Chapter 1
INTRODUCTION

Bamboo is the name given to a group of perennial evergreen plants that represents one out of the 6 to 7 main natural groups of the grass family Poaceae (Watson and Dallwitz, 1992). Previously this group of grasses was recognised as a tribe Bambuseae Kunth but this could not stand the taste of time and it was replaced by the subfamily Bambusoideae Nees which is accepted till date by most of the bamboo taxonomists.

Species of Bambusoideae Nees includes several taxonomically important characters which helps them to differentiate from other members of Poaceae. The features include the culm sheath, well developed branching complements, petiole blade with tessellate venation, 3 or 6 stamens, gynoecium with one style, one to three stigmas etc.

It was in 1789, the first genus of bamboo was scientifically described by Schreber as *Bambusa* based on the single species *Bambusa arundinacea*, a thorny bamboo from India (original not seen). This marked the beginning of bamboo taxonomy and since then a large number of scientists have made an attempt to describe and publish genera and species name. It was Van Rheede, Dutch Governor of Malabar who initiated the taxonomic study on bamboos in India. He illustrated and described two bamboo species, now known as *Bambusa arundinacea* and *Ochlandra scriptoria* in his book *Hortus Malabaricus* published in 1678 (original not seen). William Roxburg, the father of Indian Botany, enumerated seven species of bamboo in his *Hortus Bengalensis* published in 1814.

However the first comprehensive work on bamboo taxonomy was that of Ruprecht (1839) which was based on studies of Herbarium specimens (original not seen). Following Ruprecht, in 1868, Colonel Munro carried out extensive work on bamboo taxonomy. He in his *Monograph of*

Botanically, bamboo is classified thusly (Cronquist, 1988):

KINGDOM: Plantae

DIVISION: Magnoliophyta

CLASS: Liliopsida

SUBCLASS: Commelinidae

ORDER: Cyperales

FAMILY: Poaceae

SUBFAMILY: Bambusoideae

TRIBE: Bambuseae

SUBTRIBE: Bambusinae

Bambusaceae described 170 species under 20 genera and classified those under three divisions. In 1876a&b, Kurz studied bamboo as living specimens and became the first botanist to introduce the importance of the vegetative characters in bamboo identification. Gamble (1896) in his monumental work *Bambusae of British India* enumerated 15 genera. Apart from this a large number of scientists from round the globe has made an attempt to provide clear picture of bamboo taxonomy (McClure, 1936, 1966; Dransfield, 1980,1981; Soderstrom, 1985; Widjaja, 1987; Chi-Son and Renvoize, 1989, Bennet and Gaur, 1990; Tewari, 1993; Kumar, 1990, 1995; Negi and Naithani, 1994; Dransfield and Widjaja, 1995 and Seethalakshmi and Kumar, 1998). There is no work on taxonomy of bamboos of West Bengal as such.

There has always been a debate amongst the taxonomist regarding the number of species and genera of bamboo owing to the plant‟s often long flowering cycles. Several authors have estimated the number of genera and species of bamboo over time. As per Orhnberger and Goerrings (1985) there 110 genera and 1010-1140 species while Renvoize (1986) estimated the number to be 91 and 1110 respectively. In 1988, Soderstrom and Ellis figured the number to be 75 and 1250 respectively. However there are about 1575 species of both woody and herbaceous bamboo included under 111 genera (http:// www.guaduabamboo.com/bamboo-genera.html).

Geographically bamboo occupies 40 million hectares of the earth surface under forest which accounts for approximated 1% of the total forest

cover (FAO, 2005). Of the 40 million hectares (Mha), Asia has the highest coverage with 25 Mha followed by America 11 Mha and Africa 3 Mha. Bamboo is naturally distributed in all the continents with the exception of Canada, Europe, Western Asia and Antarctica where they are not found as a native plant species. They are mostly found in the tropical and subtropical belt of the globe and is commonly found in Eastern Asia, the Americas, Australasia and sub-Saharan Africa (Bystriakova *et al*., 2003 a & b). The woody bamboos are found to extend between 46º N latitude to 47º S latitude whereas the herbaceous bamboos are found to be restricted to the tropics and subtropics only (Tewari, 1993). As a woody plant, it is hardy, and can be found growing in a diverse range of climates - from the tropical jungle environment of Chile, to the high cold mountain slopes of the Himalayas, however the herbaceous bamboos have not been encountered from elevation above 1500m (Orhnberger and Goerrings, 1985).

Asia alone occupies nearly 62.5% of the total forest cover under bamboo (i.e. 25 Mha out of the total 40 Mha worldwide). In Asia bamboo is naturally distributed from 46ºN to 10ºS Latitude and 140ºW to 70ºE Longitude (Tewari, 1993). The major bamboo producing countries in Asia includes India, China, Indonesia and Lao People‟s Democratic Republic. India along with China accounts for approximately 70% of the total area under bamboo reported for Asia (Lobovikov *et al*., 2007).

In India total bamboo bearing area is estimated to be about 13.96 Mha which accounts for 34.9% and 55.84% of the total bamboo forest cover worldwide and in Asia respectively. Geographically India has the highest area under bamboo followed by China. However China has more genetic variation in bamboo than in India. Bamboo spread from tropical to temperate regions and the alluvial plains to high mountains in the Himalayas. Bamboo is found in almost all the parts of the country except Jammu and Kashmir. Among the Indian states Arunachal Pradesh has the highest area with 1.6 Mha, followed by Madhya Pradesh (1.3 Mha), Maharashtra (1.15 Mha) and Odisha (1.03 Mha) (FSI, 2011). This difference in distribution of bamboo is probably due to the bioclimatic factors. Northeastern states like Assam, Arunachal Pradesh, Manipur,

Meghalaya, Mizoram, Nagaland and Sikkim along with the state of West Bengal (North Bengal, Himalaya) houses over 50% of the total bamboo species recorded in India. Apart from this other bamboo rich area includes Penninsular India, Baster region of Madhya Pradesh, Western Ghats, Andaman and Nicobar Islands and foot hills of Eastern Uttar Pradesh.

Bamboo is one of the fastest growing plant species in the world with a growth rate ranging in between 0.3-1 m per day in the growing season (Ben-zhi *et al*., 2005). Though bamboo does not require intense care for its growth and development, yet some agro-climatic conditions must be taken into consideration for the better growth of bamboos. Bamboos grow well in most soil types composed of clay or sand, but moist soil with proper drainage and supplemented with fertilizers is best suited. Bamboo is hydrophilic and thus requires frequent and liberal watering at least in the initial stage of growth. The intensity and duration of sun light has an important influence on the growth and development of bamboo, but it varies with the type of species. Some bamboos grow well in full sun while other full shade. Being a grass, bamboo like all other grasses loves nitrogen rich soil. Bamboo has the potential to thrive in harsh environmental conditions; the tropical bamboo thought cannot withstand cold conditions, while the tropical bamboos have been recorded to survive in extreme cold attaining temperature below 0ºC (Recht and Wetterwald, 1992). Apart from the above agro-climatic conditions, bamboo loves a good layer of mulch over the roots and rhizomes. Mulching the soil around bamboo has three fold effects:

i. Keeps the soil soft and moist,
ii. Prevents weeding and
iii. Provides organic matter to the plants by recycling silica and other natural chemicals.

Bamboo can be propagated through either convention methods or non-convention methods.

Convention methods include seeds/ rhizome/off-set planting while non-conventional methods include culm/ branch cuttings and macro-proliferation.

The use of seeds is only sexual method for bamboo propagation. However this method is unreliable since bamboo flowers only once in its life time and the period ranges from 20-120 years depending upon the species (Janzen, 1976). There are species which either

don‟t flower or produces sterile seeds. Moreover, the viability of bamboo seeds is also very short ranging from one to six months.

Rhizome planting is the most commonly employed technique adopted for propagation of bamboo. In this technique healthy rhizomes are dug out during rainy season and planted in the field. This technique is however restricted to non-clump forming rhizomes.

In off-set planting technique the rhizome in conjunction with a portion of the culm is used for propagation. Once the plant is excavated from the mother plant it should be planted immediately. Here the age of the off-set plays a vital role in survival and growth of the plant (Banik, 1991).

Propagation through culm cuttings involves the use of culm with developed branches or healthy buds. Ideally the age of the culm should be 1-2 years. As per Pathak and his co-workers (2000) the cuttings must be treated with IBA prior to planting on raised bed under partial shade.

Branch cuttings technique is employed in case of bamboo with thick walls and having prominent primary branching. For good results the age of the branch should be less than one years. Branch cutting is also treated with phytohormones before plantation.

The method in which the rhizome is cut into pieces with well developed roots and shoots so that it can multiply is called macro-proliferation. This method depends upon the ability of the seedlings to proliferate.

Several attempts are made to preserve the genetic resource of bamboo in India. Both *ex situ* and *in situ* methods are adopted to preserve the green gold. As per the *in situ* methods attempts are made to preserve bamboo in the protected areas of the country which includes the National Parks, Wildlife sanctuaries, Biosphere reserves apart from sacred groves. But in spite of this *in situ* method seems to be in the lag phase and needs proper care in days to come. On the other hand *ex situ* method of conservation involves live collection centres like „Bambusetum‟ and germplasm bank. The live collections of different species and varieties of both indigenous and exotic species of bamboo found in India are now available in different „Bambusetums‟ spread across the country.

Although, these live collections of bamboos have undoubtedly helped India and other bamboo growing

countries in evolving superior plant material, but to a limited extent. However extensive *ex situ* measures should be adopted in years to come and attempts must be made to increase the number of such live collections by forming „Bambusetums‟ in different parts of the country where there is a possibility and North Bengal is no exception.

Popularly known as "Poor man‟s timber", bamboo has been closely associated with Asia as an important resource. Today bamboo is globally recognized as an important asset in eradication of poverty, economic and environmental development and thus leading to change its image to "Green Gold". Throughout the globe bamboo meets the basic requirements of the common people. Bamboo is closely associated with indigenous culture and knowledge not only in Asia but also in Africa and Latin America. There are over 1500 documented uses of bamboo worldwide (Ogunjinmi *et al*., 2009). In fact bamboo is valuable from top to rhizomes. Bamboo has multifarious uses and serves as a superior material for constructions, utensils, weapons, fuel, fodder, food, firewood, furniture, mats, chop sticks, tooth picks, handicrafts, musical instruments etc. It is extensively used in the paper and pulp industries. With the development of science and technology, the uses of bamboo have also developed. Today bamboo is used in making hard boards, flooring, corrugated sheets etc. (Bansal and Zoolagud, 2002) and thus can serve as a replacement of wood. Apart from this the shoots of bamboo are used as delicacy because of their high nutritive values. The shoots are rich in proteins, saccharides, amino acids, minerals, low in fat and the water content may be as high as 90% (Satya *et al*., 2010). The shoots are used in many exquisite culinary preparations like pickle, vegetables, soup, salads, vinegar and several other forms in different countries (Christine and Wetterwald, 1992)

The use of bamboo as traditional medicine by the Chinese dates back to some 2500 years. They used the bamboo leaves, branches, shoots, seeds, roots and juice to treat phlegm, cooling fever, laryngitis, rhinorrhagia (nose bleed) and vomiting. Thus it can safely be asserted that each part of bamboo is not only a treasure but also a medicine. The use of bamboo is endless and because of this it is an indispensable resource for the rural people.

Bamboo is prone to various diseases and disorders irrespective of whether they are in nurseries, village groves, plantations or natural strands. Bamboo is more susceptible to fungal attack than the bacterial, viral or others. Globally about 1110 species of fungi are known to attack bamboo, of which ascomycetes comprises of 630 species, 150 species belongs to basidiomycetes and rest 130 are included in mitosporic taxa (Hydel *et al*., 2002). Maximum number of fungal genera recorded from bamboo belongs to the family Hypocreaceae, followed by Xylariaceae, Lasiosphaeriaceae and Clavicipitaceae. Species wise both the families Hypocreaceae and Xylariaceae comprises of 63 species of fungus that infect bamboos and ranked first while Phyllochoraceae with 35 species is ranked second (Hydel *et al*.,2002). The species of *Phyllochora* are most commonly noted in Poaceae (Parbery, 1967) and bamboo is no exception. About 22 species of *Phyllochora* are known to infect bamboos. Among all the genera the genus *Bambusa* is most susceptible to fungal infection with a record of about 253 fungal species, followed by the genus *Phyllostachys, Sasa* and *Arundinaria* which houses 178, 84 and 82 fungal species respectively. However in India about 440 species of fungi, three bacteria, two viruses and one phytoplasm have been recorded from the bamboo stands, but only some poses great loss (Mohanan, 2004).

It is not only the fungus which causes great loss to this multipurpose plant. Bamboo suffers assiduously from insect attack. Over 40 species of Aphids are recorded from bamboo round the world (Blackman and Eastop, 1994). The most common Aphid species affecting bamboo growth includes *Hysteroneura setariae, Astegopteryx bambusae, Pseudoregma bambusicola* and *Melanaphis bambusae* (Revathi and Remadevi, 2011).

Problem areas in bamboo

We know that Bamboo, the fastest growing wood perennial plant has a rich history, and a promising future as a part of the solution to 21st century challenges. 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. 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 ever growing list of uses of bamboo cannot be neglected and thus bamboo deserves serious attention. The very first step required is to undertake an inventory of the extent and distribution of existing bamboo resources (at the national, regional and global level) it is well known that bamboo is not a staple commodity like rice or sugar, nor does it have a assured 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. 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 obsolete 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.

Micropropagation

Bamboo though being a vital resource, has not easily lent itself to modern methods of macropropagation and genetic improvement because of its long vegetative phase and monocarpic flowering behaviour. Since it is near impossible that two desirable plants will flower simultaneously, therefore conventional breeding also seems to be difficult. 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 has 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.

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 is of absolute necessity. North Bengal being in the foot hills of Himalays has adequate bamboo resources, only adequate measures need to be opted to conserve these.

Molecular documentation

Basic knowledge in the biology and genetics of bamboo is lacking due to its unusual life cycle with the vegetative phase ranging from one to 120 years. Taxonomic studies of Bambusoideae that rely on floral morphology are in a state of flux. Thus phylogenetic study using molecular markers can be useful to genetically classify cultivars or varieties of a species.

Therapeutic properties

Traditionally bamboo has been used as medicines in the treatment of various ailments in Asia, America and throughout much of the modern world but the scientific evidence of the same is restricted.

Database

International network for Bamboo and Rattan (INBAR) has developed two databases, which can give a better understanding of bamboo trade and trade development, but there is no such database which can give proper information regarding this "Green Gold". Thus there is a need to develop a scientific database with academic and social values as per needs.

Therefore the research needs

With the advent of modern micropropagation methods from only a few nodal pieces, within a period of 4-8 months thousands of new plant 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. 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.

Molecular documentation of bamboo species using different techniques can provide useful information for addressing the various aspect of bamboo taxonomy. This can be useful to define major bamboo groups and molecular variation in different plastid gene sequence region and how they are

useful in bamboo phylogenetics.

Human diseases like arteriosclerosis, ischemic injury, cancer, and neurodegenerative diseases and the processes like inflammation and ageing are global problems that are known to be caused or enhanced by free radicals (Finkel and Holbrook, 2000). Inhibition of the release of free radicals is apotential strategy to control damage and antioxidants which counteract them are receiving increased attention in medicinal research. In India medicinal plants are important elements of indigenous medical systems are gaining importance in treating diseases due to burst in free radicals. Numerous herbs are available for the treatment of ailments but unfortunately, little is known about their antioxidant effects. Epidemiological studies and intervention trials on prevention of cancer and cardiovascular disease in people taking antioxidant supplements are suggestive because dietary intake of antioxidants can help scavenge free radicals and oxidants and thus protect the body against diseases (Wilson, 1998). Medicinal plants used in Indian traditionalmedicines, albeit used extensively have never been investigated in detail for their free radical scavenging and antioxidant effects. A systematic study in these lines will be of significance in understanding the mechanism of action of these bamboos and bamboo formulations.

The database will be scientific and freely available for reasonable non-commercial, non-advertising use, especially for bamboo lovers in general and scientific community in particular. Moreover it will make the collection of publications infinitely more accessible. Research on various aspects of bamboo has been an ongoing process round the world since long and is a not a new filed to work on. However, much more is still to be explored from this „Green Gold" in India in general and North Bengal in particular Bamboo, the giant grass now known as „Green Gold" due to its versatile utility, has been chosen in the present study. This plant though, utilized by a large group of people in North Bengal for their day to day activity, but is severely neglected in terms of conservation, sustainable utilization and scientific know how. The present study therefore, aimed at profiling genetic diversity, standardization of micropropagation and exploring therapeutic properties of bamboos growing in North Bengal. I

also planed to create a database on North Bengal Bamboos.

Thus the present study was taken up with the following objectives:

- Selection of species of bamboos from North Bengal.
- Molecular Documentation.
  - Exploitation of 16S rDNA of chloroplast genome.
  - To study the trnL-trnF region of chloroplast genome of bamboo using PCR-RFLP.
  - Random Amplified Polymorphic DNA (RAPD) analysis of the whole genome of different varieties of bamboos found in North Bengal.
  - Development of microsatellite DNA markers for bamboos.
- Study of regeneration of bamboo through Tissue Culture Techniques.
- Detection of somaclonal variation among the *in vitro* regenerated plantlets.
- To study the therapeutic properties of some bamboo leaf.
- Design a database based on bamboos of North Bengal.