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# Van Sangyan

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# Van Sangyan

## Editorial Board



## Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

by e-mail to vansangyan_tfri@icfre.org

or, through post to The Editor, Van Sangyan,
Tropical Forest Research Institute,
PO-RFRC, Mandla Road,
Jabalpur (M.P.) - 482021.

The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number.

TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

**Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve**
**Photo credit: Dr. N. Roychoudhury and Dr. Rajesh Kumar Mishra, TFRI, Jabalpur (M.P.)**

# From the Editor's desk

*The issues concerning rural development are largely centered on the iniquitous income, opportunities and access of its populace. These inequities assume accentuated proportions when compared with urban segments. There is fundamental structural differentiation between rural and urban segments in terms of respective factors of production due to the distinct characteristic of rural economies. On account of relatively much intense and intrinsic relationship with natural endowments, the rural economies are generally oriented to production of primary goods. There is a fair generalization in stating that aggregated income accrual to the rural households from production of such primary goods is higher than the urban households. The rural sectors, in turn are net suppliers of primary produce and generally, the net consumers of secondary and tertiary goods and services. The demographics, human and natural resource endowments and their linkages lead to varying permutations of the dichotomy of economic activities and income generation of people and the resultant inter and intra regional differentiations in livelihood and well-being.*

*The demographic pressure and socio economic inequalities in rural domains of developing countries further complexes the relationship between humans and endowment. For instance, about 30% of world population is in the developing countries of South and South – East Asia with less than 7% world landmass. As derived from FAO Statistics (FAO 2005) this region has almost 40% of world's agricultural dependent population with less than 20% global arable land resources. With such uneven distribution of production assets, low levels of literacy, skills, awareness and connectivity and limitations of alternative options for livelihood, the high prevalence of poverty in these regions becomes the structural corollary. Any strategy towards the development and improvement of wellbeing of population therefore needs to take into account these fundamental issues in relation to agrarian structures. The scientific understanding of these differentiations becomes a prerequisite for evolving and implementing development agenda. For sustainable improvement in the rural livelihood, particularly in developing economies, studies on various aspects of the rural economic diversification are the contemporary policy requirements*

*This issue of Van Sangyan contains an article on Evaluation of the potentials in sustainable forest resource management: revitalizing the economy and rural livelihood. There are also useful articles viz. Diversity of macro-fungi in central India-VI: Schizophyllum commune, Natural dye yielding trees–sustainable rural livelihood options, Dying-off of Buchanania lanzan plantation in CFRHRD, Chhindwara, Madhya Pradesh, Mahogany: a potential multi-purpose tree for future, Phytoremediation by trees, कैसे करें वृक्षारोपण: तकनीक एवं लाभ (in Hindi), Bee keeping and honey collection as income generation activities of tribal people in Achanakmar-Amarkantak biosphere reserve and Biodiversity of Ginkgo biloba and Lamproptera curius.*

*I hope that readers would find all information in this issue relevant and valuable. Van Sangyan welcomes articles, views and queries on various issues in the field of forest science.*

*Looking forward to meet you all through forthcoming issues.*

**Dr. N. Roychoudhury**
Scientist G & Chief Editor

# Contents

# Evaluation of the potentials in sustainable forest resource management: Revitalizing the economy and rural livelihood

**Moses Fayiah[1] and Avinash Jain[2]**
[1]Department of Forestry, School of Natural Resources Management,
Njala University, Sierra Leone
[2]Forest Ecology Division
Tropical Forest Research Institute, Jabalpur

**Abstract**

This research was carried out to evaluate the potentials in sustainable forest resource management and its livelihood impacts on local communities. The field work was carried in Barha forest. Barha is a village situated in Jabalpur District in Madhya Pradesh. As per the Population Census 2011, there are total 324 families and a total 1, 526 people residing at Barha as at 2011 census. Two villages Karondi and Mahgaon were selected for the qualitative study. Respondents were selected from all social and economic background. 10 respondents were randomly selected from Below Poverty Line (BPL) category, 10 from Above Poverty Line (APL) and 10 from Above Poverty Line having 10 ha or more farm land category. A total of 30 respondents were selected for questionnaire interview. Critical observation and oral discussions were other forms of information gathered for the study. The research reveals that most of the respondents belong to Gond tribe with 60% illiteracy rate. The livelihood system of the study area is mainly agrarian but it's strongly complemented by forest resources gathering and livestock grazing. Agriculture, Non Timber Forest Product (NTFP) collection and grazing were the main sources of income for the tribal communities. The major social practice complemented by forest resources use was 43% religious and burial ceremonies, 37% marriage and 20% festival celebration. It was observed that 90% of inhabitants in both villages have at least two cattle that produce milk and at the same time help plough farms. *Diospyrosmelanoxylon* (tendu) leaves, *Madhucaindica* leaves and flowers, *Mangiferaindica* (mango) fruits, honey and Aonla formed the bases of saleable products for income generation. The studies further revealed the day to day livelihood of respondents on the forest as 80% energy, 65% building materials, 30% food security, 30% water, 31% eroded nutrients into farms, 45% medicinal purpose, 55% livestock grazing, 50% domestic utensils and household furniture and 60% spiritual fulfilment as well as traditions.

**Keys words**

Sustainable Forest, Livelihood, Dependence, Communities.

## Introduction

India's current forest and tree cover is estimated to be 79.42 million ha, constituting 24.16 per cent of the geographical area of the country (ISFR, 2015). Forest cover alone amounts to 70.17 million ha contributing 21.34% of the total geographical area of the country. Of the total 21.34 forest cover, 2.61 per cent is very dense forest (more than 70% crown density), 9.59 per cent is moderately dense forest (40% to 70% crown density), and the remaining 41.59 per cent is open forest (10% to 40% crown

density). Tree cover outside forest areas is assessed to be 9.25 million ha, and is experiencing an increase over the last few assessments, indicating a rise in green cover in non-forest land in the country (ISFR, 2015). The life style and tradition of each indigenous community in India is unique and is related to the utilization of particular natural resource and particular type of work. They had been collecting resources from forest without causing any damage to it. The forest provides them food and livelihood security. Since the ages tribal communities live in the lap of the nature. Their economy and culture are closely associated with nature and the nature is like the womb of the mother. The life style and tradition of each indigenous community is unique and is related to the utilization of particular natural resource and particular type of work (Vijay, 2012).

India has a huge population living close to the forest with their livelihoods critically linked to the forest ecosystem. There are around 1.73 lakh villages located in and around forests (MoEF, 2006). Though there is no official census figures for the forest dependent population in the country, different estimates put the figures from 275 million (World Bank, 2006) to 350,400 million (MoEF, 2009). People living in these forest fringe villages depend upon forest for a variety of goods and services. These includes collection of edible fruits, flowers, tubers, roots and leaves for food and medicines; firewood for cooking (some also sale in the market); materials for agricultural implements, house construction and fencing; fodder (grass and leave) for livestock and grazing of livestock in forest; and collection of a range of marketable non-timber forest products.

**Forest and local community's livelihood**

The concept of livelihood is rapidly gaining acceptance as a valuable means of understanding the factors that influence people's lives and well-being (James *et al*,. 2007). It is comprised of capacities, assets, and activities required for means of living. A livelihood will be sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capacities and assets, both now and in the future, while not undermining the natural resource base' (Krishna, 2004).

The forest fringe communities not just collect these forest products for their own consumption but also for commercial sale, which fetch them some income. The income from sale of the forest products for households living in and around forest constitutes 40 to 60 per cent of their total income (Bharath Kumar *et al*,. 2010; Sadashivappa*et al*, 2006; Mahapatra and Kant, 2005; Bahuguna, 2000). A study (Saha and Sundriyal, 2012) on the extent of NTFP use in north east India suggest that the tribal communities use 343 NTFPs for diverse purposes like medicinal (163 species), edible fruits (75 species) and vegetables (65 species). The dependence for firewood and house construction material is 100 and NTFPs contributed 19–32% of total household income for the communities under study (Saha and Sundriyal, 2012). Forests are not only a source of subsistence income for millions of poor households but also provide employment to poor in these hinterlands. This makes forests an important contributor to the rural economy in the forested landscapes in the country.

Sustainable forest management means the environmentally appropriate, socially beneficial, and economically viable

management of forests for present and future generations. When sustainably managed, forests can have a pivotal role in climate change mitigation and adaptation (Arnold, 1998). Forest is of course managed not only for climate change, but also for production of goods, protection of soil, water and other environmental services, conservation of biodiversity, provision of socio-cultural services, livelihood support and poverty alleviation.

At the social level, sustainable forest management contributes to livelihoods, income generation and employment. At the environmental level, it contributes to important services such as carbon sequestration and water, soil and biodiversity conservation. The forest is a renewable natural resource providing many benefits to the society (Mavsar*et al.*, 2008; Kengen, 1997). These benefits are twofold. The first group refers to the direct or manufacturing uses, i.e. material goods in the form of various timber products, and many of the non-wood forest products. Such benefits can be market-validated. The second group of forest benefits results from the usability of the forest as a natural phenomenon. The material benefits are reflected through the forest contribution to the development of other economic activities such as tourism, agriculture, water resource management, energy sector etc (Delić and Bećirović, 2012).

Intangible benefits are reflected through a positive impact on human health by ensuring a clean and fresh air, water, macro and microclimate factors regulation, providing an opportunity for recreation in order to improve the physical and mental state of man, land and settlements protection from various natural disasters, and to meet people's cultural and aesthetic needs (AFF, 2015). Natural and planted forests represent more than natural capital. They contribute to human capital by providing a range of goods, such as wild game, fruits or traditional medicines that improve health (Smith and Scherr, 2002). Income from the sales of forest products, such as woods, medicinal herbs, gums, latex, resins and spices, provide financial capital that can be used as working capital for trading activities or to educate children (Byron and Arnold, 1999). Forest food and income from forest products tide households over seasonal and unforeseen shortfalls, or provide lump sums for paying off debts. Forest incomes are a vital economic buffer, particularly for women, children and the poorest households in village communities and for the entire community during periods of stress, such as seasonal shortages and crop failures.

Forests also provide essential environmental services, whose loss often disproportionately afflicts the livelihoods of the rural poor, who have fewer alternatives (Smith and Scherr, 2002). For millions of people living in forest environments, the forest forms a dominant part of their physical, material, economic and spiritual lives, but its importance is often undervalued (Saha and Guru 2003). The forest, as well as providing a wealth of material outputs of subsistence or commercial value, is the basis for livelihood systems based on hunting and gathering, or of rotational agriculture systems that depend on the ability of bush fallow to revive the productivity of the land (Sunderlin*et al*,. 2005). The forest thus constitutes an integral part of the habitat and of the social and cultural structure of those living within it. The social benefits of forests are much more

difficult to measure because the amount and value of these contributions to society are both difficult to quantify. In this case, indirect measures are often used to allow trends to be quantified and monitored over time.(FAO, CIFOR, IFRI and World Bank, 2016).Fisher *et al*., 1997 describe the types of people depending on forest as:

- People who live inside forests, often living as hunter-gatherers or shifting cultivators, and who are heavily dependent on forests for their livelihood primarily on a subsistence basis People in this category are often indigenous peoples or people from minority ethnic groups.
- People who live near forests, usually involved in agriculture outside the forest, who regularly use forest products (timber, fuel wood, bush foods, medicinal plants etc) partly for their own subsistence purposes and partly for income generation
- People engaged in such commercial activities as trapping, collecting minerals or forest industries such as logging. Such people may be part of a mixed subsistence and cash economy.

**Research methodology**

**Study area**

Jabalpur District is one among 51 Districts of Madhya Pradesh State, India. The District Administrative head quarter is Jabalpur itself. It is Located 300 KM west towards State capital Bhopal and has a population of 2,460,714 (Census, 2011). By population it is the second largest District in Madhya Pradesh state (Kendra, 2011). The field work was carried in Barha forest. Barha is a village situated in Jabalpur District in Madhya Pradesh. As per the Population Census 2011, there are total 324 families and a total 1, 526 people residing at Barha as at 2011 census.

**Geography and climate**

Jabalpur is located at 23°10′N 79°57′E / 23.17°N 79.95°E. The central point of India is located in Jabalpur District. It has an average elevation of 411 metres (1348 ft). Jabalpur District is sharing border with Damoh District to the North, Katni District to the North, Mandla District to the South and Narsinghpur District to the west. Jabalpur District occupies an area of approximately 10,160 square kilometres. It's in the 405 meters to 377 meters elevation range. This District belongs to Hindi Belt India. The state have three pronounce seasons (Kendra, 2011).

**Demography of study area**

Hindi is the Local and most spoken Language however; other languages such as Bagheli, Bharia, Urdu, dravigian, devangari and English are also spoken. Jabalpur District is divided into 7 Tehsils, 351 Panchayats, and 1540 Villages. Kundam Tehsil is the Smallest Tehsil by population with 107337 populations. Jabalpur Tehsil is the Biggest Tehsil by population with 1427100 populations. Hindus are majority religion in Jabalpur district with 87.65%, Muslims with 8.27% and rest of Jains, Sikhs and Christians (Kendra, 2011).

**Data collection and analysis**

This research employs qualitative methods of research (Livelihood and Forest dependence study**).** A total of 30 questionnaires were administered in the two villages. A reconnaissance survey was done to choose the method of sampling. Respondents were randomly selected based on three categories; namely below

poverty line (BPL) 10 respondents, above poverty line (APL) 10 respondents and Above Poverty Line with 10 hectares and above farm lands (APL) 10 respondents. Pictures and GPS coordinates of the villages were also taken. Microsoft excel was used to analyse the data collected.

**Results and discussion**

**Livelihood and dependence survey**

The data for livelihood and dependence survey was collected by administering questionnaires to various respondents in the two selected communities namely Karondi and Mahgaon.

**Age range of respondents**

Figure 1 presents the age range of respondents interviewed. The age bracket of 41-50 and 31-40 accounted for 33% each. Only 7% fell within the age range of 21-30. In local communities these age ranges are associated with responsibilities and experience. This age range was useful in giving vital information base on experience. It was found that all respondents within this age range have lived on forest resources since birth.

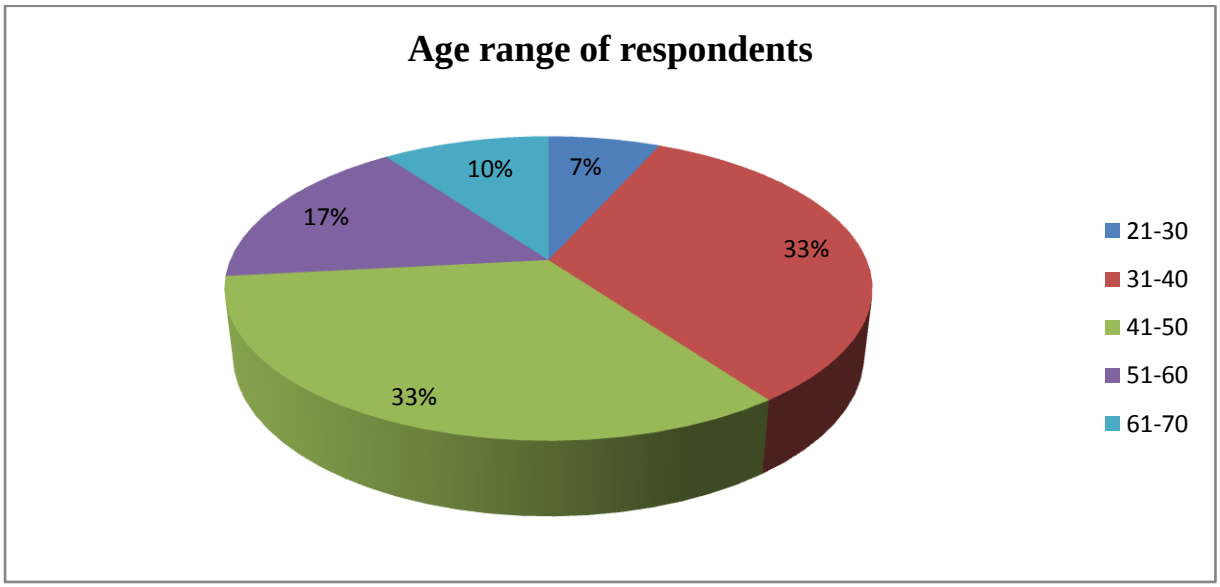


**Figure 1: Age range of respondents**

**Occupation of respondents**

The pie chart below (Figure 2) indicates the various occupations of respondents. The findings reveal that 80% of the respondents interviewed were farmers. Only 6.7% accounted for live stocking breeding as an occupation while civil servant, masonry, teaching and trading all accounted for 3.3% each. It is believed that rural farming all over the world does not need special training or degree to execute. All that is needed is the physical strength and ability with the help of family members

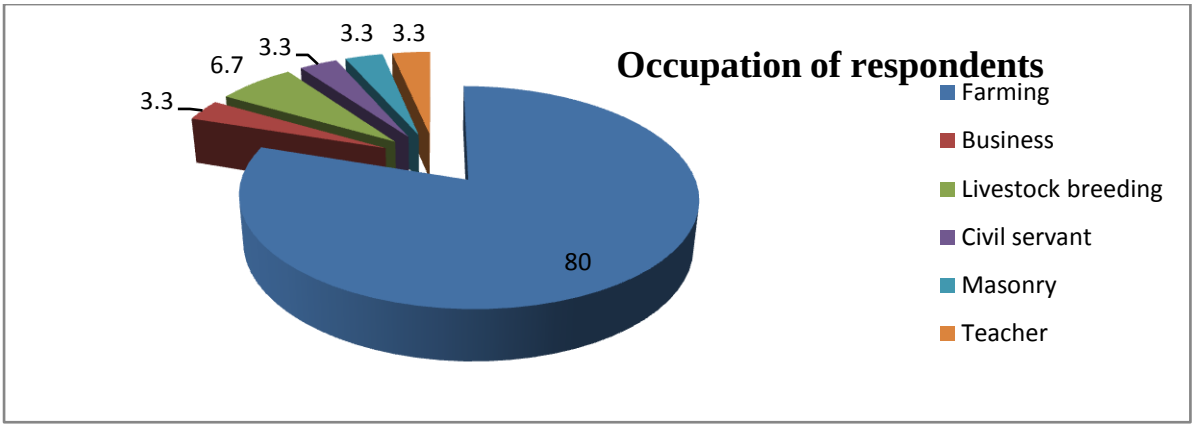


**Figure 2: Occupation of respondents**

**Educational status of respondents**

Figure 3 reveal the educational status of respondents. About 60% of the total respondents have no formal education at all while 33.3% had attempted schooling and left below sixth class. Only 6.7% in the two communities can read and write in their local languages. The educational status of respondents has direct bearing with their occupation, income status and livelihood pattern. Traditions, poverty and early marriage are believed to contribute to high illiteracy rate especially in Africa and Asia.

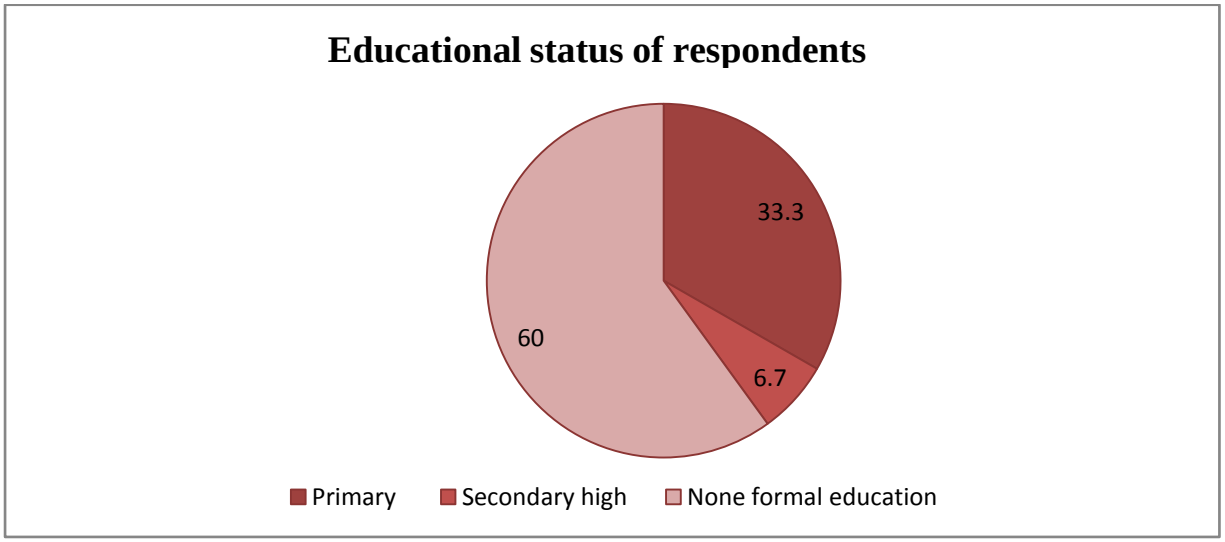


**Figure 3: Educational level of respondents**

**Family size of respondents**

According to figure 4, 77% of respondents interviewed have four and more children living together while 17% have 3-4 children. 3% accounted for 1-2 and 2-3 children. The family size may have direct link with the low educational status as well as occupation of respondents. Farming is the only way they can feed a large family because they are not employed and can't affordto buy all needed food items. Early marriage and high illiteracy rate support rural farmers in having large family which they can use as a workforce.

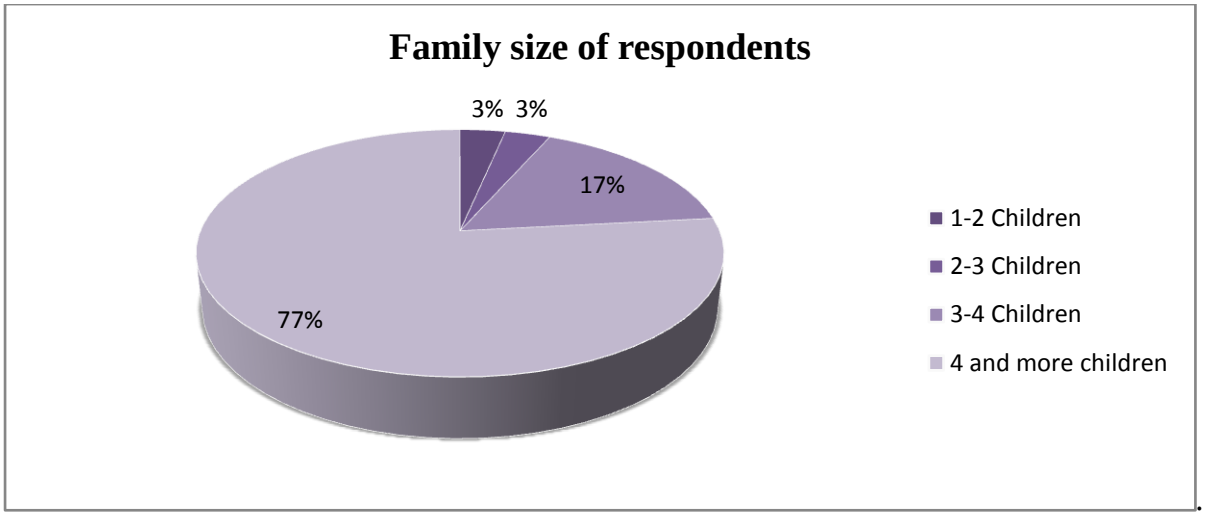


**Figure 4: Family size of respondents**

**Source of income**

Tribal people living in remote forest communities have limited sources of income and less alternative option worldwide. The figure below revealed the main sources of income for respondents in the study area. Majority of the respondents 54% said their main source of income was farming while 20% admitting that farming and forest products gathering are the source of income. Invariably 17% said forest gathering was their main source of income. Other combined sources such as salaries and forest resources gathering etc. accounted for only 3%. The provision of education to the young children and other free skill development trainings to youth in these communities will enables these forest dependent populations to diversify their livelihood options and look beyond agriculture and forest products gathering as their source of income in the near future.

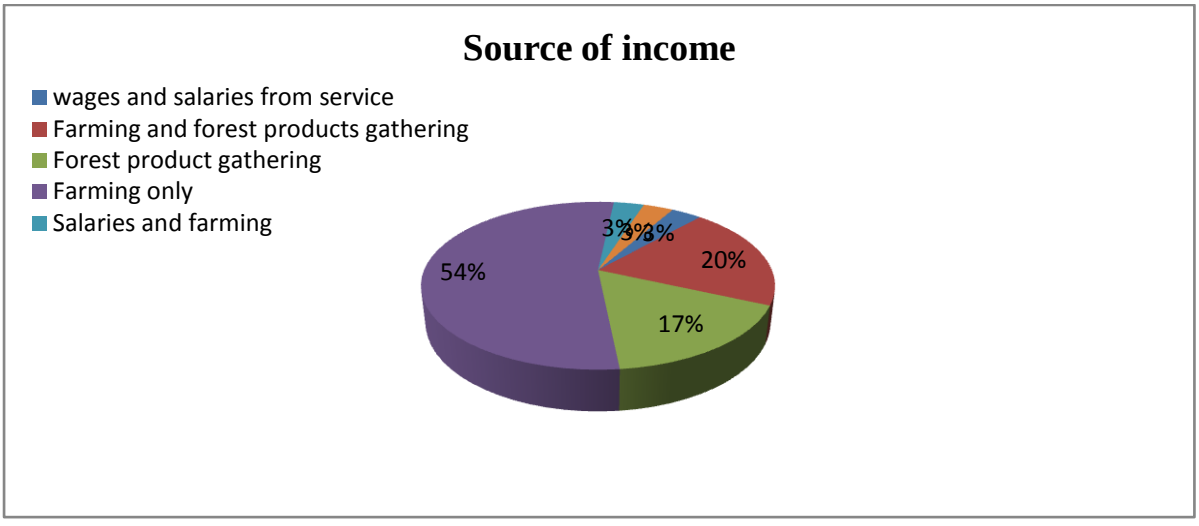


**Figure 5: Source of income of respondents**

**Income of respondents**

Figure 6 indicates the yearly income range earned by respondents in the two communities. It could be clearly seen that Majority (62%) mostly those in Below Poverty Line (BPL) category earned between 25,000 -50, 000 Rupees annually. However, 32% mostly those in the Above Poverty Line (APL) category earned between 51,000- 100,000 yearly. Only 3% of the respondents earned between 101,000- 150,000 and above respectively. This income range clearly describes the respondents as subsistence farmers who mainly eat what they grow than sell. Educational background and family size of respondents have direct bearing with what they earn yearly. It's believed that the soil type in the study area is less productive as compared to other regions of the state. The bulk of their nutrient comes from eroded debris from the forest as well as manure from animal droppings. However, families which are engaged in multiple income generating activities earned more income than those relying on only one activity.

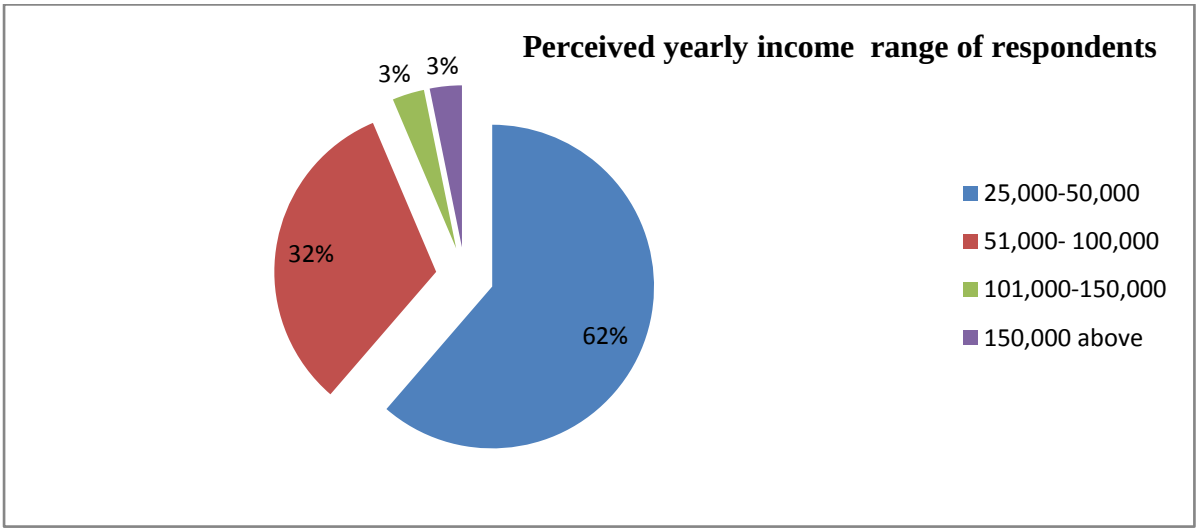


**Figure 6: Yearly income of respondents**

**Percent income earned from forest and other sources**

Figure 7 above indicates that Majority 62% of respondents earned 25,000- 50,000 annually. Majority of respondents within this category said 65% of the income was earned from farming while 20% was earned from forest products sale. 16% however was earned from miscellaneous sources. This figure indicates that the forest generate income for all inhabitants living within the two communities. The reason for the low percentage of income earned from the forest was mostly blamed on the forest products harvesting policies that forbid even local indigenous from cutting wood and harvesting certain products from the forest for commercial purposes. The commercial sale of non-timber forest is very minimal as a result of community isolation, lack of transportation facility, degraded road network and stiff forest exploitation policy. The income from sale of the forest products for households living in and around forest areas constitutes 40 to 60 per cent of their total income (Bharath Kumar et al., 2010; Sadashivappa et al., 2006; Mahapatra and Kant, 2005; Sills et al., 2003; Bahuguna, 2000).

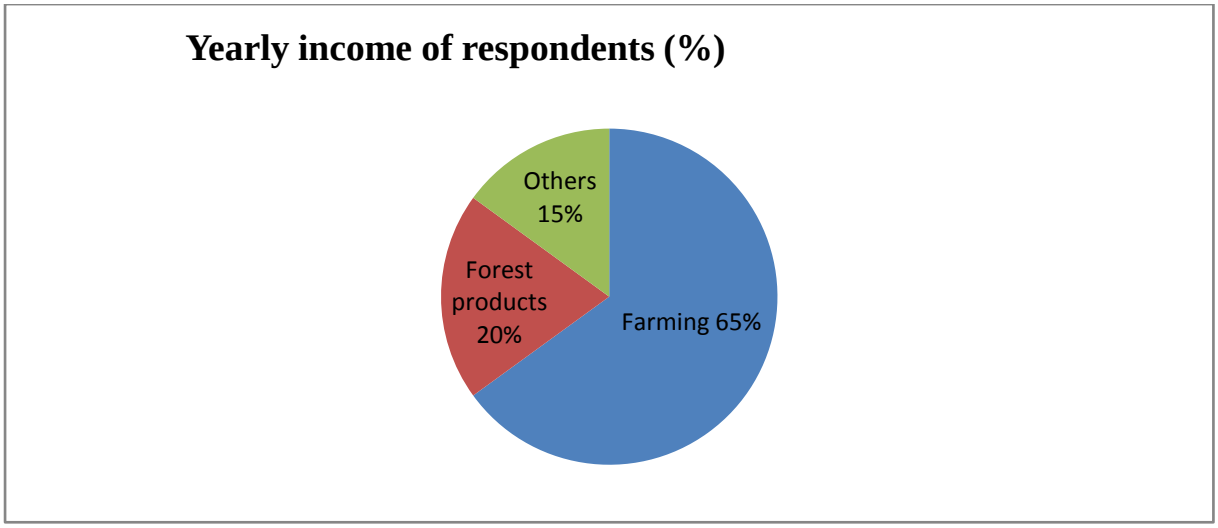


**Figure 7: Per cent yearly income earned from farming and forest products**

**Major social activities supported by forest and its products**

Figure 8 show that the Gondi native residents of the study area have strong spiritual and economic relationships with the forest together with strong perception of their culture and traditions. The figure below revealed that maximum of 43% of respondents greatly rely on forest to fulfilled their religious and burial ceremonies on a year round bases while 37% admitted that forest resources aid marriage ceremonies in their communities. Furthermore, 20% of the respondents celebrate festival with forest base resources. These Gondi tribal groups have been living within this forest for decades of years and fulfilling their spiritual and social needs always.

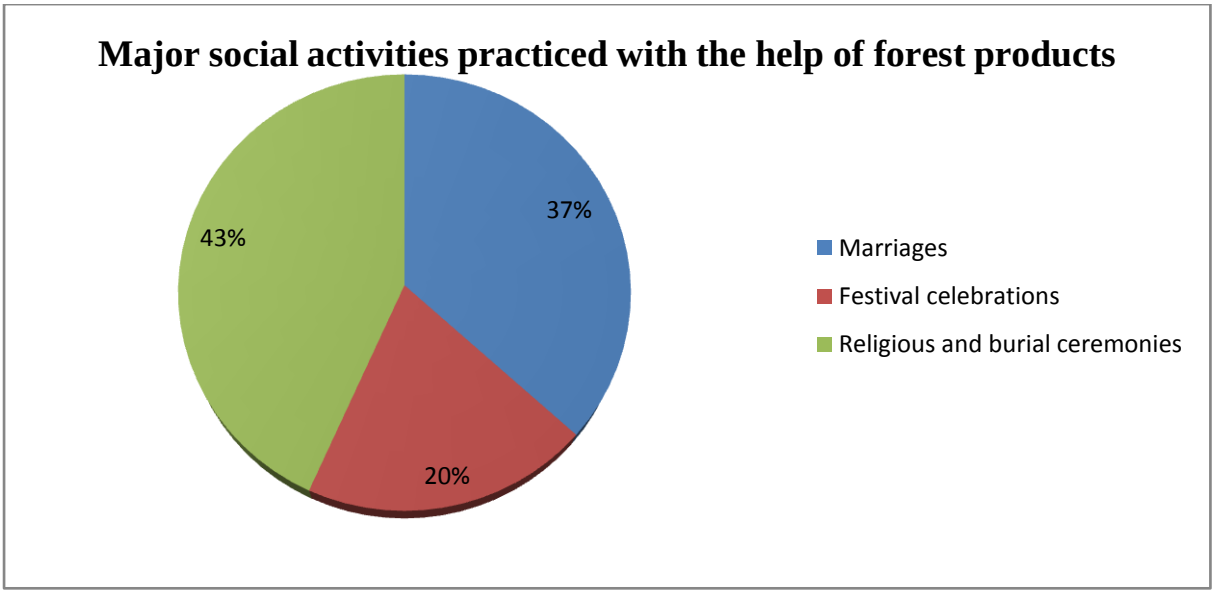


**Figure 8: Social activities complemented by forest products.**

**Forest products and their livelihood functions**

Table 1 display lists of forest products collected from the forest with their various end uses. Most of the saleable products were non wood products while all wood products were only used for domestic purposes such as building, handles, fuel wood etc. The inability of locals to trade wood products has to do with the strict law on forest exploitation country wide. However, poles and timber play a minor role in enabling livelihood as compared to bamboo products which are used on a large scale for housing construction but form the bases of fencing materials.

**Table 1: Forest products collected and their livelihood function.**

| No | **Name of forest products** | **Designation** | **Livelihood function** |
|---|---|---|---|
| 1 | Timber | wood | Construction, furniture & household utensils |
| 2 | Poles | Wood | Construction and household utensils |
| 3 | Fuel wood | Wood | Energy |
| 4 | Fodder | Non-wood | Animal grazing |
| 5 | Wooden handles | Wood | Agricultural tools and implements |
| 6 | Herbs | Non-wood | Cure of various ailments |
| 7 | Honey | Non-wood | Consumption, medicine and sale |
| 8 | Aonla | Non-wood | Consumption, medicine and sale |
| 9 | *Buchananialanzan*Chironji | Non-wood | Medicine and consumption |
| 10 | Fruits | Non-wood | Consumption and sale |
| 11 | Tendu leaves of *Diospyrosmelanoxylon* | Non- wood | wrapping tobacco and making " beedis " or Indian cigar |
| 12 | *Diospyros kaki* leaves | Non-wood | Ailments |
| 13 | *Madhucaindica* leaves and flowers | Non-wood | Food, medicine, oil, skin care and sale |
| 14 | *Mangiferaindica* Mango fruits | Non-wood | Consumption and sale |

**Livelihood activities and their dependence on forest**

The table below shoes the distribution of forest dependence based on activities that sustained livelihood. From the result it was found that 80% of the respondents depend on fuel wood collected from the forest for energy in cooking. Building materials, domestic utensils and furniture's 65%, livestock grazing 55% support livelihood sustainability in the study area table 2.Saha and Sundriyal (2012) found that the dependence for firewood and house construction material was 100% and NTFPs contributed 19–32% of total household income for local communities in humid tropics. ICFRE (2001) estimates suggest that India's forest support 270 million cattle for grazing against its carrying capacity of 30 million. Firewood constitutes the major source of cooking energy in India and more than 853 million people use firewood for cooking in India (FSI, 2015)

**Table 2: Livelihood activities of respondents and their % dependence on forest resources**

| No. | Livelihood activities | Forest dependence percentage |
|---|---|---|
| 1 | Energy (fuel wood for cooking) | 80% |
| 2 | Construction (building materials) | 65% |
| 3 | Water | 30% |
| 4 | Nutrients accumulation through erosion | 31% |
| 5 | Medicinal purpose | 45% |
| 6 | Livestock grazing | 55% |
| 7 | Domestic furniture's and household utensils | 50% |
| 8 | Spiritual fulfilment, traditions and culture | 60% |
| 9 | Food security | 30% |

**Observation**

It was observed that the Barha forest has been manipulated through enrichment stocking with diverse economic trees species such as *Tectonagrandis*, *Emblicaoffinalis*, *Albizia* species etc. It was again observed that all dwelling houses in the studied communities were mostly made of wood and mud with 60% household furniture's and utensils made from wood. Both communities lack social facilities such as market, clinic, recreational centres, and secondary school among others and can only boost of single room primary school with minimal facilities. Mud stoves with wood and animal residues were the main type of fuel used in generating energy. Almost every household have at least two cattle that serve two main purposes which is milk production and ploughing. Toilet facility, electricity and water were available to every household regardless of their social and income status. It was further observed that the national and state forest policy, bye laws and traditional values of trees observed by tribal Indians is contributing greatly to the sustainable management of the forests

**Conclusion**

In the two communities studied, it was found that every household depend on the forest for their livelihood in diverse ways with the forest being the only free source of income for most of them. The result reveals that 60% of the respondents are illiterate with 77% having a family size of four and more children and they earn less than 50, 000 rupees annually. The livelihood system of the study area is mainly agrarian but it's strongly complemented by forest resources and livestock grazing. Income derived from the forest was relatively low as compared to farming because of the stiff forest management policies. The major social practice supported by forest resources was religious and burial ceremonies 43%, marriages 37% and festival celebration 20%. The study further reveals that respondents mainly depend on the forest for energy 80%, building materials 65%, food security 30%, water 30%, nutrients in farms 31%, medicinal purpose 45%, live stock grazing 55%, domestic utensils and household furniture 50% and spiritual fulfilment as well as traditions 60%. However, the degree of use and nature of dependence on forest differs from one

family to another. Tendu leaves of *Diospyrosmelenoxylon*, *Madhuca indica* leaves and flowers, *Mangifera indica* (Wild fruits), fruits, honey and Aonla formed the bases of saleable products for income. The lack of basic social and other amenities such as, health centres, markets, schools, recreational centres, employments and government attention makes forest the major source of sustained livelihood after farming for the two communities. The study area though remote in nature but every household have access to electricity and clean drinking water as at the time of this study. A broader knowledge of the dynamic of ecosystem services and functions will help us in better management of forest resources for sustainable development of communities dependent on forest for livelihood in the 21st century.

**References**

African Forest Forum (2015). Book of Abstracts, Pre- XIV World Forestry Congress Workshop: Forests, people and environment - some perspectives from Africa. Nairobi, Kenya.

Arnold J.E.M (1998). Forestry and Sustainable Rural Livelihoods. In Carney D (ed.) Sustainable Rural Livelihoods: what contribution can we make? London, UK, Department for International Development (DFID).

Bahuguna V. K. (2008). Forests in the Economy of the Rural Poor: An Estimation of the Dependency Level. Ambio 29 (3):126-12.

Bharath Kumar L B, Patil B L, Basavaraja H, Mundinamani S M, Mahajanashetty S B, and Megeri S N. (2011). Participation Behaviour of Indigenous People in Non-Timber Forest Products Extraction in Western Ghats Forests. Karnataka Journal of Agricultural Science. 24 (2): 170–172

Byron, N. & Arnold, M. (1999). What futures for the people of the tropical forests? World Dev., 27(5): 17.

Delić S., BećirovićDž., (2012): The importance and necessity of total economic valuation of forests, Scientific conference "Forests as quality indicators of environment", Academy of Science of Bosnia and Herzegovina.

FAO, CIFOR, IFRI and World Bank. (2016). National socioeconomic surveys in forestry: guidance and survey modules for measuring the multiple roles of forests in household welfare and livelihoods, by R.K. Bakkegaard, A. Agrawal, I. Animon, N. Hogarth, D. Miller, L.

Forest resources and rural livelihoods in the north-central regions of Namibia, James MacGregor Charles Palmer, Jonathan Barnes (2007) Discussion Paper 07-01 International Institute for Environment and Development Environmental Economics Programme

Forest Survey of India (2015), Indian State of Forest Report, New Delhi, Ministry of Environment and Forest, Government of India. 286 pp

ICFRE (Indian Council of Forestry Research and Education). (2001). Forestry Statistics of India 1987-2001. Dehradun: ICFRE. 234 p

Kengen S. (1997): Forest Evaluation for Decision Making, FAO, Rome.

Krishi V. K. (2011) Jabalpur District Census 2011". Census 2011.co.in.2011. Retrieved 2011-09-30. (Jabalpur District website)

Krishna, S. (2004). Livelihood and Gender: Equity in Community Resource Management, Sage publication, New Delhi

Mahapatra K. and S. Kant. (2005). Tropical Deforestation: A Multinomial Logistic Model and Some Country Specific Policy Prescriptions. Forest Policy and Economics 7: 1-24

Mavsar R., Ramčilović S., Palahí M., Weiss G., Rametsteiner E., Tykkä S., Van Apeldoorn R., Vreke J., Van Wijk M., Janse G., Prokofieva I., Rekola M., Kuuluvainen J. (2008): Study on the Development and Marketing of Non-Market Forest 22 Goods and Services, Final Report,availableonhttp://ec.europa.eu/agriculture/analysis/external/forest_products/index_en.htm(accessed: February, 2013)

Ministry of Environment and Forest (MoEF) (2009). Asian Pacific Forestry Sector Outlook Study II: Indian Country Report. Working paper No. APFSOS II/WP/2009/06.Bankok: FAO pp78

Ministry of Environment and forest (MoEF) (2006), report of the National Forest Commission. New Delhi, Ministry of Environment and Forest Government of India 421pp

R.J. Fisher, SomjaiSrimongkontip and Cor Veer (1997) People and forests in Asia and the pacific: situation and prospects. Working Paper No: APFSOS/WP/2

Sadashivappa P, SuryaprakashS, Vijaya Krishna V. (2006). Participation Behavior of Indigenous People in Non-Timber Forest Products Extraction and Marketing in the Dry Deciduous Forests of South India. Conference on International Agricultural Research for Development, Tropentag University of Bonn, October 11–13

Saha, D. and Sundriyal, R. C. (2012). Utilization of Non-Timber Forest Products in Humid Tropics: Implications for Management and Livelihood. Forest Policy and Economics 14: 28–40

Saha, Amita and Guru, B. (2003). Poverty in Remote Rural Areas in India: A Review of Evidence and Issues, GIDR Working Paper No 139, Ahmedabad: Gujarat Institute of Development Research. 69 pp

Smith J, Scherr S.J. (2002). Forest Carbon and Local Livelihoods: Assessment of Opportunities and Policy Recommendations. CIFOR Occasional Working Paper No. 37. CIFOR, Bogor, Indonesia, p. 56

Sunderlin, W.D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L. &Wunder, S. (2005). Livelihoods, forests, and conservation in developing countries: an overview. World Dev., 33(9): 1383–1402.

Vijay O. (2012) Changing patterns of tribal livelihoods: a case study in sundargarh district, odisha a thesis submitted for the partial fulfilment of master degree in development studies Department of Humanities and Social Sciences, National Institute of Technology, Rourkela India. 769008.

World Bank (2006), Indian Unlocking Opportunities for Forest Dependent People in India.Report No34481-IN, World Bank South Asia Region. 85 pp

# Diversity of macro-fungi in central India-VI: *Schizophyllum commune*

**R.K. Verma and Poonam Verma**
Forest Pathology Division
Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
P.O. – RFRC, Mandla Road, Jabalpur (M.P.)
E-mail: vermaramk@icfre.org

## Introduction

*Schizophyllum commune* Fr. is one of the most widely distributed and common mushrooms on the planet belong to genus *Schizophyllum*. Not only is it found from sea to shining sea and on continent, except for Antarctica. It's an omnipresence mushroom. It is easily recognized. The genome of *S. commune* was sequenced in 2010 (Ohm et al., 2010). Its tiny fruiting bodies lack stems, and they attach themselves like tiny bracket fungi on the dead wood of deciduous trees. Unlike a bracket fungus, however, *S. commune* has what appear to be gills on its underside, rather than pores or a simple, flat surface. On close inspection the "gills" turn out to be merely folds in the undersurface and they are very distinctively "split" or "doubled". The gills, which produce basidiospores on their surface, split when the mushroom dries out, earning this mushroom the common name split gill (Taylor et al., 2006).

The fruiting bodies to the right are probably a year old or more. This is a great adaptation for a climate. Unlike other mushroom species, the mycelium only has to produce one set of fruiting bodies per year, which can then dry out and rehydrate and keep functioning. It's a great strategy for reproduction (James and Vilgalys, 2001).

We know that there is a single widespread species because of the work of John Raper and his colleagues at Harvard University in the 1950' - 1970's. They collected worldwide samples of this fungus. After collecting and germinating the spores into mycelium, they were able to get individuals from all over the world to mate with one another. During that time they were also able to divide the species in mating types (sexes) based on their mating reactions. As long as two strains are of different mating types they are able to mate and form fertile offspring. It has more than 28,000 sexes (Raper et al., 1958; James et al., 2001).

It's a wood decay fungus that causes a white rot, by using enzymes to decay the lignin and cellulose left behind on the decaying wood is white. Interestingly, there are also reports of this species being found in humans and other animals. A report on a big lump completely made up of split gill hyphae, on the neck of a dog, nor is reading about mushrooms formed in the sinuses of a little girl very appetizing. It is not clear from these reports how the fungus got into the animal or human, and what exactly it lives on. But it is clear that this fungus is an opportunistic pathogen in mammals, especially the vulnerable (very young and very old) and those people whose immune systems are not working well. This fungus has also been known to

cause a human mycosis in just a few cases involving immune incompetent people, brain abscess (Rihs et al., 1996), especially children. In one case, the fungus had grown through the soft palate of a child's mouth and was actually forming fruiting bodies (mushrooms) (Guarro et al., 1999; Chowdhary et al., 2014).

**Materials and methods**

**Collection of samples**

The samples of *Schizophyllum commune* were collected from central India (Chhattisgarh, Madhya Pradesh, Maharashtra and Odisha) Table 1. The specimen were deposited in the mycology herbarium of Forest Pathology Division, Tropical Forest Research Institute, Jabalpur, India provided accessesion numbers (Table 1) TF51, TF512, TF513, TF306, TF361, TF363B, TF663, TF1525, TF1563, TF1648, TF1662, TF1689, TF1724, TF1728, TF1812, TF2191, TF2039, TF3862, TF3863, TF3864, TF3865 and TF3898.

**Table 1:** Distribution of *Schizophyllum commune* on different hosts in central India

| S. No. | Host | Family | Place | Date of collection | Herb. No. (TF) |
|---|---|---|---|---|---|
| 1. | *Acacia leucophloea* | Leguminosae | Semariya, Rewa, MP | 18.11.05 | 361 |
| 2. | *Anacardium occidentale* | *Anacardiaceae* | Pithora, CG | 29.9.10 | 1728 |
| 3. | *Artocarpus heterophyllus* | Moraceae | TFRI, MP and Bhilai Nagar, Durg, CG | 04.02.17 | 3898 |
| 4. | Bamboo | Poaceae | Jabalpur, MP | 1.8.06 | 363B |
| 5. | *Boswellia serrata* | *Burseraceae* | Pithora, CG; Baraha | 29.9.09; 5.8.8 | 1724; 1368 |
| 6. | *Cassia samia* | Caesalpiniaceae | Viruda, Odisha | 8.9.09 | |
| 7. | Dead bark | - | Pachmari, MP | 14.2.04 | 51 |
| 8. | *Dendrocalamus strictus* | Poaceae | Muapali, Odisha | 18.8.09 | 2191 |
| 9. | *Diospyros melanoxylon* | *Ebenaceae* | Viruda, Odisha | 8.9.09 | |
| 10. | *Eucalyptus globulueus* | Myrtaceae | Bhudkona, Anuppur, MP | 3.06.5 | 512 |
| 11. | *Holoptelia integrifolia* | Ulmaceae | Samardha, Jungle, Bhopal, MP | 24.11.16 | |
| 12. | *Lannea grandis* | Anacardiaceae | Nagree, CG | 21.08.08 | 1648 |
| 13. | *Madhuca latifolia* | Sapotaceae | Dhugli, CG; Balampur, Bhopal, MP | 19.12.06, 22.11.16 | 663 |
| 14. | *Mangifera indica* | Anacardiaceae | Jabalpur, MP | 3.8.06 | 306 |

| | | | | | |
|---|---|---|---|---|---|
| 15. | *Morus indica* | Moraceae | Jabalpur, MP | 10.10.05 | 513 |
| 16. | *Petrocarpus marsupium* | Fabaceae | Dhamtari; Gariaband, CG | 20.8.08, 1.10.08 | 1563; 1812 |
| 17. | *Shorea robusta* | *Dipterocarpaceae* | Katghora, CG; Badakudar, Odisha; Sole, Odisha; Karanjia; Sizora | 19.8.08, 21.08.09, 18.08.09; 9.12.08 | 1525; 2039; 1245; 1281 |
| 18. | *Tectona grandis* | Lamiaceae | Nagree, CG; Pithora, CG; Gadasarai; Rasaiyadona; Taku; Budhni; | 21.08.08 29.9.08; 8.12.08; 10.12.08; 23.12.08; 24.12.08; 25.12.08s | 1662;1689;1233; 1272; 1373; 1374; 1394 |
| 19. | *Terminalia tomentosa* | Combretaceae | Gundichawadi, Odisha; Bhanpur Beat, Bhopal, MP; Samardha, Bhopal, MP; Taku | 9.9.09, 21.11.16; 23.11.16; 23.12.08 | 1379; |

**Identification of fungus**

Identification of fungal fruiting bodies has done with help of relevant literature (Acton and Sandler, 2001; Banerjee, 1947; Boa, 2004; Harding 2008; Mohanan, 2011; Mahapatra et al., 2013; Sterry and Hughes, 2009; Tiwari et al., 2013; Verma et al., 2008) and internet.

**Results and discussion**

**Taxonomic description**

***Schizophyllum commune*** Fr.

(Schizophyllum, Schizophyllaceae, Agaricales, Agaricomycetes, Basidiomycota)

≡*Agaricus alneus* (L. 1755)

=*Agaricus alneus* (Reichard 1780)

=*Agaricus multifidus* (Batsch 1786)

=*Apus alneus* (L.) Gray (1821)

=*Merulius alneus* (L.) J.F.Gmel. (1792)

=*Merulius alneus* (Reichard) Schumach. (1803)

=*Merulius communis* (Fr.) Spirin & Zmitr. (2004)

=*Schizophyllum alneum* J.Schröt. (1889)

=*Schizophyllum alneum* (Reichard) Kuntze (1898)

=*Schizophyllum commune* var. *multifidum* (Batsch) Cooke (1892)

=*Schizophyllum multifidum* (Batsch) Fr. (1875)

The cap is shell-shaped, with the tissue concentrated at the point of attachment, resembling a stem. It is often wavy and lobed, with a rigid margin when old. It is tough, felty and hairy, and slippery when moist. It is greyish white and up to 4 cm in diameter. The gills are pale reddish or grey, very narrow with a longitudinal split edge which becomes in rolled when wet; the only known fungus with split gills that is capable of retracting by movement. It is found predominantly from spring to autumn on dead wood, in coniferous and

deciduous forest. Annual, effuse-reflexed, laterally- stipitate, attached with narrow base, fan shaped to kidney shaped, inclined downwards, 15 x 22 x 1 mm (L x B x T). Pilenus: grey white in colour, shiny velvety, imbricate, concentrically zonate, thin, margin entire, thin, wavy; Hymenium: grey in colour, lamellate, lamellae 1/mm, lamellae splitting from the edge to the pileus along their entire length, edges rolled back when dry, Context: gray, 1mm thick. Hyphal system: monomitic, generative hyphae thin walled with clamp, branchesto a variable degree, 3-3.5µm wide. Basidiospore: cylindrical, slightly curved smooth, hyaline and gutullated, 6.0-9.0 x 2.0-4.0 µm. White rot.

**Spore print:** White.

**Distribution**

Saprobic on dead wood or occasionally parasitic on living wood; growing alone or, more frequently, gregariously to clustered; on decaying hardwood sticks and logs (even on planks and boards); year-round (it survives by shriveling up and waiting for more moisture); widely distributed in North America and throughout the world, South American, Europe, Asia and Africa, Ireland and Great Britain, Bay area, India, Worldwide.

Its concluded that total 26 sample was collected from different locality of central India. 6 sample collected from Orissa and 10 from Madhya Pradesh and Chhattisgarh (Table 1).

Other known hosts: Wide host range

Culinary: Although European and US guidebooks list it as inedible, this is apparently due to differing standards of taste rather than known toxicity, being regarded with little culinary interest due to its tough texture.

But it is edible and widely consumed in Mexico and elsewhere in the tropics (Ruan-Soto et al., 2006) and in North-East India, the state Manipur called it as “Kanglayen” and it one of the favorite ingredients for Manipuri-Pancake style called “Paaknam”. In Mizoram, the local name is “Pasi” (*pa* means mushroom, si means tiny) and it is one of the highest rated edible mushrooms among the Mizo community. It’s also edible in Malaysia.

It is also eaten in many tropical regions (Ruan-Soto et al., 2009) and even collected in quantites and sold in roadside stalls and markets. Here is one recipe from the Upper-Shaba region in Congo where it is called sepa: “The natives boil the mushrooms for a long time in water to which a vegetables salt, rich in potassium, has been added; this has an effect of tenderizing. After one or two hours of cooking, the drained mushrooms are mixed with sifted peanuts, seasoned with a little salt and a final addition of oil. Prepared in this way, the mushrooms are eaten with bukari (the principal starchy dish of the region).

*S. commune* is a very good source of protein, vitamins, lipids and minerals (Adejoye et al., 2007). It’s have Scavenging activity (Mirfat et al., 2010). For centuries, this mushroom has been considered in the Orient as a popular healthy food and an effective medicine to treat several diseases (Hao et al., 2010). It has been reported to possess anticancer activity. A glucan, named schizophyllan, has been isolated from this mushroom. Hydrophobin protein was first isolated from *S. commune* (Wessels, 1997). This polysaccharide has a high potential in the pharmaceutical industry due to its immunomodulating, antineoplastic and

antiviral activities, which were found to be higher than those reported for other glucans (Kumari et al., 2008). Some other components like Lentinan, genodarans, cordycepin, cordycepic acid and protein-bound polysaccharide were also extracted (Daba and Ezeronye, 2003; Vincent et al., 2000; Wasser, 2002; Ziaja et al., 2005). Polysaccharide schizophillan (1, 3 β glucan) have been confirmed to inhibit sarcoma 180 cancer (Joshi et al., 2013; Vincent et al., 2000).

Chitin-glucan complex is a fungal origin copolymer that used application in medicine and cosmetics, through submerged cultivation these product was formed (Smirnou et al., 2011). Optimized conditions for production (nutrient medium composition in g/l: sucrose– 35, yeast extract – 4, $Na_2HPO_4*12H_2O$ – 2.5, $MgSO_4*7\ H_2O$ – 0.5; medium initial pH 6.5; aeration intensity 2 l of air per 1 l of medium; 144 hours of cultivation) resulted in 3.5 ± 0.3 g/l complex yield (Smirnou et al., 2011).

In South-East Asia, *S. commune* has been consumed as a nutritional food (Han et al., 2005) and is now being cultivated in Malaysia and Thailand (Wasser, 2002). This is the first report on the broad spectrum of antimicrobial of *S. commune* extracts. The extracts were found to exhibit better antibacterial activity against Gram-positive bacteria (*Bacillus cereus, B. subtilis, Enterobacter faecalis, Staphylococcus aureus, Streptococcus mitis, S. mutans* and *S. sanguis*) than the Gram-negative bacteria (*Escherichia coli, Salmonella* sp., *S. typhi, Shigella* sp., *S. flexneri, Plesuomonas shigelloides, Proteus vulgaris,* and *Pseudomonas aeuroginosa*) (Anke, 1989). It's probably due to the inhibition of cell wall synthesis; the cells were unable to maintain rigid peptidoglycan component of the wall and therefore become susceptible to weakening and eventual toxic destruction to the cell wall or lysis. It has been proven that the less complex structure of the Gram-positive bacteria cell wall makes it more permeable to the antimicrobial compounds (Papadopoulou et al., 2005).

Sawdust was used at main substrate for mushroom cultivation in Thailand. The ratio of new sawdust: waste material at 100 :0, 75: 25, 50:50, 25: 75, and 0: 100 (w/w) and adding rice bran varied at 0, 5, 10 and 15% were set to compare the split gill mushroom produce. And maximum yield was observed at sawdust only (100:0) adding 10% of rice bran (Pipathsithee, 2001; Preecha et al., 2015). Sunflower seed hull was also used for cultivation (Figlas et al., 2014). For cultivation in Shri Lanka coconut leaves was cut in to 1 cm × 0.2 cm pieces and mix with other substrate, 10% (w/w) rice bran, 2% (w/w) $CaCO_3$ and 0.2% (w/w) $MgSO_4$ were added (Ediriweera et al., 2015). But these mushroom was quickly rot in the hot humid conditions there, making their marketing problematic.

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**References**

Acton J, Sandler N (2001) Mushroom. Kyle Cathie. ISBN 978-1-85626-739-7.

Adejoye OD, Adebayo-Tayo BC, Ogunjobi AA, Afolabi OO (2007) Physicochemical studies on *Schizophyllum*

*commune* (Fries) a Nigerian edible fungus. World Applied Sciences Journal, 2: 73-76.

Anke T (1989) Basidiomycetes: A source for new bioactive secondary metabolites. In: Bioactive metabolite from microorganisms. Bushel M. E. and Grafe U., ed., Amsterdam: Elsevier Science Publisher, 51-65.

Banerjee SN (1947) Fungus flora of Calcutta and suburbe I. Bulletin of Botanical Society of Bengal, 1: 37-54.

Boa E (2004) Wild Edible Fungi: A Global Overview of their Use and Importance to People. Food and Agriculture Organisation.

Chowdhary A, Kathuria S, Agarwal K, Meis JF (2014) Recognizing filamentous basidiomycetes as agents of human disease: A review. Medical Mycology, 52(8):782-97.

Daba AS, Ezeronye OU (2003) Anti-cancer effect of polysaccharides isolated from higher basidiomycetes mushrooms. African Journal of Biotechnology 2:672-678.

Ediriweera SS, Wijesundera RLC, Nanayakkara CM, Weerasena OVDSJ (2015) Comparative study of growth and yield of edible mushrooms, *Schizophyllum commune* Fr., *Auricularia polytricha* (Mont.) Sacc. and *Lentinus squarrosulus* Mont. on lignocellulosic substrates. Mycosphere, 6 (6):760-765.

Figlas D, González MR, Delmastro S, Curvetto N (2014) Sunflower seed hulls for log system cultivation of *Schizophyllum commune*. Micologia Aplicada International, 26(2):19-25

Guarro J, Genej SA (1999) Developments in Fungal Taxonomy. Clinical Microbiology Reviews, 12(3):454-500.

Han CH, Liu QH, Ng TB, Wang HX (2005) A novel homodimeric lactose-binding lectin from the edible split gill medicinal mushroom *Schizophyllum commune*. Biochemical and Biophysical Research Communication, 336:252-257.

Hao LM, Xing XH, Li Z, Zhang JC, Sun JX, Jia SR, Qiao CS, Wu T (2010) Optimization of effect factors for mycelial growth and exopolysaccharide production by *Schizophyllum commune*. Applied Biochemistry and Biotechnology, 160:621-631.

Harding P (2008) Mushroom Miscellany. Harper Collins

James TU, Moncalvo J-M, Li S, Vilgalys R (2001) Polymorphism of the ribosomal DNA spacers and its relation to breeding structure of the widespread mushroom Schizophyllum commune. Genetics, 157:149-161.

James TY, Vilgalys R (2001) Abundance and diversity of Schizophyllum commune spore clouds in the Caribbean detected by selective sampling. Molecular Ecology, 10:471-479.

Joshi M, Patel H, Gupta S, Gupta A (2013) Nutrient improvement for simultaneous production of exopolysaccharide and mycelial biomass by submerged cultivation of *Schizophyllum commune* AGMJ-1 using statistical optimization. Biotechnology, 3:307-318.

Kumari M, Survase S, Singhal R (2008) Production of schizophyllan using *Schizophyllum commune* NRCM. Bioresource Technology, 99:1036-1043.

Mahapatra AK, Tripathy SS and Kaviyarasan V (2013) Mushroom diversity in Eastern Ghats of India. Regional Plant resources Centre, Bhubaneswar, pp. 184.

Mohanan C (2011) Macrofungi of Kerala. Kerala Forest Research Institute, Peechi, Kerala.

Mirfat AHS, Noorlidah A, Vikineswary S (2010) Scavenging activity of *Schizophyllum commune* extracts and its correlation to total phenolic content. *J. Trop. Agric. and Fd. Sc., 38(2): 231–238.*

Ohm RA, De Jong JF, Lugones LG, Aerts A, Kothe E, Stajich JE, De Vries RP, Record E, Levasseur A, Baker SE, Bartholomew KA, Coutinho PM, Erdmann S, Fowler TJ, Gathman AC, Lombard V, Henrissat B, Knabe N, Kües U, Lilly WW, Lindquist E, Lucas S, Magnuson JK, Piumi F, Raudaskoski M, Salamov A, Schmutz J, Schwarze FW, Vankuyk PA, Horton JS, Grigoriev IV, Wösten HA (2010) Genome sequence of the model mushroom *Schizophyllum commune*, Nature Biotechnology 28, 957–963.

Papadopoulou C, Soulti K, Roussis IG (2005) Potential antimicrobial activity of red and white wine phenolic extracts against strains of *Staphylococcus aureus*, *Escherichia coli* and *Candida albicans.* Food Technology and Biotechnology, 43(1): 41-46.

Pipathsithee C (2001) Economic project analysis. Department of Economics, Faculty of Economics, Kasetsart University.

Preecha C, Wisutthiphaet W, Seephueak P, Thongliumnak S (2015) Development of spawn culture material from reused spawn for cultivation split gill mushroom (*Schizophyllum commune*). Journal of Agricultural Technology, 11(8):2177-2181.

Raper JR, Krongelb GS, Baxter MG (1958) The number and distribution of incompatibility factors in Schizophyllum. The American Naturalist, 92 (865):221-232.

Rihs JD, Padhye AA, Good CB (1996) Brain abscess caused by *Schizophyllum commune*: an emerging basidiomycete pathogen. Journal of Clinical Microbiology, 34 (7):1628-32.

Ruan-Soto F, Cifuentes J, Mariaca R, Limon F, Perez-Ramirez L, Sierra S (2009) Uso y manejo de hongos silvestres en dos comunidades de la Selva Lacandona, Chiapas, México. Revista Mexicana de Micología, 29: 61-72.

Ruán-Soto F, Garibay-Orijel R and Cifuentes J (2006) Process and dynamics of traditional selling of wild edible mushrooms in tropical Mexico. Ethnobiology and Ethnomedicine, 2(1):3.

Sterry P, Hughes B (2009) Complete Guide to British Mushrooms & Toadstools. HarperCollins p. 290.

Smirnou D, Krcmar M, Prochazkova E (2011) Chitin-glucan complex production by *Schizophyllum commune* submerged cultivation. Polish Journal of Microbiology, 60 (3): 223–228.

Taylor J, Turner E, Townsend J, Dettman J, Jacobson D (2006) Eukaryotic microbes, species recognition and the geographic limits of species: examples from The kingdom fungi. Phil. Trans. R. Soc. B., 361:1947-1963.

Tiwari CK, Parihar J, Verma RK, Prakasham U (2013) Atlas of wood decaying fungi of central India. Tropical Forest Research Institute, Jabalpur, MP, 166p.

Verma RK, Sharma Nidhi, Soni KK, Jamaluddin (2008) Forest Fungi of Central India. International Book Distributing Co. Lucknow, 418p.

Vincent E, Ooi C, Liu F (2000) Immunomodulation and anti-cancer activity of polysaccharide-protein complexes. Current Medicinal Chemistry, 7:715-729.

Wasser SP (2002) Medicinal mushrooms as a source of antitumor and immuno modulating polysaccharides. Applied Microbiology and Biotechnology, 60:258-274.

Wessels JGH (1997) Hydrophobins: proteins that change the nature of the fungal surface. Advances in Microbial Physiology, 38:1-45.

Ziaja KS, Muszy-Ska B, Ko-Ska G (2005) Biologically active compounds of fungal origin displaying antitumor activity. Acta Polonaise Pharmaceutical Drug Research, 62: 153-160.

**Fig. 1: *S. commune* in mango, mahua, saja, katahal,**

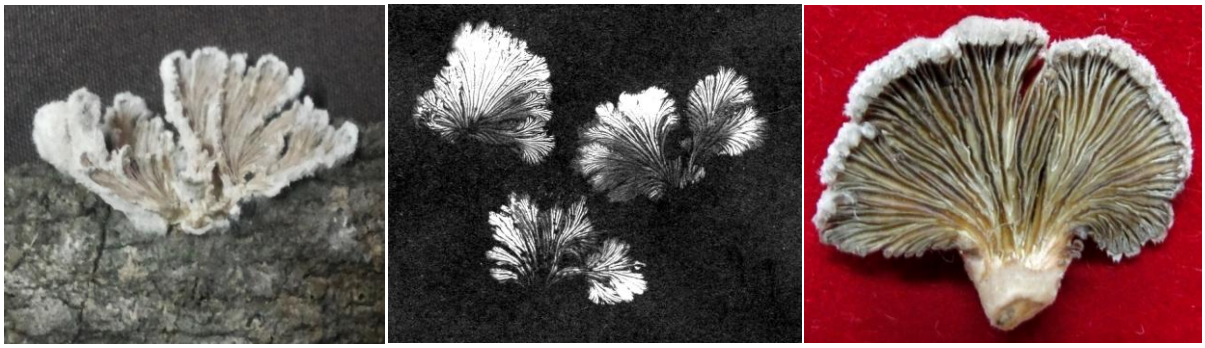

**Fig 2-4 Fruiting body of *Schizophyllum commune***

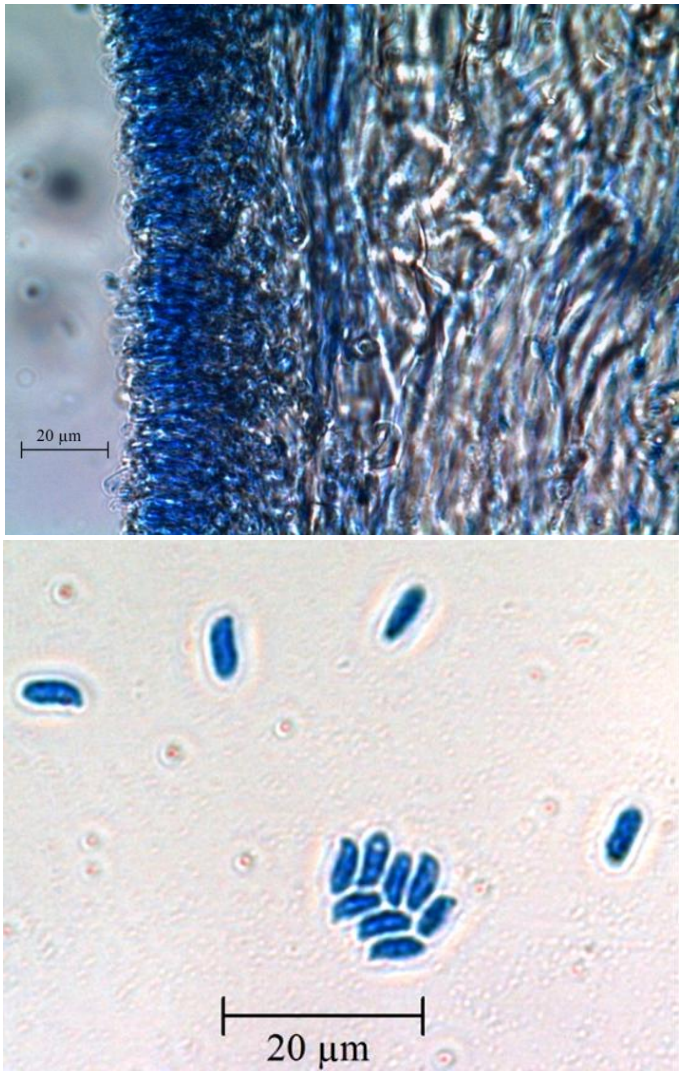


**Fig. 5: *S. commune* TS of gill and basidiospores**

# Natural dye yielding trees–Sustainable rural livelihood options

**R. Deepak Kumar**
College of Forestry
Kerala Agricultural University
Thrissur-680 656

## Introduction

Nature is full of fascinating colours without which human life would have been dull and monotonous. The colouring is one of the ancient arts of human history. Earliest written records traces back to prehistory i.e. 2600 BC years in china. Even before the Indus valley civilization (3500 BC) also evidences that use of colours in garments. Invention of the most important Indian natural dye called *indigo*which makes tremendous impact on textile industries. Natural substances were extensively used in staining the hides, decorating the shells and cave paintings. During mid eighteen centuries, the synthetic dyes were invented as substitutes for them and has beenextensively used in colouring. Nowadays there is a decreasing interest on synthetic dyes due to its ecological and environmental impacts among people. In these current scenarios, trees have huge potential of important natural dyeing sources in throughout the year with seasonal production cycle. However, there are commercial small-scale dye industries already existed in the length and breadth of the country. There is ample scope of natural dye yielding trees in leather, cosmetics, and food and pharmaceuticals industries. Some of the commercially viable dye yielding trees which will increases the natural dyes market share in India.

## Natural dyes

Almost all parts of the plant have some natural colouring substance which is imparting array of colours. Natural colouring dyes will varies with depending on different parts of the plants, seasons of harvesting, soil conditions, cultivating practices etc. (Vankar, 2000). Art of natural colorings includes extraction of dyeing substances, mordanting (a bond between the colouring matter and the fibre to be dyed) and actual dyeing. In order to imparting naturalcolours, the plants were cut into pieces and then cooked with water around 10-20 minutes. Mordants are may be natural/chemical substances which are boiled with fibres to create the strong bond to it in case of textile dyeing. For other applications mordanting the surface with other substances. This will ensure the appropriate colour to the continuous sun drying and also washing. After mordanting process, the fibres were soaked with natural dyes. Trees are huge sources of natural colour can be obtained sustainably along with other numerous benefits.

## Common natural dye yielding trees

**Babool** (*Acacia niloticaL.*)

*Acacia nilotica* Linn. is a tree belonging to the family Mimosaceae. It is primarily used for vegetable tanning, fuelwood, timber and agroforestry. Bark is grey to brownish black coloured, rough and longitudinally fissured. Its yields natural dye which is used in calico printing and dyeing (Vankar, 2004). It contains hydrolysable tannins and proanthocynidins. It is available in the crude form as well as refined dye is available with several refined dye is

available with industries spread over Chennai, Ghaziabad and Indore like cities in India.

**Cutch** (*Acaica catechu* L.f.)

It is one of the wide spread tree species across north Indian deciduous forest ecosystems as well as farming lands. It is moderate size tree with rough, dark grayish brown bark. It yields two commercially viable product called *Cutch* and *Katha* which is used in dyeing and pan industries respectively. Cutch also known as tannic acid, exhibits excellent fastness on cotton and silks in light brown to dark black colour range varies with mordants. Catechu will certainly find its unique place in textile industries as a natural colorant on commercial scale.

**Harda** (Terminalia chebulaRetz)

Harda also known as chebulic myrobolan is obtained from the fruits of *Terminalia chebula* Retz belongs to the family combretaceae. Fruits of *Terminalia chebula* have around 30-32 % of natural tannins. It can be used for main as well as auxiliary dyeing in textile and leather industries of South India (Sabbir et al., 2016). The principal constituents of the fruits are anthraquinones, chebulic acid and hydrolysable tannins such as gallotannins and ellagitannins. It the colour ranges from ivory to cream to brown with different natural mordants.

**Ventilagin**

(*Ventilagomadaraspatina*Gaertn)

*Ventilago madaraspatina* Gaertn**.** is a medicinal tree belongs to the family of Rhamnaceae. Its stem and barks yields red coloured dye called '*Ventilagin'.* It is used for natural colouring wool cotton and tasar silks (Das and Mondal, 2012). Bark paste of *Ventilago madaraspatina* is applied as cure for wounds, eye disease.

**Palas** (*Butea monosperma* Lam.)

Natural colorants were obtained from the petals of the Flame of forest (*Butea monosperma*) flowers which is used for dyeing the cotton with light colours. It is belonging to the family of Fabaceae and commonly occurs in the dry deciduous forests of India. During summer seasons, it blooms yellowish red coloured inflorescence look alike the flame of the forests.

**Kino tree** (*Pterocarpus marsupium* Roxb.)

Pterocarpus marsupium (Kino of malabar), is a popular medicinal tree species widely grown farmlands of India and has long been used in Indian system of medicine. The stem barks have epicatechin yields brownish red coloured dye which is long tradition being utilized in the dyeing of silks.

**Kamala** (*Mallotusphilipinesis* Lam.)

*Mallotus philippenesis* (Lam.) M.Arg.is one of the endangered plants belongs to the family of Euphorbiaceae. The fruit yields bright coloured dye commonly known as *kamala* dye, mostly grown in Indian subcontinent. It mostly used as a dye in food stuffs and beverages. Kamala also serves as a preservative for vegetable oils and dairy products due to its purgative in nature (Varma and Sharma, 2011). Root yields red coloured dye which is used as a dyestuff in textile industries particularly silks.The main constituents of kamala dyes are rottlerin, iso-rottlerinand Kamalin. It has been also one of the commonly plants utilized in Indian system of medicine. Various parts of the plant are used in the treatment of skin problem, bronchitis, antifungal, tape worm, eye-disease, cancer, diabetes, diarrhea, jaundice, malaria, urinogenital infection etc.

**Annatto** (*Bixoorellona* L.)

It is extracted from the seed coat of *Bixaorellana*, commonly known as Annatto or Lipstick Plant. Annatto dye is seed specific red orange pigment (apocarotenoid) and it is sole source of bixin used worldwide in food and cosmetic industries. Also,it has known for its medicinal values and applications like the seed pulp to treat heat burns, dysentery, constipation and fever (Chattopadhyay *et al.,* 2008). *Bixa* meal which remains after extraction of the pigment from seed, is a useful additive to poultry feed. The high percentage of carbohydrates makes the annatto seed a good alternative as a feed for livestocks.

**Teak** (*Tectonagrandis* L.)

This belongs to the family of *Verbenaceae* which is one of the commercially cultivated forestry species in India for its high valued timber. Young leaves of teak have the bright orange coloured dyestuffs and yellow coloured dyes from the matured leaves. It is highly preferred in the textile industries as low cost natural dyes fabrics. The principal component of this dye is a quinone. States like Manipur, people were boiled the extractof young leaves along with fish.

**Eucalyptus** (Eucalyptus spp)

Eucalyptus species belongs to the family *Myrtaceae* which is native of Australia. It is one of the widely cultivated pulpwood species in India. Most of the time, pulpwood industries will discard the outer barkin order to improve the quality of pulp and also reduce chemical wastage. This yields yellowish-brown coloured dye which can be utilized as a natural colourantsin textile industries (Ali et al., 2010). It also contains ample sources of natural tannins and polyphenols (10 – 12%).

**Sappan or Brazilian wood** (*Caesalpiniasappan* L.)

*Caesalpiniasappan*is belongs to the family of *Fabaceae* which is naturally exists and also widely cultivated in Southeast Asia and the Malay Archipelago region. Sappan wood was one of the widely used in the textile industries for its natural red colour. Also used additives in calico printing and food industries (Badami*et al.,* 2004). The roots of sappan wood yield yellow colored dyes. Also used in the folk medicines due to its astringent, anti-microbial, anti-viral, haemostatic and healing properties. Heartwood chips were boiled and made into herbal drinking water in state of Kerala.

**Beef wood** (*Casuarina equisetifolia* L.)

*Casuarina equisetifolia* belongs to the family of *Casuarinaceae*. It is widely cultivated tree species for pulpwood in India. Natural reddish coloured dye extracted from the bark which is discarded as waste by the pulpwood industries (Narayanaswamy *et al.*, 2013). This is used in textile industries as a natural source of colours. It also has antimuscarinic, antioxidant antimicrobial and antihistaminic properties.

**Conclusion**

Even though natural dyes have a tedious extraction process of colouring component from the raw material, low colour value and long dyeing time are limits the cost of dyeing with natural dyes considerably higher than with synthetic dyes. There has been increased importance of natural dyes in various industrial applications nowadays. However, there is a need to improve dye extraction technology; establishing long-term sustainability of dye yielding plant parts, improving the reproducibility will definitely lower the

cost of natural dyeing. Hence cultivation of dye yielding trees in and around farm lands will increase the livelihood opportunities of rural and marginal farmers.

**References**

Ali, S., Nisar, N. and Hussain, T. 2007. Dyeing properties of natural dyes extracted from eucalyptus. J. of the Textile Institute, 98 (6): 559-562. DOI: 10.1080/00405000701556079

Badami S., Moorkoth, S. and Suresh, B. 2004. Caesalpinia sappan a medicinal and dye yielding plant. Natural Product Radiance 3(2):75-82.

Das P. K. and Mondal A. K. 2012. biodiversity and Conservation of Some Dye Yielding Plants for justification of its economic status in the local areas of lateritic zone of west Bengal, India. Advances in Biores. 3(1): 43-53.

Gokhale, S. B., Tatya, A.U., Bakliwal, S. R. and Fursule, R. A. 2004. Natural dye yielding plants in India. Natural Product Radiance. 3(4): 228-234.

Narayanaswamy, V., Ninge, K. N. Gowda, and Sudhakar R. 2013. Natural dye from the bark of *casuarina equisetifolia* for silk. Inter. J. of Pharma and Bio Sci., 4 (3): 94-104.

Shabbir, M., Ul Islam, S., Bukhari, M. N., Rather, L. J., Khan, M. A., and Mohammad, F. 2016. Application of Terminalia chebula natural dye on wool fiber—evaluation of color and fastness properties. Textiles and Clothing Sustainability 2:1 DOI: 10.1186/s40689-016-0011-8

Sharma, J. and Varma, R. 2011. A Review on Endangered plant of *Mallotus philippensis* (Lam.) M. Arg. Pharmacologyonline 3: 1256-1265

Vankar, S. P. 2000. Chemistry of Natural Dyes. Resonance. 5 (10): 73-80.

Vankar, S. P. 2002. Commercial viability of natural dyes heena, harda, catechu and babool for textile dyeing. Natural Product Radiance.7 (7): 15-17.

# Dying -off of *Buchanania lanzan* plantation in CFRHRD, Chhindwara, Madhya Pradesh

**P.B.Meshram[1], R.K.Verma[2], Shalini Bhowate[3] and A.K.J. Asaiya[2]**
[1]Forest Entomology Division
[2]Forest Pathology Division
Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
P.O. RFRC, Mandla Road, Jabalpur (M.P.)
[3]Centre for Forestry Research & Human Resource Development, Chhindwara , M.P.
Email pbmeshram1959@gmail.com

## Introduction

Chironji, *Buchanania lanzan* (Spreng.) is an economically important local forest tree species. Seeds are used as an expectorant, tonic to the body and brain. The flesh of ripe fruits and kernels are edible and fetch of quite high rate, substituting almonds in flavouring sweetmeats, confectionary and betel net powder(Anon.1952). This economically important local forest tree species is severely attacked by various insect pests and diseases which adversely affect the growth and productivity (Beeson 1941, Mathur and Singh, 1954; Bhasin *et al.*, 1958; Browne, 1968; Joshi, 1992; Meshram and Nandeshwar, 2003; Soni *et al.*, 2005 and Meshram & Soni, 2014). The trees have suffered due to mortality caused by some biotic factors i.e. grazing, repeated fire, hacking, indiscriminate harvesting (lopping /cutting), diseases and insect pests.

In pursuance to the information regarding the dying-off problem received from Director, CFRHRD, Chhindwara during August, 2016. A team of Scientists of Tropical Forest Research Institute, Jabalpur visited and surveyed the entire plantation areas. This plantation was facing the problem of insect pests and diseases attack at different phase of growth.

## General information

Intensive block plantations of *B. lanzan* of different types of seedling raised viz. S1. Root cutting; S2. Stumps (2 years old); S3. Stumps (1 year old); S4. Seedlings (2 years old) and S5. Seedlings (1 year old) have been raised in the campus of Centre for Forestry Research & Human Resource Development (CFRHRD), Chhindwara, M. P. during 2001. After 4 years, the flowering has been started in few plants. Total trees were 400 and at present survival trees 305.

## Observations

Survey was conducted in plantation areas. The dying-off trees were thoroughly observed. The trees were attacked by insect pests i.e. red borer *Zeuzera coffeae*, bark eating caterpillar *Indarbela quadrinotata*, stem borer *Plocaederus obesus*, defoliator *Lamida carbonifera* and diseases like canker, leaf spots and blight. The observations on the status of plantation are summarized in following Table 1. The symptoms of damaged trees, insect pests /diseases, application of different control measures and status of plantation after six months are given in figs.1-23. After six months of the application of different delivery methods of treatments the results revealed that chlorpyriphos 0.05% + Ridomil 0.2%;

monocrotophos 0.05%; Dichorvos 0.5%; chlorpyriphos 0.05% and Chaubatia paste were found to be most effective against the insect pests and diseases.

**Table 1: Observations on the status of *Buchanania lanzan* plantation**

| Sl. No. | Total Trees | Semi-dying trees | % of semi-dying trees | Gummosis trees | %Gummosis trees | Canker trees | % Canker |
|---|---|---|---|---|---|---|---|
| 1 | 305 | 30 | 10.00 | 27 | 9.00 | 18 | 6.00 |

**Control measures/ Managemanet**

- Extraction and removal of all dead trees from affected areas for further spread of insect pests/diseases.
- In few water logged patch, drainage should be made for removing the water.
- Insecticide Chlorpyriphos 20 EC @ 0.05% (2.5 ml per lit of water) + Ridomil 0.2% (2 gm per lit of water), 2 lit solution of this combination per tree should be drenched around trees against stem/root borer/diseases.
- Foliar application of Monocrotophos 36 EC @ 0.05% (1.4ml per lit of water) + Bavistin 0.2% (4 gm per lit of water), this solution should be sprayed after 1 month interval against common insect pests - defoliators, sap suckers and diseases -leaf spots, blight.
- Removal of silken frass and Dichorvos (Nuvan) 0.5% (5ml/lit of water), this 10 ml solution should be injected in holes and applying mud plaster against red borer and bark eating caterpillar.
- After rainy season, Chlorpyriphos 20 EC @ 0.05% (2.5 ml per lit of water) + lime water should be applied on the stem against termites.
- Application of Chaubatia paste (Calcium carbonate 500 gm + Linseed Oil 1 lit + Red Lead 500 gm + Monocrotophos 1.5 ml**)** on cut end of twigs.
- Plantation should be protected from biotic factors like fire, grazing, wild animals etc. Proper and timely surveillance should be done in order to monitor the insect pests/diseases in plantation area.

After application of the above control measures, to semi-dying trees of *B. lanzan* in plantation, resulted in rejuvenation of trees with new flush and flowers within 6 months of the treatment.

Anon., (1995) suggested that after cleaning the ejection holes, either crystals or saturated solution of paradichlorobenzene in kerosene should be poured inside each hole and sealed with moist soil against stem borer. Meshram and Nandeshwar (2003) recommended insecticides larvin 0.1% and decis 0.005% against defoliator, *L. carbonifera.* Meshram and Soni (2014) studied the insect pests and diseases of *B. lanzan* in natural stand and their management. Meshram *et al*., (2016) recorded the insect pests and diseases of *B. lanzan* and evaluated some insecticides and fungicides against major insect pests/diseases. Application of different delivery methods of insecticides and fungicides to semi-dying trees in intensive

plantation ecosystem, it indicated that after six months of the treatment, all the trees have rejuvenated with new flush and flowers.

**Conclusion**

It can be concluded that semi-dying of trees of *B. lanan* can be protected by the application of different delivery methods of above suggested insecticides/fungicides treatments against the insect pests and diseases. Application of different delivery methods of insecticides/fungicides to semi-dying trees of *Buchanaia lanzan* in plantation resulted in rejuvenation of trees with new flush and flowers within 6 months of the treatment.

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**References**

Anon. (1952). Wealth of India, A Dictionary of Indian Raw Materials and Indian Products. Vol. **2**: B (Revised Edition). Publication and Information Directorate, CSIR, New Delhi, 350 pp.

Beeson, C.F.C. (1941). The Ecology and Control of Forest Insects of India and Neighbouring Countries. Vasant Press, Dehra Dun, ii + 1007 pp.

Bhasin, G. D., Roonwal, M. L. and Singh, B. (1958). A list of insect pests of forest plants in India and the adjacent countries. Part 3. Indian For. Bull. (N.S). Manager of Publication, Govt. of India, New Delhi, 171 (2): 1- 61 .

Browne, F. G. (1968). Pests and Diseases of Forest Plantation Trees. Clarendon Press, Oxford, 1330 pp.

Joshi, K. C. (1992). Hand Book of Forest Zoology and Entomology. Oriental Enterprises, Dehra Dun, 383 pp.

Meshram, P. B. and Nandeshwar, D.L. (2003). Incidence and chemical control of insect defoliator, *Lamida carbonifera* on chironji. Indian Journal of Tropical Biodiversity, 11: 103-105.

Meshram, P.B. and Soni, K.K. (2014). Insect pests and diseases of *Buchanania lanzan* and their management in central India.Indian Journal of Tropical Biodiversity, 22 (1): 28-38.

Soni, K. K., Asaiya, A. J., Nandeshwar, D. L. and Jamaluddin (2005). *Fusarium* wilt of *Buchanania lanzan* Spreng.– A new disease record from India. Indian J. Tropical Biodiversity, 13 (2): 112-112.

**Figs: 1-2. *Buchanania lanzan* plantation in CFRHRD,Chhindwara; 3. Semidying trees(August, 2016)**

**Figs: 4- 6. Oozing sap from trees**



**Figs. 7 – 8. Red borer larva** **9. Stem borer (powder on bark)**



**Figs: 10-12 Grubs**


**Figs:13. Beetles, *Plocaederus obesus*** **Fig. 14. Defoliator *Lamida carbonifera***



**Figs: 15. Semi-dying trees (August, 2016) Fig. 16-17 Drenching insecticides**



**Figs: 18. Spraying insecticide+Fungicide; 19. Application of Chaubatia paste; 20. Injecting dicholrvos**



**Figs: 21-22. Flowering (February, 2017) Fig. 23. After treatment (March, 2017)**

# Mahogany: A potential multi-purpose tree for future

**M .V. Durai**
Tree Improvement & Genetics Division
Institute of Wood Science & Technology
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
18th Cross, Malleswaram,
Bengaluru – 560 003 (Karnataka)
E-mail: duraimv@gmail.com

## Introduction

Mahogany is a world's finest highly prized timber species, belong to meliaceae family. The traded mahogany timbers are grouped in two categories viz., "genuine mahogany" and "true mahogany". The genuine mahoganies are *Swietenia macrophylla* (Honduran or big-leaf mahogany), *Swietenia mahagoni* (Cuban mahogany) and *Swietenia humilis.* It is indigenous to Mexico, Central and Northern South America. Other meliaceae timber species are classified as "true mahogany." Some of these true mahoganies include the African genera *Khaya* and *Entandrophragma*, New Zealand mahogany (*Dysoxylum spectabile*), Chinese mahogany (*Toona sinensis)*, Indonesian mahogany (*Toona sureni*, Indian mahogany (*Toona ciliata)*, Chinaberry (*Melia azedarach)*and Indian Mahogany (*Chukrasia velutina).* As dwindling of mahogany populations and native countries ban on its export, mahogany plantations are established out of its native place, especially South East Asian countries in 1990s to meet its international demand. As on today, Indonesia has largest area of mahogany plantation among mahogany growing countries in the world. Among genuine mahoganies, S. *macrophylla* has become a promising tree species for industrial plantations as well as for reforestation and afforestation. The number of smallholder *S. macrophylla* plantations is increasing in SE Asian countries due to its high quality wood used for furniture and cabinet making. In India, mahogany was introduced in the Botanical Garden at Kolkata in 1795. Despite of its excellent timber quality and early introduction, still it is lesser-known tree species in our country.

## Distribution

*Swietenia macrophylla* grows naturally in Belize, Bolivia, Brazil, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru and Venezuela. However, it is nearly extinct in Ecuador, Colombia, Panama and Costa Rica; close to commercial extinction in Bolivia; declining in Mexico, Belize and Brazil; and in severe decline in Guatemala, Peru, Nicaragua and Honduras. The species has been extensively planted mainly in Southern Asia and the Pacific including India, Indonesia, Philippines and Sri Lanka (Fig1). More than 200 years old mahogany plantations are available in India especially in South India, introduced by then British people as an ornamentals tree. A number of linear plantations are found in the road-side, parks and old Govt buildings in Bengaluru and Mysore (Karnataka) and Topslip, Burliyar, Pacchamalai and Mayamapadi in Tamil Nadu (Fig 3). The Kerala State has a largest area under mahogany plantations in India. Mahogany

plantations are mainly found in the districts of Nilambur, Punalur, Achenkoil, Malaiyatur, Kannur and Kasarkod (Fig 2 & 4). Also, a few mahogany plantations are found in West Bengal and Maharashtra. As mahogany timber fetches good price in the market with short rotation, the people in Kerala are planted a large number of mahogany trees in their homesteads to meet contingent family expenditure like marriage.


Fig.1 Natural range of mahogany (Source: Martinez et al. 2008)

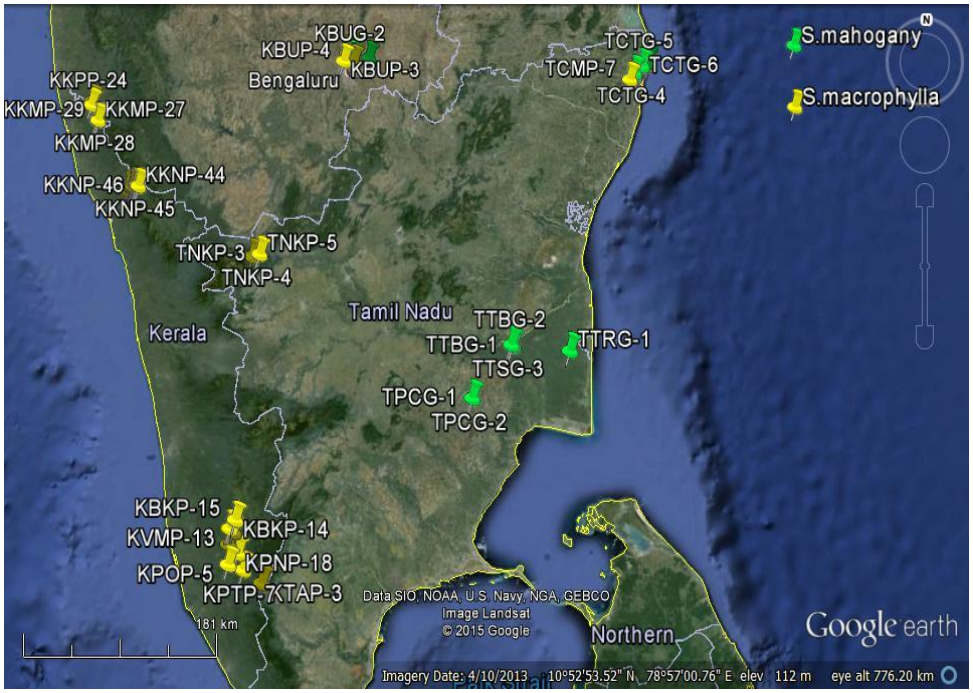


Fig.2 Distribution of mahogany plantations in south India


Fig 3 Mahogany populations in Tamil Nadu

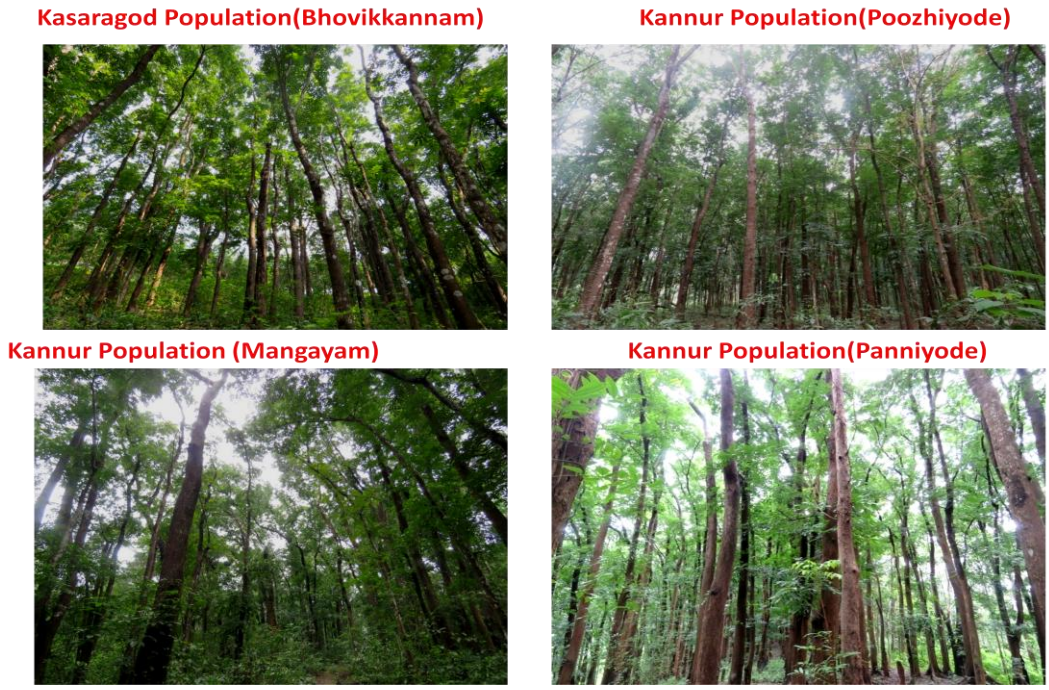


Fig 4 Mahogany populations in Kerala

**Botany**

*S. macrophylla* is large deciduous tree with an umbrella – shaped crown, reaching heights of over 30m and diameter at breast height (DBH) of more than 1.5 m. The trunk is straight and cylindrical, slightly grooved, with well-developed spurs. The crown of young trees is narrow, but old trees have a broad, dense and highly branched crown. The open, rounded crown has thick, rising branches and thick, dense foliage. The outer bark of older trees is scaly, shaggy, deeply longitudinally furrowed and brownish-grey to reddish-brown, and the inner bark is red-brown or

pinkish-red. The leaves are usually paripinnate, sometimes imparipinnate, 12 - 45 cm long, and are made up of 3–6 pairs of lanceolate or ovate leaflets. The leaflets are asymmetrical, 5–12 cm long and 2–5 cm wide, with a whole margin and an acute or acuminate apex (Schmidt and Joker 2000). The flowers are unisexual, 0.5–1.0 cm in length, and are borne in large, branched inflorescences including both male and female. The fruits (Figure 3) are capsular, oblong or ovoid, 11.6–38.7 cm in length, 6.7–12.0 cm in diameter and light grey to brown with 4–5 valves. Each fruit contains 22–71 developed seeds (Figure 4). The seeds are samaroid, bulky at their base, 7–12 cm long and 2–2.5 cm wide including the wing (Soerianegara and Lemmens 1993).

**Ecological range**

*S. macrophylla* can tolerate a wide range of soils and environmental conditions. It grows well on alluvial soils, volcanic soils, heavy clays, lateritic soils and limestone soil, igneous or metamorphic rock formations. It is considered as pioneer species for re-vegetating degraded agricultural land. It is very wind firm species. It can grow on very poor soils but perform best on deep, fertile, well-drained soils with a pH of 6.5–7.5. Within its ecological range, the optimum annual rainfall is between 1000 and 2500mm with a dry period of 0 - 4 months. Annual precipitation of 1000 - 2000 mm, a mean annual temperature of 24°C and a potential evapo-transpiration ratio of 1– 2 is required for optimum natural development of this species under tropical regions. Mahogany can grow at elevations of 0 – 1500 m above sea level, in areas with a mean annual temperature of 20 – 28 °C (Krisnawati *et al.* 2011). Recently, mahogany is planted along national highways in Vellore, Krishnagiri and Dharmapuri districts in Tamil Nadu and Bengaluru city (Karnataka) as avenue trees by the NHAI (National Highway Authority of India) and its performs well (Personal observation).

**Wood characteristics**

*Swietenia macrophylla* is a rather soft, medium-weight timber. The heartwood is reddish or pinkish, the colour darkening with age to a deep red or brown; the sapwood is usually yellowish. It has an attractive appearance, can be worked easily with hand tools and has excellent finishing qualities and dimensional stability (Martawijaya *et al*. 2005). It polishes well and does not crack or bend, making it valuable for the manufacture of quality furniture. The timber is valued particularly for its colour and workability. The wood density is in the range of 485–850 kg/m3 at 15% moisture content (Table 1). The grain of the wood is interlocked, sometimes straight, with a fine to moderately coarse texture (Soerianegara and Lemmens 1993). The surface is glossy, and the timber is often nicely figured because of the irregular grain.

**Uses**

*Swietenia macrophylla* is suitable for large-scale timber production, because of its excellent timber quality. Mahogany has a straight, fine, and even grain, and is relatively free of voids and pockets. Its reddish-brown color darkens over time, and displays a reddish sheen when polished. It has excellent workability, and is very durable. The wood can be used for construction materials, plywood (veneer), high-grade furniture and cabinet making. It is also suitable for panelling, framing, flooring, automobile bodies, interior trim

of boats, radio and phonograph cabinets, bodies of musical instruments, mouldings and other ornaments. These properties make it a favorable wood for crafting cabinets and furniture. Much of the first-quality furniture made in the American colonies from the mid 18th century was made of mahogany, when the wood first became available to American craftsmen. Mahogany is still widely used for fine furniture; however, the rarity of Cuban mahogany and over harvesting of Honduras and Brazilian mahogany has diminished their use.

The leading importer of mahogany is the United States, followed by Britain (Bridge, 2012); while the largest exporter today is Peru, which surpassed Brazil after that country banned mahogany exports in 2001 (Donald, 2011). It is estimated that some 80 or 90 percent of Peruvian mahogany exported to the United States is illegally harvested, with the economic cost of illegal logging in Peru placed conservatively at $US40-70 million annually (Nikolas and Vincente, 2007). It was estimated that in 2000, some 57,000 mahogany trees were harvested to supply the U.S. furniture trade alone (Bridge, 2012). Mahogany is the national tree of the Dominican Republic (Alan (1997) and Belize (Victoria (2012). In 2015, the price of export quality mahogany wood is $US 1,570 – 1,655/cu.m (₹ .1, 02, 050 – 1, 07, 575/-) in the US market.

Fig 5 Wood products derived from mahogany

**Medicinal uses**

Besides timber use, the mahogany has many therapeutic values. *S. macrophylla* is being tapped as "cure-all medicine" for common illnesses viz. diabetes, arthritis, rheumatism, gout, diarrhoea, fever, malaria, cough and high blood pressure. The seeds of *S. macrophylla* are traditionally used in several indigenous systems of medicine for the treatment of various ailments such as hypertension, diabetes and malaria (Chan *et al.*, 1976). Its fruit, known as "sky fruit", is used as a folk medicine in Malaysia for treating diabetes and high-blood pressure. A decoction of the crushed seeds of this tree is used to treat skin ailments and wounds. Among the Amazonian Bolivian ethnic groups, the seeds are traditionally used to induce abortion by drinking a water decoction of the seeds and to heal wounds and various ailments of the skin via external application of the mashed seeds (Vargas & Quintana, 1995). Mahogany is known as "Queen of Plant" by the people of the south pacific Soloman Islands for its health benefits for many generations. The local people of this islands use mahogany for more than 1000 years of history for the treatments of diabetes, hypertension, allergic diseases and endocrine disorders. Its seed has been recognised for its unique health effects. The local healers of East Midnapore, West- Bengal (India) uses

mahogany seed for treating diabetics and diarrhoea traditionally for generations.

In Malasia and South Pacific Soloman Islands, the local people consume raw seeds of mahogany for curing different diseases especially diabetics. The dried seeds are creamy white and bitter taste. For controlling diabetics, an adult can consume 1 -2 seeds per day or one capsule per day half an hour before meal. For poor health people, 1 capsules each in the morning, afternoon and evening half an hour before each meal. For below 6 - 12 years old children, half of a capsule in day is recommended. In India, the Country Drug Stores are selling mahogany seeds to the diabetic treatment.

As for *S. mahogany*, the seeds have been used in traditional medicine in the treatment of hypertension, diabetes and malaria in Indonesia. The decoction of the bark is extensively used as febrifuge. The seeds have also been reported to have medicinal value for treatment of cancer, amoebiasis, coughs, chest pains and intestinal parasitism. The biologically active ingredients, tetranortriterpenoids and fatty acids, are considered to be responsible for these therapeutic effects. As for *S. humilis*, the seeds are highly valued for the treatment of gastrointestinal disorders, including worms and amoebiasis. Decoctions or infusions of the ground seeds of this plant are highly valued for the treatment of worms, amebiasis, cancer, chest pains and coughs. Mahogany seed extract can correct activities of antioxidant enzymes like catalase, peroxidase, and levels of the products of free radicals like conjugated diene and thiobarbituric acid reactive substances in liver, kidney, and skeletal muscles towards the control (Eid et al. 2013; Naveen et al. 2014).

Mahogany seed extract also plays important role in improvement of over all human health. For example, flavonoids (found in Fruits and seeds) promote health and human well being beyond that of other nutritional supplements. Saponins act as soap and lubricant that help to promote blood circulation throughout body. Alkaloids help in elimination of waste chemicals through normal channels and activation of white blood cell. Mahogany is also rich in vitamins A, B1, $B_6$, D and E, dietary fibre, folic acid, protein and carbohydrate (Eid et al. 2013; Naveen et al. 2014).

As the mahogany extract is natural product, it is safe to be consumed without any side effect. The use of mahogany has been widely accepted by medical specialist and doctors. It is pure in nature and no ill effect is encountered even for long term use. Hover ever, children below 6 years old and pregnant women are not recommended to consume. Individuals, who are on prescribed medications, check doctors before use due to possible drug interaction. In recent years, the fruit has been widely accepted by medical specialists and doctors. The consumers' testimonies have earned global acceptance of its core values to be one of the best health products in the market. Thus mahogany is not only famous for timber but also it is wonderful herbal drug for in human health system. The scientific reports confirmed therapeutic values of mahogany with standard procedure including animal test (Eid et al. 2013; Naveen et al. 2014).

**Establishment of plantation**

**Seed collection**

*Swietenia macrophylla* is propagated from seeds. The best outcomes can be achieved by using seeds from a mother tree in excellent form and health. Seed production fluctuates considerably from year to year (Mayhew and Newton, 1998). Flowering and fruiting regularly occur annually from 10 to 15 years of age. Flowering and fruiting seasons differ according to geographical location. For example, in the central and northern parts of South America, the tree blooms from April to June, and the fruits ripen from January to March of the following year (Schmidt and Joker, 2000).

In Indonesia, the flowering months are usually between July and September and the fruiting season is between December and February. Flowering usually takes place when trees are leafless or just coming into new leaf shortly before the rainy season. The fruits ripen during the dry season, when the trees begin to lose part of their foliage and the warm air dries the fruits and promotes dehiscence (Mayhew and Newton, 1998). The fruits are preferably collected from the ground immediately after seed fall or from the trees just before they open by climbing. Fruits should be harvested from the tree towards the middle or the end of the fruiting season. When the fruits are ripe, the pericarp changes to a light coffee colour just before the valves open and release the seeds.

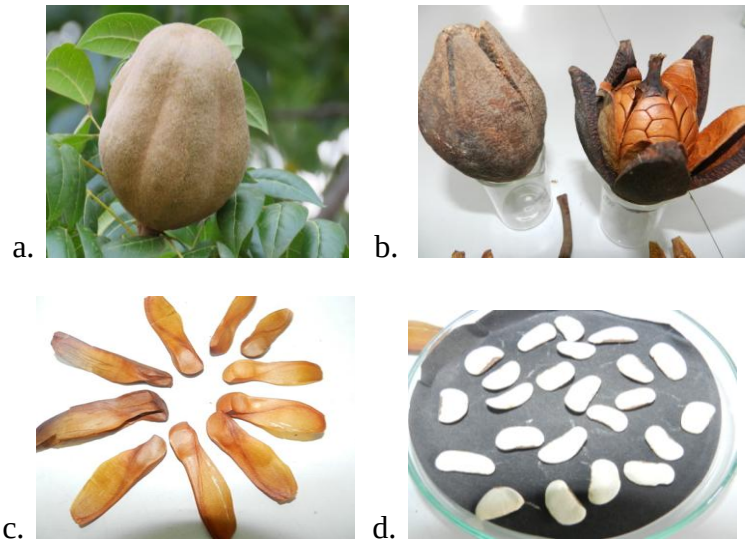


Fig 6 (a) Immature fruit (b) Mature Fruit (c) Winged seeds (d) Seeds

**Seed storage and viability**

Mature dry fruits or dry seeds (capsules) collected from the forest floor can be stored for some days in sacks without significant deterioration. Unripe capsules may need to be dried out first to encourage them to open. The capsules can be dried in the sun. Alternatively, capsules can be placed on a rack over electric lamps at a temperature of 38°C for 36-48 hours to encourage them to open. The length of time required for drying depends on the

ripeness of the capsule and ambient temperature and humidity. The fruits will split open when dried for 1-4 days, depending on maturity, after which the seeds are easily released by gentle shaking or raking of the fruits. Seed wings are removed by hand to facilitate handling and to reduce volume (Fig 6). The wing is broken 1cm above its base, and the seeds without wings are placed in a container (Mayhew and Newton 1998).

The viability of fresh *S. macrophylla* seeds is around 80–90%, although that for stored seeds can vary (Mayhew and Newton 1998). The seed viability also varies with size. For example, Chinte (1952) in Mayhew and Newton (1998) reported that large seeds have a 12% higher germination rate and produce healthier, faster-growing seedlings with better developed root systems than small seeds. Mayhew and Newton (1998) stated further that in general, *S. macrophylla* seed will not retain an acceptable level of viability if stored at room temperature and in humid conditions for more than about 3 months. Seeds of *S. macrophylla* are susceptible to chilling damage below about 16°C when they are moist. If they are to be refrigerated they have to be dried first. It has been reported that dried seeds refrigerated to 2-8 °C and maintained at constant humidity maintain viability for more than a year. If seeds are dried to a moisture content of 5% or less, deep freezing (at –20 °C) will maintain a high viability for at least 2 years and possibly many decades (Mayhew and Newton 1998).

**Seedling production**

The seeds are sown in a bed of light sand in furrows or holes 3-7 cm deep. Germinating seeds should be under shade and kept moist. The sowing density may vary depending on the desired size of the planting stock and whether or not transplanting is intended. As reported by Neil (1986) and Bauer (1987) *in* Mayhew and Newton (1998), to obtain seedlings of 30–60 cm in height, a square spacing of 10-15 cm is commonly recommended, and to obtain seedlings of 100 cm in height, a spacing of 20×30 cm is suggested. *Swietenia macrophylla* can also be sown in containers. Raising stock in containers may give a more fibrous root system and better results after planting out, but the cost may be high. Container planting stock may be more suitable for dry planting sites whereas bare-rooted stock are suitable for wet sites or sites that are subject to very strong winds (Soerianegara and Lemmens 1993).

**Preparation for planting out**

Good maintenance of *S. macrophylla* seedlings is essential for the production of healthy and fast-growing plants. Weeding should be conducted in the nursery in every 2-4 weeks until the seedlings are ready to be planted out. Chemical weeding is not possible in *S. macrophylla* as the seedlings are very sensitive to herbicide. Nurseries should also be thoroughly watered before seedlings are lifted to avoid straining or breaking the small fibrous roots (Busby 1967 *in* Mayhew and Newton 1998). Lifting and subsequent preparation of bare-rooted stock must take place as close to the planting date as possible to minimise the risk of desiccation. Root pruning in the nursery helps to create a more fibrous root system. Root pruning should be carried out about 4 weeks before lifting, but should not be done whilst seedlings are flushing (Mayhew and Newton, 1998).

The seedlings can be planted in the field when they are about 50-100 cm tall, when they are sufficiently strong and not tender and their fresh shoots have a chance to mature and harden. To increase the survival rate at the planting site, the seedlings should be handled carefully and roots kept moist. Some methods include wrapping the roots of the bundles in dry grass and soaking, putting bundles in wet sacks and putting individual plants in polythene bags, which are in turn placed in wet sacks to keep them cool (Lamb 1966). Bundles, bags or sacks should then be kept in the shade until planting out.

**Planting**

All weeds should be cleared from the planting sites. The close spacing can helps to reduce weeds growth and also serve to reduce the development of vigorous lateral branches. Spacing for planting *S. macrophylla* is usually 2-3 m. Wider spacing of about 4-5×4-5 m is also commonly applied by smallholders in South Kalimantan and Java in order to obtain multiple yields by intercropping the *S. macrophylla* trees with cassava, corn, peanut, pumpkin and other agricultural crops. In South Kalimantan, *Brachiaria decumbens* grasses are often planted under *S. macrophylla* trees to provide fodder for cattle.

**Plantation maintenance**

**Weeding**

Weeding is required to ensure maximum growth and survival of seedlings. Weeds that are as tall as or taller than the seedlings should be removed. During the first 2 years after planting, weeding and hoeing should be done 4 times every 6 months (Mindawati and Tata 2001). Either line weeding or ring weeding (in a 1m diameter around the seedling) is recommended. To prevent the regrowth of weeds, cut grass is placed as mulch around the seedlings (DIPF, 1990).

**Fertilising**

Fertilising *S. macrophylla* seedlings may reduce susceptibility to shoot borer damage by altering the chemical composition of the apical shoots and/or enhancing tolerance by improving vigour (Mayhew and Newton 1998). In Indonesia, fertilisers are usually applied after planting at a dose of 75-100 g NPK per plant in a ring around the seedlings (DIPF, 1990, Suharti et al. 1990, Mindawati and Tata 2001). In South Kalimantan, farmers often use organic fertiliser from animal waste.

**Replanting**

Replanting can be done twice during the rotation. The first replanting normally takes place in the rainy season at 1 month after planting to replace any dead seedlings and the second one is at the end of the second year. In large-scale plantations, further replanting may be necessary if the survival rate is less than 70% (DIPF, 1990).

**Pruning**

Pruning consists of removing dead or non-productive branches from the lower trunk to encourage the production of clear wood. It also reduces the risk of disease and pest infestations (e.g. shoot borer). Pruning is usually done for the first 3 years (DIPF, 1990); this is expected sufficient to reduce the threat of shoot borer as the moth usually attacks young trees only. The best time for pruning is just before the rainy season. Sometimes *S. macrophylla* trees have 2 or 3 stems during early growth at 6-9 months. In this case, pruning and singling should be done by removing the co-dominant stem. If the trees are not singled, the stem density might be too

high. In addition, multiple stems usually become tall and slender, and thus can easily be broken by rain or wind (Soerianegara and Lemmens 1993).

**Thinning**

The principal objective of thinning is to improve the growth of remaining trees with an acceptable form for the final crop. Trees selected for thinning should consist of diseased or pest-infested trees, deformed or poorly shaped trees and suppressed trees. Selective removal of damaged trees may help ensure that seeds produced by the final crop are genetically less susceptible or more tolerant to attack. Krisnawati *et al.* (2010) developed thinning scenarios for *S. macropylla* plantations and suggested that the time of the first thinning should be around 5-10 years, depending on site quality and initial stand density. The number of thinnings required in a rotation also varies depending on initial density and site quality. The interval period between thinnings is 5-10 years. In the scenarios proposed by Krisnawati *et al.* (2010), multiple thinnings are suitable only in stands planted at closer spacings (3 m × 3 m – 2 m × 3 m).

For stands with high initial planting density (spaced at 2m × 3 m), four thinnings in a rotation is recommended to obtain high timber volume at the end of the rotation. For intermediate initial density stands (spaced at 3 m × 3 m), two-three thinning appears to be essential for obtaining high timber volume, while in a wide spacing (4 m × 4 m) one thinning option is suitable. The intensity of thinning suggested by Krisnawati et al. (2010) should be heavier in the first thinning (45-55% of the standing trees removed) for high initial density in order to maintain high growth rates and shorten the rotation length. The intensity of subsequent thinnings should then be reduced gradually to 25–30%. For stand of low initial density (spaced at 4 m × 4 m) the suitable thinning intensity is about 30-43%.

**Control of pests and diseases**

The most destructive pest in *S. macrophylla* plantations is the shoot-borer *Hypsipyla robusta*. Attacks are most often noticed on saplings and pole size trees when terminal shoots show symptoms of dieback, which ultimately result in malformed trees. The larvae bore into the growing shoots of saplings, destroying the terminal bud and causing growth retardation and stem forking. Often, multiple leaders are formed. According to Morgan and Suratmo (1976), in Java young trees 3–6 years old and 2–8 m tall were the most severely attacked by shoot borer. This finding is supported by Suratmo (1977), who observed that about 90% of 3-year-old trees (2.5 m tall) were affected compared with only 5% of trees 14 years old and 13 m tall. Older trees are not susceptible to attack. At present, there is no effective method to control this insect. Extensive pruning until 3 years after planting may reduce the threat of shoot borer. Planting of trees repellent to the moth along the plantation border or in a mixed stand has also been suggested to prevent the arrival of moths for egg laying. In preliminary trials, planting of *Acacia mangium* around a *S. macrophylla* plantation prevented *H. robusta* infestation (Matsumoto et.al. 1997). Interplanting neem (*Azadirachta indica*) with *S. macrophylla* also reduced shoot-borer attacks (Suharti et al. 1995).

Minor pests observed in experimental plantings include the leaf-feeding

caterpillar *Attacus atlas* (Lepidoptera, Saturnidae) and the leaf cutter bee *Megachile* sp. (Hymenoptera, Megachilidae) (Matsumoto, 1994). The only disease noted in *S. macrophylla* is bark rot, which occurs at the base of the trunk. A lesion appears in the middle of the rainy season, spreads rapidly from the bottom upwards and often kills the trees by the end of the season. The lesion always appears on the stem surface facing the water flow along the slope and it is assumed that the pathogen arrives through water and enters through wounds. The causative organism remains unidentified (Soerianegara and Lemmens, 1993).

*Swietenia macrophylla* has great potential for reforestation and afforestation, particularly for improving soil. In the Philippines, the tree species is recommended for revegetation of scrubland and denuded areas (Soerianegara and Lemmens, 1993). In Indonesia, it is also used in agroforestry systems, for example in Java with maize, upland rice and cassava, and in our study village in South Kalimantan with cassava, corn, peanuts and pumpkin.

**Role of mahogany in Agroforestry and Tree –Outside -Forests**

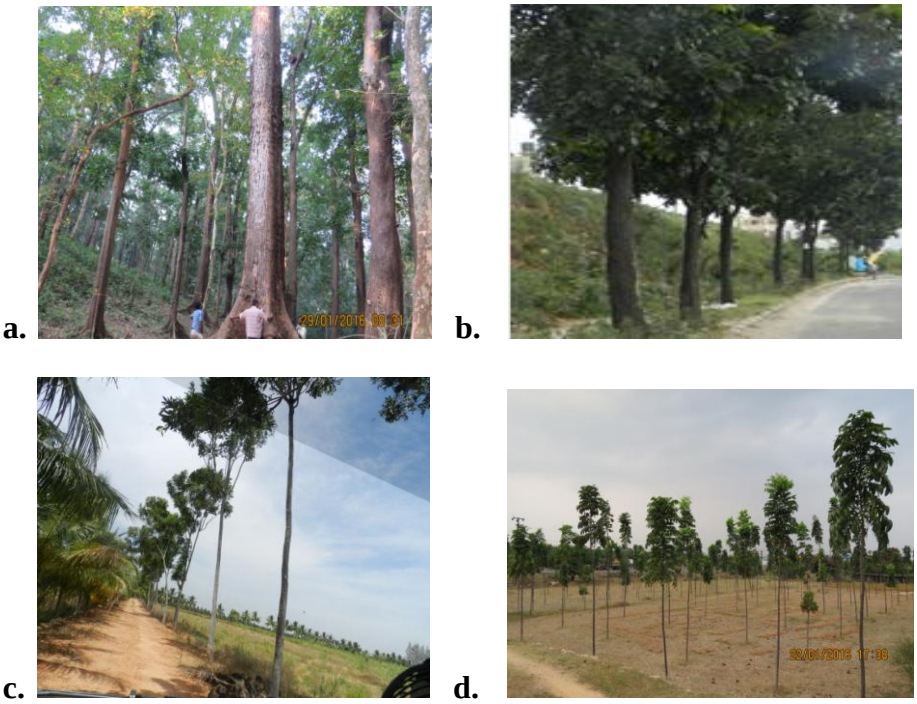


Fig 7 (a) Block plantation (b) Avenue tree (c) Bund plantation (d) Agroforestry system

**Growth and yield**

The ability to predict the growth and yield potential of *S. macrophylla* plantations is of considerable importance for plantation planning. However, relatively little reliable experimental data covering periodic stand measurement until the end of rotation are available. The information on growth and yield presented here is based on preliminary data of young *S. macrophylla* stands (up to 5 years old) collected from 76 temporary sample plots established in

smallholder plantations in South Kalimantan and some data from 6 permanent plots (covering an age range of 5–10 years) collected by Susila and Njurumana (2005) in *S. macrophylla* plantations in Nusa Tenggara. For older stands, information was taken from 36 permanent sample plots spreading over several sites in Java, which were collected by Forest Research Institute and used by Wulfing (1949) and updated by Suharlan et al. (1975) to develop preliminary stand yield tables for mahogany (combining both *S. macrophylla* and *S.mahagoni* species).

**Productivity**

*Swietenia macrophylla* plantations in Indonesia are predicted to reach a maximum volume mean annual increment (MAI) of 38.1 m3/ha/year in 15 years in the best sites, producing up to 572 m3/ha over the rotation and in medium-quality sites, a volume MAI of 19.7 m3/ha/year can be attained in 25 years, producing up to 493 m3/ha (Wulfing 1949). If the rotation is set to 30 years, stands growing in moderate sites can attain a mean height of 24.4 m and a mean diameter of 35.4 cm, producing a basal area of 30 m2/ha and total volume including thinning is 583 m3/ha. According to the scenarios proposed by Krisnawati *et al.* (2010) total timber volume (including thinning) yielded over the rotation of 15-30 years of age was between 200.5 and 501.6 m3/ ha with a mean annual volume increment of 7.7–19.3 m3/ha/year.

**Rotation**

Previously reported rotation lengths for *S. macrophylla* plantations were variable. Fattah (1992) reported that in the state-owned plantations in Java, the economic rotation for *S. macrophylla* plantations was defined to be around 30-50 years. In private farms of *S. macrophylla* plantations in the Philippines, Rodriguez (1996) suggested the harvesting time could be around 15-20 years of age. The desired rotation length may be guided by the time taken for the stands to reach their maximum mean annual volume increment (MAI) in volume. Mahogany plantation will reach the maximum mean annual volume increment at sometime between 15 and 50 years, depending on site quality. On other hand, Krisnawati et al. (2010) estimated the feasible rotation length for *S. Macrophylla* plantations in Indonesia is around 15-30 years of age, depending on site quality and initial stand density.

**References**

Alan Cambeira, Quisqueya La Bella (1997). The Dominican Republic in Historical and Cultural Perspective (M.E. Sharpe, 1997), p. 17.

Bauer, G. P. (1987). Reforestation with mahogany (*Swietenia* sp.) on Caribbean National Forest, Puerto Rico Taller de Seminarig de Cooperation y Manejo de Bosques Tropicals, Lima, Selva Central Pucal Peru.

Bauer, G.P. and Francis, J.K. (1998). *Swietenia macrophylla* King: Honduras mahogany, caoba, USDA Forest Service, SO-ITF-SM-81. 7p.

Bridgewater, Samuel. (2012). A Natural History of Belize: Inside the Maya Forest. Austin: University of Texas Press. Pp. 164-65.

Busby, R. J. N. (1967). Reforestation with large leaf mahogany (Swietenia macrophylla), Suva, Fiji, Department Forestry, 6p.

Directorate of Industrial Plantation Forests (1990). Teknik pembuatan tanaman *Swietenia macrophylla* King (Mahoni), Ministry of Forestry, Jakarta, Indonesia.

Donald R. Liddick, (2011). Crimes Against Nature: Illegal Industries and the Global Environment (ABC-CLIO, 2011), p. 104.

Eid, A. M. M., Marzugi, N. and Ali-El Enshasy (2013). Review on the phytopharmacological effect of Swietenia macrophylla, Int. J. Pharm. Sci, Vol 5, Suppl 3, 47-53.

Fattah, H.A. (1992). Mahogany forestry in Indonesia. In: Proceedings of Mahogany workshop: review and implications of CITES. 3–4 February 1992. Tropical Forest Foundation, Washington DC.

Krisnawati, H., Kallio, M. and Kanninen, M. (2011) *Swietenia macrophylla* King: ecology, silviculture and productivity. CIFOR, Bogor, Indonesia.

Krisnawati, H., Kanninen, M. and Kallio, M. (2010). Stand growth and management scenarios for mahogany (*Swietenia macrophylla*) plantations in Indonesia. Unpublished manuscript.

Lamb, F.B. (1966) *Swietenia macrophylla* of tropical America: its ecology and management. University of Michigan Press, Ann Arbor, Michigan, USA.

Marcelo M. Giugale and Vicente Fretes Cibils, (2007). An Opportunity for a Different Peru: Prosperous, Equitable, and Governable (World Bank Publications, 2007), p. 378.

Martawijaya, A. Kartasujana, I., Kadir, K. and Prawira, S.A. (2005). Atlas kayu Indonesia jilid I (edisi revisi). Pusat Penelitian dan Pengembangan Hasil Hutan, Bogor, Indonesia.

Matsumoto, K. (1994). Studies on the ecological characteristics and methods of control of insect pests of trees in forested area in Indonesia. Final report submitted to Forestry Research and Development Agency, Ministry of Forestry, Indonesia.

Matsumoto, K., Mulyadi, K. and Irianto, R.S.B. (1997). A promising method to protect mahogany plantation from attack by the shoot borer *Hypsipyla robusta* (Moore) (Lepidoptera: Pyralidae). JIRCAS Journal, 5: 23–29.

Mayhew, J. E. and Newton, A.C. (1998). The silviculture of *S. macrophylla*. CABI Publishing, New York.

Mindawati, N. and Tata, M.H. (2001). Aspek silvikultur jenis khaya, mahoni dan meranti. Prosedings Ekspose Pengembangan jenis tanaman potensial (khaya, mahoni dan meranti) untuk pembangunan hutan tanaman: 42–46.

Naveen, Y.P., Divya Rupini, G., Ahmed, F., Urooj. A. (2014). Pharmacological effects and active phytoconstituents of *Swietenia mahagoni*: a review. J Integr Med. 2014; 12(2): 86-93.

Neil, P.E., (1986). Swietenia macrophylla (mahogany) in Vanuatu. Forest Research Report No. 4/86. Vanuatu Forest Service, Port Villa, Vanuatu

Nikolas Kozloff, (2010). Rain in the Amazon: How South America's Climate Change Affects the Entire Planet (Macmillan, 2010).

Rodriguez, O. P. (1996). Managing mahogany plantations. *Greenfields*, 24 (3): 8–15.

Schmidt, L. and Jøker, D. (2000). *Swietenia macrophylla* King. Seed Leaflet No. 30, September 2000. Danida Forest Seed Centre, Denmark.

Soerianegara, I. and Lemmens, R. H. M. J. (1993). Plant resources of South-east Asia 5 (1): timber trees: major commercial timbers. Pudoc Scientific Publishers, Wageningen, Netherlands.

Suharti, M., Asmaliyah and Hawiati, W.P. (1995). Tanaman mimba (*Azadirachta indica*) sebagai sumber insektisida nabati

dalam pengendalian hama tanaman hutan. Buletin Penelitian, Hutan, 589: 1–26.

Suharti, S., Murniati, Sumarhani and Pradjadinata, S. (1990). Teknik pemupukan tanaman mahoni (*Swietenia macrophylla* King). Informasi Teknis No. 12. Pusat Penelitian dan Pengembangan Hutan, Bogor, Indonesia.

Suratmo, (1977). Infestation of the leading shoots mahogany (*Swietenia macrophylla* King) by Hypsipyla robusta Moore in West Java, Indonesia. BIOTROP Special Publication No. 2: 121–132. BIOTROP-SEAMEO, Bogor, Indonesia.

Susila, I.W.W. and Njurumana, G.N.D. (2005). Produktivitas tegakan hutan tanaman mahoni di Kanar, Sumbawa dan Takari, Kupang. Info Hutan, 2 (4): 273–279.

Victoria Day-Wilson, (2012). Living Abroad in Belize (Avalon Travel 2012), p. 14.

Wulfing, H.H.W.V. (1949). Preliminary yield table of Swietenia mahagoni/macrophylla. Pengumuman No 7. Lembaga Penelitian Kehutanan, Bogor.

# Phytoremediation by trees

**Shephali Sachan**
Forest Ecology and Rehabilitation Division
Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
P.O. – RFRC, Mandla Road, Jabalpur (M.P.)

The environmental pollution has become now a serious problem with the growing reasons like rapid industrialization, random urbanization, over exploitation of open spaces, ever-increasing number of automobiles and demographic pressure. According to World Health Organization (WHO) it has been estimated in year 2012 that there is 12.6 million deaths each year because of unhealthy environments. There are various ways and means to mitigate with the environmental pollution. The traditional technologies for removal of pollutants can be successful in specific situations, but costs associated with these technologies are very high. The biological technology is an active effort to develop new, more cost-effective methods to remediate the pollution. Bioremediation is one of those technique which employs use of microorganisms (Microbial remediation) and plants (Phytoremediation) to clean the environment by degrading, detoxifying, or sequestering toxic chemicals present in the environment. Proper planning and planting scheme depending upon the magnitude and type of pollution, selection of pollution-tolerant and dust scavenging trees and shrubs should be done for bioremediation of environmental pollution.

**What is Phytoremediation?**

Phytoremediation is one of the bioremediation technique in which plants are used for removal of contaminants from the polluted sites. Specially, selected or engineered plants are used in this process. Phytoremediation is actually a genneric term for several ways in which plants can be used to clean up contaminated site. Biotechnologies work applied to investigate the remediation capability of woody plants is increasing because of their long roots which penetrate deep into the ground. Small plants like ferns and grasses have been used where contamination is shallow. Because tree roots grow deeper, trees such as poplars and willows are used for hydraulic control or to clean up deeper soil contamination and contaminated groundwater. Some examples of phytoremediation by trees:-

- Dochinger (1973), a plant pathologist of USDA Forest Service, Ohio, reported that the filtering effects of evergreen trees are better than the deciduous trees.
- In the preliminary survey of dust fall on common roadside trees in Mumbai, carried out by Shetye and Chaphekar in 1989, reported that the shape of leaves of Mango (*Mangifera indica*), Ashoka (*Polyalthea longifolia*), Pongamia (*Derris indica*) and Umbrella (*Thespepsia populnea*) trees captured higher amounts of dust as compared to other neighboring plants.
- *Alstonia scholaris, Azadirachta indica, Melia azedarach, Butea monosperma, Grevillea*

*pteridifolia, Grevillea Robusta, Tamarindus indica* and *Terminalia arjuna are* the species directed to absorb noise pollution.

- *Alstonia scholaris, Lagerstroemia flosreginae, Mimusops elang, Cassia fistula, Bauhinia purpurea, Grevillea pteridifolia, Pongamia pinnata, Polyalthia longifolia, Peltoferrum ferrugineum, Cassia siamea, Melia azedarach, Delonix regia, Anthocephalus cadamba, Michelia champaca, Cassia siame* and *Others (Ornamental Plants)* recommended by Central Pollution Control Board (CPCB) for plantation along road borders and housing sites.
- The cultivation of *Dalbergia sissoo* as woody species may be extended to industrial and urban areas where industrial and municipal wastewater is the only source of irrigation.
- *Betula alnoides, Alnus nepalensis* and *Eucalyptus globulus*, are the trees recommended for the phytoremediation of mining-spoiled substrate.
- *Salix matsudana, S. fragilis*, and *S. purpurea* have been shown as the best metal-tolerant species.
- *Paulownia* spp ., introduced into North America and Europe, has been recently used for phytoremediation due to its ability to tolerate high concentrations of metals, strong transpiration rates, rapid growth, and high biomass production.
- The *Picea abies* species is resistant to aluminium.
- The glutathione reductase metabolism plays important role in the defence of poplar (*Populus deltoides* x *P. nigra*) against high zinc concentration.
- Phytoremediation potentials of poplar lines (*Populus nigra* and transgenic *P. canescens)* were investigated using *in vitro* leaf discs cultures and found that Zinc $^{2+}$ was phytotoxic only at high concentrations ($10^{-2}$ to $10^{-1}$ M) in all *P. canescens* lines, but *P. nigra* was more sensitive.
- *Eucalyptus globules* at moderate concentrations of metal were shown to either enhance or have no effect on rooting.
- Metal tolerance was detected in a callus culture established from *Acer rubrum* seedlings growing in soil contaminated by zinc, cadmium, nickel and arsenic.
- Transgenic white poplar has been recently obtained expressing the *PsMTa1* gene from *Pisum sativum* for a metallothionein-like protein. Transformed plants showed enhanced resistance to heavy metal, surviving high concentrations of $CuCl_2$ in *in vitro* culture, which strongly affected the nontransgenic plants.
- Increased tolerance to ionic mercury was first obtained in yellow poplar (*Lyriodendron tulipifera*) transformed with *mer-A* gene.
- For the remediation of Hg, *Populus deltoides* has been engineered with the bacterial *mer-A* (mercuric ion reductase) and *mer-B*, transgenic

trees expressing both genes showed tolerance up to 10 µM of phenylmercuric acetate.

**How Does It Work?**

- Plants remove or break down the harmful chemicals from ground when their roots take in water and nutrients from the contaminated site. Plants can help clean up contaminants as deep as their roots can reach using natural processes to:
    - Store the contaminants in the roots, stems, or leaves.
    - Converting them into less harmful chemicals within plant or, more commonly, the root zone.
    - Convert them to vapours, which are released into the air.
    - Sorb (stick) contaminants onto their roots where very small organisms called "microbes" (such as bacteria) that live in the soil break down the sorbed contaminants into less harmful chemicals.
- Phytoremediation is also used to slow the movement of contaminated groundwater. Trees act like a pump, drawing the groundwater up through their roots to keep it from moving. This method of phytoremediation is called "hydraulic control." It reduces the movement of contaminated groundwater toward clean areas offsite.
- Wetlands are created at a site to treat acid mine drainage that flows through it or as a final treatment step for water discharged into a lake or stream. The construction of wetlands may involve some excavation or regrading of soil at the site in order for water to flow through it without pumping. The area is planted with grasses and other vegetation typical of naturally occurring wetlands in the area. Water treated with constructed wetlands generally has very low concentrations of contaminants.

**History**

The ability of plants to remove contaminants from the polluted environment is about 300 years old. The phytoremediation technologies have been taking place naturally for over three centuries. Earlier this technique was used to have various applications like land farming of waste etc. During 1970s era and the following decades, plants were heavily tested and used to treat soil infiltrated with metals and contaminants in wetlands. As a result, this technique for metal tolerance is well established. In the 1980s federal and state governments, as well as non-governmental organizations began the use of phytoremediation. The use of the term phytoremediation was initiated by the Environmental Protection Agency (EPA) in 1991, and it was first used in open technical literature in 1993 by Cunningham and Berti. In the late 1990s new uses for phytoremediation were discovered, and it became known among innovative scientific technologies. Phytoremediation was derived from other fields such as agronomy, forestry, chemical and agricultural engineering, microbiology, and many others. Since its inception it has developed into an

independent field of study and a widely applicable technology. Research into and application of phytoremediation has flourished over the last 15 years. Phytoremediation has been implemented as a component of the selected remedy at 18 Superfund sites in the United States. Since 2001, the International Journal of Phytoremediation has been published quarterly. An international conference devoted to phytoremediation work has been convened seven times.

**Types of phytoremediation**

There are seven phytoremediation mechanisms, by which plants remediate from contaminated sites, i.e.:-

1. Phytoextraction
2. Rhizofilteration
3. Phytostabilization
4. Rhizodegradation
5. Phytodegradation
6. Phytovolatilization
7. Hydraulic Control

**Phytoextraction**

This is also called as phytoaccumulation, is the uptake of contaminants by plant roots and movement of the contaminants from the roots to aboveground parts of the plant. Contaminants are generally removed from the site by harvesting the plants. Phytoextraction accumulates the extremely elevated levels of contaminants in their stems and leaves. The technique is mostly applied to heavy metals like nickel, zinc, lead, chromium, cadmium, selenium, other heavy metals and radionuclides in soil, sediment, and sludges.

**Advantages**

- Compared with other remediation technologies, such as excavation, materials handling is limited (similar to those in normal agricultural processes).
- Costs are typically lower.
- Usually the technology leaves the soil fertile and able to support subsequent vegetation.

**Disadvantages**

- Technology is longer than other technologies: several crops are usually required to remove all the contaminants to the desired levels.
- Accumulation of contaminants in the aboveground part of the plants may pose a risk to animals eating these plants and fences may be needed to deter grazing animals.

**Examples**

- EDDS (Ethylene-diamine- *N*, *N* ′-disuccinic acid) chelating agents might enhance the removal of Cd, Cu, and Zn by *Salix dasyclados* .
- *Betula pendula* plants were used for the monitoring of uranium mining dumps and following heavy metal accumulation capability of *B. pendula* was found in order: Cd > Mn > Zn > Pb > Cu > Ni > Fe.
- *Betula* and *Salix* species grown in (pot) field conditions may be useful for phytoextraction as they are able to mobilize reasonably high concentrations of metals to their aboveground parts.
- Bioindication and phytoextraction potentials of poplars (*Populus nigra* × *maximovitzii* × *P. nigra var. Italica*; *Populus* × *euramericana*; *P. deltoides*) for Cd and Ni were investigated using hydroponic cultures under glasshouse conditions.
- Hybrid poplar trees were used in a field study in mine tailing wastes contaminated with As and Cd.

**Rhizofiltration**

Rhizofiltration is the adsorption or precipitation onto plant roots, or absorption into the roots of contaminants that are in solution surrounding the root zone, due to biotic or abiotic processes. Exudates from the plant roots might cause precipitation of some metals. Rhizofiltration first results in contaminant containment, in which the contaminants are immobilized or accumulated on or within the plant. Contaminants are then removed by physically removing the plant. This technique is used to remediate hydrophobic organic chemicals, heavy metals and radionuclides.

**Advantages**

- This system can be either *in situ* (floating rafts on ponds) or *ex situ* (an engineered tank system).
- An *ex situ* system can be placed anywhere because the treatment does not have to be at the original location of contamination.

**Disadvantages**

- The chemical speciation and interaction of all species in the influent have to be understood and accounted for.
- Also well-engineered and proper maintenance of system is required to control influent concentration, flow rate, periodic harvesting and plant disposal.

**Examples**

- Terrestrial plants can be grown and used hydroponically in rhizofiltration systems. These plants generally have a greater biomass and longer, faster growing root systems than aquatic plants. Seedlings have been proposed for use instead of mature plants because seedlings do not require light or nutrients for germination and growth for up to 2 weeks**.**
- Wetland plants can be used in engineered or constructed beds to take up or degrade contaminants. Hydroponically-grown plants concentrated Pb, Cr (VI), Cd, Ni, Zn, and Cu onto their roots from wastewater. Lead had the highest bioaccumulation coefficient, and zincs the lowest.
- The most commonly used are willows and poplars, which can grow 6 - 8’ per year and have a high flood tolerance. For deep contamination, hybrid poplars with roots extending 30 feet deep have been used.

**Phytostabilization**

Phytostabilization is defined as immobilization of a contaminant in soil through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants, and the use of plants and plant roots to prevent contaminant migration via wind and water erosion, leaching, and soil dispersion. This technique is used to remediate from phenols, chlorinated solvents (tetrachloromethane and trichloromethane) and hydrophobic organic compounds along with heavy metals in mine tailing ponds.

**Advantages**

- Phytostabilization can change metal solubility and mobility or impact the dissociation of organic compounds.
- Plants can also be used to reduce the erosion of metal contaminated soil.

- The term phytolignification has been used to refer to a form of phytostabilization in which organic compounds are incorporated into plant lignin.

**Disadvantages**

- Contaminants remain in place.
- The vegetation and soil may require long-term maintenance to prevent rerelease of the contaminants and future leaching.

**Examples**

- *Acacia mangium* with the addition of organic fertilizer is the best option for phytostabilization of Pb-contaminated mine tailing because it retained higher Pb concentration in the roots.
- Australian native *Acacia pycnantha* and *Eucalyptus camaldulensis* plants have phytostabilization ability for Cu and other metals (Na, Al, K, Ca, Fe, Zn, Cd and Pb).
- Poplar trees represent one vegetation option for phytostabilization of heavy metal-contaminated sites.

**Rhizodegradation**

Rhizodegradation is the breakdown of an organic contaminant in soil through microbial activity that is enhanced by the presence of the root zone. Rhizodegradation is also known as plant-assisted degradation, plant-assisted bioremediation, plant-aided *in situ* biodegradation, and enhanced rhizosphere biodegradation. This technique is used to remediate polyaromatic hydrocarbons, BTEX (benzene, toluene, ethylbenzene, xylene), and other petroleum hydrocarbons, perchlorate, atrazine, alachlor, polychlorinated biphenyl (PCB), and other organic compounds.

**Advantages**

- Translocation of the compound to the plant or atmosphere is less likely than with other phytoremediation technologies since degradation occurs at the source of the contamination.
- Mineralization of the contaminant can occur.
- The technique needs low installation and maintenance cost as compared to other remedial options.
- **Disadvantages**
- Development of an extensive root zone requires substantial time.
- Root depth can be limited due to the physical structure or moisture conditions of the soil.
- The plants need additional fertilization because of microbial competition for nutrients.
- The exudates might stimulate microorganisms that are not degraders, at the expense of degraders.
- **Examples**
- Hybrid poplar tree (*Populus deltoides* X *nigra* DN-34, Imperial Carolina) rhizosphere soil contained significantly higher populations of total heterotrophs, denitrifiers, pseudomonads, BTX degraders, and atrazine degraders than did nonrhizosphere soil.
- Rhizodegradation of perchlorate by willow trees (*Salix nigra*) was biostimulated using electron sources obtained from natural and artificial carbon sources.

**Phytodegradation**

Phytodegradation (also known as Phytotransformation) is the breakdown of

contaminants taken up by plants through metabolic processes within the plant, or the breakdown of contaminants external to the plant through the effect of compounds (such as enzymes) produced by the plants. Any degradation caused by microorganisms associated with or affected by the plant root is considered rhizodegradation. The technique is used to remediate munitions (TNT-2, 4, 6-trinitrotoluene, DNT- 2, 4-Dinitrotoluene, HMX-High Melting Explosive, nitrobenzene, picric acid, nitrotoluene), atrazine, halogenated compounds (tetrachloromethane, trichloromethane, hexachloroethane, carbon tetrachloride, TCE (trichloroethylene), tetrachloroethane, dichloroethane, DDT (Dichlorodiphenyltrichloroethane) and other chlorine and phosphorus based pesticides, phenols, and nitrites.

**Advantages**

- Contaminant degradation due to enzymes produced by a plant can occur in an environment, free of microorganisms (for example, an environment in which the microorganisms have been killed by high contaminant levels).
- Plants are able to grow in sterile soil and also in soil that has concentration levels that are toxic to microorganisms. Thus, phytodegradation potentially could occur in soils where biodegradation cannot.

**Disadvantages**

- Toxic intermediates or degradation products may form. In a study unrelated to phytoremediation research, PCP (pentachlorophenol) was metabolized to the potential mutagen tetrachlorocatechol in wheat plants and cell cultures.
- The presence or identity of metabolites within a plant might be difficult to determine; thus contaminant destruction could be difficult to confirm.

**Examples**

- The nitroreductase enzyme has also been identified in other algae, ferns, monocots, dicots, and trees.
- Degradation of TCE has been detected in hybrid poplars and in poplar cell cultures, resulting in production of metabolites and in complete mineralization of a small portion of the applied TCE. Atrazine degradation has also been confirmed in hybrid poplars (*Populus deltoides* x *nigra* DN34, Imperial Carolina). Poplars have also been used to remove nutrients from groundwater.
- Black willow (*Salix nigra*), yellow poplar (*Liriodendron tulipifera*), bald cypress (*Taxodium distichum*), river birch (*Betula nigra*), cherry bark oak (*Quercus falcata*), and liveoak (*Quercus viginiana*) were able to support some degradation of the herbicide bentazon.

**Phytovolatilization**

Phytovolatilization uses plant to uptake and then volatize the contaminants through transpiration process. The contaminants release in the atmosphere as it is or in a modified form by uptake, plant metabolism, and plant transpiration. Phytovolatilization can occur with Phytodegradation process. This technique is used to remediate chlorinated solvents (tetrachloromethane and trichloromethane), organic VOC's (volatile

organic compounds), BTEX (benzene, toluene, ethylbenzene and xylene), MTBE (methyl tert-butyl ether) and heavy metals like mercury and selenium.

**Advantages**

- Contaminants could be transformed to less-toxic forms, such as elemental mercury and dimethyl selenite gas.
- Contaminants or metabolites released to the atmosphere might be subject to more effective or rapid natural degradation processes such as photodegradation.

**Disadvantages**

- The contaminant or a hazardous metabolite (such as vinyl chloride formed from TCE-trichloroethylene) might be released into the atmosphere. One study indicated TCE transpiration, but other studies found no transpiration.
- The contaminant or a hazardous metabolite might accumulate in vegetation and be passed on in later products such as fruit or lumber. Low levels of metabolites have been found in plant tissue.

**Examples**

- University of Washington researchers have extensively studied the use of poplars in the phytoremediation of chlorinated solvents. In these studies, transformation of TCE was found to occur within the tree.
- Black locust species were studied for use in remediating TCE in groundwater.

**Hydraulic Control**

Hydraulic control uses the plants to remove groundwater through uptake and consumption in order to contain or control the migration of contaminants. Hydraulic control is also known as phytohydraulics or hydraulic plume control.

**Advantages**

- Cost of this technique is low.
- Roots will penetrate into and be in contact with a much greater volume of soil.

**Disadvantages**

- The rate of water uptake will not be constant, affected by climatic and seasonal conditions.
- Water uptake by deciduous trees will slow considerably during winter.
- Groundwater removal is limited by the root depth of the vegetation.

**Examples**

- Hybrid poplar trees were used at seven sites in the East and Midwest to contain and treat shallow groundwater contaminated with heavy metals, nutrients, or pesticides.
- Poplars were used at a site in Utah to contain groundwater contaminated with gasoline and diesel.
- Passive gradient control was studied at the French Limited Superfund site using a variety of phreatophyte trees; native no deciduous trees were found to perform the best.

**Advantages of phytoremediation**

- It is cheap and affordable on grand scale needed for marginal land reclamation and cleaning the water bodies.
- More economically viable using the same tools and supplies as agriculture.

- It is less disruptive to the environment.
- Plants help to prevent wind, rain, and groundwater flow from carrying contaminants away from the site to surrounding areas or deeper underground.
- Plants also help to mitigate with the conditions arising by climate change like increasing global warming and abiotic stresses.
- It is more likely to be accepted by the public as it is more aesthetically pleasing then traditional methods.
- It avoids excavation and transport of polluted media thus reducing the risk of spreading the contamination.
- It has the potential to treat sites polluted with more than one type of pollutant.

**Disadvantages of phytoremediation**

- It is dependant on the growing conditions required by the plant (i.e. climate, geology, altitude, temperature).
- Large scale operations require access to agricultural equipment and knowledge.
- Time needed to perform researches on various plant species (trees, shrubs, herbs and grasses seperately) in order to prepare list of species specific contaminate/pollutant dealing ability.
- Success is dependent on the tolerance capability of the plant to the pollutant.
- Contaminants collected in senescing tissues may be released back into the environment in autumn.
- Contaminants may be collected in woody tissues used as fuel.
- Time needed to remediate sites exceeds that of other technologies.
- Contaminant solubility may be increased leading to greater environmental damage and the possibility of leaching.

The present prevailing conditions arising due to strong effects of increasing environmental pollution all over the world requires a solution which again do not have any negative impact on environment. Phytoremediation is such technique which uses plants to clean up pollution in the environment on one hand and planting them will afforest the land on the other hand. There is well known fact that every plant is bestowed with some or the other economical important attributes. Raising plantations will also reverse the related economic loss. There is a growing need for changing the approach of planting trees and other plant species. Inclusion of the ornamental plants having pollution mitigating ability in the landscape plan will serve the duel purpose of making the cities green and pollution free in the long run. Plants can help clean up many kinds of pollution including metals, pesticides, explosives, and oil. Phytoremediation is a low cost, solar energy driven and natural cleanup technique, however, the success of phytoremediation at a given site cannot always be attributed when there is very complex situation; in that case combination of several techniques should be applied.

**References**

Yifru, D. D. and Nzengung, V.A. (2008). Organic carbon biostimulates rapid

rhizodegradation of perchlorate. Environmental Toxicology and Chemistry, 27 (1): 2419–2426.

Pierzynski, G. M., Schnoor, J. L., Youngman, A. and Licht, L. (2002). Poplar trees for phytostabilization of abandoned Zinc-Lead smelter. Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management, 6 (3): 177.

Decision Tree Document. (1999). Phytoremediation Decision Tree. The Interstate Technology and Regulatory Cooperation Work Group, Washington, DC.

Nirola, R., Megharaj, M., Palanisami, T., Aryal, R., Venkateswarlu, K. and Naidu, R. (2015). Evaluation of metal uptake factors of native trees colonizing an abandoned copper mine – a quest for phytostabilization. Journal of Sustainable Mining, 14(3): 115–123.

Meeinkuirt, W., Pokethitiyook, P., Kruatrachue, M., Tanhan, P. and Chaiyarat, R. (2012). Phytostabilization of a Pb-contaminated mine tailing by various tree species in pot and field trial experiments. Int J Phytoremediation, 14(9): 925-38.

Capuana, M. (2011). Heavy metals and woody plants - biotechnologies for phytoremediation. iForest, 4: 7-15.

Meers, E., Vandecasteele, B., Ruttens, A., Vangronsveld, J.and Tack, F.M.G. (2007). Potential of fi ve willow species (*Salix* spp.) for phytoextraction of heavy metals. Environ Exp Bot, 60: 57–68.

Shetye, R. P., and S. B. Chaphekar. (1989). Some estimation on dust fall in the city of Bombay, using plants, Vol. 4: pp. 61-70: In Progress in Ecology, Dochinger, L. S. 1973. Miscellaneous Publication No.1230, USDA, Forest Service, Upper Darby, Pa.

Wuana, R. A., Okieimen, F. E. and Imborvungu, J. A. (2010). Removal of heavy metals from contaminated soil using chelating organic acids. Int. J. Environ. Sci. Tech., 7: 485-496.

Etim, E. E. (2012). Phytoremediation and Its Mechanisms: A Review. International Journal of Environment and Bioenergy, 2(3): 120-136.

McCutcheon, L. E., Ashe, D. D., Houran, J. and Maltby. J. (2003). A cognitive profile of individuals who tend to worship celebrities. The Journal of Psychology, 137: 309-322.

Tsao, D.T. (2003). Overview of phytotechnologies, Vol. 78, pp. 1–50: In Advances in Biochemical Engineering/Biotechnology: Phyto remediation, Scheper, T. and Tsao, D.T. (eds.) Springer-Verlag, Berlin, Germany.

Kumar, S.R., Arumugam, T., Anandakumar, C.R., Balakrishnan, S. and Rajavel, D.S. (2013). Use of Plant Species in Controlling Environmental Pollution- A Review. Bull. Env. Pharmacol. Life Sci., 2 (2): 52- 63.

Pajević, S., BoriševM., Nikolić, N., Arsenov, D.D., Saša Orlović, S. and Župunski, M. (2016). Phytoextraction of Heavy Metals by Fast- Growing Trees: A Review, 29: In Phytoremediation, Ansari, A.A. et al. (eds.) Springer International Publishing, Switzerland.

Environmental Protection Agency (EPA), (2000). A Citizen's Guide to Phytoremediation, pp. 6, United States.

Sharma, S. and Pathak, H. (2014). Basic techniques of phytoremediation. International Journal of Scientific & Engineering Research, 5(4): 584.

# कैसे करें वृक्षारोपणः तकनीक एवं लाभ

**ममता पुरोहित, राजेश कुमार मिश्रा एवं नितिन कुलकर्णी**

उष्णकटिबंधीय वन अनुसंधान संस्थान

(भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद, पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार)

मण्डला रोड, ज़बलपुर – 482021 (म.प्र.)

तीव्र गति से बढ़ती जनसँख्या और विकास के नाम पर हुए औद्योगिकीकरण, शहरीकरण, वाहनों की संख्या व सड़क निर्माण के लिये हुई वृक्षों की अंधाधुंध कटाई की भरपाई के लिये वृक्षारोपण को भुला दिया गया परिणामस्वरुप इमारती लकड़ी, जलाऊ लकड़ी तथा वनोपज आधारित उद्योगों की

**वृक्षारोपण हेतु तैयार पौध**

मांग पूरी करने के लिये वनों पर दबाव बढ़ने लगा। पृथ्वी पर पारिस्थितिकी तंत्र के संतुलन के लिये आवश्यक वन क्षेत्रों के घटने से ग्रीन हाउस गैसों के उत्सर्जन में लगातार वृद्धि हो रही है जिससे ग्लोबल वार्मिंग की विकट समस्या खड़ी हो गई है। ग्रीन हाउस गैसों के उत्सर्जन व ग्लोबल वार्मिंग के कारण नई-नई बीमारियाँ हो रही हैं। ग्लोबल वार्मिंग के कारण तापमान में लगातार वृद्धि हो रही है जिससे ग्लेशियरों के पिघलने की रफ्तार प्रति वर्ष बढ़ रही है। जलवायु परिवर्तन से वन्य जीवों व वनस्पतियों की अनेक प्रजातियाँ लुप्त हो गई हैं तथा अनेक प्रजातियाँ लुप्त होने की कगार पर हैं। कहीं अतिवर्षा से बाढ़ तो कहीं सूखा से नदियाँ, सरोवर, ताल आदि सूख रहे हैं जिससे भूमिगत जलस्तर बहुत नीचे पहुँच गया है। भूमि की उर्वरा शक्ति घटने से कृषि उपज प्रभावित हुई है। वायु प्रदूषण बढ़ने से मानव स्वास्थ्य पर प्रतिकूल प्रभाव पड़ रहा है। राजस्थान जैसे क्षेत्रों में रेगिस्तान का फैलाव हो रहा है।

इन सब दुष्परिणामों से बचने के लिये तथा वन सम्पदा को पुनः स्थापित करने व बढ़ाने के उद्येश्य से सन् 1950 में तत्कालीन कृषि मंत्री श्री के. एम. मुंशी द्वारा वृक्षारोपण कर वन महोत्सव का शुभारंभ किया गया। तब से प्रतिवर्ष पूरे देश में जुलाई के प्रथम सप्ताह में वृक्षारोपण कर वन महोत्सव मनाया जाता है। जन चेतना से पौध रोपण एवं रोपण पश्चात पौध सुरक्षा द्वारा वृक्षारोपण कार्यक्रम को सफल बनाने के लिये आवश्यक जानकारी निम्नानुसार है।

**वृक्षारोपण तकनीक**

- पौध रोपण हेतु सबसे पहले वृक्षारोपण स्थल का चुनाव करने के लिये भूमि का सर्वेक्षण करें।

- सर्वेक्षण द्वारा भूमि का चयन कर मिट्टी की गुणवत्ता की जांच हेतु मिट्टी परीक्षण करें तथा मृदा प्रोफाइल हेतु कम से कम 1 मीटर गहरा गड्ढा खोदें।
- चयनित भूमि के अनुसार वृक्ष प्रजातियों का चयन करें।
- वृक्ष प्रजातियों के चयन के पश्चात पौध रोपण हेतु नक्शा तैयार करें।
- नक्शा तैयार करने के बाद जुताई द्वारा भूमि को समतल करें, घांस-पतवार जड़ से


**वन महोत्सव कार्यक्रम**

अलग करें तथा मिट्टी के ढेले फोड़कर भूमि को भुरभुरा बना दें।

- सिंचाई द्वारा मिट्टी को नम कर दें।
- जल निकास की व्यवस्था उत्तम हो।
- पौध रोपण हेतु वृक्ष प्रजाति की आवश्यकता अनुसार पौधे से पौधे व पंक्ति से पंक्ति की दूरी का निर्धारण करें।
- पौध प्रजाति की आवश्यकतानुसार उचित माप के गड्ढे तैयार करें।
- माह मई के दौरान गड्ढे खुद जाना चाहिए जिससे सूर्य की किरणों तथा गरम वायु से हानिकारक सूक्ष्म जीवाणु नष्ट हो जायें, खुदी हुई मिट्टी भुर-भुरी हो जाये तथा गड्ढों में ऑक्सीजन का उचित संचार हो।
- गड्ढे से निकली तथा धूप द्वारा उपचारित मिट्टी में गोबर की पकी खाद, जैविक खाद, कीटनाशक व रेत उचित अनुपात में मिलाकर भुरभुरा मृदा मिश्रण तैयार कर लें।
- वारिश की एक या दो बौछारों के बाद रोपण कार्य प्रारंभ करें।
- रोपण करते समय पौधा एकदम सीधा हो तथा उसके चारों तरफ मृदा मिश्रण अच्छी तरह दबा-दबा कर भर दें।
- जानवर आदि से बचाने के लिये पौधे के चारों तरफ काटों वाले तार की बाड़ी, ट्री गार्ड, ईंट की जुड़ाई से बना घेरा, कांटों वाली वृक्ष प्रजातियों का घेरा आदि बनायें।
- रोपण पश्चात आवश्यकतानुसार कीटनाशक एवं फंफूदनाशक दवाओं के घोल का छिड़काव करें या शुष्क पाउडर के रूप में उपयोग करें।

**पौधों की देखभाल**

- पौधे के चारों तरफ 50 से.मी. की गुलाई में थाला बनाकर निंदाई-गुड़ाई करें।
- समय-समय पर गोबर की पकी खाद डालते रहें।
- मरे हुए पौधों के स्थान पर स्वस्थ्य एवं जीवित पौधे लगायें।
- गर्मी में आवश्यकतानुसार सिंचाई करते रहें।
- आवश्यकतानुसार शाखाओं की कटाई-छटाई करें।

- उपरोक्तानुसार कार्य करने से पौधों की उचित वृद्धि होगी, कीट व रोगों की रोकथाम से पौधा स्वस्थ्य व गुणवत्तापूर्ण होगा तथा पूर्ण वृद्धि प्राप्त वृक्ष से वन उपज मिलने के साथ-साथ पर्यावरण सुधार होगा एवं प्रदूषण की रोकथाम होगी।

**जागरुकता बढ़ाने हेतु**

- किसान वर्ग एवं ग्रामीणों का जीवन आर्थिक रूप से उन्नत बनाने में वृक्षारोपण तथा वानिकी के महत्व के प्रति उन्हें जागरुक करना।
- इच्छुक किसानों एवं ग्रामीणों को रोपणी व वृक्षारोपण की तकनीकी जानकारी देने के लिये प्रशिक्षण देना।

**वृक्षारोपण अभियान**

- पर्यावरण, वन, प्रदूषण, बढ़ती जनसंख्या के कारण उत्पन्न समस्याओं आदि से संबंधित फिल्म, पोस्टर, चार्ट, संगोष्ठियों आदि के द्वारा किसानों और ग्रामीणों को जागरुक करना।
- वन अनुसंधान संस्थानों के प्रयोगात्मक एवं प्रदर्शन क्षेत्रों का भ्रमण करवाकर वानिकी के विभिन्न पहलुओं की जानकारी देना।
- चुनी हुई बहुउद्देशीय वृक्ष प्रजातियों व अन्य लाभकारी पादप प्रजातियों के उन्नत किस्म के पौधे व अन्य रोपण सामग्री जैसे कंद, कटिंग, जड़ चूषक आदि उपलब्ध कराकर खेतों की मेड़ों, घर के चारों तरफ बाड़ी, गांव की परती भूमि में वृक्षारोपण करवाना तथा समय-समय पर जाकर निरीक्षण करना, सुझाव देना व समस्या का समाधान करना।
- देश के सफल वृक्षारोपण क्षेत्रों व कृषि वानिकी प्रारुपों का भ्रमण करवाना, संबंधित पहलुओं की जानकारी देना व उनके क्षेत्रों में वृक्षारोपण व कृषि वानिकी प्रारुपों को अपनाने के लिये विचार-विमर्श करना।
- किये गये वृक्षारोपण क्षेत्रों से मिलनेवाली वनोपज की बिक्री के लिये व्यवस्था करना।
- विद्यार्थियों को वृक्षारोपण तथा वृक्ष सुरक्षा के लिए प्रोत्साहित करना।

इस प्रकार जब किसानों को व ग्रामीणों को वृक्षारोपण व कृषि वानिकी से प्रत्यक्ष लाभ (जलाऊ लकड़ी, चारा, इमारती लकड़ी, अन्य लघु वन उपज, रोजगार, कृषि वानिकी से दोहरी फसल का लाभ) व अप्रत्यक्ष लाभ (पर्यावरण सुधार, मिट्टी एवं जल संरक्षण) मिलने लगेगा तो वे अन्य किसानों व ग्रामीणों को वृक्षारोपण हेतु प्रोत्साहित करेंगें।

**वृक्षारोपण से लाभ**

- वृक्षारोपण से धरती की हरियाली और उसका सौन्दर्य पुनः स्थापित हो सकेगा । वृक्ष

प्राकृतिक सौन्दर्य प्रसाधन हैं। हरे-भरे वृक्षों से आच्छादित भूक्षेत्र को देखकर मन सौन्दर्य बोध से जागृत हो जाता है और वृक्षारोपण के लिये प्रोत्साहित होता है।

- वनों की कमी के कारण पारिस्थितिकी संतुलन बिगड़ जाता है। अतः वृक्षारोपण से पारिस्थितिकी तंत्र में सुधार होगा।
- नदियों के तटों पर लगे वृक्ष भूमि के कटाव को रोकने में सहयोग प्रदान करते हैं। वृक्ष नदी के प्रवाह से मिट्टी के बहने को रोक लेते हैं।
- वृक्षों के द्वारा मरुस्थल का फैलाव भी रुक जाता है इसलिये राजस्थान के रेगिस्तानी क्षेत्रों में व्यापक रूप से वृक्षारोपण कार्यक्रम प्रारंभ किये गये हैं।
- वृक्षों से फल, गोंद, इमारती लकड़ी आदि बहुमूल्य वनोपज प्राप्त होती है। वृक्षारोपण कार्यक्रम के द्वारा भविष्य में इन वन उत्पादों की उपलब्धता बनी रहेगी।
- वनस्पति जगत का हर पौधा आयुर्वेद की दृष्टि से महत्वपूर्ण है अर्थात वृक्ष/वनस्पतियाँ हमें औषधियाँ प्रदान करते हैं। आयुर्वेदिक दवाइयों का प्रचार-प्रसार पाश्चात्य देशों में भी हो रहा है। अतः विभिन्न प्रकार की जड़ी-बूटियों से रोजगार एवं राजस्व बढ़ेगा।
- वृक्षों से हमें ऑक्सीजन मिलती है जो मानव तथा प्राणी जगत के लिये प्राणवायु है। दूसरी ओर वृक्ष कार्बन डाई ऑक्साइड जैसी जहरीली गैस का शोषण कर लेते हैं जो मानव तथा प्राणी जगत के लिये हानिकारक है।
- आज नगरों में बढ़ते उद्योगों और वाहनों से वायु प्रदूषण बहुत हानिकारक होता जा रहा है। वृक्षारोपण से वातावरण शुद्ध होगा एवं वायु प्रदूषण से मुक्त होगी जिससे मानव के स्वास्थ्य पर अनुकूल असर पड़ेगा।
- ग्रीन हाउस गैसों के उत्सर्जन में लगातार कमी होगी जिससे ग्लोबल वार्मिंग की समस्या का समाधान होगा।
- ग्लेशियरों के पिघलने की गति कम होने लगेगी।
- जलवायु परिवर्तन में सुधार से वन्य जीवों व वनस्पतियों की प्रजातियाँ लुप्त होने से बचेंगी।
- अतिवर्षा व सूखा की समस्याऐं दूर होंगी तथा भूमिगत जलस्तर में सुधार होगा।
- भूमि की उर्वरा शक्ति बढ़ने से कृषि उत्पादन बढ़ेगा।

**पूर्ण वृद्धि प्राप्त वृक्षारोपण**

शासन द्वारा वृक्षारोपण कार्यक्रम को गति देकर मानव ही नहीं वरन प्राणीमात्र के हितों की रक्षा की जा रही है। स्वार्थी तत्वों द्वारा वृक्षों की अंधाधुंध कटाई मानव एवं प्राणी मात्र के जीवन के लिए कुठाराघात है। अतः हर व्यक्ति को कम से कम एक पौधा लगाकर वृक्ष बनने तक उसकी सुरक्षा का

दायित्व अपने ऊपर लेना चाहिए ताकि वृद्धि पश्चात वृक्षों से होने वाले लाभों से आने वाली पीढ़ियाँ वंचित न रह सकें। आमजन, छात्र-छात्राओं व अन्य सभी को अपने-अपने घरों व आसपास के खुले स्थानों, विद्यालय परिसर तथा उपलब्ध सरकारी व निजी भूमि में आवश्यक रूप से वृक्षारोपण करना चाहिए तथा जन-जन में वृक्षारोपण की चेतना जागृत करना चाहिए।

# Bee keeping and honey collection as income generation activities of tribal people in Achanakmar-Amarkantak biosphere reserve

**N. Roychoudhury and Rajesh Kumar Mishra**
Tropical Forest Research Institute
(Indian Council of Forestry Research & Education, Ministry of Environment, Forests and Climate Change, Govt. of India)
Jabalpur – 482021, Madhya Pradesh, India

Bees are the most efficient pollinators of several agricultural, horticultural, silvicultural, fodder and wild plants. The Apidae (Hymenoptera), is the main honey-producing family, its four species, *Apis dorsata*, *Apis indica*, *Apis florea* and *Apis mellifera* are most popular with bee keeping industry. Honey bees are not only important for their honey but are also of paramount importance to forest production and plant diversity, as pollinators. Honey bees stimulate germination of pollen on stigma, increase viability of seeds, stimulate faster growth of trees, increases number and sizes of seeds and yield of trees, increases fruit set and reduces fruit drop. Among the four species, *Apis mellifera* is the only most abundant ecologically important introduced pollinator and is mostly managed for honey production. This practice is very common in Achanakmar-Amrakantak biosphere reserve (Fig. 1). The tribal people used to carry out bee keeping at their house or near to the forest area and collect honey for their consumption or directly going to the market to earn money.

**Fig. 1: Bee keeping, *A. mellifera***

*Apis dorsata*, the giant honey bee, is found mainly in forested areas. They are typically around 17–20 mm (0.7–0.8 in) long. Bee hives are mainly built in exposed places far off the ground, like on tree limbs, under cliff overhangs, and sometimes on buildings (Fig. 2). These social bees are known for their aggressive defense strategies and vicious behavior when disturbed. Indigenous peoples, mostly tribal of Achanakmar-Amarkantak biosphere reserve have traditionally used this species as a source of honey and beeswax, a practice known as honey hunting. Tribal people of Achanakmar-Amarkantak biosphere reserve collect honey from the forest areas and going to the market to earn money. Recently, Self Help Group (SHG) comprise of tribal people in Achanakmar-Amarkantak biosphere reserve after

collection of honey from forest areas going to Honey processing unit, established by BR authority. The collection and processing are doing through local SHG.

**Fig. 2: Bee hives, *A. dorsata* in forest**

# Know Your Biodiversity

**Swaran Lata and Preeti Kaushal**
Himalayan Forest Research Institute (HFRI)
(Indian Council of Forestry Research & Education, Ministry of Environment Forest and Climate Change, Govt. of India)
Shimla (Himachal Pradesh)

***Ginkgo biloba***

*Ginkgo biloba*, commonly known as Ginkgo or Gingko. It is also known as Maidenhair tree or Maiden hair fern tree because of its foliage resemblance with *Adiantum* or Maiden hair fern. It belongs to order Ginkgoales and family Ginkgoaceae. It is the only living species in the division Ginkgophyta. The genus name *Ginkgo* derived from the Chinese word 'Sankyo' or 'Yin-kuo' which means silver fruit. The species name '*biloba'* means two lobes, refers to unique two-lobed fan shaped leaves. Its vegetative and anatomical characters are like conifers but reproductive features are like cycads. Beside this it also resembles with extinct Cordaitales and Cycadeoides. This resemblance of characters from various extant and extinct groups makes it a 'living fossil'.

It came into existence during the Permian and achieved worldwide distribution and luxuriance during the existence during the Triassic and Jurassic periods of Mesozoic age. It gradually started fading out of existence during the Cretaceous and onwards into the Cenozoic. This tree still grows in wild state in small and inaccessible areas in southern China (Li, 1956). It has also been reported as native plant in the province of Chekiang in eastern China. Because of its interesting history this living fossil is in demand of Natural History establishments. A primitive and ancient species, the Maiden hair fern tree is held sacred by Buddhist temples in Japan and China. The plant symbolizes longevity, hope and unity and now widely cultivated around the world, especially in USA, China and Japan. In India it is seen in cultivation at Dehradun, Mussoorie, Shimla and other cool climatic areas.

It is a dioecious tree which grows up to 30 meter with excurrent habit. The roots penetrate deep into the the substratum and constitute tap root system. Stem is erect, tall, slow growing and branched. Bark is pale brown, roughening into corky fissures and crack as tree ages.The leaves are deciduous and fan shaped, which distinguish the tree from other gymnosperms. In early stage leaves are yellow-green but later it becomes dark green and turns beautiful golden yellow before leaf fall. Microsporangiate strobilus resembles with catkin inflorescence and arises in the terminal and pendulus clusters from the tips of dwarf shoot of male tree. Megasporangiate strobilus born on the dwarf shoots of the female trees and

ovules are borne terminally on long stalks. Seeds are large, fleshy and about the size of apricot. The integument is composed of an outer orange coloured fleshy portion and inner hard and stony layer. The fleshy coat is rich in butyric acid and when crushed emits an odour like that of rancid butter.

It is very difficult to differentiate between the young male and female trees. The distinction is only possible when they bear male and female fructifications. Pollination is anemophilous i.e., through wind. The male trees are usually preferred for gardens and as a shade tree because the ripe seeds of female trees emit an unpleasant odour. The tree can be propagated by seeds or by cuttings of softwood or by grafting in order to eliminate female trees which are evil smelling in fruiting conditions.

It is commonly grown as ornamental tree in gardens and in China and Japan the tree is worshiped. The endosperm of the roasted seeds is edible. If too much of seeds are eaten it may prove fatal. The tree is highly resistant to attack of insects, bacteria, fungi, and viruses due to presence of hydroxylactones and aldehydes in the leaves. Wood is used for carving, furniture, chessboard and tubs for brewing "sake" among other items. The leaves and seeds are used in herbal medicine. Leaves contain more than 40 active components but most therapeutic of these are flavonoides and terpenoides. People in China began using the seeds of this species for medicinal purposes over 1000 year ago. In traditional Chinese medicines it is used to treat various ailments viz. asthma, bronchitis, eye problem, depression, headache, kidney problems, high blood pressure, male impotence and cardio-vascular diseases. Its leaves have traditionally been used for treating circulatory and respiratory ailments. In China and Japan, it is used for making chess boards and chess men. The seeds are even roasted at feasts aid digestion and diminish the effects of drinking wine. In the West region in recent years, Ginkgo has become popular as a natural remedy to improve mental performance and also boost short term memory. *Ginkgo biloba* leaf extract is the most widely sold phytomedicine in Europe, where it is used to treat the Alzheimer's disease, vascular dementia, peripheral claudication (tiredness in legs), and tinnitus (ringing of ears). It is one of the 10 best selling herbal medications in the United State.

According to IUCN Red List *Ginkgo biloba* is an endangered species. It is one of the oldest living trees (In Taxonomic group Gymnosperms) on the earth with high medicinal properties. It is reputed to live for 1000 years in the grounds of temples and palaces in Japan and China, where it has survived through the conservation efforts of Buddhist monks. Beside this it is extremely resistant to pollution, pest and disease hence it is commonly grown as ornamental tree in gardens all over the world. Such importance's make this tree very special if seen in historical, spiritual, horticultural and scientific perspective. Hence this species urgently requires proper mode of conservation and attention on propagation and cultivation techniques.

***Lamproptera curius***

*Lamproptera curius* is a species of swallowtail butterfly. It is commonly known as White Dragon tail. With a long white-tipped tail, its common name is probably derived from its resemblance to a

dragon when in flight. It belongs to order

Lepidoptera and family Papilionidae. A white band that runs across both the wings in the basal region distinguishes it from closely related Green Dragon tails (*Lamproptera* meges) which has greenish bands.

These are native to South Asia and Southeast Asia. It is smallest swallowtail butterfly species to be found in south eastern parts of Asia. They are confined to the North- Eastern forests of India from Assam onwards to Myanmar in moist evergreen and deciduous forest. It is usually found near running water, often puddling on the sandy shores of river banks. Unlike most 'puddlers' the Dragon tail prefers to puddle away from other butterflies.

White Dragon tail is small black and white with transparent, black-banded forewing and extra long hind wing with white tipped tail. A white band that runs across both the wings in the basal region.This white bands spreads on the fore and hind wings, and in the male, there are androconial scales in the anal pouch of the male hind wing upper side. Upper side is black or dull brownish black, with outer half of fore wing forming a triangular, black bordered colorless transparent area. Forewing is a broad outwardly oblique white transverse band that crosses from a little beyond the basal third of the coastal margin to the dorsum, its outer half hyaline (glass like), followed by a hyaline triangular area that does not reach the costa or the termen but is transverse by conspicuously black veins. It is a swift flier of open forest, where it may be seen feeding or hovering over flowers without settling on them. The top flight speed of a white dragon tail butterfly is 12 miles per hour. They are herbivore, its first food is its own eggshell and then it will eat the leaves of the plant on which it is hatched. White dragon tail butterfly is cold-blooded, which means the body temperature is not regulated on its own. They can't fly or eat if their body temperature is below 82 degrees F (28 degree Celsius). They have sense organ, on their feet or tarsi, for tasting. The dominant larval food food plants of Swallowtail butterfly species belong to Rutaceae, Annonaceae, Lauraceae and Magnoliaceae families.

Life cycle of white Dragon tail butterfly comes in different stages, eggs, larva "caterpillars", pupa "chrysalis" and adult butterfly. Average life span of an adult is about six weeks. They attach its eggs to leaves with special glue. During the early stages of development, the larva is generally black and smooth, with a black head and the sides above the prolongs being yellow-ochre. The larva also has a narrow yellow ochre border around the anal segment. In later cycles of life, the larva develops an apple green color and is darker on the back. There is a buff line going from head to tail just above the legs, as well as three yellow stripes between the seventh and the tenth segment. The head of the White Dragon tail butterfly adopts a green color with the crown having four round black spots, and two smaller spots at the jaw's angle. A white Dragon tail butterfly can see yellow, green and red colours.

From the conservation point of view these butterflies plays very important role in plant propagation through cross pollination. Most of medicinal plants are dependent on swallowtail butterflies for propagation. Beside these these butterflies are very sensitive bio- indicators because of their very specific habitat requirements. These butterflies are not known to be threatened in most of its range except in Peninsular Malaysia. Although population of White Dragon tail seems stable but habitat loss due to increasing anthropogenic activities are slowly destroying the natural population of these species. Thus we need to take care of these species before they come under threatened categories.

**Reference**

Bingham, C.T. (1907). Fauna of British India. Butterflies Vol.1.

Carr, D. (1979). The Gardeners' Handbook-2, Conifer. B.T. Bats Ford Limited London. pp. 76-77.

Gay, T., Kehimkar I.D., and Punitha, J. (2008). Butterflies of India. Oxford University Press. pp. 15.

Parker, R. N. (1973). A forest flora for the Punjab with Hazara Delhi. M/S Periodical experts, pp. 550-551.

Ridsdale, C., White, J. and Usher C. (2005). Trees. Dorling Kindersley Limited. pp. 71.

Sahni, K.C. (1990). Gymnosperms of India and Adjacent countries. Bishen Singh Mahendra Pal Singh, Dehra Dun, India. pp. 33-36.

Toogood, A. (1989). Practical garden guide conifer and Heathers. Tiger Books International, London. pp. 56.

Puttalingamma, V. (2015). *Ginkgo biloba* "living fossil" wonderful medicinal plant-A Review. International Journal of Advanced Research, 3 (3): 506-511.

Barua, K. K., Kakati, D and Kalita, J. (2004). Present Status of Swallowtail Butterflies in Garbhanga Reserve Forest, Assam, India. Zoos Print Journal, 19 (4):1439-1441.

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**P.O. RFRC, Mandla Road**
**Jabalpur – 482021 M.P. India**
**Phone: 91-761-2840484**
**Fax: 91-761-2840484**
**E-mail: vansangyan_tfri@icfre.org**
**Visit us at: http://tfri.icfre.org or http://tfri.icfre.gov.in**