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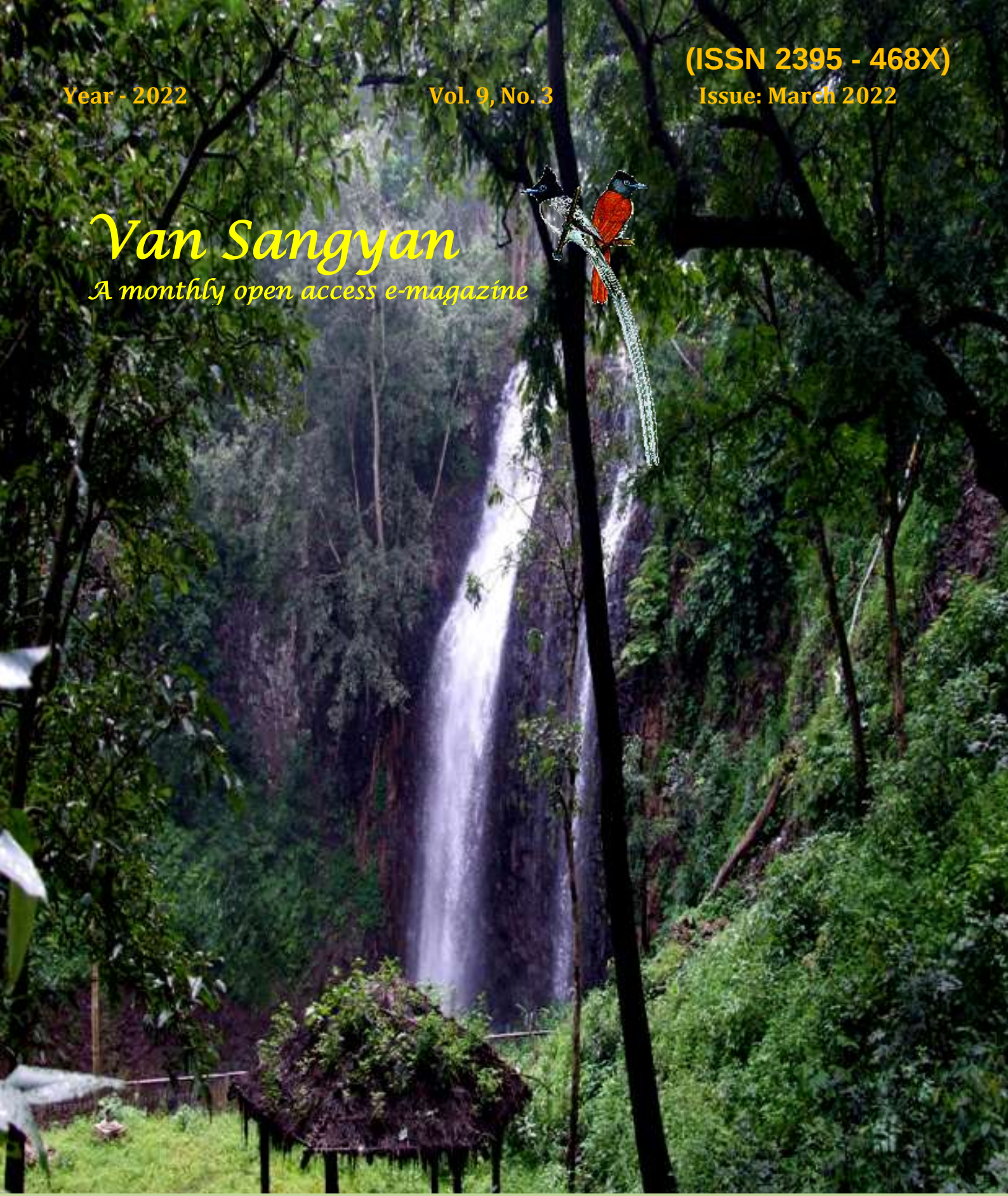

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Van Sangyan

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

Woody plant resources continue to disappear in anthropogenic landscapes. To slow down further loss of these resources requires the collaboration of farmers in tree planting in agroforestry systems. Tree planting interventions with the collaboration of farmers require a good understanding of tree management practices as well as trees that best satisfy farmers' needs.

Woody species (i.e., tree and shrubs) are threatened with local extinction and are disappearing fast. This rate of tree loss is fastest in anthropogenic landscapes outside protected areas where it is estimated to occur at a rate of 2.27% per annum. For this reason the forest estate outside protected areas reduced from 3.46 million to 2.3 million ha between 1990 and 2005, a difference of about 1.16 million ha.

The reasons that lead to loss of trees are chiefly land use change. In most parts of the world including land cover has been converted from woodlands or forests to create land for crop and livestock agriculture. The rapid human population growth estimated at more than 3% per annum has increased demand for land for cultivation and settlement, as well as woody products.

The rapid loss of trees and shrubs threatens livelihoods that are dependent on those resources. Human populations, globally, depend very much on plant resources for their sustenance and economy, for example, the use of fuelwood for cooking. In addition plants (woody or otherwise) also generate ecosystem services that are invaluable to humans in ways such as rainfall generation or provision of nectar for pollinators. Because of these reasons, the rate of woody species loss must be slowed.

To address the challenge of fast tree cover loss will require increases in rates of tree planting. Successful increase in tree/shrub cover requires the participation of small holder farmers because they own most of the land. This means therefore that small holder farmers are invaluable stakeholders in interventions for increasing tree/shrub cover.To involve farmers, we need to understand their attitudes and perceptions concerning tree management, how they currently manage species, and what challenges hinder tree growing or which opportunities exist for growing trees. Farmers make decisions whether to participate or not in interventions such as tree growing based on considerations of how such interventions maximise their welfare and also fit into their livelihood strategy and available resources. Overall these decisions are also influenced by historical events such as circumstances that have directed resource availability. Analysing people's decisions can reveal key variables that affect their behaviours and which can therefore be used to design successful and sustainable interventions.

Additionally, farming systems include a wide variety of agroforestry practices. These tend to vary from place to place in both extent and intensity of management in line with the varying agroecological and socioeconomic factors prevailing in those areas. This validates the need to make agroforestry studies location-specific and avoid too much generalization especially by development organizations.

In line with the above this issue of Van Sangyan contains an article on High valued agroforestry trees: Increasing farm return in a sustainable way. There are also useful articles viz. Ailanthus excelsa: Ideal fodder tree species for livestock in the semi arid region, Mycorrhiza and its importance in forestry, Wood destroying insects: Timber borer and their control measures, Agroforestry and social forestry, Forest ecology and adaptive tools for climate change, Invasive alien plant species – Impact, control and management, United Nation's Post-2020 Global Biodiversity Framework: Opportunities for local action, वानिकी वृक्षो के उत्पादन की उन्नत तकनीक एवं जल प्रबंधन and Bamboo leaf rollers and their control measures .

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests. Van Sangyan welcomes articles, views and queries on various such issues in the field of forest science.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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High valued agroforestry trees: Increasing farm return in a sustainable way

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Introduction

Nowadays, the primary issue confronting our farmers is declining income per acre every year. Due to changing environmental conditions and severe climatic factors, crop yield has decreased, with the possibility of total crop failure in the worst-case scenario.Agroforestry systems have the potential to conserve natural resources, reduce vulnerability, increase the resilience of farming systems, protect households from climate-related hazards, and increase overall system productivity.Agroforestry land use increases farm income & livelihood security by incorporating two or more factorssuch as crops, trees and animals.The selection of multipurpose and fast-growing high value tree species is the need of the hour in order to get handsome revenue from our agriculture farm.

The major mandate behind the introduction of the agroforestry systems is to increase the financial returns from the same piece of the land management unit. If high value fast growing multipurpose tree species such as *Santalum album*, *Tectonagrandis* and *Meliadubia*are planted alongside crops on farmland, they can considerably increase the productivity of associated crop andwill also lead in increasing the production per unitland area, resulting in more diverse and sustainable production systemsand better income from tree products on one hand, while also helping in protecting the environment on the other hand.

Sandalwood

S. album is one of the most valuable trees, renowned for aromatic oil (East Indian Sandal tree oil) extracted from heart wood. It is the sole species in genus Santalum that produces high-quality sandal oil. It is the source of highly fragrant heartwood and sandal oil which are used for carving, perfumery, incense, medicine, aromatherapy, and much other purposes.Its wood is naturally resistance to wood borers.

Indian sandalwood is designated as vulnerable by the International Union for Conservation of Nature (IUCN) in 1998. It could be due to the destruction of the sandalwood forest by various factors includingdisease (epidemic of spike), overexploitation, illicit felling, insufficient regeneration and smuggling that resulted due to its high demand in the national and international market. To fulfil demand and supply gap, sandalwood has high potential in growing on farmer fields as block plantation or as the alleys of the trees, and the space between the alleys can be used for the sowing of the agri-host of sandal wood.

Sandalwood is quite hardy species that can occur even outside their native climatic zone and tolerate extreme temperature from 04°C to 46°C.Additionally,it can also grow on dry & degraded lands and over a

variety of soil and can also withstand the soil pH up to 9.0 but is unable to grow in waterlogged sites. The plant thrives in areas receiving rainfall of 500 - 5000 mm, long dry season duration and elevation from 0–1800 meter above mean sea level (m amsl).

Height

10-15 m and 1-2 m girth at full maturity i.e., in 60-80 years.

Planting season

Monsoon season

Major Exporters

India and Indonesia

Major Importers

China and Taiwan

Largest sandal oil Importer

USA & France

Major producing countries

Australia, India, China

Major producing states

Karnataka, Tamil Nadu, Kerala

Potential area

Sandalwood has been found distributed in almost all states of India like Kerala, Andhra Pradesh, Bihar, Gujarat, Haryana, Rajasthan, Maharashtra, Madhya Pradesh, Orissa, Punjab, West Bengal, Uttar Pradesh& Himachal Pradesh with southern part of Karnataka & northern part of Tamil Nadu its natural distribution area.

Agroforestry

Sanda lwood being a hemi-parasite requires a primary host, intermediate host as well as a long-term secondary host which gives it tremendous scope in agroforestry. Specifically, in existing farming system or in silvihorticulture system, where horticultural crops act as secondary host has a huge in improving livelihood and creating employment opportunities. This enhances farm income especially in hardy situations like semi-arid zones due to less demanding climatic and edaphic requirement of this species.

Host:-Timber species

Tectona grandis (Teak), *Casuarina equisetifolia* (Casuarina), *Dalbergia sissoo* (Shisham), *Pongamia pinnata* (Karang), *Azadirachta indica* (Neem), *Melia dubia* (Melia), *Cassia Siamea* (Senna), *Acacia nilotica* (Kikkar)

Fruit trees

Amla, Jamun, Nimbu, Mango, Anar, Ber

Suitable agriculture crops

Horsegram, Redgram, wheat, turmeric, Ginger and many other local crops.

Market status in India

Total Production

Wood

Global production of sandalwood is 4000 ton. India produces about 10% of global production i.e., around 400 tons of sandalwoodproductionof sandalwood has been decreased from4000 MT in 1950 to 250 MT in 2019.

Oil yield (%)

1.6-4.0 %

Oil

100-120 MT

Demand: wood

5000-6000 MT

Major utilities

Carving Purpose, sandal oil, Medicinal industries

Yield potential

It is a slow growing tree in forest condition showing girth growth rate of 1 cm per year but under favorable and moist condition gives a rate of upto 5 cm per year. The heartwood formation starts after eight years. The oil content varies from 3-6 per cent and generally light-colored wood contains higher percentage of oil than darker

colored.Heartwood of sandal fetches up to Rs. 3.7 million per ton and wood oil up to Rs. 300,000 per kg in the international market much more than any

commercial crop grown in the agroforestry.

Challenges

The scarcity of high-quality planting material (QPM) from known sources is one of the primary impediments to widespread cultivation of sandalwood tree. Being a precious timber, this tree has higher chances of theft and smuggling. The present policies on sandalwood tree declare the state (The Forest Department and other public sector agencies) as the sole buyer and seller, thereby denying farmers the full market value of their produce.

Tectona grandis

Teak

Teak is one of the most valuable and highly sought-aftertimber for its durability, decorative grains, lightness with strength, seasoning capacity without materially altering its shape and have easy workability.Teak is an easy to grow, fairly fast-growinghardy species and can withstand biotic pressures and have fire tolerance. It is a tall evergreen light demanding pioneer species which survive and grows under a wide range of climatic and edaphic conditions from arid areas with only 500 mm of rain per year to moist areas with up to 5,000 mm of rain per year. Tree have a yellow blonde reddish brown - wood. This tree attains the height of about 30 m. Teak can grow in a variety of soil but prefer deep, well drained & fertile soil. Its altitudinal range is from 600 – 1200m amsl and requires an optimum temperature 14-36 ^{0}c.

Price and consumption of teak tree has experienced a great increase over the last few decades improving its market value and opportunities. Huge potential for teak plantation area expansion exists throughits row planting on field bunds (5-15 % of agricultural area is occupied by field bunds), teak farming on culturable waste lands, contour planting of teakon agricultural lands located on sloping terrain.

Planting season

Monsoon, mostprobably after thefirst shower

Major Exporters

Myanmar, Thailand and India

Major Importers

India, Thailand, Vietnam &China

Major producing countries

India and Indonesia

Major producing state

Kerala

Potential area

Madhya Pradesh, Uttar Pradesh, Gujarat, Kerala, Tamil Nadu, west Bengal Assam, Bihar, Orissa, Maharashtra & Karnataka in India.

Suitable agriculture crops

Rice, Garlic and Bottle gourd, Wheat, Gram, wild oats and Barley, Green gram, Sorghum and Groundnut, Maize, sorghum, chilli, groundnut, finger millet. Mungbean, turmeric

Boundary plantation in fruit orchard

Banana, Papaya, Guava, Citrus, Mango, Cashew

Medicinal and aromatic plants

Aloe vera, Kalmegh, Patharchur, Stevia, *Cymbopogonfelxuosus* lemon grass, Rusa *grass*, Tulsi, Ashwagandha, Rose

Major utilities

Plywood Construction, Poles&Ship building

Yield potential

The average yield of teak plantation planted at 2 m × 2m is predicted to be 1.5-2 m^3 per ha per year in 25 years in farmlands. At best a tree may produce a maximum of 0.60 $m^3$of timber in 20 years & there could be a maximum of 100 tree per acre. It yields a volume of 1.58 m^3 of timber per year per tree (increment).The

total area under teak plantation is estimated in 3 million hectares.

Challenges

Sometime there has been seen some decrease in yield of associated crop with teak due to shade factor & its allelopathic effects on crop. Its large leaf shape is a major cause of splash erosion.

Table. 1 Characteristics of tree species

Parameters	Tree species		
	Santalum album	***Tectonagrandis***	***Meliadubia***
Rotation age(years)	12-15	25-30	6-7
Returns/tree (Rs/tree)	15,000-20,000 3000-4000(Price (Rs) per kg heartwood)	30,000-50,000	4,000-5,000
Plants per ha	400-500	100 tree per acre	500-4444(HDP)
Volume (m^3) / weight (kg)	4-5*	0.60 cu meter	0.12 cu meter

* Weight of heart wood produced per tree

Melia dubia

M.dubia is a promising tree highly suitable for farm forestry andagroforestry for generating higher income in the semi-arid regions. *M. dubia* has found to be the fastest growing and highest biomass yielding tree in world.Its moisture percentage is around 40 % of biomass and therefore yield about 100-120 oven dry tonne of biomass ha^{-1} $year^{-1}$. The biomass yielding potentialof this species is much higher compared with the highest yielding, short rotation, high density temperate species like Salix or Populus which yield up to 50 to 60 oven dry MT ha^{-1} $year^{-1}$.

Melia dubia is a deciduous, light demanding species having an optimum temperature range of $30^{O}C$ -35 ^{O}C but is able to tolerate extreme temperature of $0^{O}C$- 45 ^{O}C. It can be grown on a variety of soils; however, it thrives well on drained, red, red loam, alluvial and black loam type of soils. It is commonly found in the hills at elevations ranging from 600 – 1800 mamsl& requires an annual rainfall of 650-1000 mm.It flourishes well in moist regions, with a mean annual rainfall exceeding 1000 mm. However, it can also be successfully grown in dry regions with supplemental irrigations.

Planting season

Onset of Monsoon and during Monsoon

Potential area

Well distributed in tropical moist deciduous forests of Sikkim Himalayas, North Bengal and upper Assam, the Khasi hills of Orissa, Deccan and the Western Ghats.

Recently it is widely planted by farmers of Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Punjab, Haryana, U.P.

Suitable agriculture crops

Groundnut, chilli, turmeric, black gram, watermelon, pulses, wheat, sugarcane, turmeric, berseem and barley.

Boundary plantations

Papaya, Banana, Drumstick, Mango and also in coffee and tea plantations

Some high potentialnew cultivar release of *Melia dubia*: GK1, Sharad, Shashi, Bhumukhi, Varsha, Megha, Dev, Ritu. The famous *Melia dubia* clone GK1 produced

from a superior plus tree that had grown to 8 m height and 45 cm girth at breast height in 1 year.

Major utilities

Match box industry, packing cases, Musical instrument, agriculture implements

Yield potential

High density planted *Melia dubia* produces biomass of 150-200 tonnsha^{-1} at age of only 5 years.

Challenges

Its shallow root system is known to compete with associated agricultural crops for water & nutrients. Due topoor extension strategies, it is not much extended to farmers fields

Ailanthus excelsa: Ideal fodder tree species for livestock in the semi arid region

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Introduction

Semi-arid regions are characterized by prevalence of poverty, drought spells, erratic and low rainfall, land degradation etc. and 80% of the population in these regions are dependent on agriculture and livestock sector for their income. Livestock sector contributes almost 96% to the farmer's total income (Rathod and Dixit, 2020) in the region as it is the main component of agriculture, which is reflected in high human to livestock ratio (1:1.5 to 1:3) in these regions compared to country's average (1:0.5). Livestock is also an important source of nutrition to people and of manure to agriculture in the region. Thus, livestock sector is very important for rural livelihood as well as economy of the region, but the sector is currently facing challenges of low milk yield as well as low productivity and hence, not able to meet up the rising demand of livestock based products. Further, to ensure high economic returns to farmers in semi arid region and sustain rural economy via enhanced income, livestock productivity needs to be enhanced further. Lack of round the year availability of green nutritious fodder coupled with poor livestock breeds, disease, improper livestock management are the main reasons attributed for low livestock productivity in the region. Livestock in the region is fed with locally growing grasses, crop residues and to some extent by feeding fodder crops. These locally growing grasses and crop residues as well as the straw are generally low in nutritional traits, especially crude protein content, palatability and digestibility. During the lean periods especially in winters and summers, the problem gets further amplified with the unavailability of protein rich green fodder. The round the year unavailability of nutritious fodder is mainly responsible for low milk yield and productivity in livestock. In, such scenario, locally growing fodder trees species can be utilized for ensuring supply of protein rich nutritious fodder to livestock, especially during the lean periods as these trees have around 14 to 24 % crude protein in their leaves; are rich in macro as well as micronutrients and many secondary metabolites that play crucial role in enhancing livestock productivity. Thus, for enhancing productivity farmers should be encouraged to introduce and grow locally available nutritious fodder shrubs and trees on community lands, on agricultural border lands and along with agricultural crops as agroforestry systems. In this context, *Ailanthus excelsa* locally known as ardu, mahaneem, arduso, maharukh, mithaneem is one of the perfect/ideal

fodder tree species for enhancing livestock productivity in the semi-arid region.

A. excelsa (Family: Simaroubaceae) is a large deciduous, fast growing multipurpose tree species native to semi arid regions of central and western India as well as northern part of the Peninsula. It is found growing in the semi arid regions of Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Maharashtra, Karnataka, and Tamil Nadu and also in some parts of West Bengal, Bihar, Orissa and Andhra Pradesh. Its trees have erect, straight and greenish grey coloured stem; long, alternate, pinnately compound leaves with 10-14 pairs of ovate to lanceolate leaflets; polygamous green coloured flowers; small one seeded fruits and stout root system.

Silvicultural characteristics

A. excelsa is a light demander tree that can grow on variety of soil but perform better on sandy loam soil and moreover it can be grown easily as a mono-crop and along with agricultural crops without impacting their yield. Moreover, its trees are drought resistant, frost hardy, have very good coppicing power and amenable to pruning as well as lopping for fodder production. Water logging conditions are harmful for the species and thus, it should not be planted in areas prone to such conditions. *A. excelsa* besides being a fodder tree is also commercially demanded by timber, plywood, pulp & paper and matchbox industries and as a fuelwood.

Fodder yield and nutritional traits of *A. excelsa*:

- Its leaves are highly palatable, digestible and with almost negligible anti-nutritional content (Table 1).
- Leaves have high crude protein content, are rich in nutrients with low crude fiber content.
- During the time when green grasses/fodder are not available its leaves can be used as high-value fodder especially in summers.
- Its leaves can also be mixed with grasses to increase the nutrient value of feed.
- It is amenable for pruning, coppicing as well as pollarding and full grown trees can yield 5-7 quintals of green leaves per tree on lopping twice a year.

Table1. Fodder quality traits of *A. excelsa* leaves

Fodder Quality Traits (% of dry matter)		Reference
Crude protein	19.87 %	Jat et al., 2006
Crude fibre	12.72 %	
Total ash	11.97%	
Ether extract	3.54 %	
Nitrogen free extract	51.81%	
Acid detergent fibre	16.38%	
Neutral detergent fibre	33.71%	
Dry matter	31.00%	
Digestible crude protein	16.24%	
Total digestible nutrients	63.80%	
Calcium	2.11%	
Phosphorus	0.24%	

Feeding trials

Dry matter digestibility of *Ailanthus excelsa* leaf fodder has been found to be higher **(**75.67 %**)** than groundnut haulms **(**67.45 %**)** and natural grazing material **(**56.45 %**)** in lambs during feeding trials. The daily weight gain of 60 grams in animals fed on *Ailanthus excelsa* fodder have been reported over 45 grams and 40 grams a day for the animals fed with groundnut haulms and natural grazing, respectively (Musa et al., 2021**).** Moreover, supplementation of *A. excelsa* leaves in ruminants has also been proved to reduce enteric methane production.

Fig. 1. *A. excelsa* tree

Growing and managing *A. excelsa* for fodder production in Semi-arid region

A. excelsa can be grown easily for fodder production in the form of alley, boundary plantation and block plantations on farms at various spatial arrangements. For alley wide spacing between tree rows should be followed (Row × tree: 6 m × 6 m or 8 m × 5 m or 10 m × 5 m); for boundary plantations 3 m or 4 m (single and double row) and for block plantations 3 m × 3m or 4 m × 4 m spacing can be followed. For establishing silvipastures spacing can be kept as 8 m × 5 m or 10 m × 5 m (Row × tree) and these silvipastures can be established easily on wastelands and degraded lands for fodder production.

For fetching fodder, fodder harvesting from trees/should start when they are fully established as well as grown, and moreover, lopping of trees should be restricted to lower 2/3rd crown length. Fully grown trees can be lopped twice a year in the month of December and May-June for fodder production.

A. excelsa have been reported to yield 11-12 kg dry leaves per tree at the age of six year and sometimes up to 20 kg depending upon the soil, climate and management practices. Further, fully grown trees of *A. excelsa* trees can yield 5-7 quintals of green leaves per tree on lopping twice a year.

Ways for utilizing *A. excelsa* for fodder production in semi arid regions:

As wasteland plantations

Non-forest and forest degraded lands in semi arid region can be utilized for planting *A. excelsa* trees as block plantations or silvipastures. *A. excelsa* is also capable of reclaiming wastelands and moreover, these plantations will help in creating long lived atmospheric carbon dioxide sinks besides providing fodder.

As boundary plantations

A. excelsa can be planted on farm boundaries either as a single row of double row at the spacing of 3 m × 3 m or 4 m × 4 m for fodder production.

As an alley on farm

A. excelsa can be planted at the spacing of 6 m × 6 m or 8 m × 5 m or 10 m

× 5 m on farm along with agricultural crops . Many crops like oats, wheat, sorghum, mustard, chickpea, grams and medicinal herbs have been found compatible with *A. excelsa*, without reduction in crops yield.

As road side plantations

Rroadsides area can be planted with *A. excelsa* trees (5 m × 5 m or 6 m × 6 m) which will not only ensure fodder production but will increase the scenic value of the region; provide timber and fuel wood along with capturing huge chunk of atmospheric carbon dioxide in biomass.

As block plantations

A. excelsa can be raised on public and private land for fodder production in the form of blocks with spacing of 3 m × 3 m or 4 m × 4 m or 5 m × 5 m or 5 m × 4 m.

Under silvipasture system

A. excelsa is compatible with fodder grasses and legumes like Cenchrus *ciliaris*, Chrysopogon *fulvus*, *Panicum maximum*, *Stylosanthes seabrana*, *S. hamata* and *clitoria ternatea*. Therefore it can be easily grown with fodder grasses and crops for fodder production under silvipasture systems with spacing of 6 m × 6 m or 8 m × 5 m or 10 m × 5 m.

***A. excelsa* based Agroforestry systems**

A. excelsa based three tier silvi-pastoral system combining *Cenchrus ciliaris* + *Ailanthus excelsa* + *Dichrostachys cinerea* in hot arid regions have been proved to provide average forage production of 2.78 t ha^{-1} dry forage from pasture + 0.95 t ha^{-1} green tree leaves. Average dry fodder yield from trees and *Cenchrus ciliaris* biomass production has been observed to be as higher as 5 and 17.28 per cent respectively in this system compared to two tier system with other fodder trees of region.

Various *Ailanthus excelsa* based agro-forestry systems have revealed it's potential to provide multiple products (fuel wood, fodder, match splints, pulp, medicines etc.) even in fragile and hostile environmental conditions of semiarid and arid regions. Wider spacing (10 x 10 m) have been found to provide maximum understory crop yield and closer spacing like 6 x 6 m and moderate spacing of 8 x 8 m have also been recommended to produce satisfactory understory productivity and enhanced system productivity. One study carried out on *A. excelsa* based agri-silviculture (10 x 5 m spacing of trees) have found that this system is capable to improve organic matter, available P and K, crop yield compared to mono cropping; and can sequester 9.64 t C ha^{-1} $year^{-1}$. Thus, *A. excelsa* is a promising species for sustainable fodder production, improvement of soil fertility and sequestration of huge amount of atmospheric carbon dioxide in semi arid regions.

Conclusion

Semiarid regions are facing shortage of quality fodder which is impacting livestock productivity negatively, therefore, *A. excelsa* being an ideal tree for quality fodder production should be promoted for large scale planting on roadsides, grasslands, wastelands, agricultural borderlands, as a boundary plantation etc. for ensuring quality fodder supply for livestock.

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Mycorrhiza and its importance in forestry

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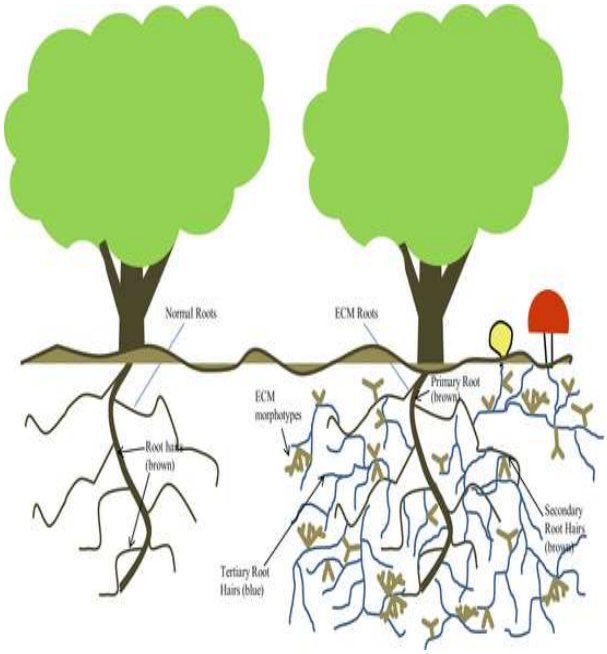
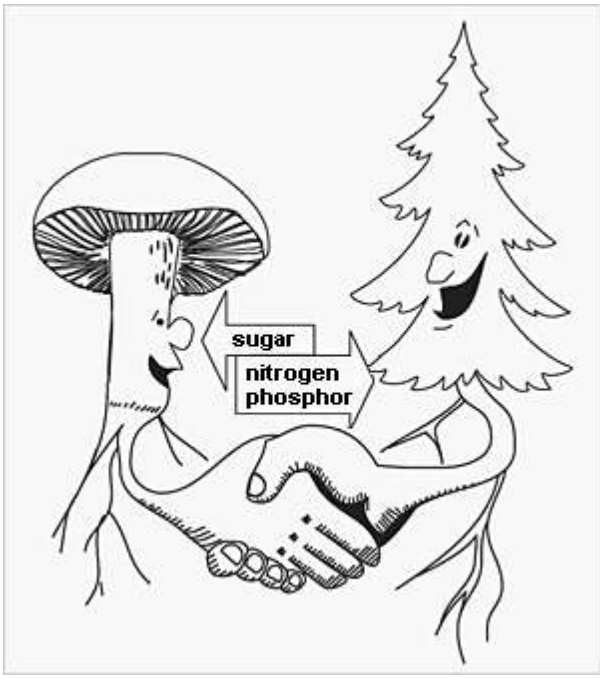
Introduction

In his investigation of soil microbial-plant connections in 1885, Albert Bernard Frank coined the term'mycorrhiza,' which comes from the Greek words mycos, which means fungus, and rhizome, which means root, and literally means 'fungus roots.' and refers to structures formed by the interaction of some fungi's mycelium with the tiny roots of a higher plant. Mycorrhizae form symbiotic relationships with plants and are important for plant growth, disease protection, and soil quality. Arbuscular and ectomycorrhizae are the most common and widespread of the seven types of mycorrhizae (arbuscular, ecto, ectendo, arbutoid, monotropoid, ericoid, and orchidaceous mycorrhizae). Arbuscular mycorrhizal (AM) fungi are the most widespread mycorrhizal association, with over 80% of all vascular plants forming mutualistic interactions with them (Brundrett, 2002). Ectomycorrhizal (ECM) fungi are also common in their distribution, although only 3 percent of vascular plant families are associated with them (Smith and Read, 1997). Ectendomycorrhizae have both ECM and AM fungal properties. Both a hartig net and mantle structures are compatible with ECM. The hartig net is a network of hyphae that grows inward and penetrates the root structure. The word "rhizosphere" was invented by Lorenz Hiltner, a German agronomist and plant physiologist. Rhizosphere is a vital region of the plant ecosystem that is roughly 2 mm from the root surface (Dotaniya et al 2015). Mycorrhizosphere refers to the rhizosphere of mycorrhiza-infected plants (Barea et al. 2002). The rhizosphere, where microorganisms interact with root exudates, is where plants take up the majority of mineral nutrients. Forests are becoming increasingly important in meeting demand for timber and providing environmental protection; about a quarter of India's total land area is currently covered by forest land and trees. The key warning sign for sustainable forest management, especially in planted forests, is deteriorating soil quality. Microorganisms play an important role in soil formation, nitrogen cycling, nutrient absorption, and ecosystem restoration. In general, forest trees rely entirely on a symbiotic relationship between their roots and ectomycorrhizal fungi. Minerals are mobilised from the soil and transferred to the plant by these fungus. In exchange, the trees provide the fungus with absorbed carbon. Ectomycorrhizal relationships are common, especially in temperate areas, and include many ecologically important tree species including Pseudotsuga, Picea, Pinus, Abies, Salix, Quercus, Betula, Fagus, Oak, Hickory, and Alder etc.





Importance in Nurseries

Nursery workers and managers all around the world are concerned about raising strong and healthy stock.

- In the nursery, artificial inoculation with mycorrhizal fungus is employed to improve seedling performance in conditions when researchers and managers know the results would be consistent.
- The mycorrhizal fungus affects seed germination, the early development of young plants, and may even boost adult growth and activity.
- In the Eastern United States, the ectomycorrhizal fungus Pisolithus tinctorius has been shown to improve the survival and growth of pine and oak seedlings on strip mine spoils.
- Artificial inoculation with arbuscular mycorrhizal fungus (for example, Glomus intraradices) increases seedling density and development in the nursery, as well as survival and early growth after outplanting on select sites, for species such as incense cedar, redwood, giant sequoia, and western redcedar.
- Mycorrhizal fungi, generally in the form of spore inoculum, can be obtained. These products are often applied to soil or medium as a dry granular before sowing or as a drench after germination in the nursery.
- Using common cover crops for 1 to 2-year rotations in bareroot forest nurseries might help improve arbuscular mycorrhizae populations and increase organic matter content. However, if fumigation happens between cover cropping and seedling establishment, this increase in mycorrhizal
- Fungi would most likely be lost.
- The ability of mycorrhizae to positively enhance seedling survival and growth will continue to attract attempts to develop superior mycorrhizal seedlings

utilising artificial and cultural approaches.

- For species including incense cedar, redwood, giant sequoia, and western redcedar, arbuscular mycorrhizal fungi (for example, Glomus intraradices) considerably boost seedling density and development in the nursery, as well as survival and early growth following outplanting on select locations.

Importance in Forestry

- When it was discovered that trees often fail to grow at new places if the ectomycorrhizal symbiont is missing, the value of ectomycorrhiza in forest plantations got a lot of attention.
- Pine wilt disease (PWD) is a widespread forest disease that highlights the significance of tree-ectomycorrhizal connections. PWD destroyed pines planted on a Japanese mountain slope (Yamaguchi Prefecture), but some trees survived on the top of the hill, where mycorrhizal associations had formed better than on lower slopes..
- Pine seedlings infected with ECM fungus have been shown to withstand environmental stressors such as acid mist (Asai and Futai, 2001).
- When compared to artificial inoculations, mycorrhizal fungi naturally present in the nursery or at a typical outplanting location colonise seedlings quickly.

Enhanced nutrient and water absorption

- The absorptive surface area of roots can be considerably increased by mycorrhizae. As a result of the expansion of roots, the plant's moisture and mineral element absorption surface rises, giving it a higher chance to live and flourish.
- By making feeder roots more resistant to infection by specific soil fungi such as Phytophthora, Pythium, and Fusarium, more nitrogen and phosphorus are taken from the soil and accumulates in plants with mycorrhizae.
- Increased availability and absorption of plant nutrients such as phosphorus, potassium, calcium magnesium sulphur, iron, manganese, zinc, and copper are aided by the relationship.
- Although the impact varies depending on the variety of Eucalyptus investigated and the fungus injected, mycorrhizal fungi are known to promote eucalyptus growth through a process of better nutrient uptake (particularly P and N) (Adjoud et al., 1996; Lu et al., 1998).
- The rhizosphere or mycorrhizosphere is influenced by the respiration of mycorrhizal roots. High respiration indicates active ion intake, and sporocarps have higher calcium, potassium, nitrogen, sodium, phosphorus, and zinc contents than pine needles.

Increased drought/stress tolerance

- Plants with mycorrhiza have been shown to be more resistant to stress such as soil salinity, alkalinity, acidity, and drought.
- Mycorrhizal plants, which have access to a greater soil volume through expanded root development and higher absorptive

area, grow faster than nonmycorrhizal plants, particularly in dry and semiarid environments where low moisture and high temperature are important for plant survival and growth (Mishra and Mishra, 2004).

- Non-mycorrhizal plants are more susceptible to hazardous heavy metals than mycorrhizal plants.
- The root system and root tips are successfully extended by the mycorrhizal fungal mycelium that develops into the soil. Extracellular auxins, vitamins, cytokinins, enzymes, and other substances produced by outgrowing hyphae alter root tissue and ion absorption.
- Mycorrhizae have a significant impact on water relations because mycorrhizal seedlings are drought resistant.
- The ectomycorrhizal fungus *Pisolithus tinctorius* has been shown to help pine and oak seedlings survive and develop.

Improved transplantability

- If nursery plants are transferred into soils rich in mycorrhizal species, there is little doubt that they will grow much faster.
- Inoculating young trees (mostly Quercus spp.) with the important late-stage fungus Tuber melanosporum is a tried-and-true management strategy with a high success rate (Hall, et al., 1994).
- To successfully limit pathogen infection that occurs during the early weeks after conifer seed germination, hostile bacteria and mycorrhizal fungi may need to be reintroduced at the time of sowing.

Others

- In general, vesicular-arbuscular mycorrhizas (VAM) infection protects plants against soil-borne fungus, however mycorrhizal plants with greater nutrient concentrations are more sensitive to foliar diseases.
- Mycorrhizal fungi are essential for carbon sequestration in forest soil. Mycorrhizae, as a carbon sink, play an important function in C allocation and can influence ecosystem nutrient cycle.
- The construction of mycorrhizal banks (fungus gardens) with specific fungi or a variety of fungi has enormous potential, as inoculum from the rhizosphere of these trees might be utilised to deliver selected fungi to seedlings in an effective and cost-effective manner.

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Wood destroying insects: Timber borer and their control measures

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Introduction

Wood is susceptible to serious insect damage not only in the natural condition in forests, but also after harvest, during storage in depots, construction and products. Wood destroying insect pests can be divided into (i) Carpenter ants (ii) Termites (iii) Bark beetles and wood borers (iv) Powder post beetles. On the basis of observations the few examples of wood destroying insect including bamboos are summarised below:

Sal heart wood borer, *Hoplocerambyx spinicornis* Newman (Cerambycidae: Coleoptera)-

Hoplocerambyx spinicornis, commonly known assal heartwood borer is the only known Indian representativeof its genus and one of the most pernicious pest ofsal that commits very serious depredations in theforest.The most serious epidemic of this borer has been recorded in sal forests of different states of country.The beetle of sal borer is uniformly dark brown and about 1.5 to 6 cm long. The elytra vary in colour from black to reddish brown. They are active by day light and particularly during the warmest part of the day. They avoid direct sun light by shelter in shady places. A beetle lived about three or five weeks.

Sal heartwood borer
***Hoplocerambyxspinicornis* (Male)**

Host Plants

Shorea robusta

Nature of Damage

The grubs feed on the bark and then in the sapwood and finally bore into the heart wood. The mature grubs make large tunnel and galleries which completely ruins the quality of the timber.

Damage symptom of sal borer

Life History

The beetles of the sal heart wood borer, *Hoplocerambyxspinicornis* begin to appear every year as soon as the monsoon rains start. After the emergence the male and female pair and then eggs are laid on the bark of sal trees. The female beetles are chosen dead or partially dead, i.e., felled trees, wind falls, trees washed out by floods, or struck by lightning or broken by storms or damage in felled areas. The newly hatched larvae feed under the bark initially, then in the sapwood and finally bore into the heartwood. During the winter and hot weather they stay in tunnels in the heartwood close it by partition of white lime (calcium carbonate) and long wood fibres closely packed. The beetle emerged from pupa in May-June and waits until the monsoon arrives. The beetle and grub of *H. spinicornis* look very much like the beetle and grub of another sal borer, *Aeolesthesholosericea*. The beetles of *A. holosercea* are found in sal wood in the cold weather and they fly in March to May, this fact often makes people think that *H. spinicornis* flies at two periods in a year.

Control Measures

(i) Carrying out of 'Trap Tree operations' regularly every year with the onset of first shower of rain in June/July and continuing the operation till the catches become nil from some continuous days in August. After the operation, it should be debarked and burnt.

(ii) Enumeration of attacked trees should be carried out twice annually in December and March-April

(iii) Clear felling and removal of all the dead or dying trees.

Ghoon, *Dinoderus* spp. (Coleoptera: Bostrichidae)

The borers on felled bamboo are known as ghoon or shot hole borers. Most of the damage is caused by species of Dinoderus (brevis). Beetles brown shining with black head and thorax, length about 3 mm elytra set with short stick reddish hairs. Larva pale yellow curled body tapers posterior with blunt rounded point.

Dinoderusbrevis

Host- Bamboo

Nature of Damage

The beetle bores into the cut bamboo at a spot where the external rind has been removed e.g, by trimming of the side branches, or smoothing nodes by splits. It also bores into the expose transverse section of cut ends and in the interval wall of the terminal internodes of the hollow bamboo. It is very difficult if not possible for beetle to bore through the hard external rind unless it can get a foot-hold on the adjacent surface angle to the attacked surface. Holes made by the earliest arriving beetles are largely used by the subsequent arrivals. The entrance tunnel is carried in for a fraction of 2.5cms towards the centre in a solid culm, and is often

expanded into a chamber for turning about. It may be continued vertically or horizontally to form an oviposition tunnel. The dust derived from the construction of the tunnel is ejected. Pairing takes place inside the tunnel and eggs are laid in such pores as one exposed in the walls. In a crowded infestation the course of the tunnel is very irregular crossing other tunnels and reversing its direction. In a hallow bamboo the larval tunnel tend to be contracted in a innermost zone when the fibrovascular tissue is dense. The tunnel is tightly packed with frass which consists of mainly coarser particles of woody tissues.

Life History-The year long life cycle has four stages viz. Egg (3-7 days in June - July), Larva (July to April), Pupa(April to May) and Adult (June -July).The beetles of sal borer emerge from infested trees each year as soon as the monsoon starts in the month of June, lasts till the end of July. The beetles are 3-7 cm. long, blackish to reddish brown in colour. Pairing takes place immediately after emergence. Female begins to lay eggs 7 to 9 days after fertilization. Eggs are laid in cracks as deep as possible on fallen trees, on the trunk and branches of standing trees. During its life period, a beetle lays 100 to 300 eggs. The eggs hatch within 3 to 7 days of the laying and 80 to 90% of them hatch into larvae. After hatching from the eggs, the larvae enter the bark and then sapwood and finally bore into the heartwood. The progress of boring by the larvae can be judged from the heaps of wood dust, which accumulates at the base of trees. Before pupation, the larva bores a tunnel running horizontally from the sapwood and makes a pupal chamber where it pupates. The pupa turns into immature beetle in May, waiting to emerge when the monsoon sets in June. The longest recorded life is 9 days for the male and 38 days for the female beetles.

Control Measures

This insect pest may be controlled by following measures

Time to fell bamboo

(i) The cold weather months are the best for checking the breeding of the borers.

(ii) Seasoning of bamboo- Best method is by immersing in water, the effect of which is to reach out certain soluble substance on which the borers feed. It also produces an unpleasant smell. Soaking should last for 2 to 3 months in still water or less in running water. Bamboos extracted from river in rafts are rarely attacked by borers.

(iii) Bamboos stored without water treatment should be rubbed with crude oil at the ends or trimmed surface stocks should be inspected at least twice a year i.e., in March and July. The attacked pieces should be removed and destroyed, rubbing bamboos with linseed, mustard or other vegetable oils does not protect them permanently unless frequently repeated

(iv) Soaking in 50:50 mixture of cold creosote and heavy fuel oil.

(v) Prophylactic treatment: Spray treatment on fresh stacks with 1 % lindane, 3 % boric acid (borax) 1:1 , boric acid + zinc chloride 1:2 give satisfactory results as a prophylactic measures. (vi) Fenvalerate 20 E.C. 0.03 % followed by Aldrin

30 E.C. @ 1 % was most effective against the ghoon.

Termites

Termites are the most wide-spread and damaging wood destroying insects. They live either under ground in soil, in wood or construct loftly attractive earthen mound or carton nests. They are principally cellulose feeders such as wood, textile, paper food, grain etc., and also attack living crops. Socially, the termite lives permanently in highly organised and integrated communities with highly developed social system, based on division of labour. The attack by wood-dwelling termites takes place through the dead or damage portions which later extend to the living tissues.

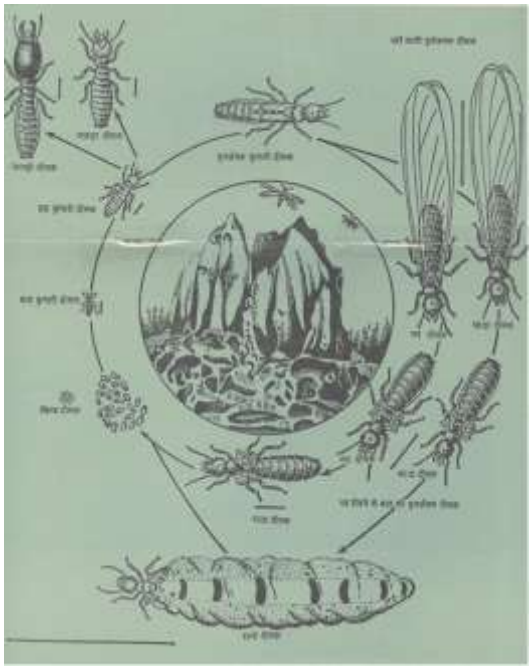
Nature of Damage

The termite attack generally takes place in the upper 20 cm soil layer. They gain entry either through the underground decayed portions of the stem, caused by any biological, mechanical injury, bleeding wound and scars. Out of a total world fauna of about 1600 over 100 are recorded from Indian region these are classified in 3 families.

Termite attack on wood

Life History

Once a year, frequently during a warm humid weather in early monsoon, the future kings and queens leaves the nests of their birth and may be seen flying around dazzling street lights in large numbers, swarming may take place even during day time. After a short flight, their wings are broken off alongdefinite sutures and then they pair off, mating takes place subsequently. The queen starts laying eggs at a very rapid rate in a small burrow or passage. It is interesting to note as many as 48,000 eggs have been found in the ovary. It is also known that she can survive and reproduce for several years. The newly hatched nymphal termites of a new colony are fed by the royal parents.



Life history of termite

The new generation develops into workers and as egg laying continues. These take over the work of looking after the nest. In some species of termites, the queens become very much enlarged and attain a length of 8-10 cm. They are unable to move and are fed by workers, who attend the royal chamber in which the queen constantly resides. The eggs laid are also removed by the workers to suitable places and cared for them. The termites normally feed entirely on vegetative substances, mainly wood, and material not ordinarily digested by the higher animals. They have also been found attacking paper, fungi, dry plants and partially digested food material

from different animals etc., their ability to digest wood and cellulose is due to the presence of certain protozoan in their digestive tracts, which help in the digestion of cellulose. Though essentially feeding on wood, they can cultivate their own food. Certain species of fungi growing on such beds are utilized by members of the colony for their own nourishment. The termites have weakness for darkness and if they have to cross open spaces, they construct covered earthen runways. Such runways are commonly seen on all infested wood works and may also form on ground surfaces and on stems of trees.

Control Measures

(i) Proper method of storing or stacking of wood and bamboo supports of concrete work stone, iron rails or creosote, wooden frame work.

(ii) Periodic inspections

(iii) If danger of attack is very great, the support should be capped with metal sheets.

(iv) If permanent non-attacking arrangements are required, ground should be soaked with waste engine oil, or crude oil.

(v) Fence posts, etc, can be protected by impregnation. (vi) To prevent the termite attack on the bark and bast, spray treatment or brush painting of the trunk may be carried out with emulsion of any of the insecticides viz, chlorpyriphos 2 % or Aldrin @ 0.1 % treatment. It should be carried out after scrapping off the earthern sheaths or galleries/runways.

Conclusion

The concept of integrated pest management can now be applied to wood boring insect pest management. The IPM concept exploits all the available options in order to drastically reduce the insecticide load on environment. Leaving aside the management options, let us act as per the old adage “Prevention is better than cure” or an “ounce of prevention is better than a pound of cure” This will be the most fitting strategy in the moderntimes. Under avoidable context, a pragmatic approach of selectionof insecticideand its application can be resorted to save the wood from pest menace and to prolong its service life. A judicious combination of IPM for wood boring insects shall be the use of mycopathogens, physically barriers and application of biodegradable pesticides. This seems to be the viable option for the future.

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Agroforestry and social forestry

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Abstract

Trees growing outside forest areas are considered as Trees outside forest (TOF). Agroforestry is a land use system where woody perennials are deliberately grown with agricultural crops in different combinations like Agri silviculture, Silvipastoral, Agrisilvipastoral and others whereas social forestry is Forestry outside the conventional forests which primarily aims at providing continuous flow of goods and services for the benefit of people which includes Farm forestry, Urban forestry, Extension forestry, Linear strip plantations and Recreation forestry etc. Agroforestry and Social forestry form the major part of TOF which is playing a key role in forest expansion and carbon sequestration. As per cent ISFR 2021 report the amount of carbon sequestration from TOF is about 70.39 tonnes per hectare and he extent of TOF has been found to be 29.29 million hectares i.e., about 36.18 % of total tree and forest cover of the country.

Key Words – TOF, Agroforestry, Social forestry, Carbon sequestration, Forest expansion.

Introduction

Trees growing outside of forest areas, regardless of patch size, are referred to as "trees outside forest." Outside-the-forest trees are now a key source of forest output in our country, with considerable amounts of lumber, firewood, and small wood coming from outside the forest region, as well as playing an important part in climate change mitigation and carbon stocking. Agroforestry and social forestry methods are also found under TOF. Currently, TOF is India's primary source of wood production, notably in the agroforestry sector.

Agroforestry is a land use system which involves trees with agricultural crop/grass and/or animals simultaneously or sequentially. Through complimentary interactions between system components, this integration aims to diversify production systems and generate environmental, economic, and social advantages. Agroforestry is gaining popularity as a land-use strategy to combat global climate change while also providing additional environmental, economic, and social benefits. Agroforestry is promoted for its potential for carbon sequestration, soil erosion and runoff control, and improved nutrient and water cycling, as well as for offering socio-economic benefits and greater agricultural productivity (Brown 2018). Agroforestry has been a way of life in India for thousands of years. That is perhaps no wonder in a country with over 5000 years of civilization and culture of agriculture (puri 2004).

Under the newly found banner of agroforestry, a National Seminar on Agroforestry organized at Imphal, Manipur, by the Indian Council of Agricultural Research (ICAR) in northeastern India in 1979 (ICAR 1981) is one of the first – if not the first – such

national initiatives. Following that, an All India Coordinated Research Project on Agroforestry was launched by ICAR in 1983 in 20 centres all over the country – the number of centres has risen to 37 in 2003. This is, again, the first major national initiative of this magnitude anywhere in the world. Further, a National Research Centre for Agroforestry was established by ICAR in 1988 at Jhansi in central India, and agroforestry research and education has been taken up in a substantial manner in most of the 32 state agricultural universities. The Indian Council of Forestry Research and Education (ICFRE) that was set up along the lines of ICAR to coordinate and promote forestry research at the national level (puri 2004).

It is necessary in order to address the growing scarcity of biomass while also protecting the environment. Several developing countries began a programme known as social forestry to address the needs of a rising population for fuel, food, and lumber. It was a novel method to addressing the problem of fuel scarcity by enlisting the help of rural residents who would plant, care for, and preserve trees on their own. In the Interim Report on Social Forestry of the National Commission on Agriculture in 1972, social forestry was first identified as an important component of forestry development and fulfilling rural needs. By launching a programme to plant trees, grasses, and fodder on farmers' land, in village communities, wastelands, and degraded woods near habitations, it will be possible to meet the demand for fuel wood, fodder, tiny wood for rural homes, and agricultural implements, among other things. The word social forestry was coined by Westoby and used in the Ninth Commonwealth Forestry Congress in 1968 (Kumar 2015). According to Prasad (1985) "Forestry outside the conventional forests which primarily aims at providing continuous flow of goods and services for the benefit of people. social forestry has always had a local household or community orientation and the effects of activities that increase the occurrence of trees and forests on the local landscape seem to be uniformly positive (Hyde 2015).

Social forestry

- **Objectives**
- To fulfil the basic requirements of people living in rural areas.
- To increase employment opportunities.
- To develop cottage industries in rural areas.
- To provide congenial environment and preserve their cultural identity as their life related to forest.
- To indoctrinate the value of village level self- sufficiency and self-management in the production as well as distribution of forest products with social justice.
- reclamation of degraded lands, conservation of soil and moisture, improvement of agricultural production and prevention of environmental deterioration.
- to increase aesthetic value.
- To protection of agricultural fields against wind speed and natural calamity.
- To solve the food problem of the rural area to a great extent. Certain edible fruits like cashew, mango, coconut and palms have high nutritional value and grow under social forestry programme.

Components of social forestry

Farm forestry

- Farm forestry was defined by NCA (1976) as the practice of forestry in all its aspects in and the around the farms or village lands integrated with other farm operations.

Extension forestry

- Practice of forestry in areas devoid of tree growth and other vegetation situated in places away from the conventional forest areas with the object of increasing the area under tree growth. It includes the following.

Mixed forestry

- Practice of forestry for raising fodder grass with scattered fodder trees, fruit trees and fuel wood trees on suitable wastelands, panchayat lands and village commons

Shelterbelts

- A belt of trees and or shrubs maintained for the purpose of shelter from wind, sun, snow drift, etc.

Linear strip plantations

- These are the plantations of fast-growing species on linear strips of land Rehabilitation of degraded forests The degraded area under forests needs immediate attention for ecological restoration and for meeting the socio-economic needs of the communities living in and around such areas.

Recreation forestry

- Recreation forestry is the practice of forestry with the object of raising flowering trees and shrubs mainly to serve as recreation forests for the urban and rural population.
- This type of forestry is also known as Aesthetic forestry which is defined as the practice of forestry with the object of developing or maintaining a forest of high scenic value

Agroforestry

Objectives

- Reducing the pressure on forest
- Efficient recycling of nutrients
- Microclimate amelioration
- Improvement of soil structure
- Increment in maintenance of outputs of food, fuelwood, fodder and timber.
- Improvement in rural living standards.

Agroforestry systems

Agroforestry systems are classified in to different kinds based on the components which includes

Agri silviculture

- It involves the conscious and deliberate use of land for the con-current production of agricultural crops including tree crops.
- Examples of this includes Improved fallow species in shifting cultivation, Taungya system, Multispecies tree gardens, Alley cropping (Hedgerow intercropping Multipurpose trees and shrubs on farmlands, Crop combinations with plantation crops, Agroforestry fuelwood production, Shelterbelts & Windbreaks and Soil Conservation hedges.

Silvipastoral

- Production of woody plants combined with pasture is referred to Silvipasture system.
- The trees and shrubs may be used primarily to produce fodder for livestock or they may be grown for timber, fuelwood, and fruit or to improve the soil.

	Area in Sq Km	Above ground biomass	Below ground biomass	Dead wood	Litter	Soc	Total
TOF	75,221	99,277	21,878	1772	6758	3,99,790	5,29,475 (70.40 ha)

- Examples include protein banks, live fence of fodder trees and hedges, Trees and shrubs on pasture.

Agrisilvopastural

- The production of woody perennial combined with annuals and pastures is referred Agrisilvopastural system.
- It includes home gardens and Woody hedgerows.

Others

It includes Apiculture with trees, Aqua forestry and mixed wood lots.

Role of social forestry & Agroforestry in carbon sequestration

The Quanta of soil organic Carbon provide us with quantitative knowledge about the amount of Carbon sequestrated per hectare, per year and the rate of sequestration.Through the conservation of current Carbon pools and the expansion of Carbon sinks through sequestration, forest-based agro-systems have the greatest potential to ameliorate the consequences of climate change. Agroforestry systems are very effective in reducing atmospheric CO2 because CO2 is extensively used in photosynthesis by crops and trees for biomass production. (Baghawati et al 2020)

Social forestry which includes Urban forests also can play a significant role reducing atmospheric carbon dioxide levels. Urban forests likely will have a greater impact per area of tree canopy cover than non-urban forests due to faster growth rates, increased proportions of large trees (Prabha et al 2013).

Social forestry and agroforestry which comes under trees outside forest (TOF) plays a major role in sequestering carbon along with forests. As per ISFR 2021 report total carbon stock of trees outside forest is 70.39 tonnes per hectare.

Role of social forestry & Agroforestry (TOF) in forest expansion

Tree cover in country is estimated state wise from the data collected during inventory in rural and urban areas. As per the current estimation (ISFR 2021) the extent of TOF has been found to be 29.29 million hectares i.e., about 36.18 % of total tree and forest cover of the country. From the report it is concluded that Maharashtra (26,866 Sq. Km) has the largest extent of TOF followed by Odisha (24,474 Sq. Km) and Karnataka (23,676 Sq. Km). in terms of percentage of geographical area,the union territory of Lakshadweep (90.50%) has the highest extent followed by Kerela (37.05%) and Goa (34.25%).

Conclusion

Agroforestry and Social forestry being a part of Trees outside forest (TOF) playing a significant role in reducing pressure on natural forest and also helping to meet the demands of increasing population. Not only production part of view, it is also playing a key role in protection of mankind by mitigating climate change and

sequestering carbon. Research on TOF in India is not given much importance which is needed for forest cover expansion.

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Forest ecology and adaptive tools for climate change

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Introduction

Maintaining the ecology and health of the forest is what all the research that is happening around the world is about. Forest ecosystems are the true pillars for the overall sustainability, but it is falling under threat due to continuous disturbances and one such disturbance is climate change along with seasonal diseases, fire, drought stress. Climate change is the major factor that is the shaping the environment in ways that is diversifying and destroying every essence of green scape. Warming climate and changing temperatures are leading to changes in species composition and structure over decades now. It is not only affecting increased levels of CO_2 and precipitation but also the plant-physiological interactions which are directly impacting the different forest ecosystems.

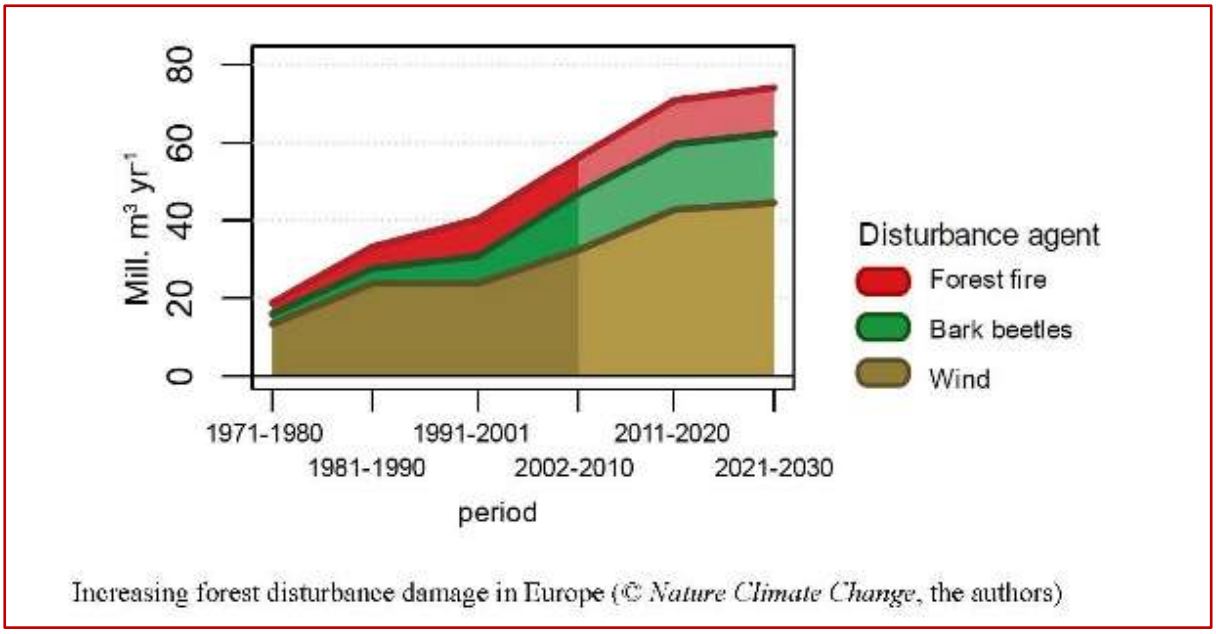
Even though with continuous efforts from various scientists to adapt the present forest to the future consequences, climatic changes are showing its dominance in some or other form. Adaptive strategies should be implemented using temporal examples or historical theories to spatially execute the framework so that strategies will work out. For example, genetic diversity can be used as an option to restore natural regeneration. Forest growth models including the genetic background of individual trees are available and increasingly applied for climate change assessment. Although all these seems very uncertain, timely monitoring will improve the ongoing strategies. Modelling tools for climate sensitive forest growth will simulate forest development subject to climate change scenarios and management options. New information continuously flows to decision makers, affecting their beliefs and expectations about climate change.

A risk-based approach is required to handle and evaluate climate change so that a structured approach can be provided to create a framework. Initiating this would be by identifying risk, analyzing the potential magnitude of consequences, selecting a set of risk-reducing actions to implement, prioritizing those actions that address risks with the highest likelihood and magnitude of consequences.

Adaptive management tools

As mentioned before, disturbances due to global change like drought, floods, disease outbreak are also great threat to wilderness. Management actions can alter the structure or the composition of the forest. In situations where the goal is to reduce the chance of future disturbances, adjustments to forest structure can be useful. Different management tools are being discovered for which lots of funds and projects are being created to improvise the framework and take it to next well for the better adaption to changing climate. All these efforts though will not have immediate effect but will for sure have a

long-standing impact if turned out to be a success. In this context, forest gap models are found to be one of the best tools in the process of developing adaptive strategies. Four assumptions originally underlie gap models: (1) The forest is considered as a composite of many small patches of land, where each patch can have a different age and successional stage; (2) patches are horizontally homogeneous, i.e., tree position within a patch is not considered; (3) the leaves of each tree are located in an indefinitely thin layer (disk) at the top of the stem; and (4) successional processes are described on each patch separately.



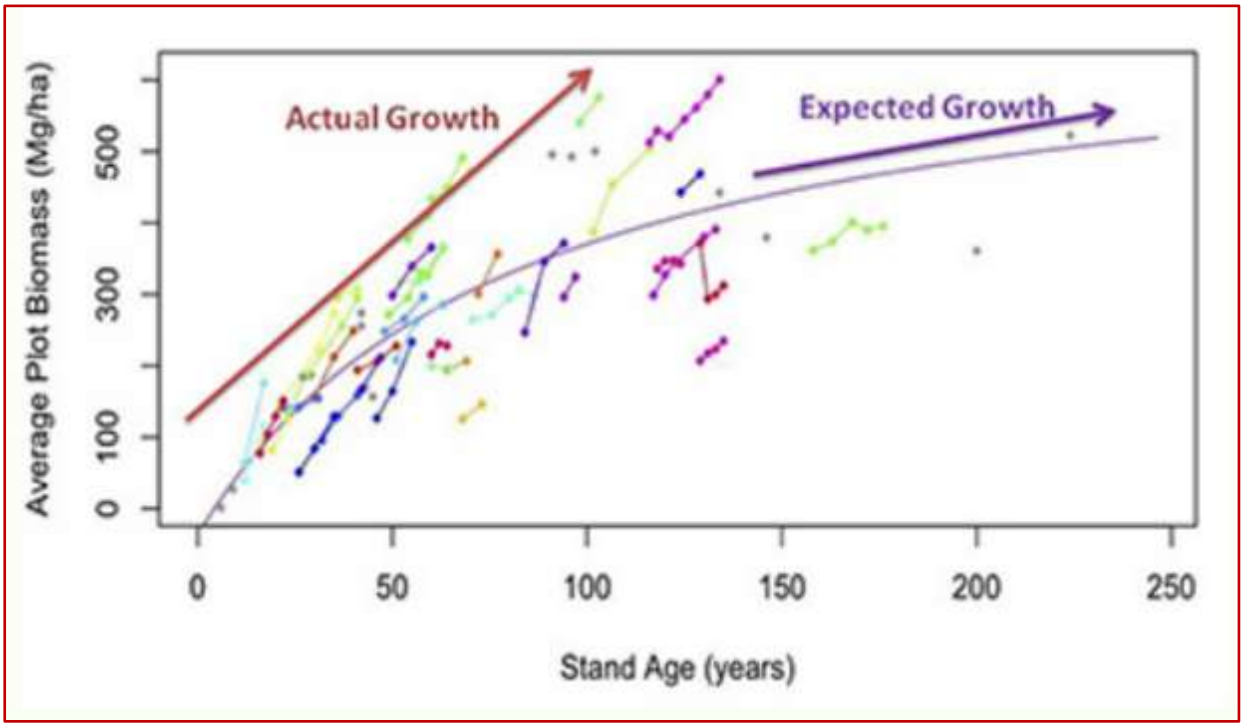
Increasing forest disturbance damage in Europe (© *Nature Climate Change*, the authors)

Source : European Forest Institute

Restoring forest landscapes helps enhance climate change mitigation and adaptation. One such smart move is done by patch of trees to tackle the future consequences due to climate change and this is proven by measuring a tree girth in Maryland forests have actually grown two to four times *faster* in the last 22 years than they have in the last 225 years. A team of scientists and volunteers measured roughly 50,000 trees over a quarter century. The trees' actual growth over those 22 years was much higher than it should have been if the trees had maintained their earlier speed. On average, they found the forest gained about two tons more per acre annually. Parker knew the trees couldn't have been growing that quickly their entire lives; otherwise, they would be much larger.

Carbon stocks are also other management tool that is efficient in fighting back climate changes. Forest carbon stocks are closely tied to forest biomass, so factors that increase tree growth rates will subsequently increase rates of carbon storage within forests. Forest biomass is that special component that stores carbon in huge amounts and so it is very important to maintain forest biomass to a level that is not toxic to the existing environment. The longer-term development of the forest carbon stock depends on biophysical contexts such as soil and climate conditions, historic and current management regimes, and events such as storms, fires, and insect outbreaks.

If harvest volumes (for wood products and energy) and losses related to mortality and disturbances (e.g. storms, insects, fire) do not exceed the growth across the whole forest, there is no net reduction in forest carbon stock.



Source : Smithsonian Environmental research center

Conclusion

Better managed forests and improved use of land help reduce vulnerability to climate change and advance both mitigation and adaptation objectives. Though all these efforts take huge manpower and skills set to achieve it is worth to spend all these tools to enhance and improve the condition of present forests to have a sustainable practice continued for coming generations of advancement.It will be increasingly important to prioritize actions for adaptation based both on the vulnerability of resources and on the likelihood that actions to reduce vulnerability will be effective.

Source: Surya Deepika Garugu

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Invasive alien plant species – Impact, control and management

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Introduction

Ecological irritations brought about by biotic invasion have been distinguished as a developingdanger to worldwide sustainability. Invasive alien plant species (IAPS) is defined as the species that is non-native to the ecosystem and has a negative impact on economic, environment and human health. It has adverse effect on biodiversity by reducing or eliminating the native species of the particular habitat through competition, predation and also disturbs the ecosystem and its functions.It has certain negative effect as they do not provide food, they out compete our native species for limited resources such as food and habitat, they explode in population because they do not have a natural predator. Invasive alien plant species are considered as one of thesignificant drivers of biodiversity loss and accordingly changing the biological system and socio-economic conditions through various instruments.

IAPS enters into new ecosystem through roots, by accidental transportation (ship vessels), by seeds, transported by winds or water, hitch on to our shoes or an animal's body and in most cases, people import invasive species for ornamental and landscaping purposes because many of these species are very attractive. In other cases, these plant species are purposely planted because they have strong root systems and can provide soil stabilization and prevent erosion.According to Convention on Biodiversity, 1992 Invasive alien species are thesecond largest cause of biodiversity loss in the world and impose high costs to agriculture,forestry, and aquatic ecosystems. Anthropogenic disturbances are the great elements liable forbiotic invasion. If human disturbances will have proceeded in the long term, there might be a riseof new IAPS, unsafe to natural/human wellbeing. The various process involved in the arrival, spread, and establishment of Invasive alien plant species can be managed sustainably i.e., economic, ecological, and social culture with a proper understanding, program, and researchwork. Arising worldwide issues, similar to biodiversity disintegration, environmental change, un-supportable agriculture, and ecological disturbances should be studied top to bottom to know their complex associating impacts on human well being.

According to recent study there are 173 species of invasive alien plants in India that represent 1%of Indian flora such as *Prosopis juliflora, Alternanthera philoxeroides,Cassiauniflora,Chromolaena odorata Eichhorniacrassipes,Lantana camara,Parthenium hysterophorus etc*

A plant must havethefollowing traits to becomeinvasive.

- In favorable environment conditions the seed production should be higher.
- It should growrapidlyfromthe vegetativetothereproductivepha se.

- It has long-lived seeds for discontinuous germination.
- It should be capable to disperse its seeds over short and long distances.
- It should produce seeds continuously throughout the growth period and in a range of environmental conditions.
- It should spread aggressively
- Itshould have a strong potential to compete with other species and natural enemy should be absent.
- They result in a monoculture.

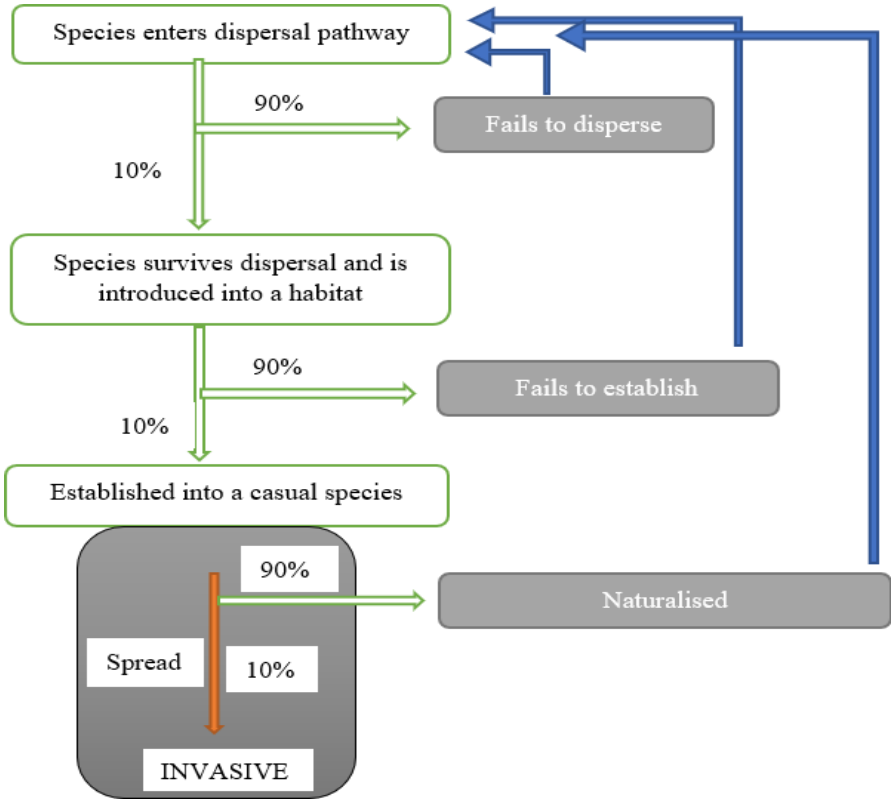

Fig: Steps involved in invasion (Babu, 2003)

What it takes to be invasive?

Impact of invasive alien plant species:

Environment impact

Environmental functioning is disturbed due to IAPS to a greater extent in the various environments globally. It has been confirmed that IAPS disturb the ecosystem functioning through three basic mechanisms, (a) reduction in the diversity indigenous plants and animals, (b) allelopathy effects and (c) make favor to fire hazard.

IAPS tend to blowout at quick rate, consequential upon the expansion of natural fire regime, which may also have antagonistic impacts on the environmental functioning. IAPS have also been played to alter the fire regimes in several terrestrial ecosystems that result in an enormous socio-economic loss.Invasions by noxious IAPS, like spotted knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*) and cheat grass (*Bromus tectorum*) may have profound

impact on the soil quality of the grassland ecosystems (Gibbons et al., 2017).

Ecosystem services

Many IAPS are well recognized as their influence on ecosystem services like aesthetic, recreational, cultural and regulatory. Since IAPS tend to impede the water navigation, they are known to impact adversely the recreation and tourism services (Eiswerth et al., 2005). The invasion of ***Opuntia stricta*** in African region adversely affected the environment and economy. Therefore, it has affected the livelihood of local people through reduction in fodder and livestock health.

Economic impacts

Numerous IAPS, familiarized for human welfare are known to create environmental and economic damage. So, people's view about IAPS as well as their local ecological knowledge can be an effective approach to categorize the IAPS impacts. It has been noted that ***Acacia mangium***, an IAPS in northern Brazilian Amazon is responsible for harmful effects to economy, environment and indigenous people through alteration of the water quality. The invasion of aquatic macrophytes like ***Eichhornia crassipes*** (water hyacinth) in Lake Victoria has become economic for human welfare as it reduces fish production and eco-tourism potential. Furthermore, the ecological niche models (CLIMEX), and Global Climate Models have predicted a shift of water hyacinth, under climate change regime, towards European and Mediterranean regions indicating the serious economic implications of such invasion (Kriticos and Brunel, 2016).

Human health impact

Biodiversity and its changes are inseparably linked with the human health, both in benefitable and harmful sense. Beneficial implications of IAPS comprise their applications in vector borne control and ethno-medicinal uses. For example, a mosquito repellent is taken out from ***Lantana camara***. However, some biotic invasive species distress the human health through environmental contamination, infect humanswith new diseases, serving asvectors for existing diseases, or causingwoundsthrough bites, stings, allergens, or other toxins.Parthenium is a poisonous, pernicious, troublesome, allergenic, and aggressive weed that present a serious hazard to humans and livestock in general.This weed is thought to be one of the most common causes of dermatitis, asthma, nasal-dermal, and nasal-bronchial disorders in India and Australia.

Table 1 -Some invasive alien flora of India

Sr. No	Common Name	Scientific name	Family	Native	Remarks
1	Pink morning glory	*Ipomoea purpurea*	Convolvulaceae	America	Aggressive colonizer. Its spreads mainly along riparian zones and seeds are poisonous if ingested
2	Lantana	*Lantana camara*	Verbenaceae	Tropical America	Common weed in forest, plantationand convert itself into one of the noxious weeds because of its invasiveness, potential for spread and its negative impact.
3.	Black Wattle	*Acacia mearnsii*	Fabaceae	South East Australia	Introduced for afforestation in western ghats regenerate rapidly after fire and forms dense thickets.
4.	Needle Bush	*Vachellia farnesiana*	Fabaceae	South America	Unwanted species that increases aggressively to form thickets when more-palatable companion plants are grazed out.
5.	Goat weed	*Ageratum conyzoides*	Asteraceae	Tropical America	It is often one of the first species to colonies degraded areas and so able to prevent other plants from establishing. It has been included in the Global Invasive Species Database (GISD 2003)
6.	Congress grass	*Parthenium hysterophorus*	Asteraceae	Tropical America	Considered as one of the most dangerous terrestrial weeds found in cultivated field, forest and garden.
7.	Water Hyacinth	*Eichhornia crassipes*	Pontederiaceae	South America	It is a free-floating perennial aquatic plant which forms dense colonies that block sunlight and gets crowded over native species.
8.	Thorn apple	*Datura stramonium*	Solanaceae	Tropical America	It contains a number of alkaloids, present in the seeds and flowers that are toxic, narcotic and hallucinogenic. and causes serious illness or death after ingestion.

9.	Mesquite	*Prosopis juliflora*	Fabaceae	Mexico, South America	It is themostnoxiousweedspeciescausingenvironmental,economic, and human health harm in arid and semi-arid areas
10.	Sleeping grass	***Mimosa pudica***	Fabaceae	***South America***	*Mimosa pudica* forms a dense ground cover, preventing reproduction of other species (PIER, 2005). It has become a serious weed in fields of corn, soybeans, tomatoes, upland rice, cotton, bananas, sugarcane, coffee, oil palms, papayas, coconuts, and rubber in many tropical areas.

Prosopis juliflora

Lantana camara

Partheniumhysterophorus

Eichhorniacrassipes

Datura stramonium

Mimosa pudica

Fig- Some invasive alien plant species of India

Control and management

Physical Control

Controlling alien plant invasions manually includes hand-pulling, uprooting, hoeing, felling, or cutting back. Such methods can be labor intensive but in regions where manual labor is readily available and can be hired cheaply manual control is often both effective and economical. In case of *Prosopis juliflora* the mosteffective, mechanical control method is by removing the plant from10-15cmbelow theground and usingtheland for crop production (Samuel *et al*., 2004). For removal of *Lantana camara* it includes the use of bulldozers and tractors (Day *et al*., 2003). In case of *Parthenium* it should be uprooted before flowering during monsoon season when the soil is wet.

Chemical Control

It involves the use of herbicides, weedicides that primarily affect the target weeds and requires repeated, regular follow-up treatments. Prosopis seedlings and plants up to 1.5 mtall can be controlled by high volume (overall spray) of triclopyr + picloram e.g., Garzon DSExtra (DAFF Queensland, 2013). For controlling *Lantana camara* glyphosate is marginally effective as a foliar spray and regrowth are common. But, the use of chemicals tends to cause harm to the native biota of the ecosystem affecting the food chain, soil health, causing water pollution, and giving genesis to ancillary problems (Neema *et al*., 2013). Parthenium can also be controlled by use of glyphosate (1 to-1.5%) for total vegetation control, but if grasses are to be saved, metribuzin (0.3 to 0.5%) or 2, 4-D (2-2.5 kg) can be used.

Biological Control

Biocontrol does not eradicate the alien plant invader, but rather weakens its competitiveness withnative plant species, suppressing its density and environmental impacts, so allowing the nativevegetationto recover (Gordon and Arne, 2013). Several host-specific insects such as Diastema Tigris (flower mining moth), *Cnaphalocrocis medinalis*. (Leaf folding caterpillar), *Cameraria ohridella* (leaf-mining beetle), have been introduced from time to time for biological suppression of Lantana camara but have not beeneffective incontrolling its infestation (Neema *et al*., 2013). The main reason for the failures being the extreme variability of the weed, extensive climate range it invades, and highlevel of parasitism on the natural enemies. *Parthenium* can be managed by its natural enemies like insects, fungi, nematodes, snails, slugs and competitive plants. Four biological control agents have been released in Australia for control of *Prosopis juliflora*: *Algarobius bottimeri* and *A. Prosopis* (seed-feedingbruchids), *Evippe* species (a leaf-tying moth), and *Prosopidopsyllaflava* (a sap sucker) (Van Klinken *et al*., 2003).

Conclusion

Invasive alien species are the organism that are not native to the environment it can be plant, animal or insect and have a negative impact on environment, economic and human health. Invasive Alien Plant Species is a major threat to biodiversity and can be introduced into new environment by propagation, winds, birds, animal, and shoes and sometimes imported for the ornamental purpose because of its attractiveness. Although Invasive alien plant species have a negative influence on the local biodiversity andenvironmentalbenefits, their part in species eliminations is controversial among the attack environmentalists. It has several characteristics that lead it to

invasion arerapid reproduction and growth, high dispersal ability, ability to adapt physiologically to new conditions, spread aggressively, result in monoculture, higher seed production; disperse its seed to longer distances. It causes damage by competing with native species, bringing diseases, destroying natural diversity, eliminating native plant, changing ecosystem functions etc. To get rid of invasive species there are various management strategies i.e., physical control, chemicalcontrol, biological control which include going in field and uprooting them, cutting back, use of several chemical herbicides and weedicides, use of natural enemies which suppress its density. Invasive species has become most important in the present scenario that article 8(h) of biodiversity convention ask to prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.

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United Nation's Post-2020 Global Biodiversity Framework: Opportunities for local action

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As the United Nations Decade on Biodiversity 2011-2020 came to an end, International Union for Conservation of Nature (IUCN) launched the development ofan ambitious new global biodiversity framework called 'Post-2020 Global Biodiversity Framework'. It is a new framework that will be the global guiding force to protect nature and to protect its essential services for humans from 2020 to2030.The framework aims to motivate urgent and transformative action by Governments and all of society to contribute to the objectives of the Convention on Biological Diversity (CBD), its Protocols, and other biodiversity related multilateral agreements, processes and instruments.

Convention on Biological Diversity

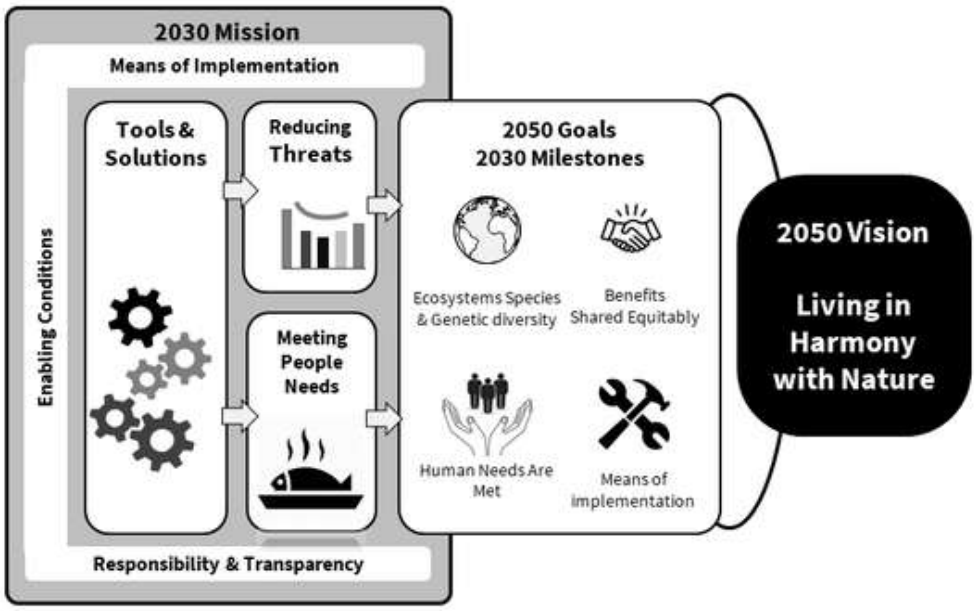
CBD is a legally binding treaty to conserve biodiversity and has been in force since 1993. It has 3 main objectives such as (i) conservation of biological diversity; (ii) sustainable use of the components of biological diversity, (iii) fair and equitable sharing of the benefits arising out of the utilization of genetic resources.Nearly 195 countries have ratified the convention. The CBD Secretariat is based in Montreal, Canada and it operates under the United Nations Environment Programme.The Parties (Countries) under CBD, meet at regular intervals and these meetings are called Conference of Parties (COP).In 2000, a supplementary agreement to the Convention known as the Cartagena Protocol on Biosafety was adopted. It came into force on 2003.The Protocol seeks to protect biological diversity from the potential risks posed by living modified organisms resulting from modern biotechnology. In 2010, The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization (ABS) was adopted at COP-10 held at Nagoya, Japan. It entered into force on 12th October 2014.It not only applies to genetic resources that are covered by the CBD, and to the benefits rising from their utilization but it also covers traditional knowledge (TK) associated with genetic resources that are covered by the CBD and the benefits arising from its utilization.Along with the Nagoya Protocol on Genetic Resources, the COP-10 also adopted a ten-year framework for action by all countries to save biodiversity.Officially known as "Strategic Plan for Biodiversity 2011-2020", it provided a set of 20 ambitious yet achievable targets collectively known as the Aichi Targets for biodiversity.

Post-2020 Global Biodiversity Framework

The draft of Post-2020 Global Biodiversity Framework encompasses a call for action to achieve 21 targets and 10 milestones by 2030. The key thrust areas propounded in the framework includes ensuring ecological conservation of at least 30% of global land and sea areas with cardinal

focus on regions that are rich in biodiversity, areas connecting protected area network and associated wildlife corridors using integrated landscape level management plan, to bring down the invasion of natural ecosystems by alien species by 50 percent and undertake strategic measures to reduce,mitigate and eliminate their adverse impacts, to trim down the leaching of nutrients by 50%, pesticides by around 65% and purge the discharge of plastic wastes. The framework also aims to streamline efforts directed at mitigation and adaptation to climate change by imploring the actors to ensure their efforts are not compounding the negative impacts on biodiversity. Clarion call has be given to redirect, repurpose, reform or eliminate incentives harmful for biodiversity in a just and equitable way while also accentuating financially bound other targets of domestic resource mobilization, leveraging private finance and national biodiversity finance planning.

The goals and targets outlined in the framework are in line with the global efforts to reach the 2050 vision of biodiversity. The document also acknowledges the requirement to engaging non-governmental actors such as NGOs, indigenous and local communities, women's groups and any other business or finance community for the realisation of the deadline linked targets.



Source: https://www.cbd.int

In an analysis of United Nation's Post-2020 Global Biodiversity Framework,brought out by two acclaimed international science bodies: bioDISCOVERY, a programme of the Future Earth organization, and the Group on Earth Observations Biodiversity Observation Network (GEO BON), more than 50 scientists from 23 nations have expressed the urgent need for integrated actions across different interconnected set of "transformative" changes, including substantial reductions in detrimental agricultural and fishingsubsidies, curbing

mindless consumerism to hold therise in temperature due to climate crisisat or below 1.5 degrees Celsius.

Governments across the globe are struggling to mend their policies of economic growth and development to bend the curve of increasing biodiversity loss. The liability or burden also lie skewed more towards less developed or developing nations than developed nations due to historical inequalities propelled against such nations under colonial rule. Nevertheless, international and intergovernmental associations are working to bridge this gap through common but differentiated responsibility.

India's efforts

India in its efforts towards a climate responsible nation, have so far accomplished in generating 36.37 percent of electricity from renewable energy sources, saved 38.6 mt CO_2 by switching onto LED bulbs, brought 1.7 million hectares of land under afforestation schemes, and reduced the number of wildlife crimes reported from a protected area to 15 (2019) through meticulous and regular monitoring for wildlife conservation. India has been ranked 10 and continued to be among the top-performing countries among the G20 nations in the recently published Climate Change Performance Index 2022 Reportby Germanwatch, the New Climate Institute and the Climate Action Network. But considering the pandemic and the recently committed goals in COP 26 at Glasgow, India has to step up its game significantly to ascertain its global position as a climate-nature responsible nation. This would certainly call for increased participation of citizenry, strong political will anchored through robust public policies to build back better. Attainment of self sufficiency in energy security through biodiversity conservation can be made possible when solutions are taken from lab to land and from papers to households. Only change can change climate change, and such a 'change' warrants the people to mend their lifestyle towards an Environmentally Responsible Behaviour (ERB) through forward and backward linkages. Any deficiency incurred while switching over from coal / firewood based village subsistence to alternate energy sources should be compensated to the village economy through livelihood generation and augmentation schemes by the district administration. Sensitization of rural en masse about climate crisis and biodiversity conservation should precede policy implementation and decentralisation of planned projects. Bringing more forested landscapes under protected area network should be complemented with addressing the grievances and livelihood constraints of the forest dependent communities.

Opportunities for local action

Overall goal of a biodiversity conservation framework is to conserve and enhance biological diversity within the country and to contribute to the conservation of global biodiversity through several mechanisms. A major means of implementing such plan is through the creating opportunities and implement it at a local level.

There needs to be a Local Biodiversity Action Plans to ensure that nationally and locally important species and habitats are conserved and enhanced in a given area through focused local action. The primary functions of such a plan are:

- To translate national targets for species and habitats, into effective action at the local level.
- To stimulate effective local working partnerships to ensure

that programmes for biodiversity conservation are developed and maintained.

- To raise awareness of the need and responsibilities for biodiversity conservation and enhancement in the local context.
- To identify biodiversity resources and priorities in the local area.
- To identify targets for species and habitats important to the local area, including both the rare and the common.
- To ensure that delivery mechanisms for conservation and enhancement of biodiversity resources are promoted and understood at the local level.
- To provide a local basis for monitoring progress in biodiversity conservation.

Additionally, an effective a land-use policy at local level is increasingly being recognized as fundamental to biodiversity conservationin many countries. Many planners and conservation scientists have called for broader use of planningand regulatory tools to support the conservation of biodiversity at local scales. Further, any policy or plancan realize its goal only when there is a combination of political will, public policy and people's participation.

Both policy changes and on-ground experiences over the last few years, have emphasized the additional measures in order to achieve the conservation of biodiversity and the sustainable use of biological resources. Some of them are (a) behavioral change among school children; (b) conservation of biodiversity-rich areas that are not currently under any Protected Area Network; (c) creation of comprehensive database to frame corrective actions and policies; (d) carbon lock-ins and energy use need to be minimized through mandatory Green Construction Codes for housings, highways and infrastructures and so on.

In this article, we have highlighted the origin and need of Convention on Biological Diversity and UN's Post-2020 Global Biodiversity Framework which global nations have already started attempting to conserve its biodiversity and sustainable management of its biological resources. Many of these are already in practice, though not always successfully; many others need to be introduced. We have also pointed out critical issues that need to be tackled while planning and implementing such measures at local or regional level. As India moves ahead to implement its obligations under UN's Post-2020 Global Biodiversity Framework, it should do well to stress on some essential pre-requisites: decentralized and participatory planning and implementation, social and ecological monitoring, and equity in decision-making and benefit-sharing.

वानिकी वृक्षो के उत्पादन की उन्नत तकनीक एवं जल प्रबंधन

अजीत विलियम्स

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प्रस्तावना

मानव जीवन में प्राचीनकाल से वनों का बड़ा ही महत्व रहा है । वन प्रेरणा तथा स्वास्थ्य के स्त्रोत रहे है। आज भी हमारे देश की लगभग 80 प्रतिशत जनता गांवो में रहती है तथा उनकी आजीविका का मुख्य साधन खेती अथवा कृषि कार्यो से मिलने वाला रोजगार है। ग्रामीण जनता की बहुत सी आवश्यकतायें जैसे जलाऊ लकड़ी, पशुओं के लिये चारा, गृह निर्माण हेतु इमारती लकड़ी तथा कृषि उपकरणों हेतु लघु-काष्ठ आदि वनों एवं वृक्षों पर आधारित है। इसके अतिरिक्त फल-फूल, शहद, मोम, महुयें का फूल, बांस, छप्पर बनाने के लिये घास तथा कुटीर उद्योगों जैसे दियासलाई, लकड़ी के खिलौने, हस्तनिर्मित कागज, दोना-पत्तल, टोकरियॉ आदि बनाने के लिये कच्चा माल भी इन्ही वनो एवं वृक्षो से प्राप्त होता है।

अनादिकाल से ही भारत का अधिकांश भाग वनाच्छादित था। जैसे-जैसे जनसंख्या बढ़ी, वनों का क्षेत्रफल घटता गया क्योंकि बढ़ती हुई जनसंख्या के बसाहट के लिये भूमि की आवष्यकता एवं भवन-निर्माण के लिये प्रकाष्ठ और खेती के लिये भूमि की आवश्यकता बढ़ी और ये आवश्यकतायें वनों को काटकर पूरी की गई। आजादी के बाद देश में हुये औद्योगीकरण ने वनों के विनाश की प्रक्रिया को और अधिक तीव्र बना दिया है। वनों के अन्धाधुन्ध दोहन से भूमि का जल स्तर नीचे गिर रहा है एवं मिट्टी का अनियंत्रित कटाव हो रहा है। जिसके कारण कहीं पर सूखे तो कहीं पर बाढ़ की स्थिति निर्मित हो रही है। परिणाम स्वरूप भूमि की उर्वराशक्ति में कमी आने से फसलों की पैदावार भी घट रही है।

दिन प्रतिदिन बढ़ती हुई वन उत्पादों की मांग पूरी करने के लिये यह जरूरी है कि व्यापक स्तर में वृक्षारोपण कार्य किया जाये। वृक्षारोपण प्राकृतिक वनों का विकल्प नहीं हो सकता है (क्योकि वन स्वयं एक पारिस्थितिकी प्रणाली होते है), लेकिन इससे ईमारती लकड़ी, इंZधन, चारा और अन्य वन उत्पादों के लिये प्राकृतिक वनों पर दबाव कम किया जा सकता है। इस प्रकार वृक्षारोपण का विकल्प मनुष्य तथा आग्र चलकर पर्यावरण के लिये लाभकारी है।

भारत में पर्यावरण संरक्षण की समस्या और चारा, ईमारती लकड़ी तथा ईंधन की लकड़ी की दुर्लभता की चुनौतियों का सामना करने का एक मात्र समाधान ग्रामीण जन समुदाय द्वारा स्वयं वृक्षारोपण के जरिये वानिकी को बढ़ावा देना है। जन-समुदाय में पर्यावरण एवं पौध रोपण से संबंधित जानकारी उचित तकनीक अपनाकर ही पूरी की जा सकती है।

वानिकी वृक्षों के उत्पादन की उन्नत तकनीक

वानिकी के आर्थिक पहलू दो प्रकार के उत्पादन पर निर्भर करते है। पहला उत्पादन उन वृक्षों को माना जाता है, जो कि कृषक अपनी आवष्यकता को ध्यान में रखते हुये कृषि योग्य भूमि पर उगाता है। इस उत्पादन को मुख्य उत्पादन कहते है। दूसरा उत्पादन कृषि फसलें, घास एवं पशुओं से प्राप्त होता है। इन दोनों तरह के उत्पादन को अधिकतम मात्रा में प्राप्त करने के लिये यह आवष्यक है कि वन पौधों का चयन इस प्रकार से किया जाये कि अधिकतम उत्पादन हो सकें, जिसमें कि दोनों उत्पादन शामिल है।

देश के सामने भारी संकट आने की संभावना को दूर करने के लिये देश के वैज्ञानिकों, प्रशासकों एवं जनता को पहले से ही जागरूक हो जाना चाहिये था। जब हमारा देश आजाद हुआ था, उस समय कुछ वैज्ञानिकों ने बड़े ही स्पष्ट शब्दों में कहा था कि भारत के पास चाहे खाने के लिये कितना ही अनाज क्यों न हो, लेकिन इस शताब्दी के अंत तक जलाने की लकड़ी में भारी कमी आ सकती है। आज यह कथन सत्य प्रतीत होता नजर आ रहा है । वन वृक्षों की प्रजातियों की कटाई की एक उम्र निश्चित होती है और इसमें किसी भी तरह का परिवर्तन नहीं कर सकते है। कुछ प्रजातियॉ तो ऐसी है जिनके वृक्षों की उम्र 40 से 50 वर्ष या उससे भी अधिक होती है और इस बीच में किसी तरह का परिवर्तन संभव नहीं है। इसलिये वन वृक्षों का चयन एक विवेकपूर्ण कार्य है ।

बांस

बलुई दोमट मिट्टी में सर्वोत्तम विकास। जलौढ़ मृदाओं तथा लाल मृदाओं पर भी। बीजों को ठंडे पानी, गर्म पानी, गोबर की ताजी खाद से उपचारित करना चाहिये। बीजों को तैयार रोपणी या पॉलीथीन की थैलियों में बुवाई करते है। क्यारियों में बीज बोने के पश्चात उसे हल्की मिट्टी से ढक दिया जाता है। बीज बोने के एक सप्ताह में प्रारम्भ होकर 30 से 45 दिन में अंकुरण पूरा होता है। बीज फरवरी-मार्च में बोते है। जुलाई माह में 45 x 45 x 45 से.मी. आकार के तैयार गड्ढों में 4 x 4 मीटर की दूरी पर लगते है।

खम्हार

उपजाऊ गहरी रेतीली दोमट मृदा उपयुक्त। बीज को ठंडे पानी (24 घंटे) गर्म पानी (पूरी रात) तथा खौलते पानी (12 घंटे) में रखकर उपचारित किया जाता है। बीजों को तैयार रोपणी में या पॉलीथीन की थैलियों में बुवाई करते है। बीज बोने के 15 से 20 दिनों में अंकुरित हो जाते है। बीज मार्च-अप्रैल में ही बो दिया जाता है। जून-जुलाई माह में 45 x 45 x 45 से.मी. आकार के तैयार गड्ढो में 4 x 4 मीटर की दूरी पर लगाते है। समय-समय पर सिंचाई करते है।

सागौन

मृदा गहरी और अधोभूमि सहित समस्त मृदा में जलनिकास अच्छा होना चाहियें। बीजों को गोबर व पानी के मिश्रण में एक सप्ताह रखकर फिर 7 से 10 दिन तक तेज धूप में सुखाया जाता है। उपचारित बीजों को तैयार रोपणी या पॉलीथीन

की थैलियों में फरवरी से जून माह में बोते है। बीज बोने के 12 से 15 दिन में अंकुरित हो जाते है। जुलाई माह में 45 x 45 x 45 से.मी. आकार के गड्ढो में 4 x 4 मीटर की दूरी पर लगाते है। समय-समय पर नियमित सिंचाई करते है।

सिस्सू

जलनिकास वाली बलुई दोमट मृदा उपयुक्त। बीजों को पूर्व उपचार की आवष्यकता नही। बीजों को तैयार रोपणी या पॉलीथीन की थैलियों में बुवाई करते है। बीज बोने के सप्ताह भर में अंकुरण आ जाता है। बीज फरवरी-मार्च में बोते है। जुलाई माह में 45 x 45 x 45 से.मी. आकार के तैयार गड्ढो में 5 x 5 या 8 x 8 मीटर की दूरी पर लगाते है । समय-समय पर नियमित सिंचाई करते है।

सफेद सिरिस

जलौढ़ मृदा, मृत्तिका मृदाओं तथा साधारण ऊसर उपयुक्त बीजों को गर्म पानी से उपचारित कर रोपणी या पॉलीथीन की थैलियों में बुवाई करते है। बीज बोने के 4 दिन में अंकुरण आ जाता है। बीज अप्रैल-मई में बोते है। जून-जुलाई माह में 45 x 45 x 45 से.मी. आकार के तैयार गड्ढो में 5 x 5 मीटर की दूरी पर लगाते है। समय-समय पर नियमित सिंचाई करते है।

वानिकी वृक्षो में जल प्रबंधन

जल एक अमूल्य निधि है और इसके अभाव में वनीकरण कार्य असंभव है। हमें जल के महत्व को समझकर इसके अपव्यय को रोकना चाहिये। जल का उचित उपभोग तथा अपव्यय को कम करने हेतु जिन उपायों को किया जाता है उसे जल प्रबंधन कहते है। साधारणतया जल को क्यारियों तक निम्न पद्धतियों से दिया जाता है उसके अंतर्गत मुख्य रूप से निम्न विधियॉ है :

1. बहाव पद्धति
2. क्यारी या पट्टी पद्धति
3. नाली पद्धति
4. थाला पद्धति
5. अगूंठी पद्धति
6. बौछार पद्धति
7. टपक या ड्रिप पद्धति

उपरोक्त विधियों में (6-7 को छोड़कर) हमें काफी अधिक मात्रा में जल की आवष्कता होती है तथा अपव्यय एवं बहाव भी अधिक होता है। जल प्रबंधन के तहत हमें यह देखना चाहिये कि जल की मात्रा तथा उसका अपव्यय कम हो। इस दृष्टि से बौछार पद्धति एवं टपक पद्धति काफी लाभदायक सिद्ध हुई है। अतः हमें रोपणी में इन विधियों द्वारा सिंचाई करना चाहियें। यद्यपि ये विधियां महंगी है पर इनके कई लाभ है तथा सबसे महत्वपूर्ण बात यह है कि इस विधियों से जल का अनुचित बहाव या व्यय रूकता है और अधिक से अधिक मात्रा में जल पौधों की जड़ों तक पहुचता है ।

वृक्षारोपण क्षेत्र में पौधों के आस-पास तथा तने के चारों ओर की भू-सतह को किसी उपयुक्त सामग्री जैसे पुआल, घास, पत्ती या प्लास्टिक शीट से ढंककर मृदा की सतह से वाष्पोत्सर्जन से होने वाली नमी के नुकसान को कम किया जा सकता

है। इससे खरपतवारों की वृद्धि में कमी तथा पौधों को दिये जाने वाले खाद व पोषक तत्व पूर्ण रूप से पौधे को उपलब्ध हो जाता है। इस प्रकार रोपण क्षेत्र में सिंचाई की बांरबारता में कमी आती है तथा बहुमूल्य जल की हानि का बचाव होता है।

Bamboo leaf rollers and their control measures

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Abstract

Leaf rollers (Lepidoptera : Pyralidae) are one of the most important groups of leaf feeders on bamboo (family Poaceae). The present article deals with leaf rollers that occur in bamboos. The control measures for suppressing pest population of leaf rollers in bamboos have been highlighted.

Key words: Bamboo, leaf rollers, control measures.

Introduction

Bamboos (family Poaceae), by virtue of their multiple socio-economical applications, are popularly known as Green Gold. They are widely distributed throughout India from flat alluvial plains to high mountains, i.e. up to 3050 m above sea level (Tewari, 1992). They are generally found as an under-story crop in natural forests. In recent years, plantations of bamboos have also been done by the State Forest Departments, Forest Corporations and private cultivators in different parts of the country (Joshi et al., 2008). The bamboo species, due to their wider distribution and rich source of nutrition, face serious threat of herbivory by number of insect pests, in nurseries, plantation and storage.

Overview of insect pests

About 170 species of insects have been reported to be associated with different species of bamboos in India and adjacent countries (Bhasin et al., 1958; Mathur and Singh, 1961). After that, in comprehensive reviews published by Singh and Bhandari (1988), Thakur (1988) and Singh (1990), nearly 44 more species of insects including termites have been reported on bamboos. Mathew and Varma (1990) have recorded 26 species of insects from bamboos in Kerala. An up-to-date search of literature on bamboo entomology reveals about 200 odd species that are associated with various species of bamboo in India and its adjoining countries, belonging primarily to Coleoptera, Homoptera, Isoptera, Lepidoptera, and Thysanoptera (Mathur, 1943; Bhasin et al., 1958; Mathur and Singh, 1959; Singh and Bhandari, 1988; Thakur, 1988; Mathew and Varma, 1990; Singh, 1990; Joshi et al., 2008; Roychoudhury and Mishra, 2022). According to their food habits and nature of damage, the insect fauna of bamboo is grouped in to seed pests (2 species), nursery pests (5 species), defoliators (48 species), sap-suckers (90 species), culm and shoot borers (12 species), borers (44 species) and termites (13 species) of felled and dried bamboos (Tewari, 1992).

Among the 48 species of insect defoliators, leaf rollers belonging to the order Lepidoptera and family Pyralidae are one of the most important groups of leaf feeders on bamboo. Haojie et al. (1998) have mentioned 12 species of leaf rollers as attacking various bamboos in Asia (Table 1). Several species often occur together. The damage is caused by larvae, which tie leaves together as leaf cases and feed on the upper tissues of the leaves

(Fig. 1). Outer leaves of the rolled leaf cases often wither and eventually fall off. The damage is conspicuous at the top of culms and branches. Outbreaks are often reported in China, India, Japan and Korea causing serious defoliation, resulting in reduced vigour and even the death of culms. Damage is found to be more severe in nurseries and plantations than in natural stands and individual plantings.

Table 1 : Leaf rollers recorded in bamboos

Common name	Scientific name	Distribution	Hosts
Greater bamboo leaf roller	*Algedonia coclesalis* Walker (syn. *Pyrausta coclesalis*, *Crypsiptya coclesalis*)	Bangladesh, Cambodia, China, India, Indonesia, Japan, Korea, Laos, Myanmar, Pakistan, Sri Lanka and Vietnam.	*Phyllostachys pubescens, P. viridis, Bambusa vulgaris, Dendrocalamus latiflorus, D. strictus, D. giganteus, Schizostachyum pergracile* and *Arundinaria* spp.
Lesser bamboo leaf roller	*Algedonia bambucivora* Moore (syn. *Pyrausta bambucivora*)	Bangladesh, India and Pakistan.	*Bambusa nutans, B. vulgaris, Dendrocalamus giganteus, D. strictus* and *Schizostachyum pergracile.*
-	*Eumorphobotys obscuralis* Caradja	China and Japan.	*Phyllostachys, Bambusa* and *Dendrocalamus* species
-	*Eumorphobotys eumorphalis* Caradja	China and Japan.	*Phyllostachys, Bambusa* and *Dendrocalamus* species
-	*Circobotys aurealis* Leech	China, Japan, Korea and Myanmar	*Phyllostachys, Bambusa* and *Pleioblastus* species
-	*Crocidophora evenorallis* Walker	China, Japan, Korea and Myanmar	*Phyllostachys, Bambusa* and *Pleioblastus* species
-	*Crocidophora ptyophora* Hampson	India and Myanmar	-
-	*Demobotys pervulgaris* Hampson	China	*Phyllostachys pubescens*

Cotton leaf roller	***Sylepta derogata* Fabricius**	**Bangladesh, India and Pakistan.**	**Highly polyphagous and attacks agricultural crops and forest plants apart from several bamboo species.**
-	*Pionea flavofimbriata* Moore	India and Sri Lanka	*Dendrocalamus strictus*
-	*Massepha absolutalis* Walker	Bangladesh, India and Sri Lanka	*Dendrocalamus strictus*
-	*Microstaga jessica*	Japan and Korea	*Phyllostachys edulis* and *P. nigra*.

Fig. 1. Leaf rolls made by leaf roller in bamboo.

Control mesaures

Control measures for suppressing pest population have proven effective against leaf rollers (Haojie et al., 1998). Light-trapping of moths at nights during adult stage, and spraying insecticides on plants are very effective in reducing the leaf-rollers' population in the following generation (Huang Ertian, 1984). Artificial releasing of *Trichogramma* species in bamboo stands is practiced and found effective (Xu Tiansen and Zhao Jingnian,

1976; Jin Changle et al., 1980; Liu Ruilan, 1988). Chemical control may be necessary when heavy attacks occur. Satisfactory results can be obtained in bamboos with large culms by injecting systemic insecticides in the culm cavity (Lan Linfu, 1980).

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