Bamboo plantations: an approach to Carbon sequestration

Seethalakshmi, K.K., Jijeesh, C.M. and Balagopalan, M.

Kerala Forest Research Institute, Peechi 680 653, Trichur, Kerala

seetha@kfri.org

Abstract

Global warming is one among the most devastating problems of the new millennium and Kyoto Protocol expresses the deep concern of scientific community on increasing carbon emission due to developmental activities. Carbon sequestration is one of the approaches in climate change mitigation policy that had received significant attention over the past several years. Being one of the most productive and fastest growing plants on the planet with its decay resistant litter, bamboo potentially acts as a valuable sink for carbon storage. On an average, one hectare of bamboo stand absorbs about 17 tonnes of carbon per year. Bamboo stands occupy an area of 36 million hectares worldwide which is equivalent to 3.2 percent of the total forest area in the world. In Asia, India is the major bamboo producing country (almost 11.4 million hectares) which accounts for roughly half the total area of bamboo reported for Asia. The dry matter accumulation by *Chusquea culeou* (Chile) is in the tune of 156-162 t ha^{-1}, while that of *Phyllostachys pubescence* (Japan), and *Gigantochloa alter* (Indonesia) is 138 ton ha^{-1} and 45 t ha^{-1}, respectively. The lowest dry matter accumulation (0.35 ton ha^{-1}) has been reported by *Bashania fangiana* (China). In our common thorny bamboo, *Bambusa bamboos* the dry matter accumulation at the age of 4, 6 and 8 has been reported to be 122, 225 and 286 t ha^{-1}, respectively and it is on par with the 10 year old fast growing *Causarina equisetifolia* (292.68 ton ha^{-1}) or *Eucalyptus tereticornis* plantation (254.97 ton ha^{-1}). The biomass production and thereby the carbon sequestration potential of many of the Indian bamboos are yet to be unravelled. If scientifically and

intelligently managed, bamboo which owes an inherent fast growth and thereby producing high biomass on a sustained basis can potentially act as the carbon sink and contribute to the global climate change mitigation initiatives.

Introduction

Global warming is one of the most devastating problems of the new millennium. Emission of carbon in to the ecosystem due to industrial and technological advancement man is one of the strongest causal factors of the global warming. According to Goodess et al (1992), the CO_2 rate increases 1.8 μmol^{-1} $_{(air)}$ $year^{-1}$, equivalent to 0.5 % $year^{-1}$. Estimates indicate that in 100 years the environmental CO_2 will reach values of 650-700 μmol^{-1} $_{(air)}$. This could eventually cause an in increase in the average global temperature of 1.5^{0}C to 4.5 ^{0}C (Saralabai *et al.* 1997; IPCC 1996). The deep concern of scientific community on increasing carbon emission due to developmental activities is strongly exposed in Kyoto Protocol. The 1997 Kyoto protocol, to the climate convention recognizes that the drawing of CO_2 from the air into the biomass is the only practical way for mitigation of the gas from the atmosphere. Trees function as the vital sinks for atmospheric carbon i.e. carbon dioxide, since 50% of their standing biomass is carbon itself (Ravindranath *et al.* 1997). Importance of forested areas in carbon sequestration is already accepted, and well documented (FSI, 1988, and Tiwari and Singh, 1987). Bamboos with the vigorous growth and sustainable yield can replace the woods in sequestering carbon. But hardly any attempts have been made to study the potential of bamboos in carbon sequestration.

Some basic concepts of carbon sequestration

Global carbon is held in a variety of different stocks. Natural stocks include oceans, fossil fuel deposits, the terrestrial system and the atmosphere. In the terrestrial system carbon is sequestered in rocks and sediments, in swamps, wetlands and forests, and in the soils of forests, grasslands and agriculture. About two-thirds of the globe's terrestrial carbon, exclusive of that sequestered in rocks and sediments, is sequestered in the standing forests, forest under-storey plants, leaf and forest debris, and in forest soils. A stock that is taking-up carbon is called a "sink" and one that is releasing carbon is called a "source." Shifts or flows of carbon over time from one stock to another, for example, from the atmosphere to the forest, are viewed as carbon "fluxes." Over time, carbon may be transferred from one stock to another. Carbon sequestration is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time - many thousands of years.

Bamboo resources

Bamboo stands occupy an area of 36 million hectares worldwide which is equivalent to 3.2 percent of the total forest area in the world. It is estimated that bamboo occupies over one percent of the tropical and subtropical forest area - over 22 million ha. Over 80% of the total area covered by bamboo is located in Asia, 10% in Africa and 10% in America. About 30% of bamboo may be classified as forest plantations vs 3.8% of wood plantations. According to the FAO/INBAR global thematic study, over 63% of bamboo resources are privately owned with 36% bamboo owned by governmental entities. In comparison 80% of all world forests are on public lands. In Asia, India is the major bamboo producing country (almost 11.4 million hectares) which accounts for roughly half the total area of bamboo reported for Asia. There are different reports on the number of genera and species of bamboo found in India. As per the latest compilation 18 genera and 128 species were reported (Seethalakshmi and Kumar 1998). The 18 genera found in India are *Arundinaria, Bambusa, Chimonobambusa, Dendrocalamus, Dinochloa, Gigantochloa, Melocanna, Ochlandra, Oxytenanthera, Phyllostachys, Pleioblastus, Pseudosasa, Pseudoxytenanthera, Racemobambos, Schizoztachyum, Sinarundinaria, Thamnocalamus* and *Thyrsostachys*. Of the total species found in India about 20 are commercially used.

Kerala is one among the major diversity centres of bamboo in the country and 22 species of bamboos under seven genera have been recorded from this area. This comes to about 20 per cent of the total bamboo distributed in India and 95 per cent of the total species reported from peninsular India (Kumar and Ramesh, 1999). The total standing crop of bamboo in homesteads was estimated as 13.61 million culms and its green weight was 0.331 million tonnes during 2004-2005 (Muraleedharan *et al.*, 2007). Where as the bamboo resource in the forest areas was estimated as 2.63 million based on the satellite imagery 1997.

Carbon sequestration potential of bamboo plantations and carbon trading

Bamboo has several advantages over tree species in terms of sustainability and carbon fixing capacity. Bamboo is one of the most productive and fastest growing plants on the planet. The fastest-growing species among the bamboos may grow up to 1.2 m a day. This unique growing capacity makes bamboo a valuable sink for carbon storage. Dry matter accumulation by various bamboo species are presented in the Table 1. The dry matter accumulation by *Chusquea culeou* (Chile) is in the tune of 156-162 t ha^{-1} , while that of *Phyllostachys pubescence* (Japan), and *Gigantochloa alter* (Indonesia) is 138 ton ha^{-1} and 45 t ha^{-1}, respectively. The lowest dry matter accumulation (0.35 ton ha$^{-1)}$ has been reported by Bashania *fangiana* (China) (Table 1). In our common thorny bamboo, *Bambusa bamboos* the dry matter accumulation at the age of 4, 6 and 8 has been reported to be 122, 225 and 286 t ha^{-1}, respectively and it is on par with the 10 year old fast growing *Causarina equisetifolia* (292.68 ton ha^{-1}) or *Eucalyptus tereticornis* plantation (254.97 ton ha^{-1}) (Table 2). The per hectare biomass accumulation by the *D. strictus* at the age of three years (Singh et al. 2004) is very high compared to that of *Tectona grandis, Dalbergia sisoo, Greveillea robusta* or *Acacia nilotica* of ten year age. The above and below ground biomass of bamboo is approximately in the ratio 3:1 and it is observed that the total carbon content comprises usually about 50% of the total biomass. Unlike other woody crops, bamboo offers the possibility of annual selective harvesting and its removal usually does not damage the total stock and environment. In the last two decades bamboo has emerged as a valuable wood substitute and the carbon captured by bamboos is sequestered effectively for a long time. The degree to which carbon is sequestrated in these products depends on its durability. Over 90% of bamboo carbon can be sequestered in durable products such as boards, panels, floors, furniture, buildings, cloth, paper and activated charcoal. The decay resistant litter produced by the bamboos also helps to sequester the carbon even though its contribution is small.

Bamboo plantations can play a major role in 'carbon trading' in a developing country like India. 'Carbon trading' which is also known as "cap and trade" is a method developed to reduce the carbon emissions which contribute to global warming. Under this arrangement, Countries with the excess emissions credits can sell their credits to the countries that find it difficult to reduce their own emissions. Reforestation and afforestation projects are part of the Kyoto Protocol's Clean Development Mechanism (CDM) which facilitates the developed countries reach their targets for reducing greenhouse gas emissions by investing in Afforestation and Reforestation projects in developing countries in exchange for carbon credits. Bamboo plantations has the immense potential for such carbon credits. Bamboo plantations, which are the great carbon sinks have significant advantage over other biomass resources due to the species diversity, vigorous growth, early establishment, adaptability to various soil and climatic conditions, short harvesting period, sustainability in yield and its multifarious uses (over 5000 applications). Hence, it may be regarded as the best among the biomass resources. The species diversity allows it to come up in any part of the world (except poles) and to tolerate the climatic exigencies. Bamboo plantations are found to be suitable for clear felled forest lands, degraded lands, boundaries of agricultural lands and non-agricultural lands and other common property resources like coastal areas, road sides, canal banks, railway lines etc. It has immense potential as a bio-energy resource which helps in the retention of carbon already sequestered in the fossil fuels such as coal, oil and gas and can save the vast natural forests.

However, the bamboo plantation establishment faces some serious constraints. The planting stock availability is the major issue for all time because, most of the bamboo takes a long time to flower and produce the seeds. Even when the seeds are produced they may not be fertile in some of the species and some species even do not produce seeds. However, the vegetative propagation methods like offset planting, culm and branch cutting, rhizome planting etc can be resorted to meet the planting stock demand. The flowering of bamboos cause serious threat to the plantations as usually flowering is followed by death of the entire culms. The nature of flowering (either gregarious or sporadic) and flowering period has to be taken care of during initiating the plantation. The availability of land for massive bamboo plantation both in forest land and homestead is yet another concern in Kerala.

Conclusion

Bamboos with their vigorous growth and adaptability can play a major role in carbon sequestration. The biomass production and thereby the carbon sequestration potential of many of the Indian bamboos are yet to be unravelled. If scientifically and intelligently managed, bamboo which owes an inherent fast growth and thereby producing high biomass on a sustained basis can potentially act as the carbon sink and contribute to the global climate change mitigation initiatives. In the present global climate change scenario role of bamboos is being viewed with added emphasis

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Table 1. Dry matter accumulation (above ground) by of different bamboo species in different locations of the world.

Species	Country	Total biomass Mg/ha (age)	Reference
Bambusa bambos	India	122 (at 4)	Shamnughavel and Francis (1996)
		225 (at 6)	
		287 (at 8)	
		241.7 (at 20)	Kumar *et al.* (2005)
		170.8 (at 3)	Das and Chathurvedi (2006)
		206.7(at 4)	
		257.25 (at 5	
Bashania fangiana	China	0.353	Zhou Shiqiang (1997)
Chusquea culeou	Chile	156-162	Veblen *et al.* (1980)
Chusquea tenuiflora	Chile	13	Veblen *et al.* (1980)
Dendroca lamus latiflorus Munro.	China	28.49	Lin Yiming (2000)
Dendrocalamus strictus	India	4 - 22	Tripathi and Singh (1994)
		182.7-207.4 (at 3)	Singh *et al.* (2004)
		30 (at 3)36 (at 4)	
		49 (at 5)	Singh and Singh (1999)
Dendrocalamopsis oldhami	China	134.49	Lin Yiming (1998)
Gigantochloa ater; G. verticilata	Indonesia	45	Christanty *et al.* (1996)
Guadua anguistifolia	Colombia	54.3 (at 6)	Riano *et al.* 2002
Phyllostachys pubescens	Japan	138	Isagi *et al.* (1997)
B, cacharensis, B. balcooa and *B.vulgaris* stand	India	99.28	Nath *et al.* 2008

Table 2. Biomass distribution in different multipurpose trees at the age of 10 years

Sl No.	Species	Total biomass (t/ ha)
1	Casurina equisetifolia	292.68
2	Eucalyptus tereticornis	254.97
3.	Tectona grandis	33.52
4.	Dalbergia sisoo	29.18
5	Greveillea robusta	101.42

Source: Mutanal *et al.* 2007.

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“Giving society cheap, abundant energy would be the equivalent of giving an idiot child a machine gun.”

Paul Ehrlich,
Professor, Stanford University