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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 1871-1874

www.thepharmajournal.com
Received: 10-11-2021
Accepted: 29-12-2021

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Bamboo based agroforestry models for livelihood security of Madhya Pradesh

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Abstract
Bamboo based agro forestry systems are one of the important component to improve socio-economic status, annual income of stakeholders as well as environment friendly. The main aim of the investigation was to find out the role of bamboo in agro forestry system for livelihood and ecological security in Khandwa, Khargone and Dhar district of Madhya Pradesh. After the establishment of bamboo clump of various species like *Bamboosa bamboos, Dendrocalamus strictus, Bamboosa tulta* etc. it can survive in water stress condition and showed nice growth and development. In Madhya Pradesh, bamboos are planted on the boundaries of agriculture field for the protection of agriculture crops from high speed wind velocity. Bamboos harvesting can compensate the monetary losses of agricultural crop due to water scarcity. Bamboos are good soil binder due to presence of fibrous root system and hence play an important role in soil and water conservation. It has the potential for effective carbon sequestration, thus helping in countering the emission of greenhouse gases, global warming and climate change. It also lowers the intensity of light and protects from harmful UV radiations. Planting of bamboo lines in east-west direction reduces shade effect, thus decrease the soil and air temperature and solar radiation, which directly influence the soil water evaporation and humidity. Leaves of bamboo were used as mulching, fodder, especially for goat. So bamboo based agro forestry model can be used extensively in water stress areas of Madhya Pradesh to boost the socio-economic conditions of farmers and ecological sustainability.

Keywords: Bamboo, agro forestry, livelihood, climate change

Introduction
Bamboo is one of the most primitive plant species that survive today as "*The Green Gold*" of the 21th century. The bamboo is extraordinary and unique plant of our planet because it is the fastest growing plant and is annually renewable and harvestable if managed intensively (Scurlock, 2000) [12]. Bamboo is productive, sustainable and versatile plant and one of the important Non-Wood Forest Products (NWFP), providing food, raw material and shelter and found in wide variety of climatic and edaphic conditions. Agroforestry is a dynamic, ecologically based natural resources management system that, through the integration of trees in farms and in the agriculture landscape, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels (Leaky, 1999) [9]. Bamboo based agroforestry can play an important role in enhancing sustainability and resource conservation. Bamboos have many advantages over tree such as, relatively short time span from planting to harvest, can grow 3 times faster than *Eucalyptus* & release 35% more O_2 than equivalent strands of other tree. Bamboos require four to five years to yield first harvest. Bamboo grows in different types of soils ranging from rich alluvium to hard lateritic soils and coastal sandy saline soils. The farming community will do well to take up bamboo planting as there is scope for regular income from well managed plantations besides providing for a multitude of other small produce like leaf for fodder, poles for agricultural use, thorns for fencing and dead rhizomes for fuel.

Materials and Methods
Area surveyed
The observation of bamboo based agroforestry system was carried out in three districts (Khandwa, Dhar, Khargone) of Nimar region of Madhya Pradesh during the year 2019 to 2020. The 20 villages were randomly selected from each district; total 60 villages selected from 3 districts represent the entire study site of Nimar region of Madhya Pradesh. In this way, total 60 villages were selected for study purpose.

Data collection

The simple random sampling procedure was adopted for selection of the villages where information collections about the role of different bamboo species in agro forestry system for livelihood and environment security. During the survey, data on the role of bamboo in agro forestry system for livelihood and environment security were investigated and documented. The open-ended interview was conducted for collecting the information on the use of bamboo for livelihood purposes. Bamboo utilization information related to agro forestry system was documented through the interview from farmers, farm women, craftsmen, village artisans, village community leaders and local body's members.

Results and Discussion

Bamboo reaches structural maturity within three-four years and the mean annual increment (MAI) of medium or large sized bamboos is as high as or higher than that of many other fast growing tree species (Banerjee *et al.*, 2009) [6]. Under this system because of growing of various intercrops, products are obtained even in the early stages of plantations and the income is much higher than sole bamboo plantation. In Jharkhand, Sinha (2010) [16] studied the intercropping study of five-year-old *Dendrocalamus asper* plantation spaced at 5 m x 5 m with potato, tomato and pea during the rabi season and ginger during kharif season. He concluded that growing of vegetable with *Dendrocalamus asper* would increase the productivity of plantation and provide additional income to the farmer. Singh *et al.*, (1992) [15] reported the impact of 25-30 years old *Bambusa nutans* clump grew in Agrisilviculture system on the chemical properties of soil. They observed that available phosphorus (P) increased whereas exchangeable K and Ca, Mg decreased with increased distance from the bamboo row. The soil pH and organic matter did not vary with distance.

Growth Pattern: The plant can grow with a growth rate ranging from 30 to 100 cm per day in growing season. It completes full growth within three to four months in growing season (rainy season). The edible young shoots are available only for 2 to 3 months. The production period could be increased upto 6 to 8 months in a year by proper cultivation in agroforestry system (proper irrigation and mulching). Nath (2014) [10] also reported that with the proper irrigation, mulching and nutritional supplements, the production period could be enhanced up to 6 to 8 months in a year. It comes into production in 3 to 4 years after plantation and reaches maximum productivity in 7 to 8 years (Anon., 2004) [2].

Soil Type: Bamboo based agroforestry system was suitable for red, sandy and laterite soil areas of region of Madhya Pradesh. Banerjee (2009) [6] was also reported that the development and standardization of bamboo based agroforestry system suitable for red and laterite zone of West Bengal involving two bamboo species (*Bambusa tulda* and *Bambusa balcooa*) and agriculture crop like paddy, groundnut, lady's finger, pigion pea, cowpea etc. has potential to provide livelihood security. It also grows on marginal and degraded land, elevated ground, along with field bunds and river banks.

Impact on Soil: Bamboo is good soil binder due to their peculiar clump formation and fibrous root system and hence plays an important role in soil and water conservation in Nimar region of Madhya Pradesh. Bamboo can tolerate diverse soil moisture regimes, can heal degraded land, stop soil erosion and help in drought proofing. Leaf litter helps in moisture conservation by forming a soft cushion on the soil. One bamboo can hold 6 m^2 of soil. Maximum improvement in soil quality was under sole bamboo. Furthermore, it conserves water and greatly reduces soil erosion (Amneth, 1996) [1]. Bamboos contain high percentage of silica. The large amount of litter production of leaves and twigs are released N, K, Ca and P to agricultural field in substantial amount after decomposition (Shanmughavel *et al.*, 2000) [14]. The fibrous root system helps in recovering most of the nutrients leached deeper in the soil profile (Christanty *et al.*, 1996) [7]. The root system also creates an effective mechanism for watershed protection.

Yield & economics: The yield of the intercrops in agroforestry system was higher in wide spacing as compared to closer spacing. This was due to the better utilization of sunlight, soil moisture, space, nutrients etc. by the intercrops. There are minimum competition among the bamboo culms and agriculture crops. Bamboo culm from agroforestry system is alternative source of depleting and costly wood resources and available at much lower price compared to wood in Madhya Pradesh. The cost-benefit analysis of *Dendrocalamus strictus* plantation at Gual Pahari, Haryana revealed that this system yielded better economic returns (Rawat *et al*., 2002) [11]. Tiwari *et al*., (2014) reported the economic analysis of the system that the economic feasibility of bamboo based agrisilviculture system (Rs. 121,029/ha) as it gave higher monetary return as compared to sole crop (Rs. 9,801/ha). Bamboo based agroforestry will act as buffer for the farmers of drought prone areas.

Agroforestry provides sustainable development: Bamboo can be utilized as existing resources of agroforestry system for filling the present needs without threatening the ability to meet their needs for future generation. Because it grows fast and easily propagates. Bamboo is renewable, abundantly available, low price and environment-friendly wood resource that uses in the place of forest timber. In this way, bamboos saved the forest and environment. The plantation of bamboo in agroforestry system brings degraded land back into productivity in Nimar region of Madhya Pradesh

Employment generation: Bamboo based agroforestry system has great potential to provide employment in planting and provides raw materials for construction, craft and manufacture of value-added products and increases the source of income in the rural areas of all three districts of Nimar region of Madhya Pradesh. The cultivation of bamboo provides food security, provides income generation for tribal and poor people of Nimar region of Madhya Pradesh. This large quantity of bamboo shoots may fulfill the demand of local people and increases the income of poor and tribal people. Tewari (1992) [17] estimated that one hectare of the bamboo plantation with 500 clumps generates 3.9 mandays of employment for unskilled labour and 47.3 mandays for supervisor annually over a period of 30 years.

Provide edible bamboo shoots: The shoots of some bamboo species are edible and have a sweet taste. Bamboo based agroforestry system provides edible young bamboo shoots. Bamboo of young shoots is called '*Karil*', crushed and fermented wet as '*Sandhana*' and fermented dry as '*haua*'. This *sandhana* is used as a vegetable in the rural areas of mostof the districts of Jharkhand. It is an ideal resource for food and used for preparing pickle and vegetable. The young culms (*Karil*) are used for making vegetable, curries and chutney etc. Young leaves are also used as fodder mainly for goats. In this way, bamboo based agroforestry system providing food security mainly in water stress areas of Nimar region of Madhya Pradesh.

Impact on environment: Bamboo is important for the environment. It is a great protector of earth's health and wealth. It maintains the balance of oxygen and CO2 in the atmosphere. Because, it has the potential for effective in carbon sequestration, thus, helping in countering the emission of greenhouse gases, global warming and climate change. It also lowers the intensity of light and protects us from harmful UV radiations. One hectare of bamboo forest can absorb 12 t of CO2 from the air and store 1000 t of water (Anon., 2008) [3]. Therefore, bamboo based agroforestry system makes a perfect tool for solving so many environmental problems. Bamboo produces 35% more oxygen than deciduous trees (Anon., 2010) [4].

Bamboo for microclimate and wind break: The canopy of bamboo provides shade which prevents the soil to become too dry and help in maintaining in microclimate. Shades reduce the soil and air temperature and solar radiation which directly influence the soil water evaporation and humidity. Arunachalam and Arunachalam (2002) [5] reported that air and soil temperature were significantly reduced and humidity was increased under bamboos. Bamboos are planted on the boundaries of agriculture field for the protecting agriculture crops from high speed wind. Bamboos used as windbreaker by the farmer in different districts of Nimar region of Madhya Pradesh.

Seasonal litter fall and nutrient cycling in agroforestry system: Bamboo litter biomass contributes significantly to soil organic matter and supplies bamboos with nutrients in natural stands and cultivated plants. Fu Maoyi *et al*., (1988) [8] observed that bamboo leaf litter occurs over whole year but has two annual peaks- in spring (April-May) and late autumn (November). The annual quantity of litter was greatly affected by both the biological properties of bamboo and the environmental condition. Tripathy and Singh (1994) [19], however, recorded *Dendrocalamus strictus* litter fall of 2.7 t/ha/yr from standing biomass of 35 t/ha with the annual nutrient return of 28, 1.3 and 12 kg/ha/yr N, P and K. According to Shanmughavel and Francis (2001) [13], in bamboos stand, 89% of total uptake of nitrogen was found to be retained while 11% returned to the soil.

Value addition of agroforestry produce: Apart from the traditional items made by the bamboo artisans of Nimar region of Madhya Pradesh, some useful but good looking ornamental items with a little bit of value addition could be prepared by the same artisans for higher income which are great demands in domestic and outside markets. Some value added products made by artisans increases the income. These value added products are Sofa chair, Lamp stand, File tray, Magazine holder, Magazine rack, Dustbin, Flower stand, Hand fan, Hanging basket, Lamp holder, Surahi pot, Corner flower stand, Hanging wallflower pot, Lampshade, Hanging lamp shade, Tray, Umbrella, Fruit basket, Corner chair, Pen stand, Flower basket, Stool, Shoe rack, Official pen stand, Temple, Bracelets, Table lamp shade, Stool, Centre table flower pot etc. It has a greater scope of value-added product that provides income generation for poor rural people of Nimar region of Madhya Pradesh. All these value added products may be produced from bamboo based agroforestry system.

Conclusion

From the above findings, it can be concluded that the bamboo based agroforestry systems are very important as regards to socio-economic and environmental status in the region of Madhya Pradesh. Because of its shorter harvesting time and excellent growth and survival on any type of soil strata, bamboo can be included in profitable agroforestry system, Besides this, bamboo can play important role in soil and water conservation as well as significant impact on various features of physical and chemical properties of soil. Besides this, bamboo plantation also helps in better carbon sequestration and adding of various types of nutrient through its litter fall to soil.

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