longer time. The propagation through rhizome/culm cutting is labour intensive and heavy material for transportation.

Farmer's friendly, cost effective, easy propagation technologies have been developed by Forest Research Institute, Dehradun mainly (i) Propagation of bamboo through branch cutting and (ii) through macro-proliferation. These two technologies are discussed in this manuscript along with the cost of quality planting stock production for mass multiplication of major bamboo species.

Key Words: *Bamboo propagation, macro-proliferation, offset planting, rooting of cuttings, rhizome and culm cutting.*

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Introduction

Bamboo is a wonderful gift of nature. The people of Asia, Africa and South America are dependent it for their housing and agricultural implements. It is extensively used for making pulp and paper, domestic commodities and in cottage industries. Bamboo shoots are eaten as vegetables, especially in Southeast and East Asia. The plant is also known as "green gold" for its fast growth rate. In addition, it conserves soil, regreens eroded slopes and provides short-term income and employment in small cottage industries. Many cultural traditions in the rural areas of Asia are intimately connected with bamboo. With a conservative estimate, Liese (1992) pointed out that 2.5 billion people depend on or use bamboo materials at a value of 7 billion US $ per annum.

There are as many as 75 genera and 1250 species of bamboo distributed in tropical, sub-tropical and temperate zones of different parts of the globe (Sharma 1980). Tropical Asia is the major centre of bamboo diversity, with as many as 45 genera and 750 species (Biswas, 1988).

Bamboos have been cultivated regularly in the villages compared to forest bamboos which occur naturally. The rural poor are the principal users of bamboo, using many times more material than the pulp and paper industries. The world's annual production of bamboo has been estimated at more than 20 million tonnes (Sharma 1980). Annual production of bamboo sometimes fluctuates within a wide margin, mainly because of large-scale death of bamboo clumps due to gregarious flowering. The yield of bamboos varies considerably, depending upon the intensity of stocking and biotic interference. It varies between 0.2 to 4.0 t/ha and in most cases is not very encouraging.

In the past, bamboo was a perpetual resource because of its vigorous vegetative regeneration. But at present, over-exploitation associated with growing human populations, destruction of tropical forests, and new demands for industrial uses (especially by the pulp and paper industry) have resulted in wide-scale reduction of bamboo stocks.

There is an urgent need to develop the bamboo resource base through massive programmes for plantations with genetically improved planting stocks. As bamboo is a fast growing and quick harvested crop, the output of plantations will be apparent 2 to 3 years after afforestation and reforestation activities. The main beneficiaries will be the rural poor because, as the resource base increases, there will be socio-economic benefits, and employment, both in harvesting and cottage industries will increase.

Priority species

The International Network for Bamboo and Rattan (INBAR) in cooperation with the International Plant Genetic Resources Institute, formerly the International Board for Plant Genetic Resources ,canvassed national experts in 1993 for information, established criteria for choosing species and through an expert group agreed upon 19 species - or groups of species - as those meriting focused research and wider use. They are:

Bambusa bambos (L.) Voss.

B. blumeuna J.A. Schultes and J.H. Schultes

B. polymorphu Munro

B. textilis McClure

B. tulda Roxb.

B.vulgarisSchrad.exWendl.

Cephalo stachyum pergracide Munro

Dendrocalamus asper (Schultes f.) Backer ex Heyne

D. giganteus Munro

D. latiflorus Munro

D. strictus (Roxb.) Nees

Gigantochloa apus J.A. Schultes and J.H. Schultes

G. Levis (Blanco) Merrill

G. pseudoarundinacea (Steud.) Widjaja Guadua angustifolia Kunth.

Melocanna baccifera (Roxb.) Kurz

Ochlandra Thw. - a number of species considered reed bamboos

Phyllostachys pubescens Maze1 ex. H. de Leh

Thyrsostachys siamensis (Kurz) Gamble

Vegetative Propagation

The bamboo plant consists of three morphological parts - the aerial part (the culm) and two underground parts (the rhizome and root). A bamboo propagule must develop all three structures. Failure in development of any of these structures leads to failure of a propagule (Banik 1980). Due to the scarcity of seeds, bamboo is generally propagated by vegetative methods. These include:

Clump divisions

This is the traditional, and perhaps the most generally prevalent method of vegetative propagation (McClure 1966). Clump divisions are generally done in two ways - offset planting, and rhizome planting.

Offset planting

The term "offset" was designated by Deogun (1937) for bamboo propagules each composed of the lower part of a single culm with the rhizome axis basal to it. According to Deogun, 1-or 2-year old offsets of *Dendrocalamus strictus* gave best results, while propagules consisting of material 3 years or more in age gave progressively poorer results. Over a century ago, Peal (1882) reported that propagation of bamboos by offset planting was common in the villages of Assam and Bengal. It is evident from Table 1 that offset planting is common in most bamboo growing countries.

Both age of the offsets and their collection time have significant effect on their survival and growth in plantations (Banik 1991). Offsets of *Bambusa balcooa, B. longispiculata, B. tulda, B. vulgaris, D. longispathus, M. baccifera, Neohouzeaua dullooa* and *O. nigrociliata* were planted both in April and June. Success was higher (44-76%) when collected and planted in April than in June (3-38%). The younger (1 year old) offsets showed higher percentage of survival than older ones (2-3 year old). Thin walled species like *M. baccifera, N. dullooa* and *0. nigrociliata* showed poor success in offset planting. In these species, success was obtained (30-40%) by planting rhizome assemblies (part-clumps) with 2-3 offsets at a time.

Rhizome planting

Reports on the propagation of bamboos by rhizome planting are meagre (McClure 1966). Dabral (1950) described it as "the best method", but he did not mention the species or details of the method. The use of rhizomes for propagating bamboo has been limited to non-clump forming species (Uchimura 1977).

Oh and Aoh (1965) mentioned that planting of rhizome cuttings, 40-50cm long, 10cm deep, gave good results in Korea. In propagating *Shizostachyum lumampao,* an endemic species of Philippines, Uchimura (1977) obtained success only by planting of rhizomes or offsets. This was usually done with 1-year old culms that were excavated along with their root systems. The culms were cut to about 1-m high and planted during the rainy season.

McClure (1966) opined that planting of rhizomes might have advantage over offsets, being lighter and less bulky. However, he also mentioned that offsets could be physiologically more suitable for plantations as they have some foliage.

Use of these propagules are practicable only in cultivating a few clumps, particularly within a small accessible area.

Whole culm cutting

Kurz (1876) described this method as "by taking whole halms (culms) with their roots and burying them length-wise in the ground". Pathak (1899) tried propagation of *Dendrocalamus strictus* using 3-5 year old culm cuttings. Although sprouting was good in the initial stages, the cuttings failed to establish during summer. McClure and Kennard (1955) did some experiments with *D. strictus* and *B. tulda* and reported that 2-year old culms produced more propagules than 1-year old culms. The success was reasonable, but the procedure was cumbersome.

Layering

The layered stem when rooted is detached to become a new plant. Three layering procedures for bamboos have been described (McClure 1966). These are:

Ground or Simple layering: Either a whole culm or only the branch bearing part of it is bent down to the ground and into a shallow trench, fastened in place by means of hooked or crossed stakes, and covering it with suitable propagating medium.

Stump layering: The 1-2 node stumps of severed culms are covered with a suitable propagating medium.

Air-layering or marcotting: A culm is kept erect, and the base of each branch complement in the mid-culm range is surrounded with a suitable propagating medium, held in place by a suitable receptacle.

McClure (1966) found that 1-year old culms of *B. textilis* and *Guadua angustifolia,* when bent down and covered with earth while still attached to the mother clump, satisfactorily produced little plants. According to him,this method was too cumbersome except in dwarf cultivars of *B. mutiplex* var. *riviereorum.* Cabandy (1957) obtained a survival of 28% for *B. blumeana* by ground-layering 1-year old culms pruned off branches.

While studying the stump layering methods in *B. longispiculata,* McClure (1966) obtained only 25% rooted branches, but it increased up to 54% when the stumps were treated with

200 ppm IBA. He also tried the same method with 4 other species: *B. textilis, B. tulda, B. tuldoides* and *D. strictus,* and reported that either the plants died or did not produce any rooted propagules.

In exploratory studies, McClure (1986) tried air layering of matured branch components of 1-year old culms of *B. tuldoides* and current year (developing) branch complements of *Semiarundinaria fastuosa* without achieving any success with either species. Cabandy (1957) obtained success (70%) in marcotting only with *B. blumeana.*

Culm- or Stem- cutting

Propagation of bamboos through culm or stem segments is known as the culm-cutting or stem-cutting technique (McClure 1966, Troup 1921). Generally, culm segments of bamboos of 1, or usually 2-3 nodes bearing healthy buds or branches, have been used for propagation (McClure 1966). The branches on each culm segments 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.

As early as in 1899, Pathak used 2-node culm cuttings for propagating *D. strictus* in Orissa, India. The success was about 95% after one year, and finally all died after 2 years. Later, Dabral (1950) reported limited success in this species at Dehra Dun. Sharma and Kaushal (1985) obtained best rooting and survival in 1-node culm cutting taken from 1-10 basal nodes of 6-8 month old culm in the month of March (Spring). Good success and survival were also obtained in *B. nutans, B. tulda,* and *D. hookeni* by culm cutting methods (Bohidar 1989, Stapleton 1987). Surendran and Seethalakshmi (1985) reported that rooting and sprouting responses were significantly enhanced by the application of growth regulators. The success rate was 80% in *B. arundinacea,* 70% in *D. strictus,* 50% *D. scriptoria* while treated with hormone in contrast to the control 40%, 50% and 10%, respectively. In *B. balcooa,* they obtained 40% success in branch cuttings, and 60% in culmcuttings. Effective hormones were IBA and NAA.

In Nepal, a good success rate (60-80%) from single node culm cuttings have been achieved in *B. balcooa, B. nutans, D. hamiltonii, D. hookeni,* and *D. nigrociliata* (Das 1988).

Propagation studies in Sri Lanka showed that 2-node culmcuttings of some major bamboo species are more satisfactory than split culm-cuttings, and the technology is being gradually transferred to the planters (Vivekanandan 1987).

In the Philippines, Chinte (1965) reported a 60% survival for *B. vulgaris* and 28% for *Gigantochloa asper,* whereas *B. blumeana* and G. *levis* failed to grow. Three node cuttings survived better than 2-node planting stocks, and the basal sections were superior to the middle and top sections. Another study on *B. blumeana* showed a greater percentage of survival (60%, 8%) in culm cuttings planted unsplit (Cabandy 1957). For G. *levis*, unsplit culm cuttings also gave better results, and the middle and top portions of the culm were the best material for propagation (Bumalong and Tamolang 1980). Mabayag (1937) found that the basal portions of culm cuttings of *B. blumeana* were better than the middle and top portion of the culm. In a separate study, 2-node split and unsplit (about 1-2 year old) culm-cuttings of 4 different bamboo species planted directly in the field showed better result (94%) after 3 months and poor results (11.7%) after 15 months of trial (Bumalong and Tamolang 1980). Suzuki and Ordinano 1977) obtained 45% survival of *B. blumeana* treated with IBA and 32% for controls; 80% for treated *B. vulgaris* and 75% for controls; 60% for treated *D. merrillianus* and 53.5% for controls. However, Uchimura (1977) found that, of the three growth regulators (IAA, IBA and NAA), cuttings treated with 100 ppm of IBA for 24 hours gave better rooting percentage and formation of longer roots in *B. vulgaris.* In a similiar study with *B. blumeana* using different concentrations of IAA, IBA and NAA, Bumalong and Tamolang (1980) observed that rooting was maximum with 600 ppm NAA. 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. Scientists also believed that the starch content and the levels of various nutrients in the cuttings might have influenced the rooting. Joseph (1958) found high amount of starch content in culm cutting of *B. arundinacea* during February and March. Banik (1987) 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, Dendrocalamusgiganteus, D. longispathus* and *Melocanna baccifera.*

Recently, Gonzales *et al.* (1991) from the Philippines reported that split-culm cuttings can reduce the weight of the planting stock in comparison to those produced as whole culm cuttings. They obtained 100 percent survival with cuttings of *Bambusa blumeana, B. blumeana* var. *luzonensis, B. philippinensis, B. vulgaris, B. vulgaris* var. *striata* and G. *asper.*

Branch cutting

White (1947) reported that it was possible to propagate *Gigantochloa verticillata* and *Sinocalamus oldhami* by branch cuttings. Delgado (1949) and Mcclure and Durand (1951) also propagated bamboos by using branch cuttings, but with poor rooting percentages. Studies showed that in most bamboo species of Bangladesh, normal branch cuttings rooted well under mist tents, but the majority of them did not produce any new culm, owing to the failure of rhizome development (Hasan 1977). Such cuttings might survive up to 4-5 years only with the help of roots but without any further shoot production and clump formation.

Banik (1980) successfully induced *in situ* rooting and rhizome at the branch bases of some thick-walled bamboo species of Bangladesh. Artificial induction was possible by chopping the culm tops and removal of newly emerging culm. He termed these "pre-rooted and pre-rhizomed branch cuttings". Such cuttings performed better than normal branch cuttings (Banik 1984, 1987a). 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 maintained under overhead misting for one month. A propagation bed is a 3-layered sand, each layer being 7-10cm deep and made up as follows:

- gravel and large size sand at the bottom
- medium size sand in the middle
- fine sand at the top

In each layer clean, sand is placed so that the bed remains well-drained. A propagation bed is 1.2m wide and 12m long, situated on level ground in the nursery. Within 30 days each of the prerooted and prerhizomed branch, cuttings produce pro-fuse active roots in the propagation bed. Once profusely rooted, the cuttings are transferred to polythene bags and kept in the nursery. The average rooting and rhizome formation ability of these type of branch cuttings are 67% in *B. balcooa*, 70% in *B. nutans*, 93% in *B. polymorpha*, 90% in *B. vulgaris* and 63% in *D. giganteus* (Banik 1984, 1991). Like seedlings, cuttings also need aftercare in the nursery at least up to the next monsoon. Survival of these cuttings in the field is as high as high 85-97%.

Macroproliferation of bamboo seedlings

Several methods of vegetative propagation are common in many grasses, e.g. use of tillers, culms, rhizomes or stolons (Langer and Ryle 1958). Like many other grasses, bamboo has the inherent proliferating capacity to reproduce itself probably due to its long interseeding period. By utilising this habit, an interesting technique has been developed by Plant Physiology discipline of Botany Division, Forest research Institute Dehradun for multiplication of a seedling through the rhizome separation method. We termed the technique macroproliferation of seedlings. It is 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 and a big portion of them may be planted while keeping a stock for future macroproliferation. The survival rate of these multiplied seedlings is 90-100%. It has also been observed that seedlings of *B. arundinacea*, *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). Therefore, seedlings raised in big polythene bags produced a higher number of multiplied seedlings (5-7 times), whereas seedlings in a small-sized bag could produce only 2-3 number of multiplied seedlings. Later, Adaresh Kumar et al. (1988) also used this method successfully for multiplication of the seedlings of *B. arundinacea, D. strictus,* and *D. hamiltonii.* Recently, in India a detailed plan has been developed by Adaresh Kumar (1991, 1992) for continuous production of field plantable saplings in massive numbers viz., *B. arundinacea*-49000; *B. tulda* 25000; *D. hamiltonii* 46000; and *D. strictus*-36000 (or in multiples) every year for any desired number of years.

Till date ten major bamboo species have been propagated through this technology at Forest Research Institute Dehradun in mass. These ten bamboo species are:

- *Arudinaria falcata*
- *Bambusa bambos*
- *B. tulde*
- *B. nutance*
- *B. vulgaris*
- *B. multiplex*
- *Dendrocalamus strictus*
- *D. hamiltonii*
- *D. asper*
- *D. membranaceous*

Advantages of this method are that once the seed or seedlings of a bamboo are available, the process can be continued at least for a number of years. Proliferated seedlings remain small in size due to continuous rhizome separation$_1$ thereby making it easy to handle and transport them. However, it is suggested that seedling multiplication in this way should not be continued for a very long time since the time gap between the last multiplication and subsequent flowering gets shorter. As a result, the last multiplied seedlings might start flowering due to their physiological maturity before attaining the commercial culm size.

Planting Stock Nursery management

Initially, seedlings do best in partial shade compared to direct sunlight. Complete shading over seedlings should be discouraged. The emergence of shoots is successive. The new shoots are bigger and taller than older ones. The germinating plumules are very thin (1-2 mm diameter) in *B. tulda* and thick (4-6 mm) 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. *M. baccifera* seedlings become most elongated (175 cm) and thick (0.8 cm, dia.) at 3 months of age (Banik 1991).

A rhizome system starts to develop in the seedling 1-2 months after germination, and at a young stage, the rhizome movement is strongly geotropic. Therefore, roots and rhizomes of a seedling penetrate the neighbouring polythene bags of other seedlings in a nursery. This creates a mass of twisted and intertwined roots and rhizomes of seedlings. As a result, the roots and rhizomes are damaged at the time of transportation. Frequent shifting of seedlings from one bed to another helps in minimizing the root rhizome intermingling. Seedlings need regular weeding and daily watering in the nursery.

Economics of Planting Stock Production

The economics of planting stock production of bamboo species in nursery has been estimated and presented as under. The cost is calculated for producing one plantlet by each method. The cost estimates are based on the labour cost in collection, nursery plantation, nursery maintenance, cost of preparation of planting media for feeling the polybags and maintenance of planting stock in the nursery for six months which includes weeding, watering, soil working and shifting.

S.No.	Methods	Cost per plant (Rs.)	Remarks
1.	Offset planting	50.00	Labour intensive and heavy planting stock
2.	Rhizome planting	30.00	Labour intensive and heavy planting stock
3.	Whole culm cutting	15.00	Labour intensive
4.	Layering	5.00	Limited planting stock may be produced

S.No.	Methods	Cost per plant (Rs.)	Remarks
5.	Culm- or Stem- cutting	8.00	Limited planting stock may be produced
6.	Branch cutting	3.00	Unlimited quality planting stock may be produced
7.	Macroproliferation of bamboo seedlings	2.50	Unlimited planting stock may be produced subject to availability of seeds once

*The cost of production per plant may vary place to place depending upon the variation in labour cost.

Weaknesses and Gaps in Conventional Propagation Methods

The traditional rhizome/offset methods are applicable only in cultivating few clumps, particularly within a small accessible area. The limitations of traditional methods are:

- The method is expensive due to high cost of the propagules and labour for excavation and transportation.
- Offsets and rhizomes are bulky and heavy (4-30 kg per propagule) and as a result, difficult to handle and transport.
- In most species, the survival success is 5-50%.
- Availability of propagules per clump is limited, as only young (1-2 year old) culms can be used as propagules. Not more than 30-50% young culms should be collected from a clump; otherwise, it would lose regeneration capability.

McClure (1966) mentioned some problems in propagating clump forming bamboo through rhizomes. These were: i) meagre development of roots, ii) decay of rhizomes, and iii) slowness of rhizome buds to break dormancy.

Other methods such as whole culm cutting are also not always applicable to all bamboo species. Both whole culm cutting and ground layering methods need sufficient space near the clump, which may not always be available. Depending on the species, a culm 10-35m long has to be buried lengthwise. After the striking of roots and shoots on the nodes, propagules have to be excavated for transplanting. The succe is also limited (10-40%). The procedure is expensive and labour intensive. The air-layering method is comparatively easier; propagules are smaller in size and success is also reasonable, but the applicability of the method is species specific.

The culm or stem-cutting method is comparatively well studied. This method is also expensive and the propagules are difficult to transport. The disadvantages of the method are:

(i) Such cuttings are generally of 1-to 2-node culm segments and, therefore, the length of the segment may vary from 0.1 to 1.5m, and obviously need big-sized pots for planting in the nursery.

(ii) Handling, carrying and transportation of these big-sized pots are difficult and expensive due to their heavy weight. Split culm cuttings can be used to overcome such problem, but applicable only to a few species.

(iii) There is the limitation of using 1-2-year-old culms, which can otherwise be put to other uses.

Abeels (1962) mentioned that "there are indications that the stem layering in bamboos may be successful if it is carried out *in situ* and the layered stem is not transported". However, while studying the air-layering in bamboos, Abeels (1962) also mentioned that "cutting out of rooted parts is not easy and on planting time in the nursery, their survival is not definite".

Prerooted and prerhizomed branch cuttings are comparatively more dependable as propagules than are normal branch cuttings. This method has been found suitable mostly for thick-walled and stout branching bamboo species.

As far as is known, most of the thick-walled bamboo species are amenable to vegetative propagation techniques. Thin-walled species like *Melocanna baccierra, Oxytenanthera nigrociliata,* and *Neohouzeaua dullooa* are difficult to propagate by any of the known conventional vegetative propagation methods. However, in general no one method of vegetative propagation of bamboos is universal and effective for all the species. From the published literature and practical experience, it is evident that there is an *optimum age flir rooting in each type* of *propagating material* (rhizome, offset, culm segment, branch cuttings, etc.).

In addition, there is also serious risk in vegetative propagation methods in propagating bamboos. Most of the species, in general, maintain a definite period of vegetative state before flowering and synchronized death. The period may vary from 15-120 years. Suppose a species *M. baccifera* flowers after a 30 year interval. If propagules are collected from a 15-year-old clump and planted in the field, they will flower within the next 15 years and die. Thus, the productive life of that vegetative propagule is always less than a naturally grown propagule (seedling). Although some techniques have been developed for determining the age of a culm present in a clump, it is completely impossible to determine the clump age. Moreover, it is not yet possible to recognise a bamboo clump that is going to flower within the next 1-2 years. Therefore, any propagule collected from a ripe "to flower" clump will flower within a few years of planting, incurring heavy loss to the planter. During 1979, in Bangladesh, a 10 ha experimental plantation of *B. tulda* was raised through planting of rhizomes collected from Syihet (Adampur). All the planted propagules flowered and died in 1980 synchronous with their mother clumps at Adampur. The species with gregarious flowering nature would impose risk in raising plantations through vegetative propagules compared to those of sporadic flowering species. However, species like 8. *vulgaris* and *B. balcooa,* so far as is known, flower rarely and after long intervals (Banik 1979, Banik and Alam 1987) and, therefore, have less risk from vegetative propagation.

The main limitation of sexual propagation in bamboos is the unpredictable availability of seeds and seedlings. As flowering is not c6mmon, the knowledge on seed productivity, seed biology, including germination, viability and storage, is inadequate and also not known for many species. Excepting for a few species, seedling raising and nursery management are also not yet practiced. Few studies have been made on the growth performance of each of the propagule types and time required for attaining commercial size. So in many cases, planters cannot make financial predictions

Farmers and field foresters often ask how to produce different types of vegetative propagules and seedlings; which method is superior for which species, and how far earlier marketable harvest can be made. With the present state of knowledge, answers to some of the queries can be given, but in most cases they cannot.

Diversity, "Seed Stand" and Seed Propagation Research

In the past, almost all the multiplication studies in bamboos have been made using different techniques, of vegetative propagation. Due to limitations of these techniques it is necessary to change the research strategy. seed must be used as a tool of propagation research, and all seedlings must be optimally utilised. In fact, seed propagation ensures a wide genetic base. It is important to study the seeding behaviour of different species.

Variation in flowering periodicity have been observed and documented among the clumps under the same bamboo species (Hasan 1980, Menon 1918, Brandis 1899, Janzen 1976).

From the study of the published literature, the physiological cycle of the various bamboo species appears to be as under:-

Bamboo *species*	**Physiological cycle**
Arundinaria wightiana	Annual
Bambusa atra	
Arundinaria spathiflora	16-17 years
Arundinaria falcata	28-30 years
Arundinaria recemosa	About 30 years
Arundinaria felconi	
Dendrocalamus strictus	30-45 years
Dendrocalamus hamiltonii	30 years
Bambusa tulda	35-60 years
Bambusa bamboo	32-34 years
Melocanna baccifera	about 45 years
Ochlandra travancorica	about 7 years
Bambusa vulgaris	Never seen flowering since its description in 1810.

In addition to the gregarious habit of flowering *Bambusa arundinacea, B. longispiculata, B. nutans, B. tulda, DendrocaJamus hamiltonii, D. tongispathus,* and *D. strictus* have also showed sporadic flowering in isolated clumps, or in small groups of clumps. Records show that *Bambusa tulda,* in addition to its 20-30 years gregarious flowering, also exhibits frequent sporadic flowering. In lower Bengal, *B. tulda* flowered 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 within 12 years (1978-1990) (Banik 1991). So, *bambusa tulda* also has a number of "flowering genotypes" occurring in nature. A number of flowering cycles have also been reported for *D. strictus*. In S. India, it is 24-28 years (Kadambi, 1949); in N, E, and C. India 40-44 years (Kadambi, 1949; Gupta, 1952); and W. India 65 years (Mathauda, 1952). In Bangladesh; the species was introduced from the Angul District of Orissa and flowered synchronously after 45 years (Banik 1981), showing the same periodicity of *D. strictus* originally from C. India. In *D. longispathus,* three flowering genotypes have been observed, haying different duration of flowering period (Banik, 1986). 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 pedigree and may have evolved through mutation. Such "flowering genotypes" should be identified in nature and centralized in one place. In the next flowering time, these genotypes are likely to flower one by one and also in between the normal gregarious flowering period. The following steps should be taken to collect these "flowering genotypes".

- Regular collection of information on the incidences and locality of flowering,
- Explore and visit both natural and planted populations to locate and identify the flowering clump(s) of indigenous and introduced species, respectively.
- Diagnose the nature of flowering (sporadic$_1$ part flowering clump, complete flowering clump, gregarious, etc.). For a given species, different clumps may exhibit these in different or the same localities in different or the same years.
- Each of the flowering clumps may be designated "flowering genotypes" and documented. For instance, *Bambusa tulda* flowered in four different years in different localities of Bangladesh and they have been labelled as follows: *-Bambusa tulda/Shishak/1977, Bambusa tulda/Kaptai/1980, Bambusa tulda/Sylhet/ 1984, Bambusa tulda/* Keochia /1989.
- Collect seeds/seedlings/other propagules from identified flowering clump(s).
- Raise seedlings and collect wild seedlings and other propagules. Mark each according to the label of the mother flowering clump and maintain separately in the nursery. Group these planting stocks according to the species.
- After one year of maintenance in the nursery plant, mark the flowering genotypes species wise in a suitable site.
- Plant the seedlings/other propagules in lines according to the seeding year under each species.
- Accordingly, a number of "flowering genotypes" within different species will be identified and centralized in one common place.

Such centralized plots may be termed "seed stands". Some species growing in different countries may flower at different times. It is worthwhile to collect "flowering genotypes" of a species and plant them in plots and thus, seed yield will be more frequent.

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Bamboo Shoots : As a Viable Food Option

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Bamboo is a strong versatile and highly renewable and environmental friendly material. Starting its journey as a weed in 19th century, it has now achieved the status of an economically most important plant, rightly considered as "Green Gold". It has emerged as a potential crop for its 1500 diversified uses, securing livelihood and security to millions of pople globally. The combined value of internal and commercial consumption of bamboo is worth US $ 10 billion (approx. Rs. 50,000 crore) which is expected to increase about US $ 20 billion by 2015 (Dutt, 2004).

Bamboo Shoots

Bamboo shoots are the pale, young protrusions that grow from the lower leaf axils of young plants. The shoots are generally eight to twelve inches long, tapering to a point and weighing upto a pound (450 g). Bamboo shoots are young new canes that are harvested for food before they are two weeks old or one foot tall. Bamboo shoots are crisp and tender, comparable to asparagus, with a flavour similar to corn. They are used frequently in Asian cuisine. Commercially canned bamboo shoots are common but fresh, locally grown bamboo shoot has far better flavour and texture. (www.agsyst.wsu.edu).

Cultivation of Bamboo Shoots

Kerala Forest Research Institute (KFRI) had worked on six species of bamboo shoots namely Bambusa bambos, Bambusa tulda, Dendrocalamus brandissi, Dendrocalamus hamiltonii, Dendrocalamus longispathus and Dendrocalamus strictus and reported of new shoots can be increased. The shoots are harvested 7-14 days after the emergence when the shoot height will be 15-30 cm depending upon the species (**www.kfri.org**). The young bamboo shoots begin to appear a few weeks after the onset of rains and they are harvested before they are two weeks old as after that they become over mature and are unfit for consumption. So, they are generally harvested during April – May and November. Their peak availability is June to October (Tewari, 1996). Bamboo cultivation has been practiced in many tropical countries for thousands of years. In India, bamboo is grown as cash crop in the North Eastern part. The emerging succulent bamboo shoots of various species are harvested and used as vegetable by the Tibeto-Mongoloids of Asia. Excellent conditions for cultivating bamboo shoots are mild winters and hot humid summers. Harvest seasons of both winter shoots and spring shoots are limited in a few certain months and are relatively short. Moreover, fresh bamboo shoots contain high water content, which makes shoots difficult to preserve, therefore, bamboo shoots are usually either eaten as fresh vegetable or processed to canned to dried shoots.

Bamboo Shoot

Bamboo is not merely a poor man's timber but is also the rich man's delicacy. It is one of the fastest growing commercial plants, which makes it ideally suited for promotion as food crop for domestic purpose as well as export. It is in this form that it has tremendous export potential which has been unexplored so for. This is mainly because of use of edible tender bamboo shoots in Indian recipe has been confined to North East, Chattisgarh and Orissa (Kumbhare and Bhargava, 2007). The young shoots of the bamboo have for centuries been held in high esteem by all Asians as an edible delicacy. Fresh, fermented and roasted tender bamboo shoots are considered culinary treats. Bamboo shoots are consumed as vegetable, pickle, salads and in various other forms in several countries. (Christino and Wetterwald, 1992). Young shoots of both running and clump forming bamboos are eaten. The tender shoots of *Dendrocalamus giganteus, Dendrocalamus hamiltonii, Dendrocalamus membranaceous* and *Dendrocalamus strictus* are consumed either as vegetable or as pickle. The tender shoots of bambusa balcoa are cooked and eaten, but are also generally preserved after fermenting and drying. (Bhagarva et al., 1996). *Bambusa Polymorpha* is considered as one of the best in the world producing quality edible shoots, which have distinct sweet taste in the raw state.

In India, the seeds of *Bambusa arundinacea, Cephalostachyum pergracile* and *Dendrocalamus strictus* are extensively eaten by poor during famines. The seeds are pickled and candied and used for making beer. Fleshly fruits of multi (Melocana bambusoids) are eaten raw or cooked; its seeds are used in some parts of the country as substitute for rice, stewed bamboo shoots and 'mesu' – a non – salted fermented bamboo shoot products are commonly used as pickle and curry ingredients and are regarded as delicacies (Tamang and Sarkar, 1996). In Manipur, the fresh succulent bamboo shoots and the fermented preparation of bamboo shoot slices, locally called 'soibum' is a highly priced vegetable item. Traditional processing of fresh edible bamboo shoots by natural fermentation for producing and indigenous food 'soibum', is popular in Manipur (Devi and Singh, 1986).

Bamboo Shoots can be used in combination with other vegetables, or alone with a meat dish, and are delicious if eaten with melted butter. They are generally pickled by Chinese. If the shoots are from sweet species, they can be sliced and used as an addition to a salad mixture. All bamboo shoots are firm and crisp in texture when eaten raw, and never become mushy when cooked. The flavour is subtle and singularly characteristic of this vegetable, but it is not strong. For this reason savoury ingredients are often incorporated in the recipe.

Anti nutrients in bamboo shoots

Cyanogenic glycosides are phytotoxins which occur in at least 2000 plant species, of which a number of species are used as food in some areas of the world. Cassava and sorghum are especially important stable foods containing cyanogenic glycoside. There are at least 2650 species of plants that produce cyanogenic glycosides and usually also a corresponding hemolytic enzyme (beta-glycosidase), which are brought together when the cell structure of the plant is disrupted by a predator, with subsequent break down to a sugar and a cyanohydrin, that rapidly decomposes to hydrogencyanide and an aldehyde or a ketone. This combination of cyanogenic glycosides and hydrolytic enzymes is the means by which cyanogenic plants are protected against predators. These are approximately 25 cyanogenic glycosider known. Although cyanide is unknown as a problem in the Chinese bamboo shoots industry, there are several reports else where of bamboo species containing significant, potentially very toxic, amounts of cyanogenic glycosides in their shoots. There is very little published material, however the available material does confirm that some bamboo species do indeed contain very high levels of cyanogenic glycosides in their shoots. More work is needed by national agricultural research institutes Taxiphyllin is the major cyanogenic glycoside found in the edible part of bamboo shoot. Taxiphyllin is unusual amongst the 60 or so known similar compounds in that it degrades readily in boiling water. Thus the normal preparation of bamboo shoots should remove any problem. However, in extending the use of bamboo shoot eating to other regions a problem may occur if people prepare bamboo shoots in a manner similar to that used for another cyanogenic crop (cassare) in Africa. The potential toxicity of a cyaneogenci plant depends primarily on the potential that its consumption will produce a concentration of HCN that is toxic to exposed animals or humans (Nartey 1980).

Toxic effects of HCN (Cyanogenic glycoside)

Hydrogen cyanide is one of the several agents known formally as 'blood' agents through the term is misnomer since the agent acts at the mitochondrial level of the cells. HCN is high concentrations is rapidly fatal. HCN acts by binding to the iron atom in cytochrome oxidase enzymes, inhibiting the catalytic functions that allows oxygen to act as an electron receptor to produce ATP. This means that hypoxia occurs at the tissue level (Baskin et al., 1992). The consumption of foods containing toxic cyanogens could result in acute or chronic cyanide toxicity. The former is fatal, resulting in a high rate of mortality and morbidility, while the latter has been associated with goiter. Epidemiological and experimental studies showed that cyanogenic glycosides in food products play an important role in the development of goiter. Thiocyanate, the detoxification product from the HCN derived from cyanogenic products, is responsible for interference with thyroid function. Neurological disorders such as ataxic neuropathy and cretinism have been associated directly with the intake of cyandgenicglycoside containing foods (Nartey, 1980).

Hydrogen cyanide will reduce the energy availability in all cells, but its effect will be most immediate on the respiratory system and heart. The lethal dose for an adult depends on body weight and nutritional status and is somewhere between 30 and 210 mg of hydrogen cyanide. Smaller, non-fatal amounts of cyanide cause acute intoxication with symptoms of rapid respiration, drop in blood pressure, rapid pulse dizziness, headache, stomach pain, vomiting and diarrhea (Food Standard, Australia, New Zealand, 2005).

HCN Present in bamboo shoots and its permissible limits

In respect of cyanogenic glycosides, bamboo shoot is the most potent followed by cassava, cauliflower, cabbage, turnip and radish (Chandra et al., 2005). Food Standard, Australia, New Zealand, 2005 stated in a report on "Cyanogenic glycosides in cassava and bamboo shoots : A Human Health risk" that there are approximately 1200 species of bamboo, although only a small number are used as food. Bamboo shoots may contain as much as 1000 mg/kg HCN, significantly higher than the amounts detected in cassava tubers, however, cyanide content is reported to decrease substantially following harvesting. The bamboo shoots sold commercially as food can be processed adequately by boiling before consumption. The process of canning bamboo shoots liberates and adequately removes hydrogen cyanide Ferreira et al., (1992) reported that high HCN content (approx. 750mg/kg) of bamboo shoots, hinders their use as a food. The content of hydrocyanic acid varies from 0.05 to 0.3 percent; the tips of immature shoots sometimes contain upto 0.8 per cent. The presence of toxic compound in bamboo shoot decreases its consumer acceptability.

Haque and Bradbury (2002) reported that tip of the bamboo shoots had the highest at HCN content (920-1600 mg/kg), followed by the mid portion (620-1140 mg/kg), and the least HCN content was reported in the basal portion (114-440 mg/kg) Bhatt et al (2005) reported 0.01 to 0.02 per cent HCN in edible bamboo shoot. The nutritional implications of cyanogens and process to reduce their levels in products to a safe limit have been extensively studied. Codex Alimentarius Commission Standard has defined the maximum safe limit as maximum of 10 mg HCN equiv. Per kg fresh shoot. The WHO safe level for total cyanide content of cassava flour is 10 ppm (FAO. WHO, 1991) and values in excess of 100 ppm are considered a danger to health. The acute oral lethal dose of HCN for human beings is reported to be 0.5 to 3.5 mg/kg body weight corresponding in 9 to 1.0 to 7.0 mg/kg body weight of KCN. The clinical signs are well described and include headache, dizziness, mental confusion, stupor, cyanosis with twitching and convulsions followed by terminal coma.

Preparation of Bamboo Shoots

Preparation of succulent shoots for the table is simple and straight forward. Cut off the tough portion of the base, and slit through the sheath length wise with a sharp knife. Strip off the death until the white meat is exposed. Cut off also any bits which are damaged or discoloured.

Fresh young bamboo shoots

↓

Washing of bamboo shoots

↓

Cutting of the tips

↓

Peeling / removal of tough outer sheath

↓

Cutting of inedible base shoot

↓

Slicing of bamboo shoots (0.25-0.50 cm thickness)

↓

Removal of HCN
(boiling, steaming, soaking, drying)

Flow chart for preparation of bamboo shoots

Reducing HCN content from processed bamboo shoots

The cyanogens present in bamboo shoots is taxihyllin which is a p-hydroxylated mandelonitrite triglochinin and therefore, one of the few of these cyanogenic compounds that decomposes quickly when placed in boiling water. Bamboo shoots become edible because of this instability. Ferreira et al (1995) reported that boiling bamboo shoots for 20 minutes at 98^0 removed nearly 70% of the HCN while all improvements on that (higher temperatures and longer intervals) removed progressively upto 96%. Thus even the highest quoted figure (800 mg/100g) would be de-toxified by cooking for two hours.

Among the traditional methods of reducing HCN content of bamboo shoot, soaking in water, sun drying soak-dry-soak method, boiling and steaming are quite popular. The above techniques, however enable greater reduction of free cyanide than bound ones. Different processes for extraction of HCN from bamboo shoots like maceration in water, batch cooking at ambient pressure, and intermittent cooking at ambient pressure also gave an acceptable extent of HCN removal. Other literatures also reported a reduction in HCN on boiling. Losses of 50-100% were reported as an effect of 30 minutes of boiling. The loss of cyanogens during boiling is attributed to be by leaching or solubilization in the boiling water.

Sopade (2000) reported reduction of 40-70 per cent of cyanogenic glycosides in bamboo shoots as a result of steaming. Steaming is reported to be as effective as bakingin detoxifying shoots but both are less effective than boiling. Toxic constituent taxiphyllin from shoots can also be removed by several changes of water during cooking or by presoaking for a long time in several changes of a solution of 2 per cent salt. (Bhargava et al., 1996).

Cyanogenic glycoside in fresh bamboo shoots can also be reduced by ferri chloride induced degradation. Approximately 85 per cent loss of cyanide on oven drying and 56 per cent on sun drying have been reported in bamboo shoots. INBAR is involved in an active research programme to develop new food products from bamboo shoots. The objective of the research programme is to stimulate new uses of bamboo shoots in existing markets and to assist developing food security in food-poor areas.

There are now simple kits to determine the presence of cyanide in bamboo shoots. Howard Bradbury from Australian National University has developed a range of practical kits that can be used by an unskilled person for looking at cyanide levels in bamboo shoots, sorghum leaves and flax seed meal. The general principle is that a small sample of product (shoot) is placed in a container with filter paper containing the required catalyst and a piece of picrate paper that reveals the amount of poison produced. The bottle is left overnight at room temperature. Next morning, when the breakdown to poisonous gas is completed, the colour of the picrate paper indicates the levels of toxicity. Effect of different processing methods (Boiling, steaming, soaking and drying) on reduction of HCN content is presented in Plate No. 1,2,3,4 & 5 at different time and temperature.

Processing methods for bamboo shoot marketing

In many places, bamboo shoots have formed a part of traditional cuisine-fresh, dried, shredded or picked. There is, however, also a growing market for processed and packaged shoots, representing an opportunity for the establishment of commercially run processing units. Bamboo shoots are good in fiber and have optimum amount of other nutrients. They are said to be anti-microbial in nature. For the processing of bamboo shoots following three packages are being supported by NMBA:

1. Cluster level shoot processing technology

The processing technology for shoots is an innovative break through for backward linkage before processing such as canning. Using this process, the shoots can be processed hygienically to stay close to fresh for 10 days. In this process, the raw shoots are cut, soaked in water to remove the bitter components and then drained the next morning. After draining the cut shoots are packed in nylon based packages and then potable water is added to keep the cuts soaked in water. After sealing, the packs are labeled for date of packing and price of the packs. The processing cost is low, the process is hygienic and product is suitable to be ideal to be sole to :

- Possessors for further processing e.g. canning and freezing.
- To meet the demand of institutional market.
- For meeting local consumption and meeting self requirements.

2. Vacuum processing of shoots

This technology is to increase the shelf life of product to five – six months. The product is suitable to be sold in the state / district, out of season and for marketing out side the state through the year. The product can also be used for processing secondary products like pickles, canned products etc. The product has attributes like economics in production, transparency and hence enhanced looks and space economy.

3. Canning

The traditional method of commercial sterilization is the form in which most of the shoots are transported after processing. This is the form in which shoots are imported. The target group is people and institutions which want convenient and clean foods.

Nutrient level in bamboo shoots :

Occurrence of various constituents of nutritional significance in succulent bamboo shoots is described by many workers. The following nutrition information is for one serving of raw bamboo shoots (75.5 g):

Macronutrients :

Water	:	68.7 g
Calories	:	20 K Cal
Protein	:	1.96 g
Carbohydrates	:	3.93 g
Fiber	:	1.7 g
Sugars	:	2.27 g
Total fat	:	0.23 g
Saturated fat	:	0.23 g
Monounsturated fat	:	0.005 g
Poly unsaturated fat	:	0.101 g
Cholesterol	:	0 mg

Micronutrients :

Calcium	:	10 mg
Iron	:	0.38 mg
Magnesium	:	2 mg
Phosphorus	:	45 mg
Potassium	:	402 mg
Sodium	:	3 mg
Zinc	:	0.83 mg
Vitamin C	:	3 mg
Thiamin	:	0.113 mg
Ribo flavin	:	0.053 mg
Niacin	:	0.453 mg
Pantothenic acid	:	0.122 mg
Vitaman B_6	:	0.181 mg
Vitamin B_{12}	:	0 mcg
Folate	:	5 mcg

Vitamin A	:	15 I.U.
Vitamin E	:	0.76 mg
Vitamin K	:	0 mcg

Phytonutrients :

Phytosterols	:	14 mg
Beta Carotene	:	9 mcg
Beta cryptoxanthin	:	0 mcg
Lycopene	:	0 mcg
Lutein and Zeasanthin	:	0 mcg

(Source : USDA National Nutrient Data base for standard reference)

Table 1 : Proximate composition of raw bamboo shoots

Components	Value
Moisture (%)	90.74
Crude protein (%)	2.39
Crude fat (%)	0.33
Total ash (%)	1.11
Crude fibe (%)	1.48
Carbohydrate (%)	3.95
Energy (Kcal/100g)	28.0

(Source : Pokhariya, 2007)

Table 2: Mineral and vitamin content of raw bamboo shoots

Components	Value (mg/100g)
Iron	0.25
Calcium	17.43
Phosphorus	60.55
Copper	0.20
Manganese	0.43
Zinc	1.21

Potassium	602.10
Sodium	6.33
Vitamin C	5.24

(Source : Pokhariya, 2007)

Table 3: Dietary fiber and sugar content of raw bamboo shoots

Components	Value
Total dietary fiber (%)	3.23
Insoluble dietary fiber (%)	2.25
Soluble dietary fiber (%)	0.98
Total sugars (%)	2.30
Non-reducing sugar (%)	1.55
Reducing sugars (%)	0.75

(Source : Pokhariya, 2007)

Health benefits of bamboo shoots

Bamboo shoot is not only a delicious food option but a health promoting food option. With the increasing economic status of the country, degenerative diseases such as diabetes cardiovascular diseases and cancer are becoming a public health problem in sizable fraction of community because of change in dietary pattern from traditional foods to more refined, high calorie and low fiber foods. Therefore, in order to overcome these problems and to attain food and nutrition security, there is an urgent need to develop products using underutilized, uncommon and nutrient dense bamboo tender shoots because it has been found to be effective in cancer prevention, increasing appetite, decreasing blood pressure and cholesterol levels in human body, Bamboo shoot can be labeled as heart protective vegetable and its component phytosterols may be suitable as neutraceuticals

With the serious problem of obesity and excessive consumption of fatty foods facing many of the countries, another wonderful property of tasty bamboo shoots is that they have been shown to actually lower body fat and to prevent constipation. Bamboo shoots are found to be a very good source of fiber. High dietary fiber of bamboo shoots makes it suitable option for the person suffering from constipation. Further bamboo is very low in fat and has almost negligible cholesterol. Thus bamboo shoot is a secret for maintaining healthy heart and avoiding heart attack. Not only is its low fat and cholesterol makes it good for heat patients but its high soluble fibre content helps in eluding the bad cholesterol (LDL) from the body by disclaiming.

It is reported that bamboo shoot has the effect in caner prevention (Lin et al., 2003). This low fat foods is thus a low calorie food also, which can be adopted by the persons on a crash diet for loosing weight. Another health benefit of bamboo shoot is that it has high protein content, which is comparable to the pulses and wheat.

Food Formulations

Bamboo Shoot Soup

Ingredients

Bamboo shoots	:	100g
Capsicum	:	100g
Coriander leaves	:	to garnish
Onion	:	100 g
Peas	:	50 g
Coconut	:	100 g
Green chillies	:	2-3
Beans	:	100 g
Salt	:	to taste

Method

- Wash and chop all the vegetable to small pieces.
- Chop the onions and sauté in the oil.
- Add the chopped vegetables into the same pan and continue sautéing until all are cooked.
- Add the paste of coconut, chillies and coriander into it and cook till done.
- Add water and being it to boil.
- Add salt and pepper at the end.
- Serve hot.

Bamboo Shoot Russian Salad

Ingredients

Bamboo shoots	:	50 g
Carrot	:	50 g
Cauliflower	:	6-7 flowerets
Potato	:	1 small
Mayonnaise sauce	:	100 g

Method

- Chop all the vegetable into dices. Cook them in pressure cooker for 15 minutes.
- Add mayonnaise sauce to the cooked vegetables and toss well for uniform mixing.
- Serve hot.

Bamboo Shoot Bajji

Ingredients

Chickpea flour	:	100 g
Bamboo shoots (boiled)	:	200g
Red chilli powder	:	1 tea spoon
Baking soda	:	2 pinch
Turmeric powder	:	½ tea spoon
Salt	:	to taste
Cumin seeds	:	5 g

Method

- Chop prepared bamboo shoots into long strips.
- Mix chickpea flour, chilli powder, salt and baking soda and cumin seeds. Sprinkle water and make a thick batter.
- Dip the bamboo shoot strip in the thick batter and fry in hot oil till cooked and golden brown.
- Serve hot with sauce.

Bamboo Shoot Fry (Pakoda)

Ingredients

Chickpea flour (besan)	:	100g
Onion (big)	:	1
Bamboo shoots (boiled)	:	200 g
Semolina	:	50 g
Chilli powder	:	1 tea spoon
Cumin seeds	:	1 tea spoon
Baking soda	:	2 pinch
Turmeric powder	:	½ tea spoon
Salt	:	to taste
Oil	:	for frying

Method

- Chop onions and prepared (boiled 25 min) bamboo shoots into small pieces.
- Mix chickpea flour, chopped onion, bamboo shoot, chilli powder, cumin seeds, semolina, salt and baking soda. Sprinkle water and make a thick mixture.
- Fry in hot oil it turns golden brown on slow heat.
- Serve hot with mint chutney or tomato sauce.

Bamboo Shoot Vegetable

Ingredients

Boiled (25 min) Bamboo shoots	:	250 g
Onion	:	100 g
Tomato	:	100 g
Turmeric Powder	:	½ tsp
Salt	:	to taste
Cumin seeds	:	¼ tsp
Oil	:	for cooking

Method

- Heat oil in skillet.
- Add cumin seeds, chopped onion and tomatoes to heated oil.
- Add salt and turmeric powder and fry for few minutes.
- Add preboiled and chopped bamboo shoots in the skillet.
- Stir for few minutes and cook till done.

Bamboo Shoot Chutney

Ingredients

Bamboo shoots	:	100 g
Sugar	:	15 g
Cardamom (shelled and crushed)	:	one
Kolonji	:	¼ tea spoon
Cinnamon	:	½ ** piece
Cumin seeds	:	¼ tea spoon
Onion	:	½ medium sized
Cloves	:	4
Garlic (chopped)	:	1 tea spoon
Red Chilli powder	:	1 tea spoon
Salt	:	to taste
Vinegar	:	as required

Method

- Grate bamboo shoot pieces and mince the onion and garlic.
- Crush cumin seeds, kalongi, cinnamon and cardamom and tie them together in a muslin cloth.
- Place the grated bamboo shoot, sugar, onion, garlic, chilli powder and salt along with 125 ml of water in a pan.
- Cook over low heat with constant stirring until the sugar dissolves completely.
- Place the bag with spices in the pan and simmer till a syrup is formed.
- Squeeze and remove the spice bag, add vinegar and cook for 3-4 minutes.
- Let the chutney cool and refresh with fried bamboo shoots.

Bamboo Shoot Masala Curry

Ingredients

Bamboo shoots	:	100 g
Onions	:	2
Tomatoes	:	2
Oil	:	1 table spoon
Ginger garlic paste	:	½ tsp
Coriander powder	:	½ tea spoon
Red Chilli powder	:	½ tea spoon
Garam masla powder	:	¼ tea spoon
Butter	:	10 g
Coriander leaves	:	to garnish
Cinnamon pieces (small)	:	3
Cloves	:	3
Salt	:	to taste

Method

- Cut prepared and boiled bamboo shoots into small pieces.
- Chop onions, tomatoes and coriander finely.
- Put oil in a pan, add pieces of cinnamon and cloves after it splutters add onions and fry till golden brown in colour.
- Add tomatoes, bamboo shoot pieces and little water.
- Continue frying until soft, add chilli powder, coriander powder, garam masala and salt.
- Garnish it with butter and chopped coriander leaves.
- Serve hot with chapatti or rice.

Bamboo Shoot Palak

Ingredients

Bamboo Shoot (boiled)	:	100 g
Spinach	:	300 g

Green chillies	:	4
Garlic cloves	:	5
Onion	:	1
Butter	:	2 table spoon
Salt	:	to taste
Coriander powder	:	2 tea spoon
Cumin seed powder	:	1 tea spoon

Method

- Heat oil in a pan and fry the pre cooked bamboo shoots till crisp.
- Cook the cut spinach leaves, green chillies, garlic, onion, coriander powder, cumin seed powder in a pressure cooker and cool.
- Grind the above pressure cooked ingredients to a smooth paste in a grinder.
- Take butter in a pan and add the ground paste and bring it to boil.
- Add the fried bamboo shoots and cook till done.
- Serve hot with rice or chapathi.

Bamboo Shoot Kadhi

Ingredients

Bamboo shoots	:	100 g
Chickpea (besan) flour	:	100 g
Ghee	:	2 table spoon
Ginger-garlic paste	:	2 table spoon
Butter milk	:	200 ml
Red Chilli Powder	:	2 table spoon

Method

- Roast and chickpea flour in ghee until a fine aroma develops.
- Cook the preprocessed and boiled dry bamboo shoots and then grind them into a paste, and keep aside.
- Add ginger – garlic paste, chilli powder and salt into chickpea flour and mix well.
- Add butter milk to it and bring it into slurry.

- Now add the bamboo shoot paste and cook for 10 minutes until thick.
- Serve hot.

Bamboo Shoot Keema

Ingredients

Bamboo shoots	:	100g
Onion (big)	:	½
Tomato	:	½
Coconut (copra)	:	½
Garlic-ginger paste	:	1 tea spoon
Red Chilli powder	:	1 tea spoon
Cumin seed powder	:	1 tea spoon
Coriander powder	:	1 tea spoon
Garam masala	:	1 tea spoon
Coriander leaves	:	a few
Oil	:	for frying

Method

- Grind the coconut, grated onion and tomato separately.
- Put oil in a pan and add onion garlic and ginger paste to it. Fry till golden brown and all the spices and fry until done.
- Add chopped onions and cook.
- Add tomato puree and very finely chopped bamboo shoots and enough water and salt.
- Cook till water evaporates and oil separates out from the pan.
- Garnish with coriander leaves and serve hot.

Bamboo Shoot Pickle

Ingredients

Bamboo shoots	:	100 g
Red Chilli powder	:	5 g

Mustard seed powder	:	10 g
Onion (big)	:	1
Asafoetide (heeng)	:	1 pinch
Turmeric powder	:	5 g
Cinnamon	:	2 g
Vinegar	:	15ml
Salt	:	for curing

Method

- Cut the bamboo shoots into small pieces and then soak in water for over night.
- Drain the water and add salt to fit for curing. Cure the bamboo shoot pieces for 15-20 days.
- Drain the salt solution.
- Add the spices along with vinegar.
- Pack the pickle into sterilized, dry glass jar/bottles aseptically.
- Prevent softening and blacking by mixing the contents into gar for some time.

Bamboo Shoot Pulav

Ingredients

Bamboo shoot	:	200 g
Basmati rice	:	250 g
Carrot	:	150 g
Ginger	:	2 tea spoon
Garlic	:	2 tea spoon
Peas	:	25 g
Beans	:	150 g
Coconut (copra)	:	150 g
Cinnamon	:	10 g
Onion	:	1
Bay leaf	:	2

Tomato	:	1
Coriander leaves	:	10g
Green Chilli	:	5
Cloves	:	4
Big cardamom	:	4
Salt	:	to taste
Oil	:	50 g

Method

- Put oil in a pan and add finely chopped onions till golden brown.
- Grind coriander, garlic-ginger paste, cinnamon-cloves paste and grated coconut to get a paste.
- Add ground masala, bay leaf, cut vegetables and bamboo shoot and fry. Add cleaned, washed rice, fry for some time and add about 650ml water.
- Add salt cook till done.
- Serve hot.

Bamboo Shoot Manchurian

Ingredients

Bamboo shoot	:	200 g
Maida/cor flour	:	100 g
Egg	:	1
Soya sauce	:	2 table spoon
Chilli sauce	:	1 table spoon
Tomato sauce	:	1 table spoon
Ainomotto	:	½ tea spoon
Vinegar	:	2 table spoon
Garlic and ginger paste	:	2 table spoon
Onions	:	4
Capsicum	:	1
Red Chilli powder	:	1 tea spoon

Tandoori colour	:	1 tea spoon
Salt	:	to taste
Oil	:	for frying

Method

- Chop prepared and boiled bamboo shoot into moderately sized pieces.
- Chop capsicum into long strips.
- Mix maida/cord flour and egg.
- Add chilli powder, soya sauce, vinegar, salt, ajinomotto, tandoori colour with water and mixture to form a thick batter.
- Dip chopped bamboo shoot in the batter and fry in oil till it turns golden brown and keep aside.
- Take little oil in a pan, put finely chopped onion, fry till it turns golden brown and add garlic ginger paste.
- Them add capsicum and fry till cooked.
- Add the fried bamboo shoot to the above.
- At least add soya sauce, vinegar, red chilli powder, tomato sauce and toss well. Sprinkle cut coriander leave.
- Serve hot with sauce.

Bamboo Shoot Halwa

Ingredients

Bamboo shoot (boiled)	:	250 g
Carrot	:	250 g
Sugar	:	300 g
Milk	:	500 ml
Cashewnuts	:	50 g
Ghee	:	1 tea spoon
Small cardamom (powder)	:	4-5

Method

- Grate carrot off and the preprocessed and cooked bamboo shoot.

- Pressure cook them for 15 minutes.
- Add sugar and milk and cook till it is quite thick.
- Melt the ghee, sauté and cashwnuts in it and add to the above mixture. Add more ghee and cardamom powder to remove any stickness if it is there.
- Serve hot.

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Improvement of Bamboo Productivity through Selection of Plus Clumps

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Abstract

The ever-increasing demand for bamboo due to various reasons is not commensurate with the current demand of bamboo materials. The main reasons for the gap are: Low productivity of bamboo forests and plantations, inadequate supply of quality planting stock and lack of scientific advancement in plantation technology. The shortfall in requirements can be met by improving the productivity of plantations using genetic improvement programmes and scientific management of natural bamboo growing areas & plantations. The bamboo productivity can be enhanced manifolds by selection of superior clumps and multiplying them for use I plantations.

Lot of variability exists in bamboos in phenotypic characters which can be exploited using suitable methods of quantitative genetigs for improving the productivity of bamboos in the country. For the selection of bamboo plus clumps, the point grading method/selection index method is to be followed, in which different points have been awarded to different traits as per the weightage in end uses viz. more weghtage should be given to internode bamboo. The general guidelines for selecting plus clumps of bamboos have been developed e.g survey of potential areas, selection criteria including number awarded for different traits e.g. internode length, height grith, straightness, number of clumps/clump and disease resistance of the clumps. The maximum and minimum scores of these characters are decided on the basis of the phenotypic average value of base population of the species. The total score while evaluating the candidate plus clump is fixed to 100. The candidate clump, if attains the pre decided score and more will be declared as plus clump. After that, the rhizomes/culm cutting/branch cutting/seeds will be taken from the selected plus clumps for establishment of germ-plasm bank and fuether multiplication using various proliferation techniques for supplying inproved planting stock in plantation activities.

Key words: Bamboo, improvement, selection, plus clump, Productivity.

Introduction

Bamboo has the potential of providing ecological and livelihood security to millions of poor in the developing world. For tapping the vast potential of bamboo, it has become necessary to give impetus to its cultivation on forests as well as non forest lands by employing suitable technologies for enhanced productivity and quality. In India bamboo encompasses about 8.96 million ha of forest area, which is equivalent to 12.8% of the total forest area of the country. Avery copious amount of bamboo grows outside forest area, particularly in homestead lands. Within the forest area, bamboo suffers from poor management, low productivity and over exploitation. Bamboo is an extremely diverse and hardy plant which can easily adapt to varid climatic and soil conditions. In India about 136 species occur, of which most of them are multipurpose and fast growing. It can be harvested within a very short span of 4 to 6 years. Subsequently, sustained yield can be obtained on annual basis by just maintaining the clumps till they flower. Interestingly bamboo is planted only once, and harvested many a times during its life cycle. In fact these characters make bamboo a highly profitable crop.

Bamboo is widely used for the constrction of houses and bidges especially in the northeast India, pulp and paper, agricultural implements, fencing handicraft and household articles etc. In addition bamboo is also used as an ornamental plant and its shoots are very delicious and edible. The demand for bamboos has increased in recent years in Asian countries as a raw material for furniture making and as panel boards. The paper and pulp industries consume about 35% of the total production of bamboo. The current demand of bamboo for various purposes is estimated as 26.69 million tones as against the supply of 13.47 million tones. Shortage of bout 20.28 million tones of raw materials, by the year 2015 for pulp and newsprint production, is predicted (Adkoli 1994) te ever increasing demand for bamboo is not commensurate with demand, which has accelerated the depletion of the natural stock and eroded the genetic base of bamboo (Rao and Rao 1992).

The main reasons attached for the gap are: low productivity of bamboo forests and plantations, inadequate supply of quality planting stock and lack of scientific advancement in plantation technology. The shortfall in requirement can be met by improving the productivity of plantations using genetic improvement programmes and scientific management of natural bamboo growing areas and plantations. Considering the returns from bamboo farming, selection of superior clumps for large scale multiplication is of prime importance and through it bamboo productivity an be enhanced to many folds by utilizing benefits of selection. However, the wide variations in morphological and anatomical characters within as well as among the species make the improvement programme (productivity enhancement) much a cumbersome process. Moreover systematic selection for bamboo planting stock improvement is a recent activity and there are only a few references available to support the contention of selection and multiplication of quality planting stock n bamboos. However seedling selection methods with regards to performance of bamboo seedlings and some of the initial works on bamboo improvement were carried out bt Banik (1995, 1997) and Kondas *et.al* (1973), respectively.

In this scenario there is a need for raising improved bamboo planting stock to enhance productivity for which a systematic approach for bamboo improvement starting from exploration, collection, preservation and evaluation of the germplasm is needed. Different institutes under Indian Council of Forestry Reseach and Education, Dehra Dun, such as Forest Research Institute, Dehra Dun, Institute of Forest genetics and tree Breeding on improvement, multiplication, germplasm collection and conservation of bamboo in the country.

Selection of Superior Clumps

The success of genetc improvement programme depends on the existence of variability in the base population. By selecting superior performers using a proper selection methodology, significant improvements have been achieved in a number of forestry species. In bamboo lot of variability exists n phenotypic character e.g. solid and compact or hollow stem, wider lumen, short and long internode, thck and thin epidermis,

long and short clumps, variable number of clump, culms congestion, ratio of new vigorous-succulent and old culms per clump, disease/susceptible etc. In addition, the variability in various traits also varies in different species of bamboos. Hence such variability can be exploited using various methods of quantitative genetics in improvement programmes to enhance the bamboo productivity n the country.

Based on end uses, bamboo can be grouped broadly in two categorie; long internode bamboos e.g. *Bambusa nutans* (Mokal bah), *B.pallida* (Bijuli bah), *B.tulda* (Jati bah), *Dendrocalamus hamiltonii* (Kako bah) and short internode gamboo e.g. *B.bambos* (Kotoha bah), *B.balcooa* (Bhaluka bah). Long internode bamboo(having less nodes) are suitable for handicrafts and paper & pulp industries, while short internode bamboo(having more nodes to provide more strength to clump) and preffered in construction purposes. Hence, the variability in internode length along with related traits should be exploited to improve the productivity of bamboo.

For the selection of bamboo plus clumps, the point grading method/selecton index method (Schmidt 1993) is to be followed, in which different points have been given to different traits as per thr weightage in end ues viz. more weightage should be given to internode length, being a important trait in consideration for long as well as short internode bamboos. However, a uniform election criteria for plus clumps of all bamboo species is not feasible but as per the experience, the general guideline for selecting plus clumps of bamboo are as:

1: Survey of potential areas:

Geographical habitats of the species having high variability should be identified through visual observations. A minimum of 50 plus clumps should be selected from as many as geographical locations to get maximum genetic gain n future programs. A proper spacing of 100 meter should be maintained between the selected plus clumps in natural forest, though it is not necessary in homesteads and plantations. Equally good looking phenotypically superior clumps (three to five) growing near by clumps should also be selected as comparison/check plus clumps. In addition observations on identified traits should also be taken from base population of bamboo to ease the selection criteria.

2. Selection criteria:

The main traits identified for selection of candidates plus clumps in selection index method will be:

- Internode length
- Height of clump
- Girth of clump (girth at breast height)
- Straightness of clump
- Number of clumps per clump
- Disease resistence

Candidate plus clumps along with checks will be selected from different areas based on the scores of the following quantitative characters(Table 1):

Table 1. Criteria of Selection of Plus Clumps in Bamboo.

S.N	Characteristics	Maximum points allotted	Description	Points
1.	Internode length	30	• Larger/smaller than average internode (whichever applicable- larger* or smaller#) • Equal to average internode • Lesser than average internode	30 20 10
2.	Height	20	• Larger than average height • Equal to average height • Lesser than average height	20 15 10
3.	Girth at Breast Height(GBH)	20	• Larger than average GBH • Equal to average GBH • Lesser than average GBH	20 15 10
4.	Straightness	10	• Straight clump • Curved clump	10 5
5.	Number of Clumps/clump	10	• More than average • Less than average	10 5
6.	Disease Resistance	10	• Disease free • Diseased	10 0

***& # applies for long internode and short internode bamboo respectively**

The maximum and minimum scores of all the above characters are decided on the basis of the phenotypic average value of base population of the species. The total score while evaluating the candidate plus clump is fixed as 100. The candidate clump, if attains the pre decided score and more would be declared as Plus clump. After that, the rhizomes/ culm cuttings/branch cuttings/seeds will be taken from the selected plus clumps for establishment of germ-plasm bank and further multiplication using various proliferation techniques for supplying improved planting stock in plantation activities.

Discussion

Genetic diversity between and within species provides a scope for selection and improvement for commercial plantations. Plantations raised from intensively selected and tested clonal material have many advantages over plantations raised from unknown seed source. These genetically improved plantations produce higher utilizable biomass and significantly reduce wastage during wood processing. It was reported that 50 to 400% of volume increase was achieved for redwood using intensively selected planting material as compared with untested material (Redelius and Libby 1993). Hence a selection methodology for selection of plus clumps of bamboo has been evolved so that significant improvements can be achieved in productivity and other traits of economic importance of bamboo. Further, these genotypes are of immense use when multipled through clonal techniques to meet the immidete demands for quality planting tock to raise improved bamboo plantations. Plantations established from selected plus clumps re expected to perform well. Nevertheless, the multilocational clonal testing of selected clumps is inevitable to test the adaptability and supeority of these plus clumps which I equally important to ascertain the suitability of various genotypes in various bamboo baed industries.

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Potential diseases and disorders of bamboos in India and their management

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Abstract

Bamboo forms the backbone of the rural economy of many states in India. The bamboo resources base is dwindling at a fast pace due to various biotic and abiotoic factors including mast flowering, diseases and disorders. To strengthen the knowledge base on diseases and disorders affecting the productivity of bamboo stands, an in-depth study was carried out. Research plots in bamboo stands were laid out in 25 different localities in the Kerala state. Experimental bamboo nursery was raised and studied the nursery diseases and their possible management. Besides, bamboo growing areas in other sates like Tamil Nadu, Karnataka, Orissa, Assam were also visited and studied the important diseases. Disease indexing was made using standard techniques. Casual agents of various diseases and disorders were isolated and identified and pathogenicity proved. Histopathological, fluorescence and transmission electron microscopy techniques were applied to confirm the association of Phytoplasma. *In vitro* and *in vivo* screening of fungicide were made to manage the disease in nurseries and stands. In bamboo stands, a total of 30 diseases caused by 37 fungi and a phutoplasma were recorded. Among these, the potential diseases affecting the productivity off the stands include: rot of emerging and growing culms caused by *Fusarium moniliforme* var. *intermedium* and *F. equiseti,* thread blight caused by *Botryobasidium salmonicolo,* bamboo blight caused by *Sarocladium oryzae,* witches' broom and little leaf caused by *Balansia liniaris* and Phytoplasma respectively, and culm basal rot caused by *Amylospotus campbellii*. In bamboo nurseries, among 13 disease recorded, web-blight caused by *Rhizoctonia solani,* foliage rust by *Dasturella divina* and seedling stunting and foliage stiping by virus (BMoV) are the most potential ones. Disease in nurseries can be controlled by adopting good nursery management practices or by prophylactic fungicidal applications. In bamboo stands, most of the potential diseases can be managed cultural measures like mild surface burning, thinning, pruning etc. and by application of

fungicides, the paper highlights the current staus oif the potential diseases and disorers of bamboos, need to develop appropriate measures to check their spread ads well as safeguard against inadvertent introduction of diseases to new areas through seeds/ propagules.

Key words: Bamboo, potential disease, culm rot, blight, witches' broom, little leaf, fungi, Phytoplasma, virus, management measures.

Introduction

The productive potential of bamboo stands in most of the bamboo growuing areas in the country is affected by various biotic and abiotic factors. Bamboos are vulnerable to various diseass and disorders, which affect them in nurseries, plantation, village groves as well as in natural stands. About 170 species of bamboo belonging to 26 genera are reported to be affected by various diseases and disoredes (Mohana, 1997). A total of 440 fungi, three bacteria, two viruses, one phytoplasma (myoplasma-like organism) and bacteria-like organism have been reported to be associated with these diseases and disorders (Mohnana, 1994a,b; 1997, 2004; Mohnana and Liese, 1990). However, only a few diseases are identified as serious ones, affecting culm production as well as productivity. Limited experiences in rising bamboo seedlings together with lack of information on disease affecting them and their management measures have often resulted in partial to complete failure of bamboo nurseries. Also, diseases affecting emerging and growing culms in man-made as well as natural stands have caused considerable damage to the bamboo industry, both in rural and modern sectors. In Kerala, state bamboo forms a significant component of the natural vegetation and occurs in tropical evergreen, semi-evergreen, and moist-deciduous forest, sub-tropical hills, and also as southern-moist-bamboo brakes (Mohanan, 1994a). Bamboo has also been raised in pure or mixed with plantations as well as in homesteads and farmlands. Bamboos play a major role in the economy of the state and they are used in tradition cottage industries as well as raw material for bamboo ply, rayon and paper industries. In this paper, information is provided on the potential diseases and disorders affecting various bamboo species, their incidence, spread and possible management measures. This paper is heavily dependents on earlier studies by the author (Mohnana, 1994a, b, Mohanan, 2004) including a study sponsored through the award of INBAR internship (Mohana, 1997).

Materials and Methods

Representatives plots of 50x50 m in bamboo stands in 18 different localities (total 52 plots) and of 20x20 m in red bamboo stands in five different localities in the Kerala State (15 plots) were laid out. The plots were visited at least twice a year, during June-September and December-March and observations on disease incidence and spread were recorded. Bamboo growing areas in other states (Tamil Nadu, Karnataka, Orissa, Assam) were also visited and observations on disease incidence were made. An experimental bamboo nursery (*Bambusa bambos, Dendroclamus strictus*) was raised at Chandhanathodu, Wayand, Kerala and studied the nursery diseases and their management. Disease severity in stands and nursery was rated on a numerical scale (0-3) of disease rating index and average severity index of a disease (DSI) was calculated (Mohanan, 1994a).

Results and Discussion

Diseases in bamboo stands and their management

Bamboos in natural stands, plantations, homesteads, village groves, etc. are vulnerable to various diseases at their different stages of growth. The woody stem arising from woody rot stock or rhizome is called culm. A young shot is a new growth of the distal end of a patchymorph rhizome or of a lateral bud of a leptomorph rhizome. The buds on rhizome nodes enlarge and tender shoots emerge as pointed cones, completely covered with imbricate sheaths. Since, there is no terminal bud in a culm, growth is achieved by the elongation of internodes. The lowest internode near the ground expands first and the top-most one last. The newly emerged tender shoots or culms (20-30 cm high) are covered with sheaths and no internode is seen outside. The new culms grow rapidly and reach their full height within 60-90 days depending on the species, clump vigour, and edaphic and microclimatic conditions. Branches develop while the culm is still growing or after the culms reaches its full height; foliage develops later. Newly emerging and growing supple culms are generally susceptible to diseases. Among large number of diseases affecting bamboos in india, ptentail diseases affecting the stand productivity include: rot of emerging and growing culms, blight, thread blight, witches'' broom, little leaf disease, and culm basal rot.

Rot of emerging culms

Bambusa bambos, B. balcooa Roxb., B. polymorpha, B. polymorpha, B. vulgaris, D. longispathis, D. strictus, Thyrsostacchys oliveri are the most severely affected bamboos. Severe infection and culm mortality were recorded in bamboo stands in high rainfall areas in the Kerala State (Table 1). The disease manifests as dark brown lesions on the outermost culm sheath of the emerging culm (15-20 cm height), near the soil level. These lesions spread rapidly and cover the entire outer culm sheaths. The infection causes rot of the tender, succulent rapidly and cover the entire outer culm sheaths. The infection causes rot of the tender, succulent emerging shoot which becomes dicoloured and give off a strong smell of molasses. The disease affects further development of the culm and causes total decay. *Fusarium moniliforme* var. *intermedium* Neish & Legget is the fungal pathogen associated with the disease. Heavy rainfall during and after the emergence of culm, water logging around the clump, mining insect activity and poor stand management are the factors favouring the infection. The disease has also been reported in various bamboo species in Bangladesh, India, and Pakistan (Mohanan, 1997).

Table 1: incidence of rot of emerging culms in bamboo stands

Bamboo species	Locality	No. of clumps observed	Percent disease incidence			
			Yr1	Yr2	Yr3	Yr4
BB	Nilambur	102	-	5.5 (109)	4.03 (124)	6.04 (149)
BB	Kollathirumedu	67	-	12.6 (127)	13.5 (156)	8.6 (140)
BB	Ezhattumugam	59	-	12.6 (119)	12.3 (146)	14.6 (148)
BB	Palappilly	60	-	10.4 (125)	11.1 (144)	10.2 (167)
BB	Irumpupalam	64	6.8 (132)	11.9 (151)	15.1 (172)	14.0 (200)
TO	Mundoor	96	3.8 (317)	3.3 (340)	4.1 (362)	4.4 (294)
BBL	Nilambur	4	606 (15)	5.3 (19)	4.5 (22)	8.7 (23)
BP	Nilambur	4	10.0 (20)	13.04 (23)	12.0 (25)	905 (21)
BV	Nilambur	19	5.3 (76)	2.9 (102)	2.06 (97)	2.4 (82)
DL	Nilambur	12	7.3 (96)	8.08 (99)	11.6 (112)	16.6 (74)
DS	Nadukani	43	25.5 (153)	18.2 (159)	14.7 (136)	18.0 (128)
TO	Mundoor	96	3.8 (317)	3.3 (340)	4.1 (362)	4.4 (294)

*BB. *Bambusa bambos*; BBL: *B.balcooa*; BP: *B. polymorpha*; BV: *B. vulgaris*; DL: *Dendrocalamus longispathus*; DS: *D. strictus*; TO: *Thyrsostachys oliveri*; -: observations not recorded; *Figures in parenthesis are total number of newly emerged clums

Cultural control measures, such as removal debris around the clumps before the onset of monsoon, light burning of the debris over the ground, loosening the soil around the clump before culm emergence, pruning and removal of branches from the basal part of the older culms during the dry period (March-April) are suggested to minimize the disease incidence. To avoid mechanical damage to the emerging culms caused by cattle and other animals, clump tending and cleaning operations are recommended only in well-protected stands. Application of Carbendazim (&0.2% a.i) or Mancozeb (@0.3% a.i) is recommended.

Rot of growing culms

Among several species of bamboos studied, *B. bambos, B. balcooa, B. polymorpha, D. strictus*, etc. are the severely affected ones (Table 2). The disease appears as water-soaked brown lesions at the base of culm sheaths where they are attached to the nodes. Injury on culm sheaths and culms at nodal region, made by the sap sucking insect Purohitha cervina Distant, predisposes the culm to fungal infection. Sap oozes out from the pin-prick wounds made by the insect, and infection develops in and around these wounds and forms large necrotic lesions. The infection often spreads to the entire culm sheath and to the tissues beneath the culm sheath. Severely elongation phase. *Fusarium equiseti* Cords (Sacc.) and *F. moniliforme* Sheldon are the fungi associated with the disease.

Disease can be managed by taking chemical control measure (spraying insecticide, Monocrotophos 0.05% a.i.) against the build-up of the insect (*Purohita cervina*) population in the bamboo stands during the culm elongation phase and by application of fungicides Carbendazim (Bavistin) or Mancozeb (Dithane M45) at 0.2% a.i. on the infected culms.

Table 2: Incidence of rot of growing culms in bamboo stands

Bamboo species	Locality	No. of clumps observed	Percent disease incidence			
			Yr1	Yr2	Yr3	Yr4
BB	Nilambur	102	-	11.0(109)	6.5(124)	3.4(149)
BB	Kollathirumedu	67	-	8.6(127)	7.7(156)	6.4(140)
BB	Ezhattumugam	59	-	10.4(119)	7.3(146)	5.9(148)
BB	Palappilly	60	-	11.2(125)	11.8(144)	7.2(167)
BB	Irumpupalam	64	12.1(132)	7.3(151)	5.2(172)	3.0(200)
TO	Mundoor	96	3.8(317)	2.4(340)	2.5(362)	2.4(294)
BBL	Nilambur	4	-	4.5(19)	-	4.8(21)
BP	Nilambur	4	25.0(20)	13.0(17)	8.0(19)	4.8(21)
DL	Nilambur	12	5.2(96)	6.3(99)	15.2(112)	17.6(74)
DS	Nilambur	11	18.4(38)	20.0(40)	18.9(37)	8.8(45)
DS	Nadukani	43	5.9(153)	4.4(159)	4.4(136)	6.3(128)
TO	Mundoor	96	3.8(317)	2.4(340)	2.5(362)	2.4(294)

*BB. *Bambusa bambos*; BBL: *B.balcooa*; BP: *B. polymorpha*; DL: *Dendrocalamus longispathus*; DS: *D. strictus*; TO: *Thyrsostachys oliveri*; -: observations not recorded; *Figures in parenthesis are total number of newly emerged clums

Bamboo blight

Bamboo blight, the most dreaded disease of bamboo stands in Bangladesh has also been recorded from bamboo growing areas in India (Jamaudhin *et al*., 1992; Mohanan, 1997). The disease has been recorded as affecting the village groves of *B. bambos, B. balcooa, B. tulda* and *B. vulgaris* throughtout Bangladesh (Boa and Rehman, 1984). The disease occurs in the coastal belts of Orissa State causing considerable damage to village groves of *B. nutans, B. vulgaris, B. tulda, B. balcooa,* and *B. bambos.* Bamboo blight mostly in well-established older clumps, aged more than 8-10 years. The disease results in a sequential die-back of culms in their first season of growth. Symptoms appear when culms are nearing full growth or shortly after this. The initial symptoms of blight are premature death of culm sheaths and partial collapse of the fragile apical region. Later, necrotic patches develop on the internode which spreads quickly resulting in die-back. Clumps which survive the first growing season remain healthy and the spread of the disease between clumps is slow. *Sarocladium oryzae* (sawada) W. Gams & D. Hawks is the principal fungal pathogen associated with blight disease.

Silviculture measures recommended for controlling the disease include: cutting and removing blighted culms, burning the debris of clumps in *situ* and addition of new soil to clumps. Light surface fire (control burning) before the onset of monsoon is suggested for reducing the disease incidence. Application of Carbendazim (Bavistin) combined with Mancozeb (Carbendazim 0.15% a.i + Mancozeb 0.3% a.i) or Fytolan combined with Carbendazim (Carbendazim 0.25 % a.i. + Fytolan 3 % a.i) is suggested for controlling the disease. Drenching the soil around the bamboo clumps with copper oxychloride (0.2 a.i) is also desirable to check the disease.

Witches' broom

The disease is wide-spread in reed bamboo growing areas in the Kerala State (Mohanan, 1990, 2004). It affects commercially important reed bamboos *viz., Ochlandra travancorica. O. scriptoria* and *O. ebracteata.* The disease incidence varied depending upon the microclimatic conditions in the locality. Very high incidence (24%) was recorded in *O. scriptoria* stands in Periya, where the annual rainfall ranged from 4000 top 6500 mm and a high relative humidity (60-90%) (Table 3). The disease was also recorded on grass (*Pennisetum polystachyon* (L.) Schutles growing in the vicinity of diseased reed bamboo stands. The disease manifests as development of numerous highly shortened shoots at the nodes of mature culms. These abnormal shoots do not develop into normal branches and produce only highly reduced shoots successively dfrom their nodes. The culm sheaths which cover the internodes also become shortened in size and become boat shaped, often with a prominent ligule. The internodes show purplish pink discolouration with reduced pale green foliage. Successive development of a large number of thin shoots in tuft from the nodes of the infected culms give rise to the characteristic appearance of witches' broom. New shoots emerging from the infected rhizome also show pronounced brooming symptoms. Shining black fructifications of the casual fungus develop on the affected shoots after 5-6 months of infection. The fungus associated with the witches' broom disease is *Balansia liniaris* (Rehm.) Diel.

Table 3:" Incidence and severity of witches' broom disease in *Ochlandra* species

Bamboo species	Locality	Year 1		Year 2		Year 3		Year 4	
		DI	DS	DI	DS	DI	DS	DI	DS
OS	Periya	21.9	L	24.7	L	24.7	L	-	-
OS	Vazhachal	9.8	L	11.5	L	11.5	L	14.8	L
OT	Kollathirumedu	8.6	L	9.3	L	10.0	L	10.7	L
OT	Pachakkanam	7.7	L	8.3	L	9.0	L	9.6	L
OE	Kottor	6.0	L	7.7	L	8.6	L	9.4	L

*OS: *Ochlandra scriptoria;* OT: *O. travancorica;* OE; *O. ebracteata;* -: Observations not recording due to mast flowering; L: low.

The disease has been recorded on different species of bamboo ion China. India, Indonesia, Japan, Taiwan-China and Vietnam (Chen, 1971; Zhu, 1989; Mohanan, 1997, 2004). In china, among different species affected with the disease, *Phyllostachys viridis, P. glauca* McCI. *P. praecox* Chu *et* Chu, P. nuda McCI. *B. multiplex* (Lour.) Raeusch. are important ones. In Indonesia, the disease has been reported on *Gigantochloa apus* Kurz, *G. atter* (Hassk.) and *G. robusta* Kurz. In Japan, the disease has been recorded on *Phyllostachys bambusoides* Sieb. Et Zucc., *P. nigra* var. henonis stapf.ex Rendle, *Sasa borealis* var. *pupurascens* and *sasa* spp. (Shinohara, 1965; Mohanan, 1997). Silviculture measures to manage the disease include: surveying and identifying the diseased clumps in the stands, physically removing and burning the infected culms and witches' brooms. As the disease is systematic, rhizome or culms from diseased clumps should not be used for vegetative propagation.

Little leaf

This disease affects *Dendrocalmus strictus* in natural as well as cultivated stands in drier tracts, *viz.,* Agaly, Attapady, Goolikadavu, Thakarapadyhas in Mannarkade Forest Divisio and Chinnar in Idukki Wildlife Division in the Kerala State (Mohanan, 1990, 1994b, 1997). The disease is characterized by the development of numerous, highly reduced, abnormal bushy shoots from thr nodes of newly emerged culms and culm branches. Foliage develops from these shoots shows prominent reduction in size and needle-like appearance. Profuse development of such abnormal shoots from each node of the developing culm and their subsequent growth give rise to a massive bushy structure around each node. The disease also affects culm elongation; infected culm shows stunted growth. Association of Phytoplasma with the disease was proved by Diene's staining, fluorescence and transmission electron mycroscopic studies and tetracycline therapy (Mohanana, 1994). Clump to clump infection was found to be slow and an increase of 6 percent was recorded at Agalay and 12 percent at Thakarapady over a period of four years (Table 4).

Table 5: Incidence and severity of little leaf disease in *D. strictus*

Locality	Year 1		Year 2		Year 3		Year 4	
	DI	DS	DI	DS	DI	DS	DI	DS
Agaly	64.0	L	64.0	L	67.2	L	70.2	L
Thakarapady	77.5	L	87.5	L	85.5	L	90.0	L
Goolikadavu	59.37	L	59.4	L	59.4	L	68.8	L
Chinnar	9.3	L	9.3	L	9.3	L	11.6	L

* DI: Disease incidence (5); DS: Disease severity; L: low.

Since, in most bamboos, the process of culm production, elongation and development are completed within six months, and after that only a biological consolidation takes place, it is not worthwhile to control the disease in emerged culms by chemicals or antibiotics. Silvicultural measures to manage the disease include: cutting and burning the severely infected culms/ clumps and planting disease resistant bamboo species (*B. bambos*).

Thread blight

Thread blight disease affects most bamboo species and the disease appears during monsoons, subsidies and almost disappears during the dry day period. Among several bamboo species studied, *B. bambos* and *D. strictus* are the severely affected species (Table 5). Large water-soaked grayish lesions occur on leaves which advance towards the leaf tip. Fine silvery white mycelia strands of the casual fungus appear on the lower surface corresponding to the lesions on the foliage. Spread of the disease is mainly through physical contact of advancing fungal hyphae on the diseased foliage with healthy neighbouring foliage. Infection causes browning and necrosis, leading to blight of the culm branches, especially, the foliage. *Botryobasidium salmonicolor* (Berk. & Br.) Venkat. is fungus associated with the disease. Pruning the diseased branches from the affected clumps and cleaning and burning the debris from the ground the clumps can minimize the disease incidence.

Table 5: Incidence and severity of thread blight in bamboo stands

Bamboo species	Locality	Percent disease incidence		
		Year 1	Year 2	Year 3
BB	Nilambur	35.29(0.38)	25.49(0.25)	29.4 (0.32)
BB	Kollathirumedu	35.8 (0.40)	46.3 (0.49)	11.9 (0.2)
BB	Ezhattumugam	38.8 (0.35)	33.9 (0.40)	18.9 (0.2)
BB	Palappilly	41.6 (0.4)	19.4 (0.31)	35.8 (0.5)
BB	Irumpupalam	34.4 (0.4)	32.8 (0.32)	14.1 (0.14)
BB	Thirunelly	14.03 (0.14)	9.65 (0.09)	6.14 (0.06)
BB	Noolpuzha	5.10 (0.05)	14.3 (0.14)	14.3 (0.14)
BB	Muthanga	14.7 (0.15)	14.7 (0.15)	19.1 (0.19)
BB	Anamari	6.6 (0.67)	9.2 (0.09)	5.0 (0.50)
DS	Nadukani	6.8 (0.06)	16.3 (0.16)	13.95 (0.14)
TO	Mundoor	-	3.13 (0.31)	2.08 (0.02)

*BB. *Bambusa bambos*; DS: *D. strictus*; TO: *Thyrsostachys oliveri*; -: observations not recorded; *Figures in parenthesis are disease severity index (DSI)

Rhizome and culm basal rot

In bamboos, diseases also affect the rhizome and roots and cause considerable damage in natural stands and plantations. The rhizome is the underground portion of the culm, closely resembling the culm and its branches in basic structure. There are two basic types of rhizomes: pachymorph (determinate, sympodial) and leptomorph (indeterminate, monopodial). Most of the tropical and sub- tropical bamboo have pachymorph rhizome system, while temperate bamboo have a leptomorphrhizome system. Every rhizome is potentially a culm bearer: but during development, adverse factors including diseases check the growth and prevent the production of culm. Diseases affecting the rhizome include: rhizome bud rot, root rot, decay of rhizome and rot of roots and basal culm. Rhizome bud rot was recorded in young one year-old *B. bambos* plantations in the State. *Pythium middletonii* Sparrow is the casual agent and it causes rot of fleshy rhizome buds, roots and tender tissues at the growing points. The disease has been recorded in plantations situated in water-logged areas. Culm basal rot caused by *Amylosporus bambos, D. strictus, D. longispathus* are the most susceptible species. The disease causes white spongy or fibrous rot of the rhizome and basal culm.

Rhizome bud rot can be managed by using healthy planting stock, as well as by improving the cultural and management practices in the plantations. During the dismantling of seedbeds and pulling out the bareroot seedlings for planting, care should be taken to avoid causing injuries to seedling rhizome. Storage and transportation of planting stocks should be done under hygienic conditions. Planting in water-logged areas should be avoided. Removal of sporocarps of the decay fungi from affected bamboo clumps, burning of dead rhizome and roots of diseased culms are suggested to manage and minimize the further spread of the rhizome and basal rot. Silvicultural measures like isolation trenches may prove effective in containing the disease in between the trenches, thus preventing its spread. However, trenching and isolation of the diseased clumps will be difficult under flood irrigation. Fungicidal treatments (Copper oxychloride @ 3% a.i. 3 to 4 application at weekly interval) and soil working around the clumps will help in checking the development of the rhizomorphs of the fungus and thereby disease incidence and severity. Severely affected clumps should not be cut, and rhizome dug out and burnt on the spot as a sanitary measure.

Infection of inflorescence and seeds

Bamboo seeds are invaded by fungi and bacteria during their different developmental stages on the plant as well as after the seeds fall. Microorganism affects the developing fruits, invade the seeds and thus reduce the amount of healthy seeds. A total of 42 fungi belonging to 23 genera and two bacteria have been recorded on stored seeds of bamboo from India (Mohanan, 1997) and a large number of fungi have been reported on bamboo seeds from Thailand (Pongpanich and Chalermpongse, 1986). Among these *Bipolaris, Exserohilum, Fusarium pallidoroseum, Drechslera, Phomopsis,* etc. are important seed-borne fungi that cause seedling infection in bamboo industry.

Bamboo seeds are usally collected from the forest floor, where they are open to attack by fungi and bacteria. Under such circumstances, the seed quality deteriorates before and after the seed collection. The period during which seeds are liable to infection by microorganisms can be greatly reduced if seed collection is dome immediately after the seed fall. The cleaned seeds should be stored in air-tight containers under reduced temperatures and moisture content. Fungicidal seed treatment (Mancozeb, Ceresan D, Hexathir WP, Vitavax WP @ 4 g/kg seeds) is suggested for maintaining the quality pof the seeds under short-term storage.

Nursery diseases and their management

Planting stock raised in conventional seedbed nurseries as well as through vegetative propogation methods are equally susceptible to various pathogens. Diseases affect the nursery stock right from the time of emergence of radical to the time of planting out, causing considerable damage depending upon the prevailing microclimatic conditions in the nursery, bamboo species and the virulence of the pathogens. In nurseries, altogether 13 diseases, caused by 15 different fungi and one virus, have been reported on bare-root, container seedlings and vegetatively propagated planting stocks. Damping-off, seedling wilt, web blight, leaf rust, leaf blight, leaf spots, leaf tip blight, leaf striping and stunting, rhizome rot, etc. are the diseases recorded as affecting the various bamboo species (Mohanan, 1994a, 1997). Among these, damping-off, web blight, leaf rust are the important ones, which cause considerable damage in nurseries.

Damping-off

The diseases is common in seedbed nurseries which affects the emerging seedlings during germination (pre-emergence damping-off) or after germination (pre-emergence damping-off), while thee seedling tissues are still succulent. The disease occurs in patches in the seedbeds 7-to12 days after sowing. The disease is characterized by the rotting of seeds and also the radical. Post-emergence damping-off is characterized by development of water-soaked brown lesions on the emerging plumule near the soil level and collapse of the affected plumule in due course. *Fusarium moniliforme* sheld, *F. oxysporum* Schlect, *Rhizoctonia solani* Kuhn are the fungal pathogens associated with the disease.

The disease can be managed by adopting proper nursery cultural practices; excessive watering and shade over the nursery beds should be avoided. Seeds dressing with fungicides such as Thiram 75 WP or Captan &% WP (@2 g/kg of seeds) is effective in controlling the disease. Application of fungicide like Carbpxin (Vitavax) @ 0.1 % a.i. in the affected nursery beds can also control the disease. Low sowing rate, i.e. 500 g seeds (*B. bambos, D, strictus*) per standard seedbed (12 x 1x 0.3 m) is preferable to prevent the build up of conditions conducive to the spread of the disease.

Web blight

The disease occurs in high humid areas and affects 20 to 30-day-old bamboo seedlings. *B. bambos, D, strictus,* and *D. brandisil* are the most susceptible species; severe infection affects the availability of transplanting stocks (Mohanan, 1993a,b;2000). Infection occurs as water-soaked lesions on seedlings stem near the soil level and later spreads rapidly affecting the entire shoots, except one or two juvenile leaves. The infected seedling stem and foliage become discoloured and necrotic. Under high humidity, mycelia of the casual fungus (*R. solani*), arise from the soil and grow epiphytically over the affected seedlings. Yellowish brown sclerotia and basidial stage of the fungus (*Thanatephorus cucumeris* (Frank) Donk) also develop on the decayed basal foliage and stem. The disease occurs in patches and the affected seedlings are killed outright within 10-20 days of infection, leaving large circular to irregular patches of dried-up seedlings in the seedbed. *Rhizoctonia solani* Kuhn belonging to different anastomosis groups (Mohanan, 1994a) is the casual fungus.

The disease can be controlled by avaoiding shade over the nursery beds, lowering the seedling density (500 g seeds per standard seed beds) and also by lowering the wter regime (120 1 per standard beds) in the nursery. Fungicidal application (Carboxin 0.2% a.i) after 7 and 21 days of seedling emergence is recommended for managing the disease.

Leaf rust

The disease affects most bamboo species *viz., B. bambos D. strictus, D. brandisil, Oxytenanthera monostigma, Ochlandra travancorica, Thyrsostachya siamensis,* etc. Of these *B. bambos D. strictus* are the most susceptible species. Infection appears as grayish brown minute flecks on the mature leaves which later spread and from large spindle-shaped lesions. Yellowish brown teliosori develop either in mature uredinial sori or separately on the adaxial surface of the leaves in linear rows. Severe infection causes necrosis and withering of affected foliage.

The leaf rust disease is caused by the fungus, *Dasturella divina* (Syd.) Mundk. & Khes. And application of fungicide like Plantavax (0.01% a.i.) or dusting with any sulphur-based fungicides can control the disease.

Seedling leaf blight and leaf spots

The disease occurs in bamboo nurseries and the severity of disease incidence depends on the bamboo species, casual agent and nursery practices. Different fungi *viz., Exserohilum rostratm* (Drech.). Leonard & Suggs., *E. holmii* (Luttr.) v. Arx., *Bipolaris maydis* (Nishikado & Miyake) Shoem., *B. urochloae* (Putterilll) Shoem., *Bipolaris* sp., *Dactylaria* sp., *Alternaria alternate* (Fr.) Keissler, *Curvularia pallescens* anamorph state of *Cochliobolus pllescens* (Tsuda & Veyama) Sivan., and *Collectotrichum gloeosporioides* (Penz.) Penz. & Sacc. Are responsible for causing foliage infections.

Most bamboo species are susceptible to these diseases. In general, application of fungicides likes Dithane M 45 (Mancozeb) @ 0.2% a.i. or Bavistin (Carbendazim) @ 0.1 % a.i. can control the diseases in nurseries.

Seedling leaf stripping and stunting

The disease caused by a virus (possibly BMoV) occurred in one-year-old *B. bambos* seedlings raised at KFRI Peechi campus. Pale yellowish to greenish white stripes occur on both young and mature leaves. Often the individual stripes merge together and the leaves becom grrenish white and leathery. Affected seedlings show stunted growth, and their stem becomes thin, fragile, pendulous and easily breakable. New shoots developed from the *rhizome* also show similar disease symptoms. Usually, the viruses that cause leaf striping, seedling stunting and mosaic diseases are transmitted mechanically, through seeds or vegetative propagules. In bamboo nurseries, disease may be transmitted through seeds; planting stock from the diseases nurseries should be subjected to through screening and seedlings exhibiting mild disease symptoms should be discarded.

The viral disease caused by BMoV affecting foliage and developing culms two major cultivated bamboo, *viz., D. latiflorus* Munro and *B. oldhamii Munro has been reported in Taiwan-China (Chen, 1985; Mohanan, 1997).* Infection causes mosaic on leaves and brown internal streaking in emerging and growing culms. Infected culms exhibit poor growth and development and their internodes become shortened in length. The emerging shoots show a hard texture and are of low quality for eating and canning. Bamboo mosaic virus (BoMV) belongs to the potex virus group is the casual agent. BoMV has no insect vectors and is likely to be transmitted mechanically, as well as through vegetative planting materials.

The large-scale use of vegetative propagules of bamboos has caused the disease to spraed throughout Taiwan-China (Chen, 1985; Lin *et al*., 1993). Infection studies showed that *Phyllostachys edulis, P. nigra,* and *B. vulgaris* var. *striata* are resistant. Strict quarantine measures against the movement of infected planting materials from the diseased areas also importing seeds from mosaic disease occurring countries should be followed.

Conclusion

In bamboo stands, rot of emerging and growing culms, thread blight, witches' broom, little leaf, culm basal rot are the potential diseases affecting the stand productivity. The disease incidence, spread and severity depend on prevailing microclimatic conditions as well as stand management practices. A close monitoring of the stands, especially during the culm emergence and elongation period is warranted to adopt appropriate control measures and thereby reducing the impact of the diseases. Most of the diseases can be controlled by adopting appropriate cultural measures before the onset of monsoon or by prophylactic fungicidal treatments. The nursery diseases can be managed by following good nursery management practices like regulation of shade, water regime as well as reducing sowing density. Application of appropriate dosage is also required to combat the disease outbreak. More importance should be given for selection of bamboo species suitable for the locality and also selection of planting materials prepared from disease free clumps/ areas.

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Biocontrol of Post-Harvest Fungal decay of Bamboo in storage

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Abstract

The major raw for pulp in India and Southest Asia in bamboo. it is highly susceptible to Post-harvest damage by the fungi and insects. Significant losses are caused by basidiomycetous decay fungi by the decomposition of cellulose, lignin and other cell wall components, during storage and use of bamboo rendering it unfit for working. Chemical control (preservatives), which provides short –term measures, is environmentally hazardous besides restriction in it's use particularly when raw materials is required for pulp making. Biological control provides the management option for this type of post – harvest damages.

Two fungi *Trichoderma haziamum and T. Pseudokoningiihave* been found effective against the primary colonizer decay fungus of stored bamboo, *Schizophyllum communein* laboratory and field trials. Formulations and delivery system of these biocontrol agents have been developed on bagasse in powder erom yielding 2X10(9) colony forming units per gram,which remained viable for some than four years at room temperature. The formulations were successfully tested in field and found superior to chemical treatment in comparison. The cost of preparation the formulation has been worked out to Rs 75 per Kg.

Introduction

Bamboo constitute one of the major raw materials for paper and pulp in indiaand Southeast Asia, besides having multitudeof uses such as building materials, scaffolding food, agriculture implements, fishing rods, parquet manufacture, furniture, oars ,water conduits, baskets, mats, hats, screens, toys, in soil conservation, in plywood and particleboard making.

According to an estimate the paper and pulp industry in India utilizes 53 percent bamboo, 40% hardwood, and rest other materials (Anon.1986). Nearly 62% of the total bamboo production is used in pulp manufacture in India (Tewari 1992).

Bamboos are subjected to post –harvest damaged by fungi and insects . Guha *et al*. (1958) reported the loss of 20 to 25% due to microbial decay during one year of storage. Harsh and Kapse (1996) have reported than a loss of about 26.5% in weight occurs in outside storage during one year due to basidiomycetous decay fungi. It is therefore, obvious that enormous fincial and material losses occur due to post harvest fungi decay. Besides, fungi decay of bamboo results in about 20% loss in yield, about 50% loss in strength of the pulp, increase in consumption of bleaching chemicals, bulking problem in digesters, loss of materials during clipping and screening and overall loss of the quality of the pulp (Bakshi *et al . 1968).* Post-harvest protection of bamboo in storage from decay fungi is, three fore, essential. There arte chemical preservatives of wood and bamboo from fungi but oil borne preservatives cannot be used in pulp making, where as most of the water born preservatives are not environment friendly, short term and effective if decay fungi are already established in the substrate .

The alternate strategy is biological control of fungi decay of post-harvest bamboo in which antagonistic and/or parasitic fungi are used against the target decay fungi. Species of *Trichoderma* have potential appelication as biocontrol agents against basidiomycetous decay fungi as they are ubiquitous, easy to handle and isolate, grow on variety of substrates, effective against wide range of plant pathogens, non-pathogenic to host plants, act as mycoparasites, competefor nutrition and sites and produce antibiotics. Several workers have reported effectiveness of *Trichoderma* species against basidiomycetous decay fungi (Ricard 1976, Bruce *et al*.1984, Richard and Highley 1988).

Material and methods

Selection of Test decay fungi and Trichoderma Species

During the survey of bamboo depots in Madhya Pradesh in central India, various basidiomycetous decay fungi were found associated with decaying bamboos collected and brought to the laboratory for identification and isolation.

Species of *Trichoderma*, were isolated from stored chips, decayed bamboos, fruit bodies of decay fungi and soil under the bamboo stacks from bamboo depots. Screening for antagonistic activity against test decay fungi was done using presumptive tests (Dhgingra and Sinclair 1985).

Laboratory Tests with bamboo blocks

Soil block method *(Bakshi et al. 1997)* was used for testing the effectiveness of selected *Trichoderma* species in controlling the growth of test decay fungus in bamboo block Bamboo block (2.5 cm in length, 3.0 cm dia) were prepared from freshly felled bamboo culms of *Dendrocalamu Strictus*. They were ovened dried (at 60 C for 48 h) and Weighed and introduced after steaming at 100 (degree) C for 30 min with cut end in contact with soil in the test glass bottles (9 cm high , 6 cm wide with plastic lid) containing (125g) sieved soil after sterilization. Test decay fungus *Schizophyllum commune*and selected antagonistic fungus were inoculated simultaneously as mycelial discs (5 mm dia) from actively growining colonies on potato dextrose agar over the bamboo blocks and then incubated at 25+2 (degree)C for 8 weeks. Suitable controls were also set without antagonistic fungi. After incubation period the blocks were taken out, cleaned from surface mycelium and oven dried and weight loss was calculated.

Preliminary field trial

A preliminary field experiment was conducted with bamboo sticks (dia meter 3 cm, 1 length 1m) prepared from freshly felled bamboo (D Strictus) dry weight was recorded and given three treatment : 1) Spraying with conidial suspension of *T. pseudokoningii* (10 (5) power spores per ml) in water, 2) Spraying with boric acid 1% and borax 2% solution in water, 3) Spraying with water alone. Then stacks (10 pieces each) were prepared and stored outside for 12 month. Observation for weight loss was recorded after completion of experiment.

Preparation of the formulation

The formulation was prepared on sugarcane bagasse with *Trichoderma harzianum* and T. pseudokoningii collected from juice corner, which was dried, powdered and packed in polypropylene bags (25g with 20 ml water) after autoclaving suspension (5 ml) of the fungi was inoculated with a syringe and incubated at 25+2 (degree) C weeks. The bags were shaked on alternate days. The colony forming units were counted using a haemocytometer slide.

Field trial

A large-scale field trial was conducted at Garra Depot, Balaghat in Medhya Pradesh (21 degree 19'N and 22 degree 24'N latitude, 79 degree 39 'E and 81degree 3'F longitude) in which the biocontrol formulation (0.1g/1), chemicals boric acid and borax (10g +20g/1) and chemicals in combination with the biocontrol formulation were sprayed on the freshly felled bamboo sticks and stacked for storage for one year. Suitable control was maintained by spraying water on the stacks. The experiment was set in randomized block design with four treatment and four replications. After oneyear observation were recordrd for visible signs of decay and other biodeterioration (termite /borer damage).

Result

Selection of decay and antagonistic fungi

Datronia caperata, polyporus arcularius (Batsch) Fr., and *Schizopyllum Commune* Fr. Were the most commenly occurring decay fungi on stored bamboo, which were brought into culture using standard techniques and used as test decay fungi in the study.

Thirteen isolates of seven *Trichoderma* species were isolated of which four, T. atroviride Rifai (A 4) T. antagonists against the test decay fungus, *Schizophyllum Commune*. *T. pseudokoningii* showed maxmum antagonistic activity followed by *T. harzianum* (Fig. 1)

Laboratory Tests with bamboo blocks

The results of laboratory tests have been presented in Fig. 2. Reduction in weigh loss was found maximum with T. pseudoknoningii followed by *T. harzianum* and *T. harzianum*.

Preliminary field trials

The result have been depicted in Fig. 3. The biocontrol preparation with T. pseudokoningii conidial suspension was effective in controlling the fungal decay and found better than chemical treatment with boric acid and borax.

Biocontrol formulation

The formulation prepared yielded 2 x 10 (9) colony forming units per gram, which were found viable for more than 4 years when stored at room temperature.

Field trial

The results of field trial have been presented in table 1. The biocontrol formulation was found effective in controlling the decay fungi in field in comparison to chemical treatment with boric acid and borax. However, when biocontrol formulation was used in combination with the chemical it was not found effective in controlling the decay fungi in stored bamboos.

Table 1. Effect in biocontrol formulation and chemical treatment on decay in stored bamboo

Treatments	Observation after one year (mean of 4 replicates)
T 1 : Spray with *T. Pseudokoningii* formulation	Discolouration in few sticks ; 4 sticks show fruit bodies per stick <5
T 2 ; Spray with boric acid and borax (1:2)	Most the sticks have fruit bodies of S. commune : No of fruit bodies / stick 10-15
T 3 : T1 + T2 Combination	12-15 sticks show fruit bodies : No of fruit bodies / stick 6-10
T 4 : Control (water spray)	All sticks exhibited fruit bodies / stick>20

Discussion

The presumptive tests and laboratory tests on bamboo blocks proved the effectiveness of the *Trichoderma spp* against decay fungi. *Trichoderma* spp. Have been reported to check the decay fungi in wood blocks, poles and stamps (Bruce and king 1983, Nelson and Thies 1986, Richard and Highly 1988). Present study is in conformity to these findings, however Trichderma spp. are being found effective against the decay fungi in bamboo for the first time. Particularly T. pseudokoningii has not been reported to be used against decay fungi.

Preliminary field experiments conducted on bamboo sticks revealed that spraying with Trichoderma conidial suspension could effectively check the decay in storage as is evident from weight loss estimations. Chemical spraying with boric acid and borax mixture though was effective in controlling the decay in stored bamboos: it was only second to the treatment with *Trichoderma.* Reisolation of Trichoderma sp. From the treated bamboo sticks confirm that the biocontrol agent has established in bamboo and would continue to work against decay fungi. The comparison indicates superiority of *Trichoderma treatment* over chemical treatment. Moreover, the chemical have short term effect against the decay fungi particularly during long period of storage.

For large-scale field application a suitable formulation and delivery system for the multiplication of successful antagonistic microorganism is necessary . According to Latge and scooper (1977) a suitable medium using inexpensive, readily available agriculture by product with the appropriate nutrient balance has the potential. From this point of view bagasse meets the requisite criteria to be used as a medium for preparing biocontrol formulations, because it contains carbohydrates for the nutritional requirement of many microorganisms. The colonized bagasse powder contains conidia, chalamydospores and hyphal fragments (colony forming units) each capable of giving rise to new fungal colonies. Besides it also contains a soyrce of nutrients to initiate and support germination. It is established that coniidia of Trichoderma require an external source of nutrients for germination (Danielson and Davey 1973), and bagasse is capable of meetings this requirement as well. The cfu count in the formulation developed on bagasse is 2x10(9) cfu pergram, which is much higher than reported on talc based formulation i. e. 224-297 x 10 (6) cfu per gram (jeyrajan and Nakeeran 1996) and by fermenter biobass technology i.e. 10(7)cfu per gram (papavizas et al.1984). Besides the viability of the prepared formulation is longer than 4 years, which is hardly a year in case of ther formulation.

The results of field trial confirm that the formulation is effective in controlling the decay fungi in stored bamboo. The cost of production of the formulation has been worked out at Rs. 75 per kg, which shows that the technology developed has potential for preparing formulation using other antagonistic fungi against diseases of agriculture, orticulture and forestry crop.

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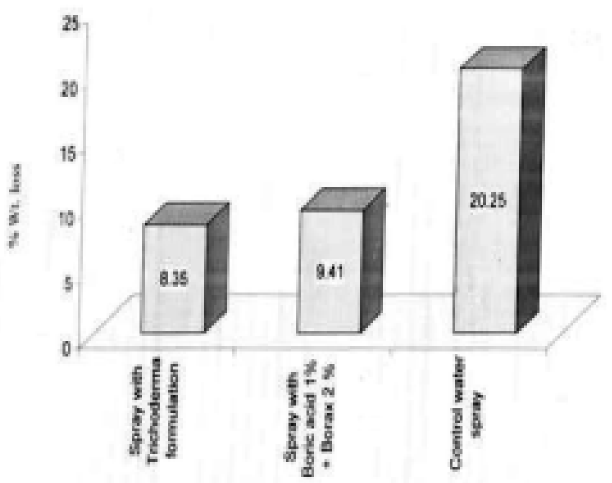
Fig. 3. Comparative efficacy of biocontrol and chemical treatments on bamboo decay.



Socio-economic status of bamboo artisan's communities in Chattishgarh

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Abstract

Bamboo is very popular in the Indian sub-continent and it is used by the people as cultural heritage in every span of life in each day. As natural resource and sound management practices in cultivation, it is eco friendly and promised for higher returns with soil-water conservation, food, shelter and aesthetic values.

Chattishgarh is known for its dense forests, wildlife and cultural heritage of predominated tribal communities due to humid sub-tropical climate having an average annual rainfall of 1200 – 1400 mm and out of total 1, 35,194 sq. km land area of the state 44 percent comes under forest which was further shared by 11 percent of bamboo forest. In the state the Bamboo species wildly occurred naturally are *Dendrocalamus strictus, Bambusa bambos, Oxyntenthera nigrociliata, Gigantichloa rostrata, Cephalstachyum/Schizostachyum pergracile* while *Bambusa bambos, Bambusa nutans, Bambusa striata, Bambusa vulgaris* and *Dendrocalamus strictus* are the cultivated ones. There is 65 thousand national tons production of bamboo in state, while demand of 100 thousand national tons created a big gap which would be further increased for various domestic, commercial and industrial purposes.

The survey was conducted among bamboo artisan's communities in Chattishgarh, where 'Kandra" and 'Basod' were the typical bamboo artisan's families for crafting the traditional bamboo articles viz; baskets, hand fans and fancy items and selling in local market called 'hat' or through middlemen. Sometimes they do not get the peasant return/profit. These people issued the bamboo ration card for getting bamboo from the government at lower and reasonable prices. Though there was provision to give 1500 bamboo cards-1 in a year-1 but only 500-800 culms were supplied, which was 71.5 percent less. The culms applied to the artisans were thin mature and having inferior quality articles. The earning

of bamboo artisans from bamboo was ranged was ranged from Rs. 70 to Rs. 190 in a day-1. The traditional occupation and earning of these bamboo families were found to be shifted to other profession for survival discussed in light of increasing the diversity of earnings of livelihood among these artisans' community in the paper.

Introduction

Bamboos belong to the family Poaceae (Graminae). Except for their large size due to elongation of structural tissues, bamboos resemble typical grasses by their linear, parallel veined leaf with amplexicaul sheath and infloroscence being composed of spikelets. It is estimated thet about 80percent of the bamboo growing areas are confined to South and Southeast Asia (Tiwari 1992). Bamboos prefer the high rainfall area ranging from 1,270 mm to 6,350 mm or even more with maximum temperature of 46.7 C thus the tropical climate of India is congenial to bamboos and is also the limiting for its wider distribution. India has 136 indigenous and exotic species of bamboo. Bamboos are most abundant in seasonal monsoon forest and prefer disturbed habitats in which they often become weedy.

India has rich bamboo resources with 22 genera and more than 130 species (Sharma 1988) distributed over an area of 9.57 million hectares which constitutes about 12.8 of total forest land area (Vermah and Bahadur 1980). They form an important constituent of the tropical deciduous moist forest of North and South India; the deciduous and semi-evergreen forests of North East India are the home of the bamboo (Sharma 1987) extending from alluvial plains to high mountains, ascending to altitudes of 3000m above sea level. Bamboo crop is highly value added resource of India for rural and industrial sector. India is one of the leading countries of the world, second only to China in bamboo production with 32, 30,00 to year in an area of 10.03 million hectares.

Bamboo in Chattishgarh

Chattishgarh with its three agro-climatic zones viz; Northern Hills, Central Plains and Southern Baster Plateau, are characterized by extensive bamboo formations due to its humid tropic climates having an annual rainfall of 1,200 to 1,600 mm with 48 C to 4 C temperature during summer and winter respectively (Anon 1994). Geographical area of Chattishgarh is 1, 35,194 sq. km. with forest area of 59,772.4 sq. km. Bamboo production area is 8,850 sq. km. (Table-1) with district wise share in order of Baster (35%) > Ambikapur (24.3%) > Bilaspur (10.7%) > Raipur (9.6%) > Raigarh (9.1%) > Rajnandgaon (6.8%) > Durg (4.5%) (Naugraiya and Puri). In the natural forest area of Chattishgarhthe main species of bamboo are. *Dendrocalamus stictus, Bambusa bambos, Gigantochloa rostrata* (Syn.

Oxytenanthera nigrociliata) and *Cephalostachayum pergracile,* though the introduced species like: *Bambusa nutans* and *Bambusa vulgaris* are also grown sporadically in some localities (Naugraiya 2008). The annual production of bamboo in the state is 65 thousand notional tons and shared 19percent of total forest revenue. There is demand of 100 thousand notional showed a big gap and thus other than *D. strictus* and *B. bambos* the bamboo is also imported from other growing ares like Madhya Pradesh, Assam, Orissa, Jharkhand, Bihar, West Bengal and North East India.

After 1974, the bamboo forests have been categorized into three quality classes on the basis of height and the minimum number of culms to be retained in each clump. Bamboos have 9m height with 20culms per clump are marked as quality class-I. Quality class-IIis supported 6 to 9m heightwith 15 culms per clump, while quality class-III was considered the up to 6m height with 10 culms per clump. Bamboos have age old-old connections with the material needs of the common people. The strength of the bamboo culms, their straightness and lightness/hardness, easy propagation and the short maturity period make them suitable for a variety of purposes (Sharma 1988).

Table-1: Bamboo production area in Chattishgarh

Districts	**Area (sq km)**	**%**
Baster, Dantewada and Kanker	3100	33.03
Ambikapur and Korea	2150	24.29
Bilaspur, Korba and Champa	950	10.73
Raipur, Mahasamund and Dhamtari	850	9.60
Raigarh and Jashpur	800	9.05
Rajnandgaon and Kavardha	600	6.78
Durg	100	4.52
Total	**8850**	

Socio-Economic Status

The bench mark survey was conducted among bamboo artisan's communities regarding their source of livelihood, whether it was traditional and/or shifted to other alternate earning sources. The study was conducted in Ambikapur (Northern Hills); Rajnandgaon, Durg, Dhamtari, Mahasamund, Raipur and Bilaspur (Central Plains) and Jagdalpur (Baster Plateau). Though the bamboo have been using for making of paper at large scale but the number of value-added goods/handicrafts have also made in the cottage industry in rural ares, these items wre pole, agricultural implements, fishing rods, mats, ladders, sticks,tool handles, brushes, pipes, fans, umbrellas, toys, sports goods, musicalinstruments, spears, bows and arrows, boats and rafts, baskets, flower pots, furniture, chiks, kites and weaving material etc.

In Chattishgarh the communities having their primary occupation making bamboos' craft artisanship as principal source of livelihood was known 'Kandra' and 'Basod'. Every member of the family worked together for making the most common items viz; Mats, Khumri (large tribal hat), Dalia (basket), Parra (Plate basket, Jhauwa (Shallow basket), Hand fan, Chik(Curtains) and fancy items. They sold these items themselves in local weekly market (Hats) or through the whole sellers and retailers. Sometimes they could not get the peasant return/profit this lead to keep them below poverty line and most of the family was found to shift their profession towards field labour work, agriculture, animal husbandry and minor forest produce collections from near by forest.

These bamboo families were supported by the government and provided the bamboo-ration card facility to get 1500 bamboos year^{-1} card^{-1} from the forest depot at lower and reasonable rates. As per the records of state forest department for there were 5227 registered Bamboos artisans' families to issue the bamboo cards in Durg (1995), Raipur (1471), Bilaspur (1399) and Kanker (362) forest divisions. The actual target was to available 1500 bamboos card $^{-1}$ but the distribution pattern showed that average 908.2bamboos were targeted to provide them which were 39.5 percent less from actual targets, while 556 bamboos card^{-1} was available in the depot which was 62.9 percent, less. This deficit was further increased to 71.5 percent and thus on an average 427.6 bamboos card-1 were finally available during the 2005-06 Thus shortage in bamboo supply was very much considerable and maybe one of the reasons to compel the traditional bamboos families to shift their means of livelihood to survive. The rate of bamboo culms was based on the length, diameter, and thickness of the culms. Therefore, there was variation in the rates fixed by the government ranging from Rs.5-15 culm -1. The culms supplied to the artisans were thin mature and having a height of 7-10m. Artisans had to purchase quality culm of the different bamboo species viz; *B. bambos, B.nutons* and *B.vulgaris* from the local growers at the rate of rupees fifty as per the length and roundness.

Perusal of an analysis of common house hold craft work shows that the average per day maximum earning was received from deep basket making (Rs. 150 to 190/day) followed by mats (Rs 97 to 130/day). The demand was remained consistently for Jhavva (Heavy duty shallow basket) mostly used for carrying the soil/ heavy articles etc. and Parra (Plate Basket) used for carrying light weight material and the production of these items gave equal profit of Rs. 70-90/day. While mats were made on demand gave them the per day profit of Rs. 97-130. Looking to per day net earning of the bamboos families, it was found comparatively much less than other skilled or field workers. The results showed that in a bamboo artisan community 10 percent bamboo artisan's families were dependent for their earning on only bamboo craft in central and southern part of Chattishgarh while it was 5 percent in northern part. Looking to the resources and market constraints, some families had also generated other source of income for their livelihood. Earning from bamboo artisanship + labour work was opted by 50 percent families in central and southern part of Chattishgarh and 20 percent in northern part. Though earning from bamboo artisanship + agriculture + labour work was highest in northern part (75%) than central and southern Chattishgarh (40%). The over all the share of income accounted from bamboo artisanship, field labour and agriculture + animal husbandry was 60, 20and 20 percent respectively in central part; 70, 10 and 20 percent respectively in northern part. In case of southern part it was 40 percent for bamboo artisanship and agriculture + animal husbandry, while 10 percent from both field labour and non-timber forest produces collection.

Study reveals that the source of income of bamboo families was found to be gradually shifted to other profession. The reason behind this might be due to availability of poor quality and quantity of raw material on bamboos' card, were as in open market quality material was available at very high prizes. These families were also not aware by advance production technology thus they used old age manual and very laborious technologies also caused the less profit leading to shifting from the traditional bamboo work to other profession. Lack of proper and systematic marketing channels of articles further resulted adverse way to these bamboo artisans. Srivastav (2008) also stretched similar problem of big gap between demand and supply in Allahabad district by 80-90 percent and advocated the domestication of bamboo cultivation under agro forestry system.

Thus, there is a need for growing fairly good bamboo species either as home-stead or around the residence of bamboo families or as community plantation at large scale with right of property to these bamboos communities. These families should also be allotted the length only for growing the bamboo. This will help the artisans to raise their socio-economic status as the availability of better quality of bamboo. Similarly the training on mechanization in bamboo craft work and advancement in production technologies should also be given at very grass root level because most of the bamboo families belong to land less and rural categories.

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Table - 2: Staus of rationalizing the bamboo in Chattishgarh during 2005-06

Forest Division	No. of Depot	Registered Bansod	Actual Target	Bamboo distribution pattern in Year		
				Proposed Target	Available	Sold
Raipur (Raipur, East Raipur, Mahasamund and Dhamtari)	47	1471	22,06,500 (1,500)	16,99,500 (1,122.3)	9, 33,024 (634.3)	6,75,181 (459.0)
Bilaspur (Bilaspur, Marvahi, Korba, Katghora, Raigarh, Dhananjaygarh and Janjgir-chanpa)	37	1399	20,698,500 (1,500)	3,66,700 (262.1)	4,99,168 (356.8)	4,08,235 (291.8)
Durg (Durg, Rajnandgaon, Kavardha, and Khairagarh)	55	1995	29,92,500 (1,500)	25,09,290 (1,257.8)	13,14,063 (658.7)	10,01,162 (501.8)
Kanker (Southand north Kondagaon, East and West Bhanupratap pur and Narayanpur)	22	362	5,43,000 (1,500)	1,71,500 (473.8)	1,59,922 (441.8)	1,50,752 (416.4)
Surguja- (Surguja, Korea, Jashpur and Manendragarh)	-	-	-	-	-	-
Jagdalpur- (Jagdalpur, Baster, Sukma, Bijapur and Dantewada)	-	-	-	-	-	-
Total	161	5227	78,40,500 (1,500)	47,46,990 (908.2)	29,06,178 (908.2)	22,35,330 (427.6)
Deficit from actual target (%)	-	-	-	39.5	62.9	71.5

Note: Values in parenthesis are based on per card. Data was not available from Surguja and Jagdalpur divisions.

Source: Personal correspondence from State Forest department of Chattishgarh

Table - 3: Bamboo price for different species in Chattishgarh

Species	Height (m)	Girth (cm)	Cost of Bamboo Rs./culm
D. strictus	4.5	15	15
B. bambos	5.4	33	50
B. nutans	6.0	30	50
B. vulgaris	6.0	35	50

Table - 4: Economics of the bamboo artisans in Chattishgarh

Items	No. of culms used	Cost of Rs culm^{-1}	Item culm^{-1}	Rate Rs/article	Total gain Rs.	Man days	Net profitmat Rs. Day $^{-1}$
Mat *(3x5m)* *(5x5m)*	 3 3	 10 10	 5 3	 200-250 300-400	 1000-1250 900-1200	 10 9	 97-122 97-130
Supa *(Grain cleaning shallow plate)*	1	10	4 (6L)	20-50	80-100	1	70-90
Dalia *(Deep basket)*	1	10	2 (60L) 2 (18L)	50-60 30-40	100-120 60-80	1	150-190
Khumri *(Tribal large hat)*	1	10	4 (8L)	20-25	80-100	1	70-90
Jhavva *(Shallow Basket)*	1	10	4 (25L)	20-25	80-100	1	70-90
Parra *(Plate basket)*	1	10	4 (13L)	20-25	80-100	1	70-90

Values in parenthesis are carrying capacity of each article in Liter

Table – 5: Income of Bansod's families in Chattishgarh

Source of Income	Families (%)		
	Central	Northern	Northern
Bamboo craft	10	5	10
Bamboo + labour work	50	20	50
Bamboo + Agriculture + AH	40	75	40

Table – 6: Share of income in Bamboo artisan communities in Chattishgarh

Source of Income	Share of Income (%)		
	Central	Northern	Southern
Bamboo craft	60	70	40
Labour work	20	10	10
Agriculture & Animal Husbandry	20	20	40
NTFP collection	-	-	10

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Plantation of monopodial bamboo in India

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Abstract

Monopodial bamboo refers to bamboo species having single under ground rhizome system modified into runners, which multiply through it. It is sparsely disturbed in India at very few pockets. It has very high degree of economic importance due to its straightness, durability and excellent shoot. The species is commonly found in cool wet subtropical to temperature forest in between 700-200m. Most part of India is having very conductive climatic condition for its commercial cultivation to boost up the growing bamboo industry.

Introduction

There are more than 500 monopodial bamboo species with 39 genera in the world(Xia Jianghua, 2003). This group of bamboo includes *Phyllostatachys bambusoides*, *Phyllostachys pubescens*, *Phyllostachys manaii*, *P.praecox*, *Chimnobambusa callosa* etc which has single underground rhizome system. More than 95% of all the monopodial bamboo species and genera are naturally distributed in China and occupy an area of more than 4 million ha, which is about 80% of the total bamboo area. Most bamboo alone in China occupy an area of 3 million ha, accounting for more than 2/3 of the total bamboo area of the country. Therefore China is considered the home of monopodial bamboo species. India is the second largest bamboo growing country next to China and monopodial bamboo equally grows naturally in north eastern part of India viz; Arunachal Pradesh, Meghalaya, Sikkim, Nagaland, Mizorzm, Manipur and some part of Assam. Its distribution is confined to cool wet low hill and plain subtropical to temperate zones. Moso bamboo is also indigenous to China and it is introduced to India and cultivated in Arunachal Pradesh for the last nine years and recently in Himachal Pradesh also. No much work has been done on monopodial bamboo of India except few in Abotani belts of Arunachal Pradesh particular to the Apatani, Nyishi, Adi, Monpa, Miji and Aka tribe though there is abundant distribution occurs in entire state. The commonly cultivated area of monopodial bamboo in Arunachal Pradesh is particularly in Ziro, Yazali and Joram (Lower Subansiri District), Sagalee, Mengio, Bobia, Laporiang, Karoi (in Papumpare district), Seppa, Bamin, Chayang Tajo (in East Kameng district), Bomdila-Nafra(in West Kameng district), Daporijo, (in upper subansiri), also sparsely distributed in Esat Siang, West Siang, Upper Siang, Dibang valley, Lohit and Changlang district with different names, Tabiu, Tabu, Bije, etc.

Importance and scope

Bamboo quality is an important factor in its appropriate utilization. Many species among the bamboo may not be suitable for industrial application and some are very expensive to use. Monopodial bamboo is widely used in globe for its superiority in both bamboo shoot and culm for industrial application due to its straightness in culm, less branching and superior timber texture as it bear all the superior parameters such as smoothness, culm thickness, length of internodes, splitting ability. Monopodial bamboo are alsao used in tourism industry, landscapes arrangement and bears strong root systems that can be used as a shelter wood species in soil and water conservation due to its high water holding and soil fixing capacity, such bamboos are like *Phyllostatachys bambusoides*, *Phyllostachys pubescens*(moso bamboo), etc.Its soil fixing capacity is 1.5 times as much as that of horsetail pine and water-holding capacity is 1.3 times as much as that of Chinese fir(Xia Jianghua, 2003).

In Arunachal Pradesh Phyllostachys bamboo leaves are used inn religious taboos and totems during festivals and functions. Shoots are considered one of the best vegetable and culm for construction and handicraft. Therefore monopodial bamboo is considered one of the best bamboo species. Social and economic progress in China since 1950's is greatly contributed by development of bamboo industry, mainly because of monopodial bamboo species in both cultivation and utilization. Its areas has increased several times by artificially establishing bamboo plantations, also raise in productivity in culm , shoot and rhizome.

Honorable Supreme Court ban on felling of trees and timber based industries has adversely affected the economy of the North eastern Region; hence there was drastic economic fall in forestry sector in the region. So only the hopes remain with timber substitute is on bamboo of quality species. The population growth and environment hazard is continued in India. We have to depend on natural resources to feed, nourish and strengthen ourselves, so we need to develop a sustainable economy model and protect environment through available natural resources. Bamboo industry can play an important role in developing economy of the mountainous region of our country for poverty alleviation of millions of farmers and improving environment Abundant bamboo resources are the foundation for the growth and development of bamboo industry in India. Launching of National Bamboo Mission in India by government is a positive step towards development particularly for rural people.

Propagation and multiplication

Most of the high altitude bamboos are monopodial and amphipodial on nature and are also mostly having thin walled culm. The rhizomes are modified into runners form continue underground indefinitely with roots all the nodes producing well separated culms (Chris stapleton, 1994). The propagation time for these bamboos also differs from other low altitude bamboos. The period of shoot bud initiation and planting period differs from sympodial bamboo. Propagation through culm cutting, branch cutting, layering, etc is not possible in certain groups of bamboo. The best method employed for such bamboos are runners/rhizome cutting using some rooting hormones like NAA, IBA and rootex-3.

In this method the runners of 1-2c years old having viable buds are selected and excavated very carefully without injuring and disturbing with spade/khurpi/knife. The selected runners are then cut with sharp secature/knife keeping 3-4 inter nodes and are taken to prepared nursery bed 10m x 1.5m. Before burying under the soil, rooting hormones are applied by dipping the base of cut end and buried into the nursery bed with a furrow depth of 2-3 cm and covered with top soil. The bed is irrigated lightly daily till it is uprooted. The propagules start sprouting and produce shoot after 1-2 months and rooting after 2-3 months. The well rooted plants are taken out from nursery bed and each node with sufficient rooted plants are separated and planted in the poly bags. The polybags are kept under over head protected bed/green house and irrigated regularly. After 4-6 months, seedlings are ready to transfer to the planting site. The best time for this method is during dormant period mostly in the month of January-February. Examples of such bamboo sp. are *Phyllostachys bambusoides* (Tabiu/Bije), *Phyllostachys pubescens* (Chinese moso), etc. (*Taj et al*, 2007).

Cultivation and management

India which is known for rich biodiversity of bamboo resources has recently gaining importance after launching of National Bamboo Mission. The commercial cultivation of monopodial bamboo is easier as compared to sympdial bamboo because of its monopodial growth nature. Intensive management like intercultural operation, hoeing, weeding, harvesting, etc is also comparatively more convenient and less expensive. The Apatanis in Lower Subansiri District of Arunachal Pradesh have traditionally cultivated monopodial bamboo with sustained productivity from the lat many decades which is similar to Chinese system of cultivation.

With scientific and management to improve productivity level, paddy husk is used as main component of mulching and also as organic manure, this has enhance better shoot and culm productivity in monopodial bamboo as compared to sympodial bamboo. Though commercial cultivation of monopodial bamboo like *Phyllostachys pubescens* in India has started lately, but its vigorous and luxuriant monopodial bamboo locations on trial indicates that India can be the second highest monopodial bamboo growing country after 10-15 years which will boost up bamboo industry   India. In China it is recorded that one hectare of high yielding monopodial plantation produces 15 tones of culms annually and average yield plantation gives 8 tones/ha. For fresh bamboo shoot production, a high yield plantation has an annual yield of 10 tons/ha. Low yield plantations of such superior species like *P. praecox and P. iridescence* have an annual yield of 15 tones of fresh bamboo shoot each hectare (Xiao Jianghua, 2003).

The most peculiar characteristics in monopodial bamboo are quick spreading nature through runners and leads to heavy encroachment of the area. The spreading can be checked only through tunnel/drainage cutting wherever boundary demarcation is necessary. This group of bamboo grows luxuriant in moist subtropical to temperate zones having sufficient rainfall with slightly acidic soil PH ranges from 4.5-7. It is observed that, in most of the *Phyllostachys* spp of bamboo individual plant when it attains the age of 9-10 years start drying and wilting due to its weakness in strength.

Harvesting

Harvesting is generally of two types.

1. Shoot Harvesting:

Most of the monopodial bamboo start producing shoot from the month of February and continued till April Shoots are harvested when it attain a height of 1 m tall from ground level to get optimum usage volume. Late harvesting may give lesser amount of ediable portion, similar is the case in early harvesting. The harvesting should be done in random picking method.

2. Culm harvesting:

Harvesting of culm must be done when it is fully matured from third year and there are no scientific indices in clum maturity. However its maturity can be recognized from colour changes by the growers/expert. The culm harvesting time should not coincide with shoot harvesting and it should be preferably during the month of October-November. Random picking method is employed in clum harvesting.

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Sensory and nutritional quality of formulated food products of bamboo shoots

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Abstract

Bamboo shoot is an uncommon food, with lots of nutrient benefits. The present study was conducted to judge the organoleptic and nutritional quality of formulated products of this newer food. Fresh shoots of *Dendrocalamus strictus* were procured from the Agroforestry Research Centre (AFRC), Pantnagar. Bamboo shoot *pakora* was not only more acceptable than bamboo shoot vegetable but also had an edge over bamboo shoot vegetable in terms of all sensory characteristics. Bamboo shoot pakora was found to contain more protein, energy, and carbohydrate as compared to bamboo shoot vegetable.

Keywords: Sensory evaluation, nutrient composition, bamboo shoots, *Dendrocalamus strictus*, product formulation

Bamboo shoot is not merely the "poor man's timber" but is also the "rich man's delicacy". It is one of the fastest growing commercial plants, which makes it ideally suited for promotion as a food crop for domestic consumption as well as for export. It is in this form that it has yremendous export potential which has been unexplored so far. The bamboos are an incredibly versatile and useful group of plants and it has multifarious uses of shelter, furniture, handicraft, medicine, and and one of its important uses is as a food. But the potential of bamboo as a food has been unexplored so far. In Asia bamboo takes the character of "poor man's timber". This is mainly because the use of edible tender bamboo in Indian recipe has been confined to the northeastern region.

There are many deliciopus ways to prepare nutrient-packed edible bamboo shoots. Whether as an accompanying vegetable or as the main ingredient, bamboo shoots make a wonderful addition to any salad, stir-fry, or soup. Bamboo shoot is used in oriental cooking as an extender because it takes on the flavour of the ingredients it is cooked with. Bamboo shoots can also be dried, marinated, and sautéed, and can be enjoyed as a regular part of a healthy diet. *"Soibum"* and *"Khorisa"* are the fermented products of bamboo. Former is the highly prized vegetable item of Manipur while the latter is the delicacy of Assam. All bamboo shoots are firm and crisp in texture when eaten raw and never become mushy on cooking. The flavour is subtle and singularly characteristic of this vegetable but it is not very strong.

Bamboo shoot is not merely a delicious food option but a health promoting food option. At harvesting, a shoot may contain as much as 90 per cent of the water. The edible content of the newly harvested shoot is typically around 30 per cent (www.bambootech.org). bamboo shoot is found to be low in saturated fats and very low in cholesterol. They are also rich in vitamins (vitamin C, vitamin B-6, and riboflavin) and minerals (zinc,copper, potassium, and manganese).Cellulose and amino-acid content is also high in bamboo shoot.The edible bamboo shoots are also a good source of dietary fibre. Benefits of bamboo shoots in lowering of body fat and preventing constipation increase its value. This low fat food is thus a low calorie food also, which can be adopted by the person on a crash diet for loosing weight. Bamboo shoots are also a good source of potassium. Hundred grams of bamboo shoot provides 640 mg of potassium, which is 18 per cent of the daily recommended amount. Potassium is a heart-healthy mineral. Thus bamboo shoots help to maintain normal blood pressure and a steady heart beat. It is reported that bamboo shoots has the effect in cancer prevention. As a widely consumed vegetable, bamboo shoots can be labeled as a heart protective vegetable and its component phytosterols may be suitable as nutraceuticals. Another health benefit of bamboo is that it has high protein content, which is comparable to the pulses and wheat. Thus the easily available source of nutrients from the forest should be consumed for increasing the nutrition as well as safeguarding against possible deficiencies.

Bamboo shoots have high nutritional value and low in fat, and are a good source of fiber, rich in vitamin, cellulose and amino acids. This nutrient packed bamboo shoot is consumed as vehetable, pickles, salads and in various other forms in several countries. [1]

In India, the use of bamboo as food is practiced mainly in North-Eastern regions. Since, bamboo shoot is an uncommon food so there is a need to promote this crop for human consumption and check the acceptability of the food products. The present investigation, therefore , was undertaken with a view to probe further into the nutrient quality of bamboo shoot and to explore its possibility of using product formulation and to judge the acceptability of formulated products by way of sensory evaluation.

Materials and Methods

Fresh succulent tender shoots of *Dendrocalamus strictus* (15-30 cm of height) were procured from the Agroforestry Research centre, Pantnagar in the month of July-August, 2006.

Ingredients required for product formulation other than the sample (bamboo shoots) were procured from local market, Pantnagar.

Samples of bamboo shoots need to be processed before consuming it. Since bamboo shoot is covered with thick sheath so processing of bamboo shoots is must. Bamboo shoots were washed after procuring it from the field for removal of dust and dirt. Then tip was cut, thick outer sheath was peeled off, inedible base shoot was cut and finally bamboo shoots were sliced (0.25-0.5 cm thickness) to be able to get the edible portion of bamboo shoots.

For product formulation, bamboo shoots were boiled for 25 min in plain water and then water was drained off to get rid of the HCN content. Two products were formulated viz; "Bamboo shoot *pakora*" and "Bamboo shoot vegetable", using bamboo shoots as a raw material. Formulated products were then evaluated using sensory score card method to test various attributes which contributes to acceptability of the products and nine point Hedonic Scale for judging the liking or disliking for the products [2]. The evaluation was done using the semi trained panel of fifteen members from the department of Foods and Nutrition.

For nutrient analysis of raw bamboo shoot and formulated products, the samples were dried in hot air oven at 60 degree C for 48 hrs, ground to powder form in a moisture free environment and stored in airtight plastic containers. Raw bamboo shoot was analysed for its nutrient content which included proximate composition using AOAC (1975) methods [3]. Similarly, Standard analytical methods (AOAC,1975) were used for nutrient of formulated products [3].

Preparation of Products: Fresh and processed (boiled for 25 min) bamboo shoots were used for preparation of bamboo shoot *pakora* and bamboo shoot vegetable.

Bamboo shoot *pakora*: Onion (50 g) and bamboo shoots (200 g) were chopped into very fine pieces. Bengal gram flour (100 g), semolina (50 g), turmeric powder (2.5 g), salt (to taste), were mixed with chopped onion and bamboo shoots and a thick batter was prepared using water.

Pakora were fried in oil on simmer flame till it turned golden brown.

Bamboo shoot vegetable: Oil (2 tsp) was heated in a skillet and cumin seeds (1/4 tsp), chopped onion (100 g) and chopped tomatoes (100 g), were fried in heated oil for few minutes and then salt (to taste) and turmeric powder (1/2 tsp) were added to it and stirred for few minutes. Pre boiled (25 min) and chopped bamboo shoots were added in the skillet and cooked till done.

Statistical analysis

Data on the proximate composition of bamboo shoots were calculated for their mean value and standard deviation. Fisher's t-test was used for comparison of results of sensory characteristics of two formulated products.

Results and discussion

The mean sensory scores of bamboo shoot *pakora* and bamboo shoot vegetable are presented in Table 1. The results showed that there was a significant difference in sensory scores of both the products in all the sensory characteristics. The bamboo shoot *pakora* scored high as compared to bamboo shoot vegetable in each of the sensory attributes i.e. colour, appearance, taste, flavour, texture/mouth feel and overall acceptability. Thus it could be seen that bamboo shoot *pakora* was more acceptable as compared to bamboo shoot vegetable. Results of nine point Hedonic Scale showed that bamboo shoot *pakora* was "liked very much" (scored 8 out of 9) and bamboo shoot vegetable was "liked moderately" (scored 7 out of 9) by majority of the panel members.

Data on nutrient composition of raw bamboo shoot are given in Table 2, and Table 3 depicts the nutrient composition of formulated products of bamboo shoot. The moisture content of raw bamboo shoots was 90.74% which shows that major portion of bamboo shoots is water. Similar values of moisture in bamboo shoots have been reported (88.88 pert cent) [4]. Kerala Forest Research Institute (KFRI), Jabalpur also reported 90 per cent of water in bamboo shoots at the time of harvesting (www.kfri.org). National Mission on Bamboo Applications (NMBA) has reported moisture content of 7 species and the range they gave was 85.98 to 92.37 per cent (www.bambootech.org). These reported values are comparable to the result of the present study.

Crude protein content of raw bamboo shoots was 2.39 per cent. Slightly higher value of crude protein in edible bamboo shoots i.e. 3.9 per cent have been reported [4]. Similarly, higher value in different species of bamboo shoots have been reported i.e. 3.20 to 7.46 per cent [7]. The protein content in different bamboo species reported by earliar investigations varied from 2.0 to 4.4 per cent [5, 6, 8]. Crude protein content of 7 different species of bamboo shoots was 1.98 to 3.29 per cent as reported by NMBA (National Mission on Bamboo Applications) (www.bambootech.org). This reported value is in agreement with the result of the present study.

Crude fat value of bamboo in present study was 0.33 per cent which shows that bamboo shoots are very low in fat. Somewhat similar value – 0.5 per cent of crude fat in bamboo shoot has been reported [4]. Average value of fat of various species of bamboo shoots has been reported as 0.3 per cent [9]. This shows that result obtained is comparable to earlier findings. Slightly higher values of crude fat in different species of bamboo shoots i.e. 0.6 per cent to 1.0 per cent has also been reported [10].

Total ash was found to be 1.11 per cent in the present study. Similar value of 1.10 per cent total ash was reported [4]. Similar value of ash i.e. 0.9 per cent as an average value of various species of bamboo shoots has been reported [9]. Similarly other investigations reported 0.8 to 0.9 per cent of ash in different species of bamboo shoots [11]. The value obtained in the present investigation is in close agreement with the reported values. Further according to earlier reports, the ash content of fresh bamboo shoots ranged from 0.70 to 1.20 per cent [5,6,12]

The crude fibre content in the raw shoots was found to be 1.48 %. According to earliar investigations the crude fibre content ranged from 0.7 to 1.9% [5,6]. However, 0.71 to 0.98 per cent of crude fibre content in different species of bamboo shoots is also reported [11].

The value of carbohydrate was calculated to be 3.92 %. This value of carbohydrate is in agreement with the values of previous workers who reported a wide range of carbohydrate content from 2.0 to 6.4 % [5,6,7,8] in bamboo shoots of different species. However, reported average value of carbohydrate in various species of bamboo shoots is 4.5 per cent [9]. Similar results were reported as 4.5 to 5.2 per cent of carbohydrate in different species shoots [10]. However, slightly higher value of carbohydrate content of bamboo shoots (5.7 per cent) is also reported [4]. Whereas, slightly lower values of carbohydrate content in different species of bamboo shoots has been reported as 2.6 to 2.4 per cent [11]. The values of carbohydrate reported by earliar investigators are comparable to the result of the present study.

The energy value in bamboo shoots was calculated to be 28 kcal/100 g which shows that bamboo shoot is a low caloric food thus can be adapted by person on a crash diet for loosing weight.

Nutrient composition of bamboo shoot *pakora* and bamboo shoot vegetable showed that crude protein content of bamboo shoot *pakora* (5.09) was higher than vegetable (3.13). Crude fat was also very high in *pakora* (26.11) than in vegetable (10.51), as *pakora* is a deep fried product. However, total ash content and crude fibre content were higher in case of bamboo shoot vegetable than *pakora*. Since, bamboo shoot *pakora* is a deep fried product so the energy value is high in case of *pakora* (334 kcal/100g) than bamboo shoot vegetable (160 kcal/100g).

Bamboo shoot was found to be good source of protein (2.39%) and low in calories and fat (0.33%). Further, both the formulated products of bamboo shoot were acceptable, though the *pakora* was a more acceptable and liked product as compared to the vegetable.

Table 1: Mean sensory scores of bamboo shoot *pakora* and bamboo shoot vegetable

Sensory Characteristics	*Pakora*	Vegetable	t-value
Colour	8.46	7.80	2.56*
Appearance	8.40	7.73	2.97*
Taste	8.66	7.93	3.31*
Flavour	8.60	8.00	2.55*
Texture/mouth feel	8.53	7.60	4.42*
Overall acceptability	8.73	8.06	3.07*

Tabulated t-value : 2.048

Significant : (*)

Table 2 : Nutrient composition of raw bamboo shoots

Nutrient composition	Mean value* +,- S.D
Moisture (%)	90.74 +,-0.095
Crude protein (%)	2.39 +,- 0.095
Crude fat (%)	0.33 +,- 0.055
Total ash (%)	1.11 +,- 0.042
Crude fibre (%)	1.48 +,- 0.142
Carbohydrate (%_)	3.95 +,-0.206
Energy (kcal/100 g)	28 +,- 1.604

***Expressed on fresh weight basis**

Note: Values are mean of three observations

Table 3: Nutrient composition of formulated products

Nutrient Composition	Mean* (Pakora)	Mean value* (Vegetable)
Crude protein (5)	5.09	3.135
Crude fat (%)	26.11	10.51
Total ash (%)	0.80	1.50
Crude fibre(%)	0.78	2.43
Carbohydrate (%)	19.62	13.25
Energy (kcal/100 g)	334	160

***: Expressed on fresh weight basis**

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Role of different finishes in controlling moisture entry into strips of *Dendrocalamus strips*

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Abstract

Astudy was taken up to assess the ability of ditterent wood finishes on the surface of strips of *D. Strictus* in blocking water from entering the strips. The result indicates that varnish effect a pronounced ability in this direction compared to French polish or linseed oil. Compounded with the high gloss nature of varnish, this finish can provide value addition to products made out of D. Strictus in terms dimensional stability as well.

Introduction

Bamboo forms the single most important item of forest produce used by the rural communities in Asia and pacific. Though once called the "poor man's timber'' it is no longer so , its use as along fibre raw material in the pulp and paper industry is well known and is one of the much sought after raw materials in the tropics . Its use in housing , agriculture and horticulture pursuits , fishing industry , basket making , transport system (both on land and water), handicraft and producing edible shoots warrant reconsideration of the classification of bamboo as a 'Minor Forest Produce

In some countries and in others as non commercial species. It deserves an improved status in the forestry parlance and greater in –depth study. Signification awareness on the importance of bamboo has been created during the decade especially after methods of preservation and thus enhancement in the service life of bamboos were achieved (Dev et al, 1993)

Every wood work before use requires an attractive appearance as well as protection from degradation caused by changing atmosphere condition like temperature, alternate wetting and drying, exposure to light and dirt etc. These twin objectives are generally achieved by application of suitable wood finishes like paints, varnishes or polishes. A wide variety variety of organic coatings (translucent. Transparent or opaque) have been formulated for the purpose and are being used in trade. Some methods have been propounded for assessing the effectiveness of polishes in stopping moisture entry into wood (Badoni et al, 1990: Crank, 1975, Feist et al, 1985). Though application of preservatives has effectives has effected the enhancement in durability of various bamboos, it is the finishes applied to a bamboo

Product which ensures a large portion of value addition in terms of appearance as well as controlling moisture transport between the product and the surroundings.

Keep[ing the above point in mind, effectiveness of a penetrating type (Linseed oil) and two film forming (Varnish, sprit polish / French polish) finished in controlling water diffusion into *Dendrocalamus Strictus strips* was studied with an aim to find their usefulness as finishing materials for this widely used bamboo. This species is one of the two moist important bamboos in India. It is found suitable even for reclamation of ravine land (Shrivastava and Qureshi 1996). Dendrocalamus strictus is extensively used as raw material in paper mills and also for variety of purposes such as construction, agriculture implements, musical instruments, furniture etc.

Materials and Methods

Twelve number of six inch long rectangle of *D. Strictus* were prepared from split sections by removing the outer scale and the inner curve from a suitable culm. To avoid any fungal attack during the experimentation, these strips were treated with 5% concentration solution of Borax and Boric acid using a piece of cloth. The strips were than allowed to dry in air. The oven dry weights of each strip were calculated by measuring the OD weights of sub samples prepared along with the strips using standard methods. The dried samples were sanded using 80 grit size sand paper followed by 120. The sample weights were determined. These samples were than divided into four sets of three strips each. One set was used as control and the samples in the other three sets were polished with Linseed oil, varnish and French polish. Using a brush or a piece of cloth, two coats of various polishes were uniformly applied on to the surface. The second coats were applied after ensuring that the first coat had dried well under sunlight. The weights of the polished sample were than recorded to exclude the weights of the polish from subsequent calculation of moisture. To stimulate extreme moisture conditions, the samples (including the controls) were kept dipped in water for 72 hours and were taken out, and dripping water was wiped using a piece of cloth and also the surfaces were allowed to dry adequately. Afterwards, the weights of these water exposed samples were recorded. The capability of a particular finish in blocking moisture entry into the bamboo strips was studied by looking at the moisture gain of each sample for its oven-dry we3ight. For this, since the samples were given a uniform water immersion of 72 hours, the ratio of weight gain to the oven-dry weight of easample was used. Obviously, the quality will have no unit as it is a ratio of weights. A nomenclature of water Uptake capacity (WUC) was adopted for this ratio. Effect of subsurface finishes on various moisture properties were ascertained through Analysis of variance (ANOVA). In order to find out which pair of treatment differs significantly, the least significant difference (LSD) known as the critical difference was calculated at 95% confidence level (Gupta and Kapoor, 1976).

Results

The initial weights of the samples used in the study were mainly in the 7 to 10 gram category and the initial Moisture contents (MC) after the samples were air dried before application of fishes were in the 5 to 14% range. The final moisture contents after dipping the samples in water for 72 hrs showed a clear pattern with controls attaining MC in the 87-99% range. The polished samples, on the other hand as expected showed lower values of final MC in the range of 14-71%.

The figure broadly suggests that varnish is probably the most effective in blocking moisture from entering the bamboo. However, the other two finishes also have yielded promising moisture blocking property compared to the control. The average values suggested that in the case of varnish, the MC increased by only 1.2 times after soaking the samples for 72 hours. In the other cases the mc enhancements were 6 to9 times.

This observation phenomenon was quantitatively investigated by calculating by calculating the water uptake capacities as the ratio of moisture gain by a sample to its OD weight as described earlier. This way, any differences due to the initial MC and sizes of the samples can be normalized. While calculating the weight gain of a sample, care was taken to avoid the actual weight of the polish used. Table 1 gives these values for the samples.

Table 1: Moisture gain per OD weight user different finishes

Finishing Treatment	Weight of water taken in (gm)	Oven Dry Weight (gm)	WUC= Moisture gain per oven Dry Weight
Control	5.998	7.079	0.847
Control	8.111	10.867	0.746
Control	5.790	6.630	0.873
Mean			0.822

Linseed oil	4.939	8.926	0.553
Linseed oil	4.134	7.556	0.547
Linseed oil	5.630	8.984	0.627
Mean			0.576
Varnish 0.835	8.430	0.099	
Varnish 0.786	8.394	0.094	
Varnish 0.709	9.799	0.072	
Mean			0.088
French Polish	20976	7.385	0.403
French polish	3.243	8.125	0.399
French polish	3.372	8.151	0.414
Mean			0.405

It is very evident that when the samples are given some kind of coating, the ability of the sample to take in water reduces. The value obtained for Varnish is much too low indicating its superiority in this respect. To ascertain this observation the data was subjected to one-way ANOVA. Since the absolute values of the ratio are rather small, square root transformation was adopted before subjecyting the data to ANOVA. The result of ANOVA are given in table 2

Source of Variation	SS	Df	MS	F	P-value	F crit
Between finishes	0.6074	3	0.202467	279.9913	1.94E-08	4.06618
Within finishes	0.005785	8	0.000723			
Total	**0.613185**	**11**				

Table 2 shows that values of the ratio indicating the water uptake capacity have significant different between them. To asses the differences between individual treatments, the method of least significantly differences was employed. For calculating the critical difference, the students t value at 95% confidence interval and 8 degree of freedom was calculated to be 2.306006. The CD was calculated as 0.05. Table 3 gives the least significant differences (LCD) obtained.

Treatment	Average	C-	L-	V-	FP-
C	0.91	0	-0.15	-0.61	-0.27
L	0.76	0.15	0	-0.46	-0.12
V	0.30	0.61	0.46	0	0.34
FP	0.64	0.27	0.12	-0.34	0

From table 3 it is seen that linseed oil polish shows significantly less water intake only in comparison with control. French polish comes next where the water intake is higher only than the varnished samples. And in the case of varnished samples, the difference is always lower than CD. Thus varnish gives the most efficient water repelling characteristics when we use this bamboo for making various products.

Conclusion

The study on the three different finishes applied on to the surface of *Dendrocalamus Strictus* reveal that varnish exhibits the best efficiency to block moisture from entering this bamboo compared to linseed oil finish or French polish. Thus varnish can be very good on *D.* Strictus from the point of view of dimension stability. Moreover, as varnish is usually a high gloss finish, this can be good candidate for value addition in product made from *D. Strictus*

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Community based Market Information System (MIS) for Bamboo

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Abstract

Market information relates to generating information about markets, means of accessing the markets, market environment and competition. In order to develop a market Information System (MIS) for bamboo and its products, information is needed on the demand for bamboo, production and supply of the bamboo and bamboo products. Knowledge about markets channels, price and institutions involved in the marketing is also required.

In order to develop a community based MIS, it becomes necessary to know the need of stakeholders viz. growers, traders, artisans, researchers, industries etc. through questionnanaires/ personal interactions. After the analyses of collected information the same may be compiled and disseminated in the form of newsletter and websites at regular intervals. The same information may also be disseminated through the brochures, handouts, involvement of media – both electronic and print, IT network etc.

Community based bamboo MIS has a great benefit to its various stakeholders. Through MIS, the producers come to know about prevailing market prices, market trends, demand for bamboo and bamboo products, technical inputs and information about bulk buyers. The traders also know about inter market information, volume of supply and areas of production of quality products. The manufacturers, artisans in turn also get the information about growers, areas of production, volume of supply and prevailing prices through MIS. These aspects of community based bamboo MIS are described in detail in the paper.

Keywords: Community, MIS, bamboo, markets, dissemination.

Introduction

India is the second richest country in terms of bamboo diversity with a total of 136 species under 75 genera. Apart from availability in natural forests, bamboo is raised by plantations, in homesteads, farmlands and also introduced under various agro forestry systems. According to the Forest Survey of India, the total forest area under bamboo is 8.96 million ha, which is about 12.8 per cent of total forest area of the country. But the growth rate of plantations is very slow as per the required demand of raw material for various stakeholders. The estimated annual harvest of bamboo in India, which is being put to different uses, is about 13.47 million tones against the demand estimated at 26.69 million tones. A lacuna in this regard reported that private growers, not having proper technical know how of bamboo cultivation, marketing and its utilisation aspects. Traditionally people have sold their bamboo products in the local markets, however, new markets have to be explored for which information on bamboo markets is the need of the hour.

Traditionally, forestry development programmes have focussed on improving production and not on the products and their marketing. These programmes have successfully raised production levels, but hardly helping farmers to meet marketing needs. Producers often lack understanding of basic marketing fundamentals to get the best of their products. To find and penetrate markets effectively, one must have knowledge of critical market information (Sullivan *et.al.* 1991). Increased availability of market information will help producers strengthen their marketing skills and get higher prices, and lead to increased awareness of important marketing practices. Majority of producers neither have the knowledge of bamboo products in demand nor aware of expansion of markets of bamboo products. Hence, a system is needed that will help local producers to find new markets and expand existing markets as well (Hammett, A.L., 1994).

Majority of farmers, cultivating bamboo are hardly aware of markets available and the means of getting their final products (solid/ hollow bamboo seasoned/ unseasoned, basal/ pore, furniture, handicraft items made from bamboo and edible bamboos) to these markets. The result is that farmers have been receiving lower prices, due to lack of new or different market opportunities. Traders visiting local areas are often the only outlets. Even the producers do not know how to price their products, or determine demand, especially in new or distant markets. This lack of knowledge makes producers ineffective when dealing with middlemen.

Community-based Market Information System (MIS) is an instrument which is generally developed and used by a group of people with a common interest in improving the marketing of their products; ideally, a community-based MIS is a collaborative effort where each participant contributes his or her knowledge about the market to a common pool of information.

In this way, lack of market is an entry barrier to both production and trade. Market information can be particularly valuable, where growers have access to information; shifts in cultivation practices to higher value produce have been noted. In the area of trade, individuals find it difficult to begin trading without information, so reducing competition within markets. Available market information reduces transaction costs (i.e. the costs of selling the produce) by reducing risks. Growers/ artisans, with timely available reliable information and the ability to interpret it, can decide to which market they should send their produce to maximise returns or, indeed, whether to send their produce to market at all.

A good Market Information System is that which should provide commercially useful information to various stakeholders timely, on the following lines. This paper highlights some of the experiences leading up to the pilot test for a locally managed Market Information System (MIS) suitable for bamboo in India.

Need Based Assessment

Marketing needs to be flexible enough so that it can be adapted to changing needs of the market place. The testing of farm forestry products before they are produced or marketed is usually not possible. However, through increased knowledge of markets, important indications of product marketability can be assessed before valuable resources are planned or committed. An assessment of market information need is critical to the successful establishment of a local level market information sys tem. It is important to first identify and describe existing market in local, regional level in which products are available for sale. Besides this, one must also identify the various stakeholders, such as, local government leaders, leaders of any established farmers group and individual progressive private growers, researchers, Forest department/ FDCs, traders, artisans, Handicraft Department and middlemen in target area to determine the needs of market information. (Hammett, 1994).

Based on the reconnaissance survey a detailed information on prioritised requirement of all the above stakeholders, should be collected, so that a profile can be chalked out for developing MIS.

Marketing Capability and Channels

Marketing capabilities include basic knowledge of marketing skills to apply that knowledge in practice and appropriate attitudes to recognise and appreciate the value of marketing as one of the basic functions of NWFP's business (Lintu, 1995). In case of bamboo capabilities are needed at growers, intermediaries, processing industries and other all end users, the members involved in marketing and distribution channels also need the requisite capabilities for their day to day operations. Planners and operators in these sectors create awareness for understanding and to take advantages of appropriate marketing approaches.

In addition to existing marketing channels adopted in the trade of bamboo and bamboo products, possible new channels should also be included. Generally, following market channels for trading of bamboos and bamboo products have been recorded from the different part of the country.

A. Bamboo

Growers> Middlemen> Traders> Consumers

Growers> Traders> Consumers

Growers> Consumers

B. Bamboo Products

Producers> Shopkeepers> Buyers

Producers> Middlemen/Agents> Buyers

Producers> Buyers

Prominent Bamboo Markets in India

There are several timber markets in India, in which bamboo is also marketed. Following are some of the prominent bamboo markets in various states of India (Singh, *et. al*. 2002).

Prominent Bamboo Markets in Indian States

Sl No	Name of State	Markets
1	Andhra Pradesh	Chittoor, Hyderabad, Janaram, Karimnagar, Kothagudem, Mancherial, Rajhamundri, Vijayawada and Warangal
2	Arunachal Pradesh	Bandardewa, Bhalukpong, Deomali, Itanagar, Likabali, Mahadevpur and Miao
3	Assam	Barpeta Road, Biswanath Chariali, Bongaigaon, Dhuburi, Dhola, Diphu, Dhemaji, Goalpara, Golaghat, Guwahati, Haflong, Hailakandi, Jorhat, Jogighopa, Karimganj, Lakhimpur, Lumding,

		Morigaon, Nagaon, Nalbari, North Lakhimpur, Silchar, Silapathar, Tinsukia, Tezpur and Titabor.
4	Bihar	Daltonganj
5	Chattishgarh	Akaltara, Bilaspur, Lumani Mungeli, Raipur and Ratanpur
6	Gujarat	Amreli, Songarh, and Umapada
7	Haryana	Ambala, Kurukshetra, Kaithal, Ladwa, Peohwa, Pundri, Radhaur and Sahabad
8	Jharkhand	Bokaro, Dhanbad, Jamshedpur and Ranchi
9	Himachal Pradesh	Baddi, Mandi, Parwanoo, and Una
10	Karnataka	Bangalore
11	Kerala	Ernakulam, Kannur, Kozhikode, Kottayam, Kasargod, Palakkad, Thrissur, and Wayanad
12	Madhya Pradesh	Balaghat, Bhopal, Jabalpur, Mandala, Seoni and Shahdol
13	Manipur	Churachandpur, Imphal, Jiribam, Thoubal and Tamenglong
14	Meghalaya	Baghmara, Byrnihat, Jorabat, Nongpoh, Shillong, Tura, and Williamnagar
15	Mizoram	Aizawl, Kolasib, Lunglei, and Vairengti
16	Nagaland	Dimapur, Kohima, Mokokchung, and Tuli
17	Maharashtra	Mumbai (Thane), Ballarshah, Chandrapur, and Nagpur
18	Orissa	Calicut, Jeypore, and Rayagadha
19	Punjab	Amritsar, Ajnala, Hoshiarpur, Dasuya, Jalandhar, Kapurthala, Ludhiana, Patiala, and Pathankot.
20	Rajasthan	Jaipur
21	Sikkim	Gangtok and Sewak Road
22	Tamil Nadu	Andhiyor, Chennai, Dharampuri, Pollachi, Puliampatti, Tripathur, Gobichettipalayam, Sathyamangalam, Tiruchirapalli and Salem
23	Tripura	Agartala, Dharmanagar, Udaipur and Teliamura
24	Uttar Pradesh	Agra, Bareilly, Gorakhpur, hapur, Jhansi, Kanpur, Renukoot, karvi, Lalitpur, Mirzapur, Nazibabad, Sitapur, and Tanakpur
25	Uttarakhand	Dehradun, Haldwani, Jwalapur, Khatima, and Ramnagar
26	West Bengal	Asansol, Kolkata, Howrah, Malda, Hashimara and Siliguri

Data Collection

The basic principles of the community-based information system, applies to most products produced at the community level will also be applicable to bamboo and bamboo products. Certain aspects require specific considerations, while dealing with marketing and Marketing Information Systems on bamboo and its products. As bamboo products are not linked with official marketing systems like that of agricultural produce, the MIS of bamboo should be an advantage for bamboo growers. However, since most bamboo are in the informal market structures, the information about prices, product flows and potential markets is less known and special skills in marketing information and analysis may be required. Many bamboos are harvested on open access areas and increased market transparency may result in overexploitation of the resource. While the gestation period of bamboos varies from species to species, the monitoring of their supply will be critical. In situations when open access and common lands are the predominant sources, there are likely to be many stakeholders, sometimes with potentially conflicting uses. Such aspects should be taken into account in designing an MIS and discussing the organisation of its operation.

Developing a locally appropriate system to collect and disseminate market information can be implemented after modest commitment of resources and is suitable for many farm forestry products. Collaboration with farmers as a group and with input from other organisations is important – and save small producers' time and valuable resources.

Sources of Marketing Information

The information for incorporation in the MIS newsletter will be collected from all sources such as growers (public/ private), traders, buyers and middlemen for marketing, manufacturing units and small end users (artisans), forest department/ FDCs, research institutes, NGOs, press, other electronic media and seminars and related publications.

Mode and Method, Collection of Market Information

The required data will be collected in well structured formats/ questionnaires formulated after consultation of various stakeholders, through appointed and trained resource persons, face-to-face interaction/ interview, consulting relevant literature and internet accessing on the various aspects viz. source of availability of planting material and technical know-how, bamboo using sectors, market prices of various sizes and shapes of bamboo available in the markets, different bamboo products and their market prices, sector wise supply/ demand of bamboo as raw material. The information on export-import of bamboo/ bamboo products is also collected for the development of bamboo marketing in future on national and international level.

Processing of Data

Collected data will be compiled, tabulated for publication in the form of a newsletter, handout, pamphlets, leaflet, brochure etc. The contents of newsletter decided as per the requirement of various stakeholders. The data will also be processed for development of website, price trends and other analysis.

The proposed quarterly newsletter as well as websites will include prices of bamboos/ bamboo products, demand and supply status, price trends in different markets, addresses of major traders in different markets, sources of quality planting material and other current scientific information pertaining to bamboos on regular interval.

Dissemination of Information

The published material including newsletter will be disseminated to various stakeholders of the bamboo growing areas in the country. Market information once available through market intelligence systems, can also be disseminated through the mass media. For example, in India the major means for disseminating market information to remote cultivators include – All India Radio (A.I.R.) with almost 100% coverage of the country's area of inhabitation, national television channels with 95% coverage and the business sections of various newspapers (Dwivedi, 1993). Transfer of information of newsletter to website, developed for different stakeholders, releasing the information to print/ electronic media and to be used in holding meetings with stakeholders and group discussions with them.

Expected outcome of MIS

The expected outcome of the MIS will be very useful for all end users of bamboo and its products. Accessibility of market information enables farmers to obtain a relatively better deal in local market transactions. The overall consequence is the increased economic well-being of remote rural farmers – keeping them aware, about the prevailing market prices at regular intervals, price trends, supply and demand status and locations of markets etc. The growers will also be aware about the latest scientific information on cultivation aspects at local levels. Besides, this data bank will also be developed for all the related research institutions and those involved in future planning.

A marketing system can only be market driven. If the trader sees a profit he will go to the remotest areas. However, easier availability of market intelligence and the establishment of Tree Growing Cooperatives or proper market yards will ensure that the farmers get a fair price for the bamboo produce from his field (Issar, 1994).

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Recent developments in a Bamboo Housing Technology at IPIRTI, Bangalore, India

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Abstract

The paper describes in brief the bamboo based housing activities at Indian Plywood Industries Research and Training Institute (ipirti0, Bangalore. To begin with, IPIRTI in collaboration with TRADA, U.K. developed the technology for ground floor construction. The IPIRTI-TRADA bamboo housing system differs significantly from other established bamboo construction practices in many ways. The technology was popularized by constructing several demonstration houses in different parts of India through Building Material technology promotion Council, (BMTPC) New Delhi.

Having successfully developed the technology for construction of bamboo based housing system; the challenge was to develop the technology, which is equally viable for other structures, typically two storey buildings and community centers. Hence, the development of technology for construction of two-storey houses was taken up in the project mode sponsored by the BMTPC New Delhi. Construction of two storey bamboo house has just been completed. Some of the new concepts of walling system, roof beams, bamboo flooring system, connections between beam and column, wall and slab, box windows are demonstrated in this structure. Alternative design concepts are also included based on demonstration/experimental structures. At each stage of construction, various elements were tested and models of such elements were made before the actual construction was carried out. The house constructed in campus explores the new thinking in bamboo construction.

IPIRTI, which has developed technologies for manufacture of several bamboo composites such as bamboo mat board, bamboo mat corrugated roofing sheets, bamboo mat ridge caps, bamboo floor tiles and laminates wanted to demonstrate the use of the bamboo composites in pre-fabricated structures as the potential for using bamboo based composites in construction for pre-fabricated housing is very promising in disaster prone areas. The main advantage of development of modular houses is that they can be pre-fabricated in large quantities and can be easily transported to construction sites. Hence, the design and development of pre-fabricated modular housing system using bamboo based composites was taken up at IPIRTI, funded by BMPTC, New Delhi.

Construction of two prototypes has been recently completed. IPIRTI's bamboo composite panel based pre-fabricated houses could be efficiently transported in 'one pack' houses and can be assembled quickly. Such technology would be highly relevant in particular for relief agencies for disaster management.

Bamboo is being currently looked upon as an alternative low cost material for the enormous housing problems faced by several developing countries. To increase the self-sufficiency of developing countries indigenous materials must be exploited to the full. Bamboo is one such, which is highly useful. Several countries in Asia and Latin America still depend on bamboo as an important source of building material not only for construction of rural houses but also for pucca houses and buildings in towns and cities.

Fast growing nature of bamboo to provide sustainable supply to meet the demands of the building industry and many positive aspects of modern engineering materials found in bamboo has renewed interest of engineers architect to use bamboo as an engineering material. Some of the advantages of bamboo are high tensile strength compared to that of mild steel – can be used for reinforcement in place of mild steel; high strength to weight ratio and high specific load bearing capacity; requires less energy for production compared to material like steel, plastics, aluminium etc.; Physical – mechanical properties of bamboo which grows to maturity in 4 to 5 years compares favorably with that of hardwood which requires 40 to 50 years to attain maturity; service life of bamboo can be enhanced considerably by providing suitable preservative treatment; Studies as in China and India has further established its versatility to be converted into panel and composite material possessing enhanced strength properties suitable for structural applications; Like wood, bamboo also possesses high residual strength to absorb shocks and impacts – this makes it highly suitable material for construction of houses to resist seismic and high wind forces; Bamboo along with fast grown plantation species is very efficient in sequestering carbon and contributes to the reduction of green house effect.

Affordable housing technology was developed at IPIRTI using bamboo and bamboo in collaboration with TRADA, U.K. Engineering and materi8awl properties were studied exhaustively to utilize the full potential of bamboo as an engineering material in housing. Bamboo housing technology clearly demonstrates the engineering application bamboo in housing. All load bearing and semi load bearing elements have been made either of round or split bamboo in the form of slivers in combination with bamboo based composites like BMB and BMCS for roofing with minimal use of timber and high energy consuming materials like iron, steel and cement.

The IRIRTI – TRADA bamboo housing differs significantly from other established bamboo construction practices in many ways viz., 1. Use of round bamboo columns and trussed rafters as main load bearing element, 2. Use of split bamboo grids/chicken mesh and plastered with cement mortar to act as sheer walls for transmitting wind loads and to provide overall stability to the structure, 3. Application of appropriate preservative treatment of bamboo depending on the degree of hazard and service conditions, 4. Use of BMB suggests in combination with mild steel bolts for load bearing joints in roofing structure, and 5. Use of BMCFS as roof claddings.

The low mass of the bamboo based building is an advantage under earthquake condition as compared to masonry structures. The buildings constructed in bamboo using this method are able to withstand the highest levels of earthquake loading likely to be experienced in India. The test building of 2.7m2 resisted seven repetitions of a Zone 5 earthquake, the highest in India and e4quivalent to 7 on the Richter scale, as well as the application of the notorious Japanese Kobe earthquake (Richter 7.8), without any damage whatsoever.

Two-storey bamboo house

Having successfully developed the technology for construction of bamboo based housing system; the challenge was to develop the technology, which is equally viable for other structures, typically two-storey buildings, community centers etc. in areas, which have not have the exposure to the new thinking that bamboo exposure offers.

Hence, the development of technology for construction of two-storey house was taken in the project mode sponsored by the BMTPC, New Delhi. In the technology some of the concepts of walling system, roof beams bamboo flooring system, connections beam and column, wall and slab, box windows are demonstrated. Alternative design concepts are also included based on demonstration/experimental structures. At each stage construction, various elements were tested and models of such elements were made before the actual construction was carried out. The house constructed in campus explores the new thinking in bamboo construction. The plan has been kept very simple keeping in mind the construction system to be adopted. The salient features in terms of techniques adopted for the construction of two-storey bamboo house constructed at IPIRTI campus in collaboration with BMPTC are:

1. To arrest settlements due to the difference in levels in the ground, the outer periphery of the house above the foundation was provided with nominal reinforcement in the plinth beam.

2. 'T' shaped steel angles are provided in the Column-wall plate-Column Junctions of the first and ground floors. Steel angles are designed separately for single and double columns.
3. Double columns placed above the plinth beams are inserted into 16 mm diameter steel rods projected and bottom portions were cemented grouted.
4. To assess the axial load carrying capacity of bamboo columns, since the exist possibilities of loss of lateral restraints, single and double bamboo columns were tested for its performance.
5. Bamboo-steel composite Beams and Composite slabs were tested for their performance.
6. Box windows were constructed at the places required using the similar bamboo grid wall technology.
7. Concept of shrunken slab has been demonstrated above the toilet room by filling up the light weight material (cinder) and concrete screed applied over it.
8. To get natural ventilation sufficient numbers ventilators provided below the first floor roof.
9. The two storied bamboo house constructed in the campus explores the new thinking in bamboo construction.

Pre-fabricated house using bamboo composites

Wood, steel concrete have been widely used in many countries for modular housing. Modern methods for pre-fabricated housing have been extensively used in Europe, USA, Canada and Japan in the last decades. As to the material used to the above method construction, currently the most commonly used are steel, concrete and large quantities of pre-engineered timber and wood based panels. Wooden roof trusses, I-joists and wall/ partitions have been traditionally important pre-fabricated components. Bamboo based panels have similar properties to the wooden panels. The potential market for using bamboo based composites in construction for pre-fabricated housing is very promising.

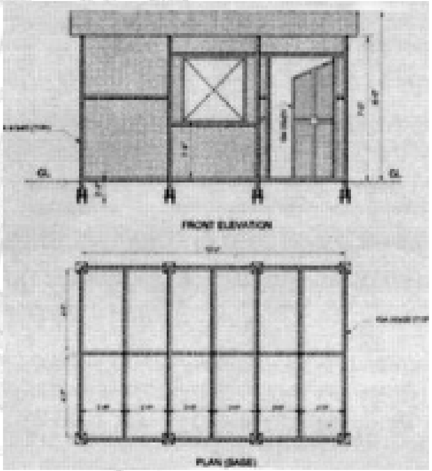
The main advantage of development of modular houses is that they can be pre-fabricated in large quantities and can be easily transported to construction sites. IPIRTI'S bamboo composite panels based pre-fabricated houses can be efficiently transported in 'one pack' and can be assembled quickly. Such technology would be highly relevant in particular for relief agencies for disaster management.

Besides the benefits of a quick supply of houses in large quantities, the design and development of a bamboo based modular housing production chain would also directly benefit to bamboo growers, harvesters and employees of the building industries by generating direct and indirect employment and linking them with industries in pre-processing and processing of panel components. It would develop long-term rural-urban market linkages. Lastly this type of bamboo composite based pre-fabricated houses on bamboo rather than wood could save thousands of hectares of forests and would save our earth from destruction.

Hence, the design and development of pre-fabricated modular housing system using bamboo and bamboo based composites was taken up at IPIRT, funded by BMPTC, New Delhi, INDIA.

Model - I. Portable pre-fabricated single walled modular house

The design specifications of single walled modular house with attached bath having size 8ft x 12ft x 8ft are as follows:



Plan and elevation Pre-fabricated and Single Walled Modular House

Construction methodology

Bamboo composite materials such as BMB is fastened on rolled steel framed angle ISA sections allowing provisions for doors and windows and then erected quickly on site. The steel angles erected through proper grouting, and welding to get the proper shelter dimensions along with steel purlins on the top to support the roofing sheets (BMCS). The doors are made from 6mm thick bamboo mat boards fixed window frames. The whole structure is resting on cement concrete floor through grouting. Generally, the dimensions (length and breath) of the floor are built slightly larger than the inside dimensions of the shelter to protect the foundations of supporting steel structures. As the UV attack of sunrays disintegrates the polymeric resin thus reducing the life of the mat boards, the outer walls of the houses are painted with weather coats for improved life span.

Structural

All structural components are composed of rolled steel sections conforming to IS: 808. The angles are of equal angle sections subjecting to withstand wind load and dead load in both directions. This provides excellent structural integrity.

Base

The base consists of grid steel framed structure ISA 50 x 50, 3mm angle running in both directions. Spacing of bottom runner is 0.6m c/c, which is placed in inverted position. Elevation of ground level is 0.66m.

Wall Panels

Wall panels are composed of 8′ x 4′, 6mm thick bamboo mat board. The panels are attached to the structural steel frame by screw rivets bon the building interior. The wall panels are water heat resistant and conform to IS: 13958.

Connection

All structural components a interconnected by 2 mm diameter nuts and bolts to create a utilized framework to make it completely dismantable type.

Floor

Flooring consists of 6′ x 4′ 16mm thick bamboo mat board and conforms to IS: 13958. A coating on Rhino prime is given on the top surface to avoid any abrasion. The panels are kept above steel grid frame and then nut bolted on top.

Ceiling

The ceiling consist 8′ x 4′, 6mm thick bamboo mat board placed on the steel grid frame with purlins and rafters of ISA 35 x 35, 3mm thick. The edge joint are sealed with silicon sealant on top surface to avoid any water seepage.

Doors and windows

Standard outfitted window having char glass panes and ISA 25 x 25, 3 mm thick as frames were fixed. The door frames are also of ISA 25 x 25, 3 mm thick having 8′ x 4′, 6mm thick bamboo mat board as door panels which are lockable from both sides.

Toilet

It is of size 4′ x 4′, having partition wall with 8′ 4′, 6mm thick bamboo mat board attached to structural frame which is completely dismantable type with a provision of EWC.

Uses

In farm-house, rest houses, temporary sheds hilly areas where conventional houses are not possible.

This prototype house was exhibited in India International Trade Fair (IITF), 2006 during November 14-27, at Pragati Maidan, New Delhi. Nearly 200 visitors from India, Nepal, and Bhutan very much appreciated the house. It is found that these types of houses are having lot of demand in the Northern part of India especially in hilly areas where constructions of conventional houses are too costly.

Model - II. Pre-fabricated double walled modular house

The material of construction to be used in disaster prone areas should be such that they absorb and reduce seismic energy and are able to withstand wind forces. Conventional heavy and brittle building materials such as stones, brick, mortar, granite etc. do not absorb shock waves but the amplify them, causing more destruction. In contrast light weight; bamboo mat boards fixed on steel frames with nuts and bolts are more flexible allowing lateral movements of the structures. They absorb and reduce seismic energy. In view of this, construction of model – II was taken up to provide quick build pre-fabricated houses for disaster management.

Construction Methodology

Structural frame was fabricated using INSTACOM steel sections of 50 mm wide thick. Bamboo composite materials such as BMB are fastened on INSTACOM steel sections on both the sides (interior and exterior) after erection of structural framed wall at site. These natural materials have all the properties required for a general-purpose board and can be used in place of wood or MDF synthetic resin boards. The INSTACOM sections are erected through proper grouting, bolting and welding to get the proper shelter dimensions. Four numbers of MS trusses of height 2.5 ft were fixed on the top frame along with steel purlins running on the top to support the roofing sheets (BMCS). The boards fastened to the structural frames allowing provisions for doors and windows. The doors are made of composite boards and windows of glass panes. The flooring is also made from bamboo mat boards fixed on a steel grid at a height at 2.5 ft above. The flooring is also made from bamboo mat boards fixed on a steel grid at a height of 2.5 ft aboveground level. The grid frame is fixed on brick/stone masonry pillars if elevated. Generally, the dimensions 9length and breadth) of the floor are built slightly larger than the inside dimensions of the shelter to protect the foundations of supporting the steel structures. As the UV attack of sunrays disintegrates the polymeric resin thus reducing the life of the mat boards, the outer walls of the houses are painted with weather coats for improved life span.

Flexible construction steel frames fixed would bear tensile, compression and structural stresses and allows lateral movements of the structure thus reducing the effect of seismic forces. Lightweight material used for walls and portioning also absorbs and reduces seismic energy and its impact or effect. The material used for constructing the houses is modular in nature and once the fabrication is completed, these houses could be easily dismantled and transported to different locations.

Contract farming in Bamboo - Tamil Nadu Experience

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Abstract

The State of Tamil Nadu is experienced with 39 mills of which two mills viz., Tamil Nadu News print and Papers ltd, karur and Seshasayee Paper Board, Erode are the two wood based mills. These two mills nearly utilize around 40 per cent of woody biomass which are mostly derived currently from casuarinas and eucalyptus plantations. Both the mills have expanded their paper production which demanded nearly 8-10 lakhs tones. This ushered in a total mismatch between the demand and supply which necessiatates massive import of wood pulp. In order to promote pupp wood plantation as per the guidelines of 1988 forest policy, the tamil Nadu Newsprint and Papers(TNPL), Karur District, Tamil Nadu have initiated farm and agroforestry programmes through contrast farming system by adopting tri and quadpartite models. In these systems, foue spec ies of bamboo viz; Bambusa bambos, Bambusa balcooa, Bambusa valgaris and Dendrocalamus strictus have been promoted as pulp wood plantations. The contrast farming system facilities supply of quality planting materials to the farmers at subsidizes prices coupled with assurance of minimum support price or the current market price which ever is high.

Introduction

Contract farming is an efficient and effective system of success for production and consumption systems of agricultural and allied sector. It is an essential agreement between unequal parties which include the growers, processors and consumers (Eaton, 1998). Contract farming is viewed as essentially benefiting the promoters or users agencies by enabling them to obtain the essential raw material on sustainable basis. In the age of market liberalization, globalization and expanding agribusiness, there is a danger that small scale farmers will find difficulty in fully participating in the market economy (Jackson and cheater, 1994). In many cases, small farmers could become marginalized as large farms become increasingly necessary for profitable operations. This system of contractual farming have been existed from time immemorial but the success in many sectors of agricultural production is of recent origin.

In contrast to agriculture, the production system in forestry is long rotation in nature (Luna, 1989). Besides, the forest of the country is shrinking under acute socio economic pressure and till the deforestation rate in the country was estimated to be 1.5 million per year. Currently the forest area in the country is around 23% and in the state of Tamil Nadu it is around 17.5% whicdh is low againt the mandate requirement of 33% (ESI, 2001). Not only the wealth of the country is poor but also its productivity in therms of MAI is also one of the lowest. The less forest ares coupled with low productivity of Indian forest has ushered in a total mismatch between demand and supply of both domestic and industrial wood requirements (Parthiban and Govinda Rao, 2007).

The biggest challenge faced by wood based industries is the spectare of raw material unavailability. A regressive forest policy coupled with promotationm of farmers/industries linked plantation activitiews in and under cultivable and marginal agricultural lands will help to migrate the crisis. This necessitates a business farm forewstry model, in order to expand the area under farm and aforstry plantation through industrial industrial participation. Such industrial oriented business model incorporating various bamboo species along with traditional agriculture system is not available either for demonstration purposes or for horizontal expansion across the farmland.

The success of industrial wood plantation schemesand the related plantation establishment is widely questioned. The reasons for the failure are numerious , but the key reasons aren non involvement of local; people, lack of assued buy back and minimal support price. Besides, the middlemen and local contractors in the existing marketing schemes play a significant role and in mos6t cases they decide the harvesting time and also price fixation. Absence of efficient production to consumption system couples with price incentives and assurd buy back agreement is a major constraint faced by the tree growing farmers. This constraint on industrial agroforestry can be overcome through augmenting the existing supply chain system by linking the farmers directly with industries through contract farming system. This augumented supply chain system will assure strong buy back system with a mnimum support price. Hence, the industry has developed contracrt farming systems involvimng various levelsa of stake holders using bamboo as a source of raw material.

Contract Farming Model

The industry is associated with Tamil Nadu Agricultural University has developed a tripartite and quad partite model for promotation of pulp wood based conmtract framiong systems using bamboo a major species.

Tripartite Model

This model incorporates industry, growers and financial institutions. Under this systems, the industry supplies quality planting material at subsidized rate ans assures minimum support price of Rs. 2000 per tones or the prevailing market price which ever is higher. The financial institutes prvide credit facilities to the growers at the rate of Rs. 15000 to Rs. 20000 per acre in three installments. For credit facilities a simple interest rate with subsidy in interest is followed and the replacement starts after felling.

Quad-Partite Model

This system is similar to tri partite model barring the involvement of research institute. In this system, research institute particularly forest College and Research Institute (TNAU) play a significant role for technical advancements through varietal development and also to advice site specific precision technology to the growers. The institute partner also helps to develop human resources through on and off institute mode.

Choices of species

Currently the industries promotes the following bamboo species as a source of pulpable raw material viz; *Dendrocalamus strictus*, *Bambusa bambos* and thorn less varieties viz; *Bambusa balcooa* and *Bambusa valgaris.* The farmers in the state mostly prefer thron less variety viz; Bambusa balcooa and Bambusa valgaris for which the industry has already established a clonal multiplication area (CMA) for large scale multiplication.

Planting material

The industry has developed centralized facilityies for mass multiplication of bamboo through clonal approaches using rooting of culm cuttings and also through rhizome. The clonal technology developed by Tamil Nadu Agricultuarl University for mass multiplication of bamboo using clam through fueeow and rill method was transferred to industry for large scale adoption and multiplicxation. The clonal planting materials have been multiplied in centralized manner and supplied to all stake holders through farming systems.

Approaches

The promotation of industrial wood plantation in the farm lands was viewed through three approaches:

a. Farm forestry plantations: The farmers raised bamboo based pulpwood plantations in their farm land as block plantations at an espacement of 5x5 m.

b. Agrofoestry plantation: The farmers raised bamboo based pulpwood plantations as the major crop cou-led with local; intercrops.

c. Captive plantation: The industry developed bamboo based pulpwood plantations in the farm land through lease or through benefit sharing mechanism.

Salient features of the contract farming system

- The industry supply quality planting material both through seedlings and clones at subsidized cost.
- The industry is associated with TNAU ex technological support right from planting, intrim precision silivicultural management coupled with plant protection measures.
- The industry assures strong buy back with minimum support price of Rs. 2000 per tonne for the clums sizes of more than 1 inches diameter.
- The industry also facilitates harvesting of bamboo culm and transportation to the mill yard.
- The industry extends credit facilities to the small and marginal farmers through nationalized bank at simple ans subsidized rate of interest.

Features of bank finance under contrast farming system

- All the bamboo growers intended for industrial tie-up are eligible to avail bank loan facilities.
- The contract farming systems extends no collateral security for loan amount upto Rs. 100,000 per farmer.
- It provide simple and subsidized rate of interest irrespective of loan amount.
- The schemes facilities repayment of principal and interest only after harvest.

Area of operation

In order to have better monitoring and to improve working efficiency as also to have minimum logistic expense, farm forestry activities were confined to a compact area i.e; the area with in the radius of around 200 km from the mill as far as possible. As on date, 16 District are covered under the farm forestry projects and bamboos have been p[romoted in five districts viz; Karur, Pudukottai, Coimbatore, tanjore and Erode taking in to consideration the basic factors of locality and site quality.

Conclusion

Tree farming is gaining momentum in the state through the institute-industrial linked public participation. The industry promoted bamboo based contract farming systems and contributed significantly for the successful establishment of bamboo based pulp wood plantations. However, availability of proven and elite genetic material is the major problem for which the industry has established a collaborative research with TNAU for development of improved genetic resources in bamboos. The contract farming system proves lucrative to the farmers of the state.

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Nutrient Cycling in Plantation Bamboo Stands under Lateritic Soil of South West Bengal, India

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Abstract

Nutrient cycling is a good indicator of continuity and stability of any living system. The significance of nutrient management has also become relevant with the advent of commercial forestry wherein there is a continuous increase in production and removal of biomass out of the system as in bamboo stands.

In the present paper nutrient cycling in five year old plantations of five bamboo species (*Bambusa balcooa, B. bambos, B. nutans, B. vulgaris* and *Dendrocalamus strictus*) have been assessed under lateritic soil of South West Bengal based on production, accumulation and partitioning of above ground biomass (AGB), litterfall, soil nutrient reserve, nutrient retention and release.

On individual clump basis, on an average, culm biomass contributes maximum (66.5 to 79.6%) on total AGB. Clumps of *B. bambos* are superior in producing total dry matter per sample clump (219.66 kg) followed by *B. vulgaris* and *B. balcooa*. However, stands of *B. nutans* produces maximum AGB (29.91 t/ha) followed by *B. bambos* (27.46 t/ha), *B. balcooa* (27.21 t/ha), *B. vulgaris* (21.03 t/ha). Annual litterfall pattern shows greater intensity from December to February and is mainly contributed through leaf fall. *B. nutans* favours maximum litterfall (2152.9 kg/ha) and at higher percentage (8.12%) of total AGB.

Within the standing biomass, accumulation of N, P, K, Ca and Mg are in the ratio of 6.2-8.1: 1: 9.9-12.1: 6.2-6.4: 3.0-3.6. It is estimated that five year old bamboo stands in their biomass retain about 3.70 to 5.59 % N, 0.30 to 0.53 % P, 0.51 to 0.84 % K, 0.43 to 0.75 % Ca and 0.33 to 0.62% Mg of total soil reserve. *B. nutans* is capable of retaining maximum amount of P, K, Ca and Mg while *B. bambos* retains maximum N. The extent of annual nutrient return through litterfall has been quantified at 7.03-8.66, 5.83-8.29, 4.68-6.08, 4.97-6.57 and 4.50-9.73% for N, P, K, Ca and Mg respectively on total accumulation. Based on

the extent of yearly nutrient accumulation and return through litterfall in the stand, about 9.9-13.3% N, 10.3-13.1% P, 7.9-9.8% K, 7.2-10.4% Ca and 7.1-14.6% Mg are annually recycled in five year old bamboo stands.

(**Key words :** Bamboo species, Biomass, Nutrient Cycling, Lateritic Soil, West Bengal, India).

Introduction

Bamboos (*Bambusoideae*) comprise a subfamily of the grasses (*Poaceae*). Its range of uses for humans is extensive and important. As for many other crops, demand for bamboo products is beginning to outstrip supply, resulting in over-exploitation and exhaustion of bamboo resources. One of the major goals for the future is to increase productivity and resource use through improved management of growth and the growth environment.

Nutrient cycling may be a good indicator of the continuity and stability of any living system and may believe to be a useful strategy for ecosystem analysis. The cycling and uptake of nutrients have been shown to be critical processes for the health of the forest ecosystem. To achieve a reasonable balance between product extraction and maintenance of nutrient processes, forest managers must understand the potential impacts of various silvicultural practices on this nutrient-related process. The significance of nutrient management has also become relevant with the advent of commercial forestry where in there is a continuous increase in production and removal of biomass out of the system as in case of bamboo stands. A considerable work has been done in this field in Indian forests with so many species but very little with bamboos (Shanmughavel and Francis 2001; Joshi et al 1991; Tripathi and Singh 1994). Further, such study in Eastern India is completely lacking.

In the present paper nutrient cycling in five year old plantations of five bamboo species (*Bambusa balcooa, B. bambos, B. nutans, B. vulgaris* and *Dendrocalamus strictus*) under lateritic soil of South West Bengal have been assessed based on productivity, accumulation and partitioning of above ground biomass (AGB), litterfall, soil nutrient reserve, nutrient rentention and release.

Study Site

The study site, within *Hot Dry Sub-Humid* Agro-Ecological Sub-region of *Rahr and Eastern Plateau*, was selected from 5 year old bamboo plantations raised at Netaipur, Paschim Medinipur, South West Bengal. The site (22°34¢ N Latitude and 87°34¢ E longitude and

65 m above MSL) falls under lateritic soil zone and is situated at a distance of 130 km from the nearest coast of Bay of Bengal. The study site has mean annual maximum and minimum temperatures of 34.65^{o} and 16.83^{o}C respectively and experiences annual precipitation of 1533 mm.

According to Champion and Seth (1968), the forests under lateritic soil tract of south West Bengal fall under Sub-Group 5B (Northern Tropical Dry Deciduous Forests), Type C1 (Dry Sal bearing forests) and Sub-type C1c (Dry Peninsular Sal Forest).

Materials and Methods

Soil Collection and analysis

Standard methods (USDA Soil Survey Mannual) were followed for soil profile digging, morphological studies and collection of samples prior to plantation establishment (March 1996) and experimentation (December 2000). The physical, physico-chemical and nutrient attributes of the representative profile and field soil samples under bamboo stands have been analyzed following methods of Black (1965), Jackson (1973) and Piper (1966). Based on the bulk density and nutrient status of the soils during plantation and at the end of five growing seasons, the total nutrient reserves have been estimated.

Bamboo productivity, litterfall seasonality and nutrient cycling

In order to study nutrient dynamics in bamboos, 5 year old plantations of *Bambusa bambos, B. balcooa, B. nutans*, *B. vulgaris* and *Dendrocalamus strictus* were selected. These were established at Netaipur with planting stock raised during July 1996 through vegetative propagation of culm cuttings at 7.5m x 7.5m spacing. The clump density, at the out set of the study was 125 to 141 per ha. The variation is due to destruction and uprooting of some of the clumps by wild elephants.

Estimation of above ground biomass

Biomass study was conducted during November-December, 2000 after completion of five growing seasons. Five clumps were selected from each stand for each species and their growth parameters (culm length and collar diameter) in respect of culms emerged at different growing seasons (previously labeled), were recorded. Five sample culms of each age series (1 to 5 years), selected from these five clumps, were felled (15 cm above groundl) and separated into bole (culm-stem), branches and leaves. The fresh mass of each of the fractions were recorded and samples of bole (three sub-samples from lower, middle and upper portion), leaves and branches of each harvested culm were sent to the laboratory, dried at 65^0C for 15 days in hot air oven till constant weight for moisture and dry matter (DM) estimation. The mean values from five culms of each age group for each species have been taken to calculate component wise and total dry matter (TDM) production by sample clumps. From the mean oven dry weight of the samples, and subsequently from each sample culm of each age group, the total standing biomass was worked out. During December, 2001 component wise biomass production of new culms emerged during sixth growing season (July-August 2001) were estimated following the same procedure.

Litterfall study

Four litter traps each of $1m^2$ size were designed and laid within the sample plot for each species. From January 2000 to December 2000, the litters were collected fortnightly, separated into leaf and branch fractions. The culm sheath component of the litter was included with the leaf fraction. Fresh and dry mass (at 65^0C for 7 days) of each litter component were recorded periodically and analyzed.

Nutrient concentration in bamboo and litter components and Nutrient cycling

Plant and litter samples collected for biomass estimation and moisture determination were processed, ground and analyzed for total N, P, K, Ca and Mg as per methods of Black (1965) and Jackson (1973). The mean values of nutrient concentration of different plant and litter parts were calculated by pooling the values of sub-samples of each bole, leaf and branch samples of the harvested bamboos of all the age series and periodic litter analysis data for all species. From the results so obtained, nutrient content of standing crop, uptake, retention and return of nutrients were worked out. Nutrient cycling in different bamboo stands has been assessed on the basis of soil nutrient reserve, nutrient retained in the stand, nutrient accumulaion in the growing biomass within a defined duration and nutrient returned through litterfall for that period.

Results and Discussion

Soil Characteristics and Nutrient Reserve under bamboo

The soils of the study site are lateritic in nature and generally characterized by shallow in depth, low water holding capacity, organic carbon content, cation exchange capacity and also low in available and total nutrient contents (Table 1). Percent composition of sand, silt and clay indicates that these soils are loamy sand to sandy loam in texture. On the basis of soil depth, bulk density and nutrient status determined at the time of plantation and biomass estimation, the soil reserves have been worked out. During 1996 the soils under bamboo contained 4295.7, 6908.0, 47136.6, 31172.8 and 19969.2 kg/ha N, P, K, Ca and Mg respectively. The same have been changed to 4117.5, 6862.5, 46774.8, 31018.5 and 19873.8 kg/ha after 5 years of bamboo cultivation. According to modern classification, the soil of representative profile may be grouped under *Typic Ochraqualf (*Soil Survey Staff, 1999).

Accumulation and partitioning of biomass

Tables 2 and 3 show the component-wise above ground sample culm and clump biomass and TDM production in bamboo stands. In general, emerged culm number increases gradually with concomitant increase in culm size for all species with the advancement of clump age. Maximum culm recruitment has been encountered with *B. nutans* followed by *B. balcooa* and *D. strictus.* As regards culm size, *B. nutans* is the thickest and tallest among all the species followed by *B. vulgaris* and *B. bambos* in length and *B. balcooa* and *B. bambos* in thickness. Though intensity of culm recruitment in *D. stictus* is better than *B. bambos* and *B. vulgaris,* its culms are much shorter and thinner. The moisture content of bamboo plant components varies widely (data not presented) from 27.4 to 49.4% for boles, 26.8 to 49.5% for branch and twigs and 42.9 to 51.2% for leaves. Younger culms, in general, contain more moisture than older ones.

Bole, branch and leaf biomass of sample culms (Table 2) have been found to increase with clump age and culm size, irrespective of species. Higher and comparable bole DM production has been recorded with *B. balcooa* and *B. bambos.* In 6 years, sample culms of *B. bambos* produces 9.71 kg DM/bole followed by *B. balcooa* (9.59 kg), *B. vulgaris* (7.46 kg), *B. nutans* (7.21 kg) and *D. strictus* (6.30 kg). *B. bambos* produces maximum branch biomass (2.71 kg in 5 yr and 2.45 kg in 6 yr) compared to other species (0.97 – 1.72 kg). This contributes in highest sample culm and sample clump DM production (219.66 kg/clump in 5 yr) with lesser number of culms/clump than all other species. Leaf DM production is maximum for *B. nutans* (1.22 and 1.26 kg/culm in 5 and 6 yr respectively) followed by *B. bambos,* and *B. vulgaris* and minimum for *D. strictus* (0.48 and 0.43 kg/culm in 5 and 6 yr).

There is noticeable variation in stand biomass between species (Tables 2 and 3). Species to species variation in dry matter production by individual culms would be further clear if we observe the dry matter production at comparable d^2l (d is collar diameter at 15cm and l is culm length) values for culms of corresponding age. For many forest species, d^2l

was found to be highly correlated with biomass among the predictor variables tried, DBH was found to be the most reliable parameter for prediction of biomass (Tandon et al 1988). Oli (2005) developed a regression model based on d^2l as a prediction variable to estimate biomass of *B. nutans*. In the present study for example, 4 yr old culms in 5 yr old clump of *B. bambos* and *B. vulgaris* have almost identical d^2l values but the former produced 5.24 kg dry bole against 4.62 kg in the latter one. Similarly *B. balcooa* is more productive than *B. nutans* since with lower d^2l value of 1yr old culm in the 5yr old stand, the former produces more (8.51 kg) bole DM than that of *B. nutans* (6.42 kg) having much higher d^2l value i.e., with greater culm length and diameter. Like wise, productivity in terms of bole DM yield is more in *B. vulgaris* than *B. nutans* and in *D. strictus* than *B. vulgaris, B. nutans, B. balcooa* and *B. bambos*. Thus at a comparable culm length and diameter, *D. strictus* culms produce maximum dry matter due to its least hollowness among the species studied.

Bamboo DM production is a function of culming intensity. In spite of lesser DM accumulation in sample culms, *B. balcooa* and *B. nutans* with higher culm recruitment manifest better clump total biomass. Like that of sample culm, maximum branch biomass per clump (Table 3) has also been met with *B. bambos* followed by *B. nutans, B. balcooa* and *B. vulgaris.* Figures as high as 51.56 kg/clump and 6.44 t/ha in 5 yr old *B. bambos* stand is not surprising while comparing with much higher branch biomass production by *Dendrocalamopsis oldhami* (28.17 t/ha) and *Phyllostachys pubescens* (15.5 t/ha) as recorded by Isagi et al. (1997) and Li et al. (1998). In terms of photosynthetic DM production, *B. nutans* favours greater contribution (13.5%) to above ground biomass (AGB) with maximum leaf dry matter (28.74 kg/clump and 4.05 t/ha) followed by *B. bambos* (22.14 kg/clump and 2.77 t/ha) and *B. vulgaris* (18.12 kg/clump and 1.76 t/ha). *D. strictus* produces least quantity of leaf bilmass (10.12 kg/clump and 1.38 t/ha) and contributes only 6.6% to total AGB.

On an average, boles contribute maximum (66.5 to 79.6%) towards total DM accumulation in clumps. The maximum culm DM accumulation in *B. balcooa* (79.6% on TDM and 162.80 kg/clump) is due to its higher thickness of culm wall and the next higher values in *D. strictus* (78.4% and 119.77 kg/culm) may be attributed to solid nature of its culms. *B. bambos* produces an intricate thorny and elongated branch network that even descends from the upper culm segments to the ground level and *B. nutans* produces profuse branch and branch-lets and thereby contributing more towards branch and foliage production as stated. This might be the reason for their lower contribution (66.5%) through culms in TDM as compared to other species. According to Kleinhenz and Midmore (2001), in sympodial species, AGB is allocated to 77% in boles, 13% in branches and 10% in leaf.

The present DM partitioning are almost in conformity with these values except that of *B. bambos* and *B. nutans.*

Pertaining to productivity of the bamboos under lateritic soil, it is observed from Table 3 that *B. nutans* produces maximum DM (29.91 t/ha) followed by *B. bambos* (27.46 t/ha), *B. balcooa* (27.21 t/ha), *B. vulgaris* (21.03 t/ha) and *D. strictus* (20.77 t/ha). The higher order of productivity in *B. bambos* and *B. balcooa* stands may be linked to higher branch and leaf biomass in case of the former and greater bole DM proportion on TDM for the latter species. On the other hand, the maximum DM accumulation in *B. nutans* is attributed to its maximum culm density (35.8 in 5 yr old clump), clump density (141 per ha) and culm length. The present data on culm DM production by *B. nutans* is in agreement with those observed by Oli (2005) for corresponding culm components having comparable length and diameter of the species. However, for *B. bambos*, the values are far less than those recorded by Shanmughavel and Francis (2001) who measured astonishing productivity (225 t/ha) in 6 years with the same species. The minimum DM accumulation in *D. strictus* compared to other species except *B. vulgaris* is due to its culm dimension. However, the present values are comparatively more than what of Joshi et al (1971) found but less than that observed by other workers (Tripathi and Singh 1994).

Annual Productivity

The biomass accumulated in new culms emerged during 6th growing season (2001) may give an indication about annual productivity if we compensate the photosynthetic biomass produced during the period with that of the preceding year. Further, for a stand of 5 years of age the newest culms-biomass may be treated as annual productivity. During 6th growing season the substantial part of older culms were found to be degraded in respect of loss of foliage, natural pollarding of branch and branch-lets and also loss of culm dry matter. At the same time, accumulated litter is in the process of advanced and continuous degradation. Moreover, clump expansion is found to be rapid up to 5th and 6th year of plantation (Banik 1988) in case of *Bambusa* species and culm recruitment and growth attain their maximum in 5 to 7 years of planting. Under that situation productivity of bamboo stands has to be ascertained for both 5th and 6th year. Accordingly it is seen from Table 3 that annual productivity of bamboo under lateritic soil varies from 10.99 to 14.07 t/ha without leaf fraction and 11.81 to 15.77 t/ha with leaf for five year old culms and 11.47 to 16.02 t/ha without leaf and 12.16 to 17.13 t/ha with leaf for six year old culms irrespective of species. Species-wise, higher productivity was recorded in *B. balcooa* (16.02 t/ha) excluding foliage followed by *B. bambos* (15.81 t/ha) and *B. nutans* (14.36 t/ha).

Comparable non-photosynthetic productivity of 11.47 to 11.54 t/ha and 12.16 to 12.91 t/ha TDM per year after 5th growing season are manifested by *B. vulgaris* and *D. strictus*. These figures are in conformity with those of reported by Hunter and Wu (2002). Kleinhenz and Midmore (2001) showed that for most species culms are distributed between four years of growth. Their average total biomass figure of 130-142 t/ha can therefore be roughly re-worked to show a maximum annual productivity between 32 and 36 t/ha – lower if the culms last for longer. However, growth rates between 10 and 30 t/ha are not exceptional amongst woody biomass species (Hunter and Wu 2002).

Litterfall seasonality

Table 4 shows litter fall seasonality of bamboo species under lateritic soil condition. It is seen that litter production is maximum under *B. nutans* (2.15t/ha) followed by *B. bambos* (1.88 t/ha), *B. balcooa* (1.68 t/ha), *D. strictus* (1.43 t/ha) and *B. vulgaris* (1.21 t/ha). The contribution of leaf fraction on total litter ranges from 81.02 to 88.70%.

The per cent litter production on total AGB is maximum with *B. nutans* (8.12%) followed by *D. strictus* (7.49%), *B. bambos* (6.86%), *B. balcooa* (6.56%) and *B. vulgaris* (5.91%). The present values are in well agreement with those observed by Joshi et al (1991), Tripathi and Singh (1994) but higher than those with *D. strictus* of lower Siwalik bamboo forest in the Garwal Himalayas (Joshi et al 1991). On the contrary, Shanmughavel and Francis (1997) recorded much higher values for *B. bamboos* in Tamil Nadu. When looked into the monthly variation in litter fall, no definite trend has been noted for the bamboo species. However, on an average, intensity of litter fall starts increasing from November and that continued till April/May coinciding with the drier climate. A sudden surge in greater contribution of branch and branch-lets during June to August might be due to the climatic condition at the site which experiences occasional cyclone and storm on account of south West Monsoon.

Litter biomass contributes significantly to soil organic matter and supplies bamboos with nutrients in natural stands and cultivated plantations. While working on nutrient cycling in stands of *P. pubescens* in China, Fu Maoyi et al (1988) witnessed that bamboo leaf litter occurs over the whole year but has two annual peaks - in spring (April-May) and late autumn (November). Thus the annual litterfall is greatly affected by both the biological properties of bamboos and the environmental condition.

Nutrient concentration and stand nutrient contents

From tables 5 and 6 it is seen that, in bamboo clumps, photosynthetic part retains higher concentration of nutrients followed by branch and boles. Level of N is more in leaf followed by K, Ca, Mg and P. However, the decreasing trend is K>N>Ca>Mg>P in branches and K>Ca>N>Mg>P in boles with a very few exceptions.

While comparing the values of retention of individual nutrients in standing biomass, it is observed that retention of K is maximum (251 to 391 kg/ha) with least values for P. The accumulation of N (152 to 230kg/ha) and Ca (134 to 234kg/ha) are comparable. The present levels of nutrient retention by the stand biomass (Table 5) are in general agreement with earlier findings of Rao and Ramkrishna (1990). Within the standing biomass, accumulation of N, P, K, Ca and Mg are in the ratio of 6.2-8.1: 1: 9.9-12.06: 6.2-6.4: 3.0-3.6. An overview of accumulation and partitioning of the major plant nutrients (Joshi et al 1991; Li et al 1998; Mailly et al 1997; Virtucio 1996) revealed that average total accumulation of N, P and K in bamboo is 288, 44 and 324 kg./ha and at the ratio of 7: 1 : 7. In the present site *B. bambos* supports higher N accumulation where as maximum contents of P, K, Ca and Mg are stored in *B. nutans*. The higher biomass and nutrient concentrations on TDM are the reasons for this.

Nutrient levels and accumulation in 6 yr old culms of different bamboo species (Table 6) point out that about 93.96 to 161.06 kg N/ha is being taken up by a well developed stands. The ranges for P, K, Ca and Mg uptake by different species of lateritic belt of West Bengal are 12.49 - 20.28, 145.27 – 200.96, 84.79 – 148.71 and 32.03 – 57.78 kg/ha respectively. The species to species variation in accumulating these nutrients in above ground parts, clump density and other clump parameters are the factors that control net nutrient reserve in standing biomass.

Litter nutrient concentration and nutrient return through litterfall

Litter samples of the bamboos retain lesser concentration of nutrients than in standing bamboos in corresponding parts irrespective of species and this could be attributed to re-translocation of nutrients prior to leaf fall (Gosz et al 1973). According to Tuckey (1970), leaching is much less important than re-translocation in removing the nutrients from the senescing leaves except K. From average annual status of nutrients in litters (Table 7) it is clearly seen that leaf fraction contains all the nutrients in greater concentration.

The annual quantity of litter was greatly affected by both the biological properties of bamboos and the environmental condition. The present study reveals that nutrient recuperation in bamboo soil is controlled not only by the quantity of litter produced but also the nutrient levels in it as evidenced from highest N, P and Mg return by *B.* bambos though it produces about 10% less litter than *B. nutans.* Annual nutrient incorporation in soil under 5 yr old bamboo stands are found to be 9.68 – 17.63 kg N, 1.64 – 2.99 kg P, 13.63 – 21.14 kg K, 8.37 – 12.19 kg Ca and 3.84 – 9.47 kg Mg/ha. These values are at least 5 to 10 times less than that observed by Shanmughavel and Francis (2001) with *B. bamboos.* On the contrary, Tripathy and Singh (1994) measured litterfall in *D. strictus* to the tune of 2.7 t/ha/yr stand from a standing biomass of 35 t/ha with annual N, P and K return of 28, 1.3 and 12 kg/ha/yr respectively. The present values for *D. strictus* are almost at par with the values of Tripathi and Singh (1994) at least for P and K. Joshi et al (1991), however, measured N, P, K release to the tune of 5, 1 and 2 kg/ha/yr through litter fall from *D. strictus* stands. Among the different bamboo species, under lateritic soil of South West Bengal, highest amount of nutrients are being returned from *B. nutans* stands followed by *B. bambos, B. balcooa, D. strictus* and *B. vulgaris*. These quantities have a significant relation with their annual litterfall.

Nutrient balance and turnover of nutrients

The fractional nutrient concentrations in standing biomass and annual biomass production, quantity of litterfall and soil nutrient status have been converted to work out the soil nutrients pool, nutrient accumulated in bamboo stands, annual nutrient uptake, and nutrient return through litter in order to get an idea of nutrient cycling under bamboo and bamboo-soil interrelationship. These are of paramount importance in finding out the adequate silvicultural management of bamboos for sustainable yield.

The soil nutrient reserves at the study site based on total N, P, K, Ca and Mg status determined at the time of biomass estimation (December, 2000) are about 4117.5, 6862.5, 46774.8, 31018.5 and 19873.8 kg/ha for N, P, K, Ca and Mg respectively. Bamboo stands in five years retain about 3.70 to 5.59 % N, 0.30 to 0.53 % P, 0.51 to 0.84 % K, 0.43 to 0.75 % Ca and 0.33 to 0.62 % Mg of total soil reserve in their biomass. *B. nutans* is capable of retaining maximum of P, K, Ca and Mg while *B. bambos* retains maximum N. As regards percent nutrient returned on total accumulation in the stands, the range of values are 7.03 to 8.66, 5.83 to 8.29, 4.68 to 6.08, 4.97 to 6.57 and 4.50 to 9.73 % of N, P, K, Ca and Mg respectively. The lower values of percent return in *B. nutans* and *B. balcoa* for most nutrients indicate their greater efficiency in improving their nutrient accumulation and consequently biomass production as noted in earlier discussion. In this respect, *D. strictus* is the least efficient among all the species. However, intensity of nutrient cycling under *D. strictus* is thought to be comparatively more since, manifestation of dynamicity may be understood from values of maximum yearly accumulation and yearly release of a particular element. Perusal of Table 8 also reveals that, on an average, the decreasing order of annual nutrient uptake is K > N @ Ca > Mg > P in the five year old bamboo stand. For N and P, annual uptake is maximum in *B. bambos* (140.63 kg/ha and 22.74 kg/ha followed by *B. nutans* (134.715 and 20.889), *B. balcooa* (114.584 and 18.979), *D strictus* (110.108 and 14.015kg/ha) respectively. For K, Ca and Mg, annual uptake is maximum in *B. nutans* followed by *B. bambos, B. balcooa* and *B. vulgaris*. The ranges of yearly uptake of K, Ca and Mg in the bamboo stands are 152.90 to 227.28, 84.42 to 135.84 and 43.63 to 73.56 kg/ha respectively.

From the present study it may thus be concluded that the circulation of the chemical elements may be the characteristic property of both the individual elements and the bamboos species under cultivation. It is also clear that based on the extent of yearly nutrient accumulation and return through litterfall in the stand, about 9.9 to 13.3% N, 10.3 to 13.1% P, 7.9 to 9.8% K, 7.2 to 10.4% Ca, 7.1 to 14.6% Mg are annually recycled in different bamboo stands of 5 years of age. Hence addition of nutrients should preferably be oriented towards the nutrients being removed through harvest in view of sustainable productivity and economic return.

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Table 1. Changes in soil properties under bamboo stands.

Sl.	Soil Parameters	1996 (March)	Soil Nutrient Reserve (1996) (kg ha^{-1})	2000 (December)	Soil Nutrient Reserve (2000) (kg ha^{-1})
1	Mean Soil Depth (cm)	45	-	45	-
2	Texture	Loamy sand	-	Loamy sand	-
3	Sand (%)	68	-	66	-
4	Silt (%)	23	-	25	-
5	Clay (%)	9	-	9	-
6	Bulk Density (g cm^{-3})	1.28	-	1.22	-
7	PH	5.45	-	5.4	-
8	EC (dS m^{-1})	0.035	-	0.045	-
9	CEC [cmol(p^{+}) kg^{-1}]	5.4	-	7.9	-
10	Oraganic Carbon (%)	0.135	-	0.482	-
11	Available N (ppm)	115	-	148	-
12	Available P (ppm)	3.7	-	5.8	-
13	Available K (ppm)	78	-	93	-
14	Total N (%)	0.064	4295.7	0.075	4117.5
15	Total P (%)	0.116	6908.0	0.125	6862.5
16	Total K (%)	0.753	47136.6	0.852	46774.8
17	Total Ca (%)	0.486	31172.8	0.565	31018.5
18	Total Mg (%)	0.285	19969.0	0.362	19873.8

Table 2. Sample Culm dry matter production by bamboos grown under Lateritic Soil.

Sl.	Species	Growth season	Mean Culm Number	Culm Length (l)	Collar Dia. (d)	d^2l	Sample culm bole DM (kg)	Sample culm branch DM (kg)	Sample culm leaf DM (kg)	TDM/ culm (kg)
							(a)	(b)	(c)	(a+b+c)
1	*B. balcooa*	1	1.4	1.63	0.97	1.5	0.45	0.07	0.00	0.53
		2	4.2	3.58	2.49	22.2	0.86	0.44	0.07	1.37
		3	6.8	5.17	4.67	112.7	2.37	0.73	0.23	3.33
		4	8.8	7.87	5.47	235.1	5.55	1.07	0.45	7.08
		5	11.0	9.62	7.23	502.3	8.51	1.11	0.67	10.29
	Sample Clump Total		32.2							
		6	11.2	10.11	7.75	606.6	9.59	1.17	0.74	11.50
2	*B. bambos*	1	1.4	1.25	0.83	0.9	0.30	0.17	0.00	0.47
		2	3.6	3.26	2.05	13.7	0.91	0.79	0.03	1.73
		3	5.8	5.43	3.50	66.4	3.15	1.14	0.65	4.94
		4	8.0	7.89	4.98	195.3	5.24	1.84	0.97	8.05
		5	10.0	9.95	6.24	386.7	8.21	2.71	1.05	11.97
	Sample Clump Total		28.8							
		6	10.4	11.14	6.95	537.6	9.71	2.45	1.01	13.17
3	*B. nutans*	1	1.8	1.00	1.41	2.0	0.17	0.19	0.00	0.36
		2	4.4	3.65	2.86	29.8	0.61	0.47	0.03	1.10
		3	7.8	5.77	5.39	167.9	2.09	0.66	0.44	3.19
		4	9.8	8.56	6.85	401.9	4.83	1.23	1.07	7.13
		5	12.0	11.53	7.72	687.4	6.42	1.68	1.22	9.32
	Sample Clump Total		35.8							
		6	11.4	12.70	8.16	846.4	7.21	1.72	1.26	10.20
4	*B. vulgaris*	1	1.8	1.57	0.68	0.7	0.24	0.12	0.04	0.40
		2	4.0	3.63	2.27	18.7	0.66	0.28	0.23	1.17
		3	6.4	5.74	3.91	88.0	1.93	0.55	0.44	2.93
		4	7.4	8.73	4.69	192.2	4.61	0.80	0.54	5.96
		5	10.0	11.70	5.77	390.1	7.32	1.26	1.02	9.61
	Sample Clump Total		29.6							
		6	10.6	11.91	6.36	482.2	7.46	1.05	1.01	9.51
5	*D. strictus*	1	1.8	1.47	1.13	1.9	0.35	0.11	0.05	0.51
		2	3.4	3.06	2.52	19.4	0.92	0.22	0.09	1.23
		3	5.8	4.70	3.46	56.2	1.88	0.24	0.17	2.30
		4	8.8	6.83	3.86	102.0	4.09	0.90	0.40	5.38
		5	10.8	9.79	4.05	160.6	6.40	1.16	0.48	8.04
	Sample Clump Total		30.6							
		6	11.6	10.83	4.99	269.5	6.30	0.97	0.43	7.71

Table 3. Sample Clump and total dry matter production by bamboos under Lateritic Soil.

Sl.	Species	Growth season	Mean Culm No.	Sample culm bole DM/clump (kg)	Sample culm Branch DM/clump (kg)	Sample culm Leaf DM/ clump (kg)	TDM/ sample clump (kg)	Density (Clump/ha)	Total Culm No./ha	TDM (t/ha)	DM (Non-Photosyn-thetic (t/ha)
1	*B. balcooa*	1	1.4	0.63	0.10	0.00	0.74	133	186	0.10	0.10
		2	4.2	3.62	1.84	0.31	5.77		559	0.77	0.73
		3	6.8	16.10	5.00	1.56	22.66		904	3.01	2.81
		4	8.8	48.85	9.45	3.98	62.28		1170	8.28	7.75
		5	11.0	93.60	12.21	7.36	113.18		1463	15.05	14.07
	Sample Clump Total		32.2	162.80	28.60	13.21	204.62		4283	27.21	25.46
		6	11.2	107.38	13.09	8.30	128.76		1490	17.13	16.02
2	*B. bambos*	1	1.4	0.43	0.24	0.00	0.66	125	175	0.08	0.08
		2	3.6	3.28	2.84	0.11	6.22		450	0.78	0.76
		3	5.8	18.29	6.59	3.77	28.65		725	3.58	3.11
		4	8.0	41.90	14.76	7.74	64.40		1000	8.05	7.08
		5	10.0	82.08	27.12	10.53	119.72		1250	14.97	13.65
	Sample Clump Total		28.8	145.97	51.55	22.14	219.66		3600	27.46	24.69
		6	10.4	100.94	25.50	10.48	136.92		1300	17.12	15.81
3	*B. nutans*	1	1.8	0.31	0.33	0.00	0.64	141	254	0.09	0.09
		2	4.4	2.67	2.05	0.13	4.85		620	0.68	0.67
		3	7.8	16.31	5.11	3.46	24.88		1100	3.51	3.02
		4	9.8	47.34	12.08	10.49	69.91		1382	9.86	8.38
		5	12.0	77.03	20.18	14.66	111.87		1692	15.77	13.71
	Sample Clump Total		35.8	143.66	39.75	28.74	212.15		5048	n	25.86
		6	11.4	82.21	19.62	14.41	116.24		1607	16.39	14.36
4	*B. vulgaris*	1	1.8	0.43	0.22	0.06	0.72	128	230	0.09	0.08
		2	4.0	2.64	1.11	0.93	4.67		512	0.60	0.48
		3	6.4	12.35	3.54	2.84	18.74		819	2.40	2.03
		4	7.4	34.14	5.91	4.03	44.08		947	5.64	5.13
		5	10.0	73.23	12.61	10.25	96.08		1280	12.30	10.99
	Sample Clump Total		29.6	122.78	23.40	18.12	164.30		3789	21.03	18.71
		6	10.6	79.04	11.10	10.68	100.82		1357	12.91	11.54
5	*D. strictus*	1	1.8	0.64	0.19	0.08	0.91	136	245	0.12	0.11
		2	3.4	3.11	0.76	0.32	4.19		462	0.57	0.53
		3	5.8	10.92	1.41	1.00	13.34		789	1.81	1.68
		4	8.8	36.01	7.89	3.48	47.38		1197	6.44	5.97
		5	10.8	69.08	12.55	5.23	86.87		1469	11.81	11.10
	Sample Clump Total		30.6	119.77	22.81	10.12	152.69		4162	20.77	19.39
		6	11.6	73.13	11.22	5.03	89.38		1578	12.16	11.47

Table 4. Litter fall seasonality on bamboo stand under lateritic soil condition of South West Bengal

			Monthwise litter collection (DM in kg/ha)													(% Litter
Sl	Species	Litter	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total	on AGB)
1	*Bambusa*	AGB (kg/ha)														25577
	balcooa	Leaf kg/ha)	283.9	133.7	132.0	100.6	81.7	68.1	90.1	87.0	47.8	55.3	91.1	187.5	1358.8	5.31
		Branch (kg/ha)	16.8	18.3	8.6	6.2	10.2	62.8	65.5	13.9	36.9	24.6	24.6	30.0	318.3	1.24
		Total	300.7	152.0	140.6	106.8	91.9	130.9	155.6	100.9	84.7	79.9	115.8	217.5	1677.1	6.56
2	*Bambusa*	AGB (kg/ha)														27457
	bambos	Leaf (kg/ha)	162.6	163.5	161.8	97.1	152.1	84.1	98.8	116.5	71.5	82.6	59.0	345.9	1595.5	5.81
		Branch (kg/ha)	35.6	40.1	6.7	24.1	21.4	35.6	16.2	9.1	16.6	17.9	17.5	46.2	286.9	1.04
		Total	198.2	203.6	168.5	121.2	173.5	119.7	115.0	125.6	88.0	100.5	76.5	392.1	1882.3	6.86
3	*Bambusa*	AGB (kg/ha)														26519
	nutans	Leaf kg/ha)	306.8	147.2	104.8	118.7	114.8	104.8	109.0	82.1	75.4	149.2	233.0	293.4	1839.2	6.94
		Branch (kg/ha)	14.2	5.9	11.6	7.5	39.4	98.7	12.6	7.7	64.7	7.0	23.1	21.1	313.7	1.18
		Total	321.0	153.1	116.3	126.2	154.2	203.5	121.5	89.9	140.2	156.2	256.2	314.5	2152.9	8.12
4	*Bambusa*	AGB (kg/ha)														20537
	vulgaris	Leaf kg/ha)	201.3	97.4	48.7	61.6	24.0	60.9	60.4	68.5	68.5	87.8	95.5	199.9	1074.5	5.23
		Branch (kg/ha)	10.9	6.6	5.2	8.1	4.9	36.1	4.7	20.2	11.4	11.7	7.0	12.9	139.8	0.68
		Total	212.2	103.9	53.9	69.8	28.8	97.0	65.1	88.8	80.0	99.5	102.5	212.8	1214.3	5.91
5	*Dendro-*	AGB (kg/ha)														19086
	calamus	Leaf kg/ha)	214.2	212.2	79.7	35.7	34.7	63.3	89.5	75.4	52.3	49.3	127.9	233.3	1267.5	6.64
	strictus	Branch (kg/ha)	11.1	5.0	8.8	6.5	6.2	38.7	12.6	19.9	24.4	7.5	7.6	13.0	161.5	0.85
		Total	225.2	217.2	88.6	42.2	40.9	102.1	102.1	95.3	76.7	56.8	135.5	246.3	1429.0	7.49

Table 5. Nutrient retention in five year old bamboo stands

Sl	Species		Mean value in culms of five yr old clumps (% on dry matter)					Dry matter	Nutrient retention in five yr old bamboo stands (kg/ha)				
			N	P	K	Ca	Mg	kg/ha	N	P	K	Ca	Mg
1	*B. balcooa*	Leaf	1.74	0.24	1.37	1.03	0.59	1757.2	30.54	4.13	23.99	18.01	10.35
		Branch	1.12	0.13	1.31	0.93	0.43	3804.3	42.72	4.76	49.87	0.46	0.00
		bole	0.53	0.10	1.06	0.78	0.37	21652.66	114.54	20.79	229.95	168.02	79.68
		Total							187.80	29.67	303.81	186.50	90.03
2	*B. bambos*	Leaf	1.66	0.24	1.49	1.04	0.53	2767.5	46.00	6.73	41.13	28.64	14.72
		Branch	1.01	0.13	1.35	0.78	0.42	6443.3	65.21	8.51	86.86	50.45	26.74
		bole	0.65	0.12	1.27	0.82	0.37	18246.15	119.15	20.98	230.81	149.98	67.33
		Total							230.35	36.21	358.79	229.08	108.79
3	*B. nutans*	Leaf	1.61	0.18	1.42	0.85	0.53	4052.3	65.08	7.46	57.70	34.24	21.27
		Branch	0.98	0.15	1.37	0.83	0.41	5605.2	54.71	8.13	76.51	46.64	23.21
		bole	0.53	0.10	1.27	0.76	0.39	20255.91	107.76	21.07	256.84	153.13	78.59
		Total							227.55	36.65	391.06	234.01	123.07
4	*B. vulgaris*	Leaf	1.64	0.21	1.34	1.07	0.52	2318.9	38.08	4.80	31.03	24.72	11.97
		Branch	0.95	0.14	0.98	0.84	0.48	2994.8	28.48	4.04	29.47	25.01	14.43
		bole	0.55	0.09	1.13	0.63	0.38	15716.11	85.81	14.77	176.81	99.33	58.94
		Total							152.37	23.62	237.30	149.05	85.34
5	*D. strictus*	Leaf	1.73	0.21	1.65	1.25	0.41	1375.7	23.79	2.82	22.75	17.17	5.67
		Branch	1.12	0.14	1.53	0.94	0.37	3101.7	34.80	4.22	47.52	29.25	11.38
		bole	0.68	0.09	1.12	0.54	0.30	16288.54	110.44	13.85	181.62	87.63	48.38
		Total							169.02	20.88	251.89	134.05	65.43

Table 6. Nutrient Conent in Six Year old culms (kg/ha)

Sl	Species		N	P	K	Ca	Mg	TDM	Nutrient Conent in Six yr old culms (kg/ha)				
			% on dry matter					in new culms	N	P	K	Ca	Mg
1	*B. balcooa*	Leaf	1.764	0.235	1.432	1.135	0.652	8.295	19.46	2.59	15.80	12.52	7.19
		Branch	1.235	0.131	1.268	0.844	0.533	13.088	21.50	2.28	22.07	14.69	9.28
		bole	0.673	0.088	1.116	0.715	0.289	107.376	96.11	12.57	159.38	102.11	41.27
		Total							137.07	17.44	197.25	129.32	57.74
2	*B. bambos*	Leaf	1.732	0.256	1.376	1.256	0.458	10.476	22.68	3.35	18.02	16.45	6.00
		Branch	1.115	0.143	1.254	1.121	0.439	25.504	35.55	4.56	39.98	35.74	14.00
		bole	0.815	0.098	1.133	0.765	0.265	100.944	102.84	12.37	142.96	96.53	33.44
		Total							161.06	20.28	200.96	148.71	53.43
3	*B. nutans*	Leaf	1.623	0.179	1.365	0.767	0.476	14.415	32.99	3.64	27.74	15.59	9.67
		Branch	1.125	0.162	1.128	0.772	0.296	19.618	31.12	4.48	31.2	21.35	8.19
		bole	0.512	0.098	1.115	0.654	0.325	82.211	59.35	11.36	129.25	75.81	37.67
		Total							123.46	19.48	188.19	112.75	55.54
4	*B. vulgaris*	Leaf	1.639	0.235	1.438	1.025	0.584	10.678	22.4	3.21	19.65	14.01	7.98
		Branch	0.977	0.146	1.125	1.115	0.511	11.104	13.89	2.08	15.99	15.85	7.26
		bole	0.635	0.087	1.367	0.543	0.361	79.042	64.25	8.8	138.3	54.94	36.52
		Total							100.53	14.09	173.95	84.79	51.77
5	*D. strictus*	Leaf	1.764	0.188	1.587	1.285	0.432	5.033	12.07	1.29	10.86	8.8	2.96
		Branch	1.117	0.128	1.489	1.213	0.315	11.217	17.04	1.95	22.71	18.5	4.81
		bole	0.652	0.093	1.123	0.586	0.244	73.129	64.84	9.25	111.69	58.28	24.27
		Total							93.96	12.49	145.27	85.58	32.03

Table 7. Annual Nutrient return through litterfall

Sl	Species		N	P	K	Ca	Mg	Annual Litterfall (kg/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (kg/ha)
			(% on dry matter)										
1	*B. balcooa*	Leaf	0.851	0.124	1.131	0.567	0.484	1358.83	11.564	1.685	15.368	7.705	6.577
		Branch	0.568	0.085	0.843	0.578	0.293	318.28	1.808	0.271	2.683	1.840	0.933
		Total							13.371	1.955	18.051	9.544	7.509
2	*B. bambos*	Leaf	0.953	0.163	0.903	0.635	0.528	1595.47	15.205	2.601	14.407	10.131	8.424
		Branch	0.846	0.135	0.832	0.436	0.364	286.86	2.427	0.387	2.387	1.251	1.044
		Total							17.632	2.988	16.794	11.382	9.468
3	*B. nutans*	Leaf	0.765	0.102	1.019	0.589	0.41	1839.23	14.070	1.876	18.742	10.833	7.541
		Branch	0.613	0.083	0.763	0.431	0.325	313.66	1.923	0.260	2.393	1.352	1.019
		Total						1074.33	15.993	2.136	21.135	12.185	8.560
4	*B. vulgaris*	Leaf	0.812	0.165	1.162	0.716	0.318	1074.33	8.724	1.773	12.484	7.692	3.416
		Branch	0.685	0.132	0.823	0.485	0.306	139.79	0.958	0.185	1.150	0.678	0.428
		Total							9.681	1.957	13.634	8.370	3.844
5	*D. strictus*	Leaf	1.061	0.113	1.115	0.634	0.456	1267.47	13.448	1.432	14.132	8.036	5.780
		Branch	0.735	0.128	0.725	0.476	0.363	161.49	1.187	0.207	1.171	0.769	0.586
		Total							14.635	1.639	15.303	8.804	6.366

Table 8. Nutrient balance in bamboo stands under lateritic soil

Species			N	P	K	Ca	Mg
		Soil Reserve (kg/ha) →	4117.5	6862.5	46774.8	31018.5	19873.8
1. *B. balcooa*	i)	Retention in above ground stand (kg/ha)	187.8	29.7	303.8	186.5	90.0
	ii)	% Retention over Soil Reserve	4.6	0.4	0.6	0.6	0.5
	iii)	Returned through litterfall (5th Yr) (kg/ha)	13.4	2.0	18.1	9.5	7.5
	iv)	% Returned over Retention	7.1	6.6	5.9	5.1	8.3
	v)	Mean annual Uptake (kg/ha/yr)	37.6	5.9	60.8	37.3	18.0
	vi)	Current retention in 5 yr old culms (kg/ha/yr)	101.2	17.0	166.6	122.4	58.8
	vii)	Current retention in 6 yr old culms (kg/ha/yr)	137.1	17.4	197.2	129.3	57.7
	viii)	Annual Uptake by 5 yr. old clumps (kg/ha/yr)	114.6	19.0	184.7	131.9	66.3
2. *B. bambos*	i)	Retention in above ground stand (kg/ha)	230.4	36.2	358.8	229.1	108.8
	ii)	% Retention over Soil Reserve	5.6	0.5	0.8	0.7	0.5
	iii)	Returned through litterfall (5th Yr) (kg/ha)	17.6	3.0	16.8	11.4	9.5
	iv)	% Returned over Retention	7.7	8.3	4.7	5.0	8.7
	v)	Mean annual Uptake (kg/ha/yr)	46.1	7.2	71.8	45.8	21.8
	vi)	Current retention in 5 yr old culms (kg/ha/yr)	123.0	19.8	195.8	124.4	59.3
	vii)	Current retention in 6 yr old culms (kg/ha/yr)	161.1	20.3	201.0	148.8	53.4
	viii)	Annual Uptake by 5 yr. old clumps (kg/ha/yr)	140.6	22.7	212.5	135.8	68.7
3. *B. nutans*	i)	Retention in above ground stand (kg/ha)	227.6	36.7	391.1	234.0	123.1
	ii)	% Retention over Soil Reserve	5.5	0.5	0.8	0.8	0.6
	iii)	Returned through litterfall (5th Yr) (kg/ha)	16.0	2.1	21.1	12.2	8.6
	iv)	% Returned over Retention	7.0	5.8	5.4	5.2	7.0
	v)	Mean annual Uptake (kg/ha/yr)	45.5	7.3	78.2	46.8	24.6
	vi)	Current retention in 5 yr old culms (kg/ha/yr)	118.7	18.8	206.1	123.7	65.0
	vii)	Current retention in 6 yr old culms (kg/ha/yr)	123.5	19.5	188.2	112.8	55.6
	viii)	Annual Uptake by 5 yr. old clumps (kg/ha/yr)	134.7	20.9	227.3	135.8	73.6

Table 8. Nutrient balance in bamboo stands under lateritic soil (continued)

Species			N	P	K	Ca	Mg
		Soil Reserve (kg/ha) →	4117.5	6862.5	46774.8	31018.5	19873.8
4. *B. vulgaris*	i)	Retention in above ground stand (kg/ha)	152.4	23.6	237.3	149.1	85.3
	ii)	% Retention over Soil Reserve	3.7	0.3	0.5	0.5	0.4
	iii)	Returned through litterfall (5th Yr) (kg/ha)	9.7	2.0	13.6	8.4	3.8
	iv)	% Returned over Retention	6.4	8.3	5.7	5.6	4.5
	v)	Mean annual Uptake (kg/ha/yr)	30.5	4.7	47.5	29.8	17.1
	vi)	Current retention in 5 yr old culms (kg/ha/yr)	88.4	13.6	139.3	87.7	50.2
	vii)	Current retention in 6 yr old culms (kg/ha/yr)	100.4	14.1	174.0	84.7	51.7
	viii)	Annual Uptake by 5 yr. old clumps (kg/ha/yr)	98.1	15.5	152.9	96.0	54.0
5. *D. strictus*	i)	Retention in above ground stand (kg/ha)	169.0	20.9	251.9	134.1	65.4
	ii)	% Retention over Soil Reserve	4.1	0.3	0.5	0.4	0.3
	iii)	Returned through litterfall (5th Yr) (kg/ha)	14.6	1.6	15.3	8.8	6.4
	iv)	% Returned over Retention	8.7	7.8	6.1	6.6	9.7
	v)	Mean annual Uptake (kg/ha/yr)	33.8	4.2	50.4	26.8	13.1
	vi)	Current retention in 5 yr old culms (kg/ha/yr)	95.5	12.4	143.1	75.6	37.3
	vii)	Current retention in 6 yr old culms (kg/ha/yr)	94.0	12.5	145.2	85.5	32.1
	viii)	Annual Uptake in 5 yr. old clumps (kg/ha/yr)	110.1	14.0	158.4	84.4	43.6

Industrial Utilization and Value Addition of Reed Bamboo in Kerala

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Abstract

Reed bamboos or reeds are thin walled bamboos and belong to the genera Ochlandra. Reeds occur in abundance in the low level evergreen and semi – evergreen forests of Kerala. Among Indian bamboos, Ochlandra *travancorica* yields maximum percentage of pulp with largest fibre length and therefore, is rated as of high quality. The mature culms are mostly exploited for production of pulp and paper and are a major raw material for M/s Hindustan Newsprint Ltd, Vellore. The culms are also in very high demand for making baskets, mats and boards. Bambooply is a value added eco- friendly product manufactured by M/s Kerala State Bamboo Corporation Ltd, Angamali from reed mats. Reeds are harvested year after year from natural forests without sufficient attention being given to long term conservation, as a result of which the yield is on decline. No efforts for enrichment or augmentation of production base are carried out. While other forest crops have received input and research support worth millions, this traditional generator of income to rural poor and versatile raw material to industry, is left to languish. The potential of reeds as a source of raw material and economic resource capable of generating employment for the rural poor and scope for production of value added eco- friendly products has so far remained largely underutilized due to lack of appropriate policy, skewed priorities and technology up gradation. In priorities and funding it is often eclipsed by the big brother, bamboo. Dedicated funds and conservation programmes for reeds should get concerted priority and focused attention of policy makers and administrators, lest this gold laying goose is destined to doom.

Key words : ***Bambooply, culm, long fibre, social cost, value addition.***

Introduction

The widely distributed genera of bamboos in Kerala are *Bambusa, Dendrocalamus* and *Ochalandra*, of which *Ochlandra* is generally known as the reed bamboo. *Ochlandra* is known to have twelve species, of which ten species have so far been reported from Kerala viz., *O.beddomei*, O.ebracteata, O.setigera, O.sivagiriana, O.travancorica, O.wightii, O.keralensis, O.soderstomiana, *O.styrostylis* and *O.scriptoria*.

Reeds occur in abundance in the low level evergreen and semi- evergreen forests. Pure patches which grow as impenetrable thickets are also found along the sides of rivers and streams. It prefers diffused sunlight and requires more than 1500 mm rainfall. This species is a very efficient soil binder. Maximum height of reeds recorded is over 15.0 m. maximum weight is 4.0 kg with an average of 2.0 kg/reed. Reeds in the catchments are usually bigger in size and length. Concentration of reed is substantially in 9.0 – 18.0 cm girth class with maximum distribution in 5.0 – 10.0 m height class. All reeds above 2 years old can be reckoned as matured for felling and hence felling cycle has been fixed as 3 years. All matured culms prescribed for felling are to be harvested down to 20.0 mm in girth. No felling is allowed during sprouting season i.e., from 1st June to 30th August.

Industrial utilization and value addition

The two major industries in Kerala using reed as raw material are:

1. M/s Hindustan Newsprint Ltd, Vellore (CPSU – Mini Ratna category I status)
2. M/s Kerala State Bamboo Corporation Ltd, Angamali (SPSU).

a) Utilization in newsprint industry

Government of Kerala is under contractual obligation to supply 1,89,000 mt of reeds and bamboos (long fibre) at 50% moisture content annually to M/s HNL, established in 1983 with production capacity of 80,000 mt/annum of newsprint and currently augmented to 1,10,000 mt/annum (37.5% capacity augmentation). The price is fixed as per the Kerala Forest Produce (Fixation of Selling Price) Act, 1978. The current rate is Rs.1300 + Rs. 25 (additional price) + 5% Forest Development Tax = Rs 1391.25. The collection charges are borne by the user agency.

Table 1 – Allotment and collection of reeds by M/s HNL and M/s KSBC

Year	Consumption of reeds by M/s HNL (in mt)			Reeds collected by M/s KSBC (No. of poles in million)
	Allotment	Collection		
		Net weight	50% MC	
1994 – 1995	189000	76142	75720	15.84
1995 – 1996	186500	60313	62995	15.93
1996 – 1997	135850	59476	61192	14.83
1997 – 1998	176000	68341	71274	16.28
1998 – 1999	134050	74113	74952	15.89
1999 – 2000	85425	69412	72431	13.14
2000 – 2001	83836	70131	71920	13.86
2001 – 2002	70710	68940	69937	11.59
2002 – 2003	81410	65510	72061	9.50
2003 – 2004	65198	46678	49004	8.04
2004 – 2005	85700	43020	44620	8.10
2005 – 2006	69372	22454	23815	—

(800 reeds = 1.0 mt)

The collection period for M/s HNL is from September to May, whereas M/s KSBC collects round the year to provide stable employment to mat weavers /basket makers.

Table 2 – Comparison of pulping characteristics of reed with bamboo and other pulpable woods as raw material in paper industry

SI No	Parameter	Unit	Acacia auriculiformis	Euclyptus graandis	Eucalyptus tereticornis (E. hybrid)	Bamboo	Reed
1	Ash	%	0.89	0.28	0.40	2.10	3.55
2	Cold water solubility	%	3.57	2.06	2.37	2.13	2.39
3	Hot water solubility	%	4.39	3.58	2.79	2.68	3.55
4	1% NaOH	%	13.23	15.67	14.69	13.07	18.22
5	Alcohol – benzene solubility	%	8.28	2.69	2.12	3.31	3.62
6	Lignin (ash corrected)	%	25.09	28.61	30.68	28.31	22.92
7	Halo cellulose	%	64.89	68.87	65.49	66.38	70.66
8	Alpha cellulose	%	44.03	40.26	39.89	47.01	50.36
9	Beta cellulose	%	6.22	9.72	8.32	4.27	10.66
10	Gamma cellulose	%	14.64	18.89	17.28	15.10	9.64

b) Value addition as bamboo ply

M/s Kerala State Bamboo Corporation Ltd was established in 1971 with a share capital of Rs. 659.38 lakhs aiming at the upliftment of about 1.0 lakh poor bamboo workers in Angamaly and Kalady areas of central Kerala, the reed based activities are more than a century old. In olden days reed collection and mat weaving were being carried out by individuals in households and they were unable to market the products to distant places. This resulted in dominance of private traders in the marketing scene. The state government appointed a commission in 1970 to examine the operations of the industry and suggest measures for streamlining the activities with the primary objective of enhancing the well – being of the traditional workers. The commission stressed the need for establishing an appropriate organization for solving the problems of the industry, which paved the way for setting up of Kerala State Bamboo Corporation.

M/s KSBC has been given the right of reed collection from forests from 1977 onwards. It has also been assigned the responsibility of supplying reeds to weavers, co-operative societies and traditional users such as small scale industries and bona fide consumers. Accordingly the government provides 30,000 tonnes of reed annually free of cost to the corporation. M/s KSBC supplies reeds at a subsidized rate (on a credit basis) to weavers. It has more than 100 redistribution and mat collection centres, mostly located in central and southern Kerala. There are over 15,000 mat weaving families, 2,500 reed cutters and 1,000 loading and unloading workers under it. Mat weavers associated with the corporation are known as "registered weavers".

Table 3 – Quantity of reed collected and sold to SSI units and depots

Year	Quantity collected (No of poles in lakhs)	Quantity sold to SSI units (No of poles in lakhs)	Quantity sold in depots (No of poles in lakhs)
1994-95	158.42	59	99.42
1995-96	159.35	52	107.35
1996-97	148.31	52	96.31
1997-98	162.83	60	102.83
1998-99	158.96	59	99.96
1999-00	131.42	38	93.42
2000-01	138.66	43	70.1
2001-02	115.92	36	57.61
2002-03	95.07	37	56.1
2003-04	80.42	24	53.87
2004-05	81.01	25	53.92

The corporation has its own marketing networks. The mats produced by the weaving families are collected in the depots of the corporation. Earlier mats were supplied mainly to government agencies such as Food Corporation of India and Central Warehousing Corporation. The corporation could not run profitably during the past may years due to high the social cost tagged to production cost. During 1999-2000, the corporation took up value addition efforts and started production of bambooply. Since installation of bambooply unit, mats have predominantly been used for meeting the requirements of this unit.

Table 4 – Performance details of M/s KSBC

Year	Sale of bambooply (Rs. Lakhs)	Turn over (Rs lakhs)	Profit / loss (Rs lakhs)
2000-2001	810.20	1466	(-)120
2001-2002	697.00	1218	(-)15
2002-2003	721.61	1004	(-)96
2003-2004	678.15	897	(-)264
2004-2005	756.05	966	(-)302
2005-2006	765.20	1018	(-)196
2006-2007	732.28	912	(-)196
2007-2008	816.84 upto 2/08	1500 (expected)	(+)40 (expected)

Table 5 – Standard sizes and prices of bamboo ply

SI No	Thickness (mm)	Rate per sheet (Rs)		
		6′ x 3′	6′x 4′	8′ x 4′
1	3.0	415.80	554.40	739.20
2	4.0 (Standard)	466.20	621.60	828.80
	4.0 (Premium)	500.40	667.20	889.60
3	6.0	660.60	880.80	1174.40
4	9.0	934.20	1245.60	1660.80
5	12.0	1139.40	1519.20	2025.60

The main problem faced by the corporation at present is marketing of the products. The demand for reed mats and bambooply has been dwindling due to the entry of low cost and artificial substitutes, some of which are more attractive than reed products. There has been a steady decline in number of poles collected from forests since 2001- 02. This is due to two reasons: (i) low availability of reeds in the forests (ii) decline in demand from the traditional workers.

Swot Parameters

I Strength

i) Low capital base.

ii) Source of livelihood to a very large number of workers, who have been traditionally exploited.

iii) Large quantity of raw material available in Kerala, with very good fibre. Only different species of bamboo are available at other places.

II Weakness

i) Raw material and workers scattered all over the state, which make the work cumbersome and add to overhead expenses.

ii) Social cost added to production cost makes the total production cost higher. This makes the selling price of products higher and difficult to compete in the market.

iii) Organized bargaining capacity of trade unions in the various functional areas often leads to decline in productivity and higher expenses.

III Opportunity

i) Bamboo sector is given enhanced importance in recent years both by central and state governments.

ii) Affinity and customer taste for natural / eco-friendly products the world over.

iii) Availability of large quantity of bamboos in addition to reeds in Kerala.

iv) Huge requirements in housing sector, especially in areas prone to earthquake and for rehabilitation programmes.

IV Threat

i) Availability of similar and substitute products in bulk at cheaper rates. Bulk quantity of bamboo mats is made available to sugar mill sector in Maharashtra from north-eastern states and also bamboo boards to the southern states.

ii) Depletion in the availability of matured reeds in different forest divisions due to various reasons, such as gregarious flowering, clear felling of reeds for industrial consumption etc.

iii) The stock and crop density of reeds are on the decline due to biotic interferences, fire, over exploitation and invasion of alien weeds like *Mikania micrantha, Eupatorium chinensis* etc.

iv) Large scale outflow of labour from bamboo sector to other areas due to lesser earnings, low status symbol in the society, lack of social security etc.

v) Low productivity and production loss due to often undue and militant demands from various trade unions, avoidable strikes etc.

Policy Intervention – Scope and Need

With the Indian economy on a solid growth path and share of service sector in GDP rising every year, our paper industry holds a huge potential for growth. At present per capita consumption of paper in India is low at 8.2 kg, compared to 42 kg and 350 kg in China and developed countries respectively. The paper industry is poised to grow over 100% in the next decade and this is three times faster than the rest of the world due to combined effect of phenomenal rise in literacy and teeming population. The last five years witnessed yearly growth of 7%, which is expected to go upto 9% in the next three years.

A major handicap the industry faces is inadequate availability of quality raw materials at competitive rate. The cost of raw material, which accounts for 30 – 35% of total production cost, in India is $ 50/mt compared to around $ 30 internationally.

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Bamboo in Jammu & Kashmir: Present status and future opportunities

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Abstract

Bamboo forests in Jammu and Kashmir cover about 0.06 per cent out of total 2.5 m ha area under forests. Dendrocalamu strictus is the major bamboo species found in mixed deciduous forests under low altitude sub-tropical zone, ranging between 300-1200 m a.m.s.1. Bamboo plantation has been raised under Social forestry as mixture with broad leaved species. A few scattered clumps are also seen on farmers' field boundaries. Bamboos play an important role in the lives of village communities, supplying them with many of their everyday requirement. Bamboos play an important role in the lives of village communities, supplying them with many of their everyday requirements. The rural people in the state have the reputation of making variety of bamboo products which are commonly used in their house-holds. They also use bamboo leaf fodder for their cattle and horses. Planting of bamboo culms on eroded agricultural land is one of the important practices, used for soil conservation measures. Heavy biotic pressure and lack of proper monitoring may result in complete vanishing of bamboo resources. There is a urgent need for careful management of the natural environment where bamboos are indigenous. Introduction of exotic species into suitable climatic belts, both in plains and hills of the state may enrich the lives of the people who cannot conceive living without this useful group of plants. Past present and future strategies are discussed for developing bamboo resources to generate employment opportunities and providing ecological security in this hilly state of Jammu & Kashmir.

Keywords: *Dendrocalamus strictus*, bamboo, strategies, employment, ecological security.

Introduction

Bamboo is the most universally used plant known to man. In South-Eastern Asian region, it is common an article for daily use and contributes much to human being even in the modern industrial society which is characterized by plastic and steel. The species provide material on an appropriate part of world's population for food, fodder, shelter, medicine and is also a major source of raw material for cottage and pulp and paper industry (Austin *et al*,1997 Liease,1985). Bamboos are native to every continent except Europe and Antartica. They form rich belts of vegetation in tropical and sub tropical habitats and occur upto 3,700 m altitude in Himalayas. India accounts for about half the total bamboo area of the world (Varmah & Bahadur, 1980). It is reported that over 77 genera and 1,250 species of bamboo occur in the word (Mc Clure, Chaturvedi, 1986) and about 136 (100 are indegenious) species belonging to 20 genera grow in India (Sharma, 1980; Gaur,1985).

Table 1: Occurrence of bamboo *(Dendrocalamus strictus)* in Kathua Forest Division
(-) wiped out

Range	Compt. No.	Gross area(ha)	Area (ha)	% area	No of culms/clump		Height (m)		DBH(cm)
					Max	Min	Max	Min	
Kathua	01	242.00	-	-	-	-	-		-
	02	210.00	-	-	-	-	-		-
	03	293.00	-	-	-	-	-		-
	04	222.00	151.00	68.02	78.28	17.01	16.50	5.20	6.76
Jasrota	01	225.00	-	-	-	-	-		-
	02	117.00	63.50	54.27	85.42	18.44	17.0	4.83	5.73
	03	125.00	81.00	64.80	90.30	20.37	17.4	3.75	6.63
	04	162.00	28.00	17.28	68.43	21.64	15.0	4.10	5.50
	05	107.00	-	-	-		-		-
	06	84.00	36.00	-	-		-		-
	07	68.00	151.00	52.94	72.75	18.66	14.7	5.26	6.00
	08	160.00	60.00	94.38	81.23	20.71	16.5	3.55	6.50
	09	123.00	-	48.78	85.00	19.53	17.0	4.29	5.00
	10	101.00	-	-	-	-	-	-	-
	11	142.00	-	-	-	-	-		-
	12	111.00	-	-	-	-	-		-
	13	76.00	-	-	-	-	-		-
	14	134.00	-	-	-	-	-		-
	15	55.00	-	-	-	-	-		-
	Total	2,757.50	570.50	20.68	-	-	-		-

In Jammu and Kashmir, the outer plains and low altitude sub-tropical area known as 'Kandi Belt', cover 1,170.5 ha under bamboo, constituting approximately 0.06 per cent area of the tropical forest cover. *Dendrocalaus strictus* is the major species growing in mixed deciduous forests. This species has long been recognized as multipurpose, widely adopted and most important among bamboos. The species has been given preference in Jammu and Kashmir under social forestry plantations as a mixture with broad leaved species. Farmers generally grow bamboo as a living fence, on sloping degraded hill soils and on eroding agricultural lands for soil conservation measures. The economic condition of the people living in the area is miserable. The main source of their livelihood is agriculture and animal husbandry. Sice most of the area is rainfed, only two major crops i.e Maize I kharif and Wheat in rabi are cultivated Farming is not remunerative being rain fed and also due to small holdings. Animal husbandry too is also not well developed because of lack of adoption of good quality breeds and scarcity of quality green fodder. The importance of bamboo under such environments cannot be overlooked as they play an important role in the lives of rural people by supplying them with many of their everyday requirements, and also help in employment generation. To reduce pressure on forests and to ensure the traditional skills of making handicrafts and other useful articles using bamboo as raw material may not die out, there is an urgent need for careful management of bamboo growing area in Jammu and Kashmir state. A priority action is required for their planned conservation, exploration, utilization and marketing. Introduction of indigenous and exotic species into suitable climatic belts and on marginal degraded agricultural lands, would enrich the lives of the people who cannot conceive lifewithout this useful group of plants.

Bamboo Production and uses in J&K

Occurrence

The natural forests of bamboo *(D.strictus)* occur only in Kathua and Reasi Forest Divisions. A negligible percentage of bamboos also occur in scrub forest of Ramnagar forest division. The old records and working plans show an area of 419.5 ha in Jasrota and 151.0 ha in Kathua ranges, making a total 570.5 ha under bamboo in Kathua Forest Division. Out of 19 compartments of Kathua Forest Division, bamoo from 12 compartments is wiped out because of heavy pressure from people who are living close to bamboo forests and Bakkarwals who migrate to the area from Kashmir during winter season (Table-1). Clumps in most of the components are heavily infested with termites and covered with climbers. The congested clumps lack required silvicultural and management practices with poor or negligible annual regeneration of culms. Besides natural occurrence, bamboo plantation has also been raised under social forestry as mixed species in forest area. A few scattered clumps also grow on farmers' field. In Reasi Forest Division, an area of 600 ha has been shown in old records under bamboo, but the survey undertaken by the author during the year 1997-98, revealed vanishing of bamboo from most of the compartments.

Culm Production

40 clumps representing the whole bamboo growing area in Kathua Forest Division were randomly selected for recording observations on number of culms/clump, height and dbh of individual culms. Data recorded revealed maximum 90 and minimum 20 culms per clump. Height and dbh measurements of individual clumps ranged maximum upto 17.4 m and 6.36cm, respectively (Table-1). Data so obtained indicates good site conditions for growth of the species and further scope for improvement. Most of the clumps are congested, heavily infested with termites with proper silvicultural and management practices. There is no official record of the quantities of the bamboo culms harvested from natural forests and their value. However, large number of clums appears to be cut and used in the rural area adjoining to the bamboo forests.

Uses

Bamboos are put to a wide variety of uses and have been intimately associated with mankind from ancient times. Its versatility has led to the use of terms such as 'poor man's timber', 'green gold', 'miracle grass', 'cradle to coffin timber' etc. The rural people in Jammu and Kashmir have the reputation of making a variety of handicraft items using bamboo as raw material. Low cost furniture and items of artistic nature such as name plates for office and hous-hold use and numerous other souvenirs are great attractions for tourists visiting the state. Besides, other articles of every day use which do not require much craftsmanship are commonly made from bamboo culms by the rural people for domestic use. Bamboo leaf fodder is preferred for feeding to cattle specially horses and camels. Planting bamboo on eroded agricultural lands and hill slopes is a traditional practice with the farmers for soil conservation purposes. Use of bamboo sticks for support to climb hill terrain from Katra to Bhawan of Mata Vaishno Devi is a special and attractive feature for pilgrimage.

Table 2: List of bamboo based products in J&K

Handicraft Items	Low cost furniture	Rural Housing	Daily use items	Miscellenious
1. Name plates 2. Lamp shades 3. Kite frames 4. Hats 5. Toys 6. Flower vases 7. Letter boxes 8. Waste paper baskets 9. Wall hangings 10. Serving tray 11. Fruit baskets 12. Mats 13. Umbrella 14. Fishing rods 15. Hand fans	1. Chairs. 2. Tables 3. Sofas 4. Stools 5. Television stand 6. Bookracks 7. Settee 8. Beds and cots 9. Door chicks	1. Scaffolding 2. Dias 3. Pandals 4. Road-side shelter 5.Animal sheds 6. Thach-huts 7. Agricultural fair and other industrial shows.	1.Walking sticks 2. Ladders 3. Mosquito net stands 4. Tool handles 5. Broom handles 6. Rakes for gathering fuels 7. Grain bins 8. Baboo young tree guards 9.Containers for administering medicine to animals 10. Yokes	1. Silkworm-feeding 2. Trays 3. Fencing 4. Stakes for vegetable and flowers 5. Leaf fodder for cattle and horses 6.Soil conservation 7. Fuel food

It has roughly been estimated that 60-65 per cent bamboo at present is being utilized as constructional material and in agricultural related items commonly prepared by the traditional craftsman living in villages. The utilization of bamboo for handicrafts and low cost furniture is presently 10 and 15 per cent, respectively. About 10 per cent of culms are also used for fencing, stakes, silkworm feeding trays, soil conservation and as fuelwood (Table-2). This potential of bamboos led the state government to establish 07 bamboo based handicrafts units in Kathua district of Jammu division. But unfortunately production from these units is lacking because of various reasons, major being sustainable supply of raw material.

Major future thrusts

Bamboo being recognized as multi-purpose species, still remains an ideal substitute for wood in rural J&K. to reduce pressure on forests, upkeep traditional skills and use of bamboo in employment generation, urgent steps on the following are required for production, utilization and marketing of bamboo and bamboo products.

- To organize the activities related to bamboo production ad utilization, identification of rural families, actually involved n bamboo based handicrafts and cottage articles, is must to conduct training and awareness programmes for manufacturing better quality products and their sale both in domestid, national and international markets. Computing of basic data may facilitate proper planning and formulation of development projects. Unfortunately, this significant aspect has not been taken up by any Government or Non-Government agency so far.

- Coordinated efforts towards research and developmental activities on bamboo by state Forest Department, Agriculture Department, Universities and other related Developments. A coherent policy for promotion of bamboo is required to be framed with financial assistance from National Bamboo Mission and other national and international organizations.
- Scientific exploitation, conservation and management of the environment of the area where bamboos are indigenous, deserve a priority action.
- Introduction of exotic suitable species including edible bamboos in Shivaliks and Pir Panjal ranges. Tender shoots of many bamboo species are edible and considered a delicacy in many countries. Jammu and Kashmir being a tourist state, the popularization of bamboo shoots as food and its commercial production for the local market may boost economy and generate employment.
- Bamboo plantations an marginal/degraded wastelands are also in combination with suitable agricultural crops should be taken as priority species.
- Traditional skills of local artisans can be strengthened by setting up of bamboo based rural industries to utilize raw material.

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Micropropagation, the practical way for mass scale production and conservation of green gold

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Abstract:

Bamboo is a highly versatile resource facing threat of extinction due to its peculiar flowering habit and overexploitation. *In vitro* techniques like production of somatic embryos and multiple shoots on embryonal axis of caryopses can be useful for mass scale propagation of quality bamboos. Multiple shoot induction and formation of plantlets with rhizomes was achieved in *Bambusa bambos* var *gigantea*, *Dendrocalamus stri*ctus and *D.membranaceous* by using growth regulators like BAP, GA_3, NAA and their combinations in MS medium . High survivability rate was observed in rhizome induced plants *in vivo*. Rhizome induction in multiple shoots reduces the requirement of root formation under *in vitro* conditions as production of roots from rhizomes is ensured during germination. Formation of somatic embryos was observed from compact callus in *B.bambos* and *D.strictus* which matured into plantlets on B5 medium supplemented with growth regulators like BAP and GA_3. Formation of rhizomes in these plantlets allowed their easy transfer to the field. Similarly direct rhizome induction occurred in caryopses of *B.bambos* var *gigantea* and *D.strictus* on MS medium with combination of BAP,GA_3 and NAA with high amount of sucrose.

Key words: Multiple shoots, rhizome, somatic embryogenesis

Abbreviations: BAP-N^6 Benzyl aminopurine, GA-Gibberellic acid, NAA- á-Naphthyl acetic acid, 2,4-D-2,4 Dichlorophenoxy acetic acid MS –Murashige & Skoog (1962), B5-Gamborg *et al* (1968)

Introduction

Bamboos, giant arborescent grasses commonly known as green gold, is considered one of the world's great natural and perpetually available renewable resource. With increasing demand and constant over exploitation, alongwith flowering causing death of the plant, there is a decline in the availability of this versatile natural resource. Bamboo has to be developed both as an economic and environmental resource to facilitate human development and quality of life as it has potential for health and nutritional security, and mitigation of climate change apart from being a source of livelihood security. Bamboo should be used to achieve ecological security but there is a severe shortage of quality bamboo propagules (Planning Commission Government of India, 2003). To mitigate this challenge and maintain the supply of quality bamboo propagules like that of *Bambusa bambos*, *Dendrocalamus strictus*, tissue culture technique can be useful and *in vitro* methods offer an attractive alternative to conventional methods for mass scale production and conservation of bamboos. Conventional method of propagation of bamboos is time consuming, cumbersome and beset with many inherent problems.

Bamboo plant is characterized by the presence of subterranean rhizomes which impart perenniality and longitivity to this wonder grass. *In vitro* propagation involving clonal propagation or somatic embryogenesis supplemented with rhizome induction in bamboos provide a reliable method for mass scale production and establishment of plantlets, thus leading to conservation of this valuable resource. The present study reports *in vitro* rhizome induced plantlets of bamboos like *Bambusa bambos, B.bambos* var. *gigantea*, *Dendrocalamus asper* and *D. membranaceous* via multiple shoot formation on embryonal end of caryopses. Similarly formation of rhizomes in plantlets obtained through somatic embryogenesis has been achieved in *D. strictus* and *B. bambos*.

Material and methods

Caryopses of *Bambusa bambos*, *B.bambos* var *gigantea*, *Dendrocalamus strictus* and *D. membranaceous* and *D .asper* were obtained from Banerghatta Forest Research Institute Bangalore, Kerala Forest Research Institute and Forest Research Institute (FRI) Dehradun, India. Multiple shoots were induced by forced axillary branching on the embryonal end of caryopses in *B. bambos* var. *gigantea*, *Dendrocalamus asper* and *D. membranaceous* on MS (Murashige and Skoog, 1962) medium supplemented with cytokinins BAP (10^{-7}M - 7.5 x10^{-6}M) and kinetin (10^{-7}M-10^{-5}M). Similarly for somatic embryogenesis, caryopses of *B. bambos* and *D. strictus* were inoculated on B5 medium supplemented with auxins 2,4-D (10^{-7}M-10^{-5}M) and NAA (10^{-7}M-10^{-5}M) after dehusking and sterilization with 0.1% mercuric chlorite for 1minute followed by a rinse with sterile distilled water. Cultures were kept at 25±2°C till the emergence of radicle, later on these cultures were shifted to 16h/8h light – dark period regime provided by cool white 40 watt fluorescence tubes (30µMol $m^{-2}s^{-1}$

Phillips). Multiple shoots as well as somatic embryos were further multiplied every four weeks to obtain a large number of propagules. For *in vitro* rhizome induction, the multiple shoots were treated with combinations of growth regulators like BAP, GA_3 and NAA. The somatic embryos were cultured on the maturation medium (B5) without growth regulators for plantlet regeneration followed by transfer to B5 medium containing BAP, GA_3 and NAA. Cultures with rhizome induced plantlets were maintained under continuous light at 25±2°C for rooting. Rhizome induced plantlets with roots were washed in running tap water to remove agar and transferred to soil: sand: manure (1:1:1) mixture in pots and hardened in growth chamber at 28±2°C with 80% relative humidity and then transplanted in the field.

Results and Discussion

Multiple shoot induction and *in vitro* rhizome formation in *Bambusa bambos* var. *gigantea*, *Dendrocalamus asper* and *D. membranaceous*:

Prolific multiplication of embryonal end of caryopses occurred on MS medium supplemented with $5x10^{-6}$M BAP in *B. bambos* var. *gigantea*, $2.5x10^{-6}$M BAP and $5x10^{-6}$M BAP in *Dendrocalamus asper* and *D. membranaceous,* respectively. Formation of multiple shoots through axillary branching has been shown to occur in the presence of cytokinin especially BAP in bamboos (Saxena, 1990; Arya and Arya, 1997; Arya and Sharma, 1998; Arya *et al*., 1999; Raghav, 2002). In *B. bambos* var. *gigantea*, BAP proved to more effective in multiplication of the embryonal end of caryopses and formation of multiple shoots. Arya *et al*., (1999) have also reported enhanced proliferation of multiple shoots of *D. asper* when MS basal medium was supplemented with $3.0mgl^{-1}$ BAP. There may be a feed back inhibition of multiplication at higher concentration of BAP because of which proliferation at vigorous rate was promoted at lower concentration of BAP. In *B. bambos* var. *gigantea,* for elongation of shoots, GA_3 (10^{-7} M) was introduced in MS medium containing above mentioned concentrations of BAP and in this way alternate cycles of subculture of multiple shoots on MS medium with BAP and BAP + GA_3 were maintained, resulting in formation of vigorously multiplying shoots. Addition of GA_3 decreased the multiplication rate of multiple shoots but increased their length in *B. bambos* var. *gigantea* (Kapoor and Rao, 2006). A novel way for micropropagation of multiple shoots was adopted in *B. bambos* var. *gigantea* in which defoliated shoots were used for proliferation on medium supplemented with varying concentrations of BAP. Mature leaves are major source of auxin transported to phloem and then it is radially transferred to xylem vessels for polar transport (Cambridge and Morris, 1996). Skoog and Miller (1957) hypothesized that the route of development of regenerants in cell culture was determined by the relative ratio of auxin to cytokinin. It can now hardly be claimed that a single growth regulator is responsible for a growth or developmental process. The level of one growth regulator affects the level of the others by affecting their biosynthesis, degradation, conjugation or transport (Itai and Binnbaum, 1991). This is called hormone cross talk (Gaspar *et. al*., 2003). The objective of removing the upper leaves was to remove the potential site of endogenous auxin, so that exogenously supplied cytokinin alongwith endogenously available cytokinin could affect prolific multiplication of shoots in the presence of probably reduced auxin concentration in the system. Also reduction in the mass of the individual propagule makes for the economy of the propagating material, simplifies the labour of preparing it and reduces the requirements of space and other facilities (McClure, 1966). Prolifically multiplying stock cultures of *Dendrocalamus membranaceous* and *D.asper* were obtained on BAP substituted medium. In *D.asper*, shoots also showed elongation during multiplication in the culture jars.

On transfer to medium with NAA ($2.5x10^{-5}$ M and $5x10^{-5}$ M) with high amount of sucrose (5%), the formation of rhizomes was observed on the base of multiple shoots in *B. bambos* var. *gigantea*. $2.5x10^{-6}$M BAP led to proliferation of multiple shoots and $5x10^{-5}$M NAA induced prolific rooting of these shoots in *B.bambos* var *gigantea*. When BAP and NAA at these concentrations were used together, formation of rhizomes occurred. BAP alone suppressed rooting and NAA alone did not favor proliferation of shoots but together supported proliferation of multiple shoots along with *de novo* organogenesis in the form of rhizomes (Kapoor and Rao, 2006). Similar to this report, in orchid, *Cymbidium goeringii*, BAP and NAA have been shown to influence the process of *in vitro* rhizome formation (Shimasaki and Uemoto, 1991). Incorporation of 10^{-7}M GA_3 alongwith optimal concentration of BAP and NAA enhanced the percentage of cultures showing rhizome formation. Also GA_3 exerted its influence in rhizome development by inducing formation of intermediary nodes and subsequent development of culm shoots from these nodes in the rhizome. GA_3 acted in synergism with BAP and NAA in the process of *in vitro* rhizome formation in *B. bambos* var. *gigantea* (Kapoor and Rao, 2006).After rooting of rhizome induced plantlets and hardening, these were transferred to field where 90-95% survivability was observed. Formation of rhizomes in *D. asper* and *D. membranaceous* was also observed similarly on transfer of multiple shoots to NAA enriched medium. The methods provide for ensured survival of bamboos with simultaneous mass scale production and conservation of elite and rare varieties like *Bambusa bambos* var *gigantea*. Formation of rhizomes in the multiple shoots reduces the requirement of rooting in these propagules as rhizome on germination produces both new shoots and roots heping in the establishment of plants in the field

Somatic embryogenesis and *in vitro* rhizome induction in *B. bambos* and *D. strictus*:

There was formation of compact and friable callus on B5 medium supplemented with NAA and 2, 4-D in *B. bambos* and *D. strictus* and somatic embryo originated from compact callus. Secondary embryogenesis was also observed in *D. strictus* and the epidermal cells of developing primary embryos gave rise to globular masses which later developed into secondary embryos. In comparison with multiplication of embryogenic compact callus followed by differentiation of embryos, secondary somatic embryos were found to be more rapid. The embryos developed after round of embryo multiplication were transferred from maturation and germination on B5 medium with growth regulators for *D. strictus* and B5 medium containing BAP and GA_3 in *B. bambos*. The plantlets formed were removed to a medium that permitted further growth or precocious rhizome induction was carried out under continuous light. The ungerminated embryos were retransferred for another round of embryo maturation and germination.

Direct rhizome induction in *B.bambos* var. *gigantea* and *D.strictus*:

After successful *in vitro* rhizome induction in multiple shoots in *various bamboo species*, to further assess the utility of *in vitro* rhizome induction, which acts as a "seed" forming both culm shoot and root, caryopses of *Bambusa bambos* var *gigantea* and *Dendrocalamus strictus* were tried out. Caryopses of both the bamboos were inoculated on MS medium with high amount of sucrose and plant growth regulators like BAP,GA_3 and NAA. On $5x10^{-6}$M BAP+10^{-7}M GA_3+$5x10^{-5}$M NAA, there was direct *in vitro* rhizome formation in the caryopses of *B.bambos* var *gigantea*. This aspect of precocious rhizome induction in caryopses is similar to the phenomenon of rhizome induction observed in the multiple shoots of *Bambusa bambos* var *gigantea*. The caryopses of *D.strictus* formed rhizome directly on the BAP and NAA enriched MS medium containing high concentration of sucrose. Similar to this report, Pillai et al. (1990) also reported an easy method of inducing early rhizome in seedlings of *B.bambos*. The method of precocious rhizome induction in caryopses has immense potential as it will not help in mitigating the crisis arising out of mass scale flowering and seeding in bamboos (Panwar, 2004) but also provide propagules with ensured survivability for raising large scale plantations of bamboos. *In vitro* rhizome induced plantlets were hardened and transferred to field with high survivability. Early induction of rhizome not only enables earlier culm formation but also protects the plantlets against grazing as survival through the underground rhizome is assured. Somatic embryogenesis and regeneration of plantlets was reported for the first time in bamboos, *B. bambos* and *D. strictus* by Mehta *et al*., (1982) and Rao *et al.*, (1985) Micropropagation methods mentioned in paper either via somatic embryogenesis or multiple shoot formation provide reliable production of bamboo propagules for plantations as well as conservation.

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International Conference on "Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood"

DELHI DECLARATION

1. An International Conference on Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood was held from 15-17th April, 2008 at New Delhi, the capital city of India. It was organized by the National Bamboo Mission, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India. The Conference was ably coordinated by the Cane and Bamboo Technology Centre, Guwahati, Assam and supported among other by the World Bamboo Organization,the International Network for Bamboo and Rattan, and several State and Central Ministries and organizations.

2. The Conference was carried out through six technical sessions, a plenary and concluding session, a business session and a poster session covering all aspects but with an emphasis on the three themes of the topic i.e., Productivity, Marketing and Sustainable Livelihoods. An exhibition of various bamboo crafts and value added new generation products by the private enterprise and services of Bamboo Technology Organization and their on going projects was held simultaneously at the NASC Complex, PUSA where the Technical Sessions were organized.

3. The following are the recommendations of the Conference attended by over 500 national and international participants representing government, non-government, international agencies, private enterprise and educational and research institution and farmers.

   - Bamboo development in India has come a long way since the launch of Bamboo Mission by the Government on 5th June, 1999.

   - The country is at a crossroads and should take this moment to make a journey on the road to bamboo development – an inclusive development judiciously using a resource that is a versatile vehicle for both grass roots and industrial development –as it happened in China. The key to this would be development from grassroots upwards so that such prosperity is more rooted and sustainable.

- There is an urgent need for a coherent strategy for bamboo involving all stakeholders – enthusiasts, manufacturers, investors, bankers, and the government in order for India to achieve the target and the objectives as set forth by the government under NMBA and NBM.
- Bamboo is still a peripheral sector in India and the existing agencies implement routine schemes that are not bringing in dividends appropriate to the resource.
- There is a need for an agency to fully own bamboo and to develop it in an integrated fashion to its fullest potential for ecological and economic benefits. Forward and backward linkages must be developed and to do this both policy support and an institutional mechanism are necessary.
- By the year 2020, the world will have seen tremendous changes. The population will most likely exceed 8 billion people, with more than 90% growth taking place in developing countries such as India and China Continued population growth, combined with an increasing economic status in these countries, will require a global effort to feed, house, cloth and provide the energy to sustain global economic growth. Bamboo could contribute significantly towards this end.
- Bamboo development in the past decade, especially in Asia, can be called 'Golden Revolution' for global wood security akin to green revolution for food security that took place in India in the sixties.

RECOMMENDATIONS

An International Conference on Improvement of Bamboo Productivity and Marketing for Sustainable Livelihood was held from 15-17 April, 2008 at New Delhi, the capital city of India. It was organized by the National Bamboo Mission, Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India. The Conference was ably coordinated by the Cane and Bamboo Technology Centre, Guwahati, Assam and supported among others by the World Bamboo Organization, the International Network for Bamboo and Rattan, Central and State Ministries and organizations.

The Conference was carried out through six technical sessions, a plenary and concluding session, a business session and a poster session covering all aspects with an emphasis on the three themes of the topic i.e., Productivity, Marketing and Sustainable Livelihoods. An exhibition of various bamboo crafts and value added new generation products by the private entrepreneurs, besides, various on going projects of various organizations was also held simultaneously at the NASC Complex, PUSA where the Technical Sessions were organized.

The Conference was attended by over 500 national and international participants representing government, non-government, international agencies, private enterprise and educational and research institution and farmers. The following are the recommendation of the Conference:

Technical Session 1

Mass production and certification of quality planting stock

Recognizing that the non-availability of quality planting stock of desired species of bamboo is the major constraint in improving productivity and quality of bamboo, it is recommended that:

i) NBM should take necessary initiative in collaboration with States, for establishment of clonal banks and clonal nurseries in different agro-climatic zone in India.

ii) NBM should support a bamboo breeding program in India.

iii) Guidelines and provision should be made for certification of nurseries and planting stock.

iv) States in collaboration with R&D organization should develop and implement program for genetic improvement of bamboos.

v) Planting material could be a limiting factor for the development of bamboos. Tissue culture has potential but ways to be found out to make them affordable via text credits, etc.

vi) Presently bamboo is not eligible for carbon credit. Government of India jointly with International Network for Bamboo and Rattan (INBAR), pursue vigorously to make bamboo eligible so that it will be attractive for the Bankers, farmers and others.

vii) To strengthen and generate human resource in bamboo sector there is urgency to establish a National Bamboo on Institute.

Technical Session 2

Post-harvest management and storage

Realizing that there are significant losses and damage to raw material due to inappropriate management and storage of harvested bamboo, the house recommends that:

i) Standard harvest schedules and methods should be developed for priority species of bamboo.

ii) Standard techniques should be developed for treatment of harvested bamboo for its protection during transport and storage period.

iii) Appropriate methods should be developed for seasoning of bamboo and bamboo products to avoid possible defects which may deteriorate the quality of raw bamboo as well as products.

iv) Ecofriendly, cost effective preservatives and efficient bamboo treatment techniques should be developed.

Technical Session 3

New Generation value-added products

Realization that low return from bamboo plantation and bamboo product detract cultivators and entrepreneurs to invest in bamboo sector, the house recommends that:

i) More emphasis should be laid on development of value-added products and the necessary technologies.

ii) Inventory of high value products, technologies, production houses and R&D institutions should be prepare and the information should be made available in web.

Technical Session 4

Investment potential and marketing

Realizing that difficulties faced by cultivators and artisans in marketing their product is the major hurdle in the way of growth of bamboo sector in India, it is recommended that:

i) Market facilities should be created for disposal of bamboo and bamboo products in key bamboo areas.

ii) Daily market news bulletin should be displayed on bamboo web.

iii) Farmers, artisans and entrepreneurs should made aware of availability and price of quality planting stock, new products, product designs and technologies through interactive web and t.v. programme.

iv) Public sector banks and financial institutions should be sensitized for extending easy loan facility to farmers and entrepreneurs.

Technical Session 5

Cultivation and Stand Management

Realizing that unscientific cultivation and stand management practices have lead to very poor productivity and quality in bamboo, it is recommended that:

i) Package of practices should be developed for improved productivity and quality of desired species of bamboo for different agroclimatic zone.

ii) Suitable Agroforestry models and practices should be developed for cultivation of bamboo together with agricultural/horticultural crops.

iii) Necessary training should be imparted to farmers for scientific bamboo cultivation and stand management.

Technical Session 6

Policy Issues

Realizing that forest laws regulating harvest and transport of trees are the major impediment to the growth of bamboo sector in India, it is recommended that:

i) State governments should relax rules for harvest and transport of bamboo within and between different States to facilitate private cultivation and trade of bamboo.

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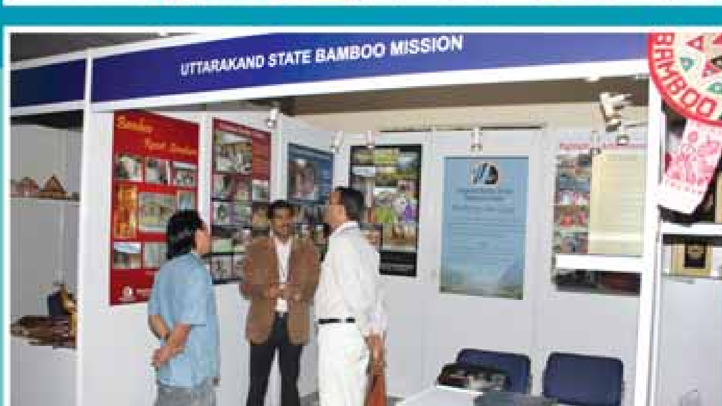
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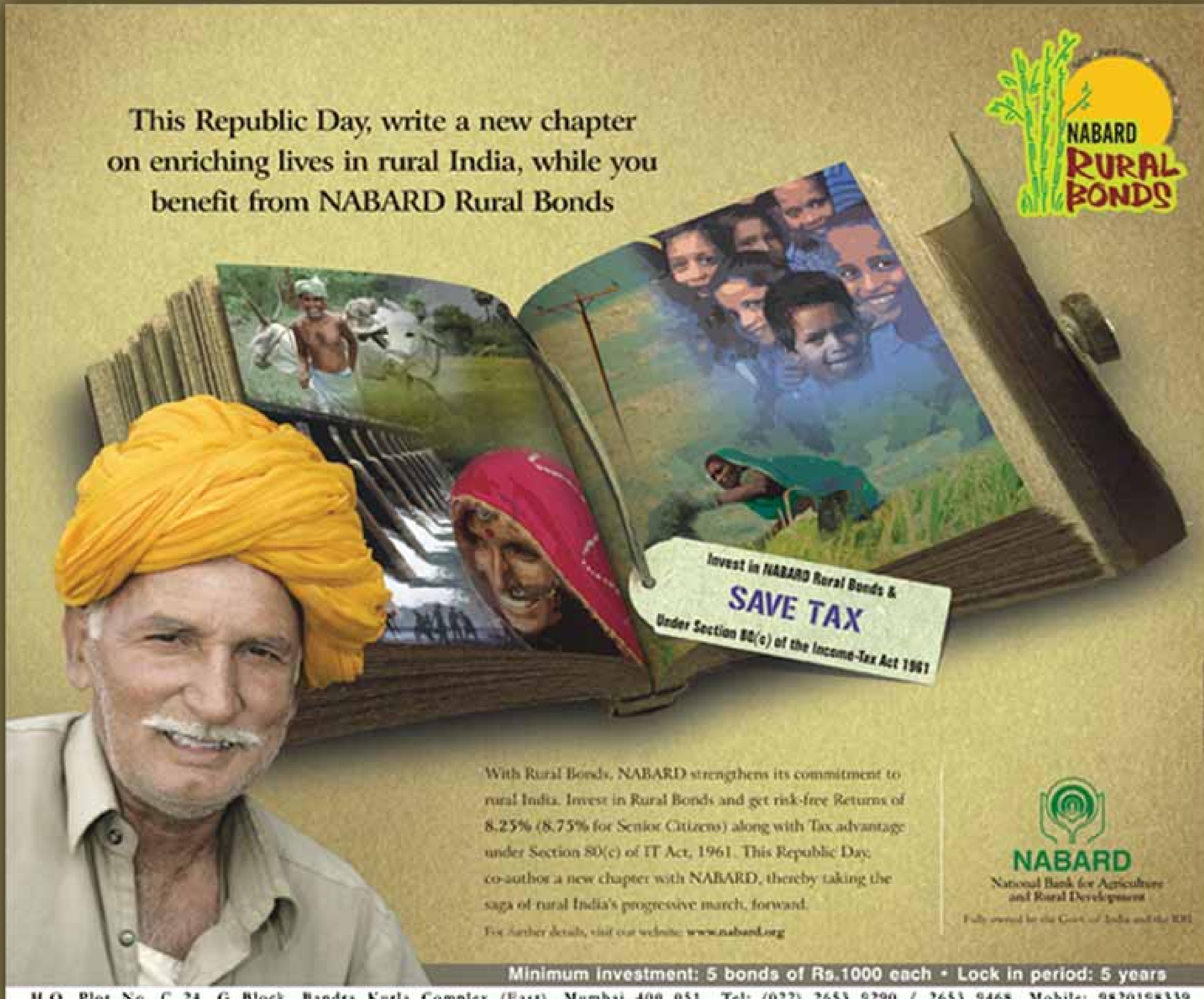
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