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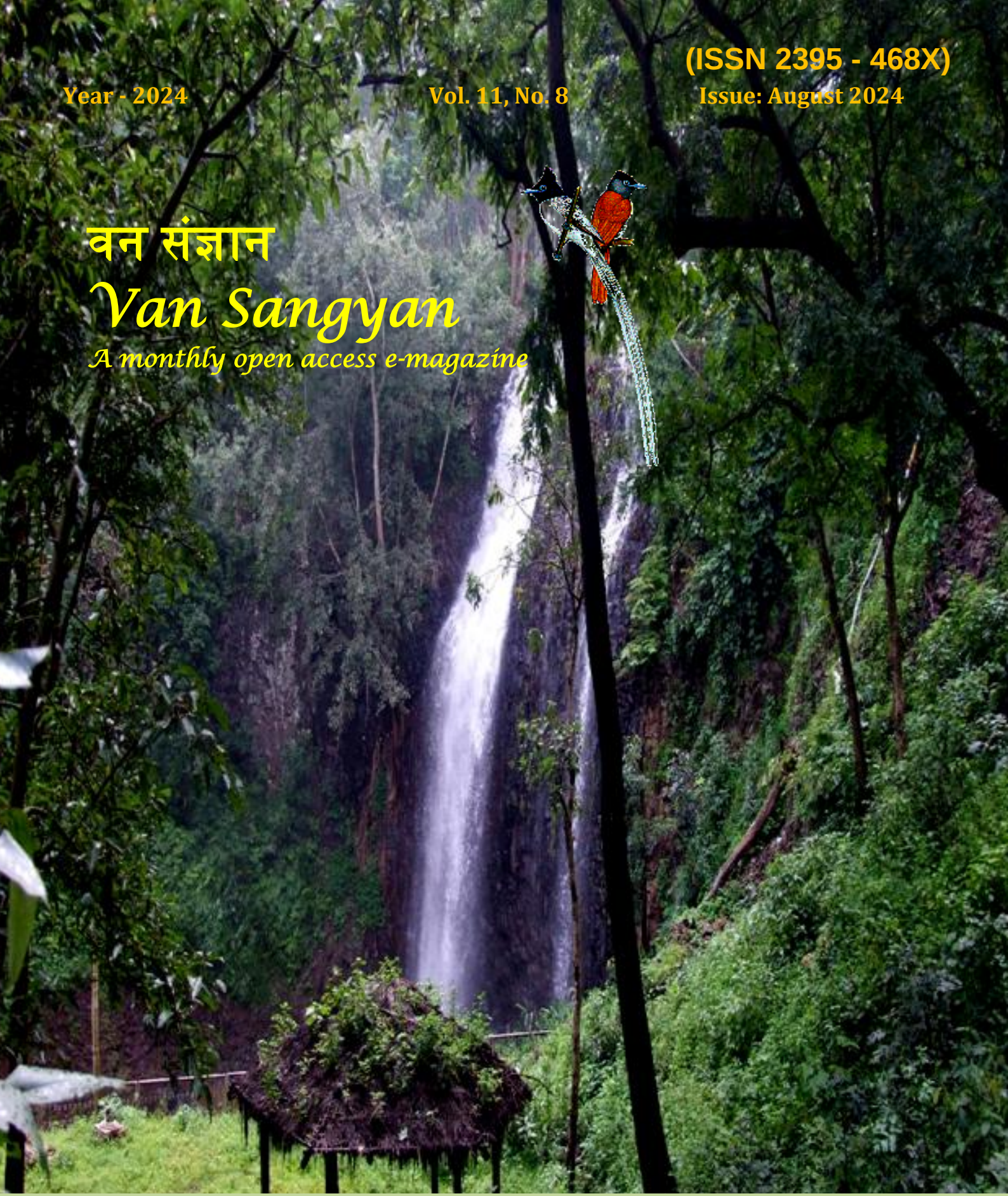

वन संज्ञान
Van Sangyan
A monthly open access e-magazine

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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:

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or, through post to The Editor, Van Sangyan,
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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

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From the Editor's desk

The utilization of biochar for environmental amelioration presents a promising strategy for addressing various ecological challenges. As a stable carbon-rich material produced through the pyrolysis of biomass, biochar can improve soil health by enhancing nutrient retention, increasing moisture capacity, and promoting microbial activity. Its ability to adsorb pollutants makes it effective in remediating contaminated soils and water bodies, mitigating the impact of heavy metals and organic contaminants. Additionally, biochar contributes to carbon sequestration, helping to reduce greenhouse gas emissions and combat climate change. By integrating biochar into agricultural practices and waste management systems, we can foster a more sustainable approach to resource recovery, soil enhancement, and environmental protection.

In this issue of Van Sangyan, we feature an article on the utilization of biochar for environmental amelioration. Additionally, you'll find insightful articles on topics such as: Carambola: Cultivation Practices and Medicinal Importance, Fusion Reactors: Environmental Safety, Multipurpose Tree Species (MPTs) and Their Agroforestry Characteristics, नाग छतरी (*Trillium govanianum): A Rare Medicinal Herb of the Himalayas, International Efforts to Prevent Ozone Depletion' Thinning as a Stand Management Tool: Enhancing Forest Health and Productivity, Promising Properties of Transparent Wood for Various Applications, The Role of Patidoi or Pati-Bet in Livelihood Generation, and Empowering Smallholder Farmers: The Role of Agroforestry in India's Agricultural Landscape*

I look forward to engaging with all of you through our upcoming issues!

Dr. Naseer Mohammad
Chief Editor

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Utilization of biochar for environmental amelioration

Kanica Upadhyay

Department of Forest Products and Utilization
College of Forestry and Horticulture
Jhalawar, Agriculture University, Kota

Introduction

Agricultural waste is usually handled as liability, often because the means to transform it into an asset is lacking. Crop residues in fields can cause considerable crop management problems as they accumulate. The major crop residues produced in India are straws of paddy, wheat, millet, sorghum, pulses (pigeon pea), oilseed crops (castor, mustard), maize stover and cobs, cotton and jute sticks, sugarcane trash, leaves, fibrous materials, roots, branches and twigs of varying sizes, shapes, forms and densities. Similarly, the agro-industrial residueswhich causes accumulation problem (disease and pests) due to lack of proper management. Biochar is a fine-grained, carbon-rich, porous product remaining after plant biomass has been subjected to thermo-chemical conversion process (pyrolysis) at low temperatures (~350–600°C) in an environment with little or no oxygen.

Fig 1: Biochar

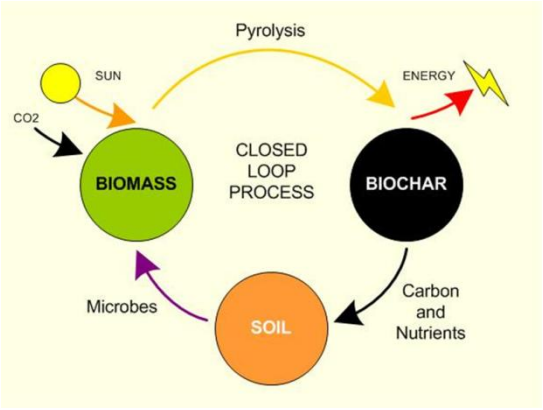


Fig 2: Carbon negative technology of biochar

The Biochar utility as soil amendment is due to its highly porous structure, potentially responsible for improved water retention and increased soil surface area. The Char produced at high temperature, under long heating times and with controlled supply of oxygen which is utilized as activated carbon. Traditional charcoal production should be more accurately described as ‘carbonization’, which involves smothering of biomass with soil prior to ignition or combustion of biomass whilst wet. Drying and roasting of biomass at even lower temperatures is known as ‘torrefaction’. Biochar from pyrolysis and conventional charcoal share a main characteristic which is related to carbon sequestration and soil fertility. Intensive study of biochar-rich dark earths in the Amazon (Terra preta), has led to a wider appreciation of biochar’s unique properties as a soil enhancer.

Characteristics of biochar

It is highly porous structure, responsible for improved water retention and increased soil surface area.Biochar is not a pure carbon, but rather mix of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash in different proportions (Masek, 2009).Low temperature biochar is stronger but, is brittle and prone to abrade into fine fractions.Increase in temperature (400 to 900^{o}C) increases surface area of biochar (120 to 460 m^{2}/g). Mixture of carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulphur (S) and ash (Masek, 2009).At low temperature, biochar may be suitable for controlling release of nutrients , while high temperatures would lead to activated carbon (Ogawa *et al*., 2006).

Preparation of biochar

Heap method

Charcoal making is one of the traditional practices to generate income in various parts of India. In traditional method, a heap of pyramid like structure (traditional earth kiln: Fig. 3) is prepared by keeping wood logs and roots of plants for making charcoal. To allow the combustion products to escape, vents are opened starting from the top and working downwards. When smoke production is stopped, the cooling process is started by covering stack with a layer of moist earth. The cooling process takes several days before the earth is removed and the biochar produced is separated from the surrounding carbonized portions. Earth-mound kilns equipped with a chimney are most advanced among earth kilns. The ability to alter the chimney diameter according to the oxygen demand, and precise control of the draft of the chimney, which is dependent on height, results in better control of the pyrolysis process (Elliott, 2007).

Biochar making from *Prosopisjulifera* is practiced in the rain-fed tracts of Ramanathapuram district of Tamil Nadu during off-season. Generally, people use the heap method of charcoal production as it is easy and cost involved in char production is very low. The charcoal is transported to various districts of Tamil Nadu and also certain states like Maharashtra and Gujarat for industrial purpose. Similarly, a very simple biochar kiln ‘Holy Mother Biochar Kiln’ has been designed by Sarada Matt (Holy Mother) at Almora, Uttarakhand, India, made up of bricks and clay (Fig 4). The biomass is added continuously. The primary air source at the bottom will be kept open as long as biomass is added. It is convenient to operate the kiln during less windy days. As the biomass reaches the level just below the secondary air vents, further addition of biomass should be stopped and the primary air inlet is closed. After some time, water is sprinkled to extinguish the embers (quench). The biochar can be collected immediately or after some time.

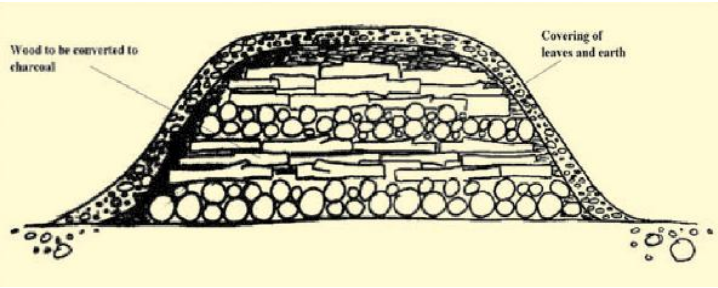


Fig 3. Traditional earth kiln

Source: http://en.howtopedia.org/wiki/Biomass (Technical_Brief)

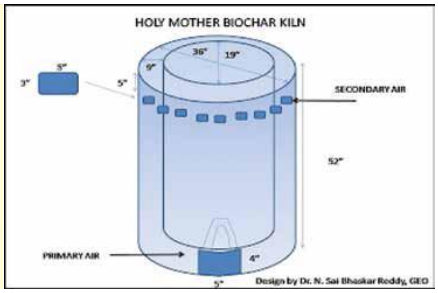


Fig 4. Holy mother biochar kiln

Source: http://biocharklin.blogspot.in/

Drum method

Kilns that are built in place, typically are constructed from soil or other local materials, are located close to biomass resources and are small. They are economically viable if the cost of construction and transportation of biochar is lower than the cost of transporting and processing of biomass. In a modified method, char production is done by pyrolysis kiln. Venkatesh *et al.* (2010) developed a low-cost charring kiln by modifying oil drums at CRIDA, Hyderabad. A cylindrical metal oil drum (200 L capacity) with both sides intact was procured from local market and was modified for use as charring kiln. A square shaped hole of 16 cm x 16 cm was made on the centre of top side of the drum for loading the crop residues. On the opposite side (bottom) of the oil drum, a total of 36 holes each measuring 4 cm 2 were made in concentric circles with a 5 cm 2 hole at the center covering 20% of the total surface area of the bottom portion of the oil drum to facilitate uniform circulation of air from below. After making sufficient modifications, inner sides of the charring kiln were cleaned by burning some waste jute bags so as to make free from residual hydrocarbon.

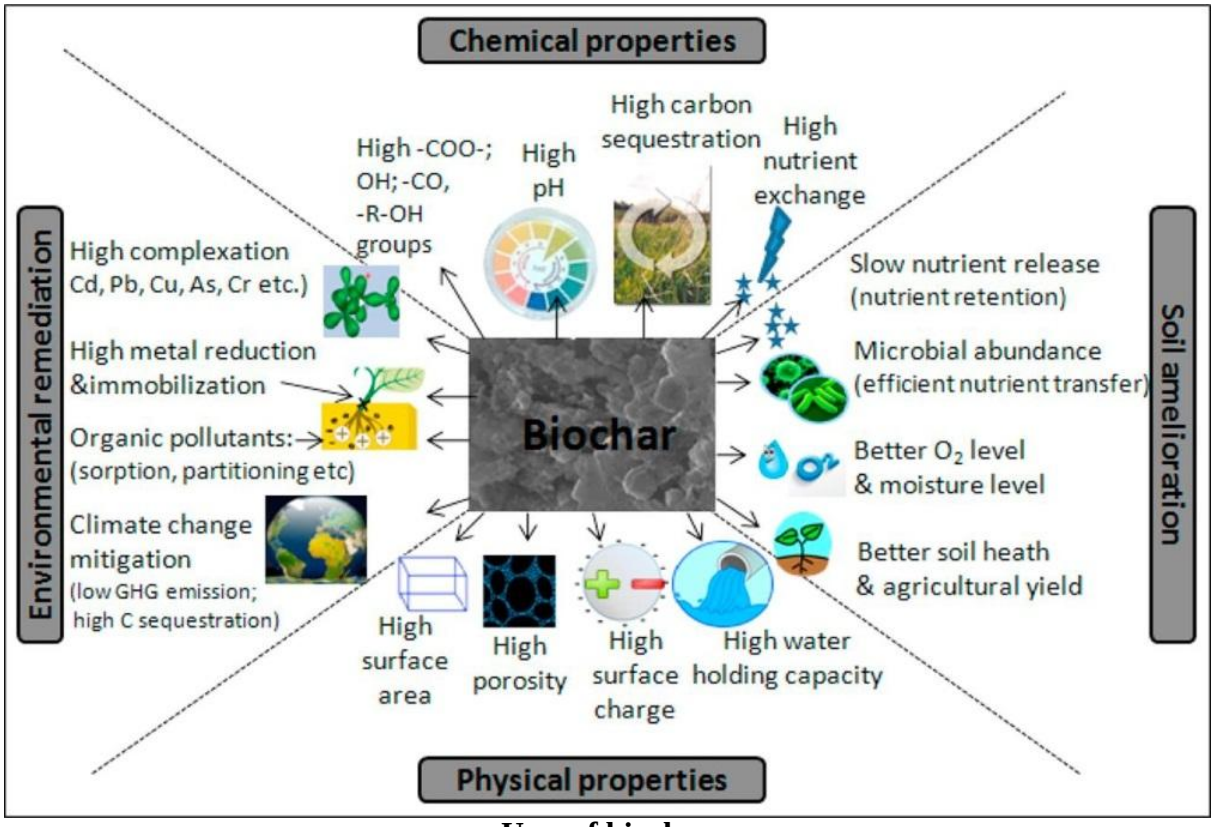
Loading the charring kiln

Before loading the modified kiln with the maize stalks, initial weight of the charring kiln was recorded using a platform balance. The dried maize stalks were loaded through top square hole, by holding a big wooden stick of 5-8 cm diameter at the center of the kiln to create a central vent. While loading, few stalks were smeared with diesel and placed at the bottom to aid initial ignition. Maize stalks were loaded in the kiln at five different quantities viz. 6.7, 8.2, 8.7, 9.7 and 10 kg. After loading the maize stalks, the wooden stick was carefully removed leaving a central vent in the drum. Weight of the loaded kiln was recorded using platform balance.

Heap method of biochar preparation in Tamil Nadu (Source: Jeyaraman, TNAU)

Future research

While biochar has been the topic of much research, there are still large knowledge gaps that need to be addressed. The longevity of biochar in field conditions and its long-term impacts of are still under study. The mechanisms behind how biochar impacts the soil environment, including changes in soil physical and chemical properties as well as the impact of biochar on the soil microbial communities need to be further explored especially in regards to changes in biogeochemical cycles (Desmondand Kingston, 2007). More research is needed to find ways to alter biochar to further reduce GHG emission when amended into soils, especially in field experiments. Thus, it can be concluded that biochar as black gold can continue to be utilized as a soil conditioner; but still there is much research findings which need to be done for increasing its efficacy for carbon sequestration and enhancing soil nutrient retention.



Uses of biochar

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Carambola: Cultivation practices and medicinal importance

Vinita Bisht

Banda University of Agriculture & Technology
Banda, UP-210001
E-mail: jyotivinita89@gmail.com

Carambola or starfruit, (*Averrhoa carambola*) is a species of tree native to the Philippines, Indonesia, Malaysia, Vietnam, Nepal, India, Bangladesh, SriLanka, Mauritius and Seychlles.The carambola is a tropical and subtropical fruit which can be grown at elevations up to 1,200 metres (4,000 feet). It prefers full sun exposure, but requires enough humidity and annual rainfall of at least 1,800 mm (70 in). It does not have a soil type preference, but it requires good drainage. The carambola is classified as subtropical because mature trees can tolerate temperatures as low as 27° F for short periods of time with little damage. Like many other subtropicals, however, young plants are more susceptible to frost and can be killed at 32° F.The starfruit gets its name from the shape of a cross-section of the fruit. This unique feature earns itself a status in the exotic fruit league and slices of this smooth, juicy, crispy and sour-sweet delight are often used in the adornment of cuisine and salads. Also known as carambola, which, in Portuguese meaning food appetizer, it is often consumed fresh and also processed into jam, jelly, sweets, fresh juice and cordial concentrates. Carambola fruits possess good nutrition value, as they contain very low fat, are high in vitamin B and C content, and also a source of potassium and fiber.

Description

The fruit is about 5 to 15 centimetres (2 to 6 inches) in length and is an oval shape. It usually has five prominent longitudinal ridges, but in rare instances it can have as few as four or as many as eight. In cross section, it resembles a star. The skin is thin, smooth, and waxy and turns a light to dark yellow when ripe. The flesh is translucent and light yellow to yellow in color. Each fruit can have 10 to 12 flat light brown seeds about 6 to 13 mm (0.25 to 0.5 in) in width and enclosed in gelatinous aril. Once removed from the fruit, they lose viability within a few days.

Crop requirements

Climate

The Carambola plant suits well to the tropical climate. It needs plenty of rainfall and a dry weather. Soils Carambola will grow very well in friable and well-drained soil. Carambola can live well in other various types of soil right from sandy soil to clayey soil but it needs a good soil improvement and management especially irrigation system and application of fertiliser.

Varieties

When selecting a Star Fruit be sure it is fully yellow then allow ripening on your counter until the fruit becomes golden and the ribs begin to brown. Some of the common varieties of Carambola include: King, Bell, Sri Kembangan, Arkin, and Fwang Tung. Once your star

fruit is mature it is capable of producing up to 200 pounds of fruit a year.

Soil

Carambolaare not too particular of soil of types, but grow faster and produce more fruit in a soil with more organic matter. Needs good drainage and does not like wet feet.

Cultural practices

Planting materials

There are 2 types of vegetative propagation carried out on carambola for the reproduction of planting materials. They are patch budding/bud grafting and cleft methods. Both methods are suitable but the more popular method is bud grafting. The plant can be planted into the field 4 months after grafting.

Spacing

The most common planting system is square planting at 6m x 6m, resulting in a planting density of 278 plants per hectare. Establishment Planting holes of 0.6m x 0.6m x 0.6 m are dug after liming is done. Organic matter or compost at 5-10 kg, CIRP 200 gm are incorporated into the holes and the seedling is then planted with minimal disturbance of the roots.

Shade requirement

During the establishment stage, the plant requires shading of 40- 50%.

Food uses

Ripe carambolas are eaten out-of-hand, sliced and served in salads, or used as garnish on avocado or seafood.

They are also cooked in puddings, tarts, stews and curries. Slightly underripe fruits are salted, pickled or made into jam or other preserves.

Cross-sections may be covered with honey, allowed to stand overnight, and then cooked briefly and, put into sterilized jars. Some cooks add raisins to give the product more character.

A relish may be made of chopped unripe fruits combined with horseradish, celery, vinegar, seasonings and spices.

Carambola juice is served as a cooling beverage. To make jelly, it is necessary to use unripe "sweet" types or ripe sour types and to add commercial pectin or some other fruit rich in pectin such as green papaya, together with lemon or lime juice.

Health benefits of star fruit

- Star fruit is one of the very low-calorie exotic fruits. 100 g fruit just provides 31 calories, which is much lower than for any other popular tropical fruits. Nonetheless, it has an impressive list of essential nutrients, antioxidants, and vitamins required for well-being.
- The fruit along with its waxy peel provides a good amount of dietary fiber. Fiber helps prevent absorption of dietary LDL-cholesterol in the gut. The dietary fibers also help protect the mucous membrane of the colon from exposure to toxic substances by binding to cancer-causing chemicals in the colon.
- Star fruit contains good quantities of vitamin-C. Vitamin-C is a powerful natural antioxidant. 100 g of fresh fruit provides 34.7 mg or 57% of daily required levels of vitamin-C. In general, consumption of fruits rich in vitamin-C helps the human body develop resistance against infectious agents and scavenge harmful, pro-

inflammatory free radicals from the body.

- Star fruit is rich in antioxidant phytonutrient *polyphenolic flavonoids*. Some of the important flavonoids present are quercetin, epicatechin, and gallic acid. Total polyphenol contents (Folin assay) in this fruit are 143 mg/100 g. Altogether, these compounds help protect from deleterious effects of oxygen-derived free radicals by warding them off the body.
- Besides, it is a good source of B-complex vitamins such as folates, riboflavin, and pyridoxine (vitamin B-6). Together, these vitamins help as co-factors for enzymes in metabolism as well as in various synthetic functions inside the body.
- It also carries a small amount of minerals and electrolytes like potassium, phosphorus, and zinc and iron. Potassium is an important component of cell and body fluids helps controlling heart rate and blood pressure; thus, it counters bad influences of sodium.
- Carambola possesses huge phenolic antioxidants that provide health benefits. The huge presence of phenolics and antioxidant activity provides various benefits to the health when it is used in functional food products.
- The pulp of ripe Carambola possesses the hypoglycemic effect which reduces the levels of blood glucose. The report shows that the dietary fibers, alcohol insoluble solid and water insoluble solid segregated from the pomace of Carambola acquire the hypoglycaemic effects.

Pest and diseases

Fuits are attacked by several insects including two species of fruit flies, *Bactroceracarambolaeand B. papayae* and two species of lepidopteran borers -- *Homona sp.* and *Cryptophlebia sp.*

The flowers are commonly infested by the flower moth *Diacrotrichafasciola* Zeller (Pterophoridae). Mites (*Tetranychus sp.*) are occassionally a problem in prolonged hot dry weather.

To minimize the economic impact of insects, several measures are taken by the growers to control this important pest. Control programs are based on the use of methyl eugenol, insecticide sprays, poisoned protein hydrolysate bait, and the bagging of fruit. Bagging of fruits is usually done when the fruit reaches a length of 4-5cm, at a stage, which is well before any onset of fruitfly, attack can take place.

Algal disease (*Cephaleuros virescens*)

Symptoms

Orange, rusty pustules on leaves, stems, twigs and fruit; swelling tissue; leaves on infected twigs wilting and turning yellow; dieback of shoots

Management

Maintain proper irrigation, pruning and fertilization regimes in carambola plantations; appropriate copper based fungicides may be required to control the disease in severely infected plantations

Alternaria black spot (brown spot) (*alternaria alternate*)

Symptoms

Small, circular light brown or black spots on skin of fruits; lesions develop sunken centres and olive-brown spores

Management

Avoid wounding fruits during harvest.

Cercospora leaf spot (*cercospora averrhoae*)

Symptoms

Tiny necrotic or chlorotic spots on leaflets; spots grow larger and developgray-white centers, reddish-brown margins and chlorotic halos; spots coalesce to form large lesions; leaves turn yellow and drop from palm

Comments

Spores transmitted by rainsplash, wind, insects and irrigation water

Management

Plant carambola varieties, that are more tolerant of the disease in areas where disease is present; disease can be controlled with regular applications of appropriate foliar fungicides.

Pythium root rot (*pythiumsplendens*)

Symptoms

Canopy has sparse appearance; wilting during periods of water stress; foliage may show symptoms of nutrient deficiencies

Management

Plant only disease-free nursery stock; plant in areas with no history of the disease; avoid planting trees in low lying areas

Fusion reactor: Safe for environment

Sanjay Goswami

Managing Editor
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Yamuna G/13, Anushakti Nagar, Mumbai-94

Fusion reactor doesn't emit harmful substances like carbon dioxide or other greenhouse gases into the atmosphere. Its major by-product is helium: an inert, non-toxic gas. No long-lived radioactive waste: nuclear fusion reactors produce any high activity, long-lived nuclear waste.

Today Nuclear Scientists have try to make a major breakthrough in their quest to develop a practical nuclear fusion which energy process that powers in Sun & stars. The ITER facility in southern France is supported by a consortium of world governments, including from EU member states, the US, China and Russia. It is expected to be the last step in proving nuclear fusion can become a reliable energy provider in the second half of this century.

Nuclear reactions are basically two types.

Type-1

Nuclear fission: In 1939, O. Halin and F. Strassmann discovered that among the complex results of bombarding uranium with slow neutrons, one very important one was the splitting of the uranium nucleus into two parts having atomic masses found in the middle of the periodic table. This is termed as "fission" and it was later shown that nuclide U235 which occurs at a low abundance of 0.712 % in natural uranium is the one that undergoes fission. Along with the fission of the U235 nucleus, several free neutrons are also found to be produced in the same nuclear reaction. Each new neutron could, if properly slowed down by a moderating material, cause another fission, releasing more energy and still more neutrons. This reaction can therefore contain a chain reaction for a length of time and thud out nuclear energy on a large scale.

$$92U^{235} + {}_0n^1 \longrightarrow 92U^{236} \xrightarrow{\text{fission}} {}_{56}Xe^{139} + {}_{36}Sr^{94} + 3({}_0n^1) + 200\ \text{Mev (approx.)}$$

Unstable

The total mass on the left hand side is actually a little more than the sum of the masses of the products shown on the right side of the above reaction. This mass is converted into energy according to Einstein's mass energy formula. $E = MC^2$

Where E is energy

M is mass, and C is the velocity of light in empty space.

This large amount of energy is carried as kinetic energy by the fission fragments and the neutrons.

A variety of such fission reactions occur in which the ${}_{92}U^{236}$ compound nucleus forms after a slow neutron is captured by the ${}_{92}U^{235}$ nucleus and is transformed. These differ in the fission product nuclides formed and also in the number of neutrons produced. Each type of such fission reaction has a definite proportion or yield associated with it. These mean that if 100 fission reactions occur, the indicated reaction will occur in 6.5 of them. The neutrons produced per fission averaged 2.5.

If this reaction occurs in a vessel, present-day nuclear reactors are devices for starting and controlling a self-sustaining fission chain reaction.

Type-2

Nuclear fusion

When two light nuclei combine to form a big nucleus, they are able to overcome the Coulomb repulsion force and approach each other at very high temperatures.

Fusion reaction

$^{2}H(D) + ^{2}H (D) \longrightarrow {}^{4}He + 24Mev$

$^{2}H(D) + ^{3}H (T) \longrightarrow {}^{4}He + {}_{0}n^{1} + 17.6Mev$

For achieving the fusion reaction between two protons the minimum energy required

$E=Z_1.Z_2.e^2/4\pi\in(r1+r2)=0.36Mev$

The K.E. of each proton is 0.36Mev

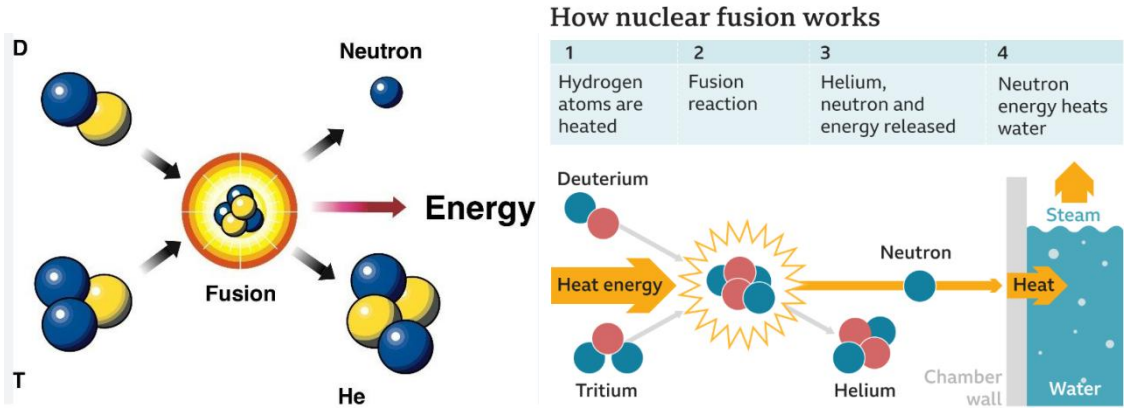
This type of temperature is in sun & stars.

Deuterium found in seawater is one deuterium atom in every 5000 hydrogen atoms. This does not require much energy to separate deuterium from hydrogen atoms.

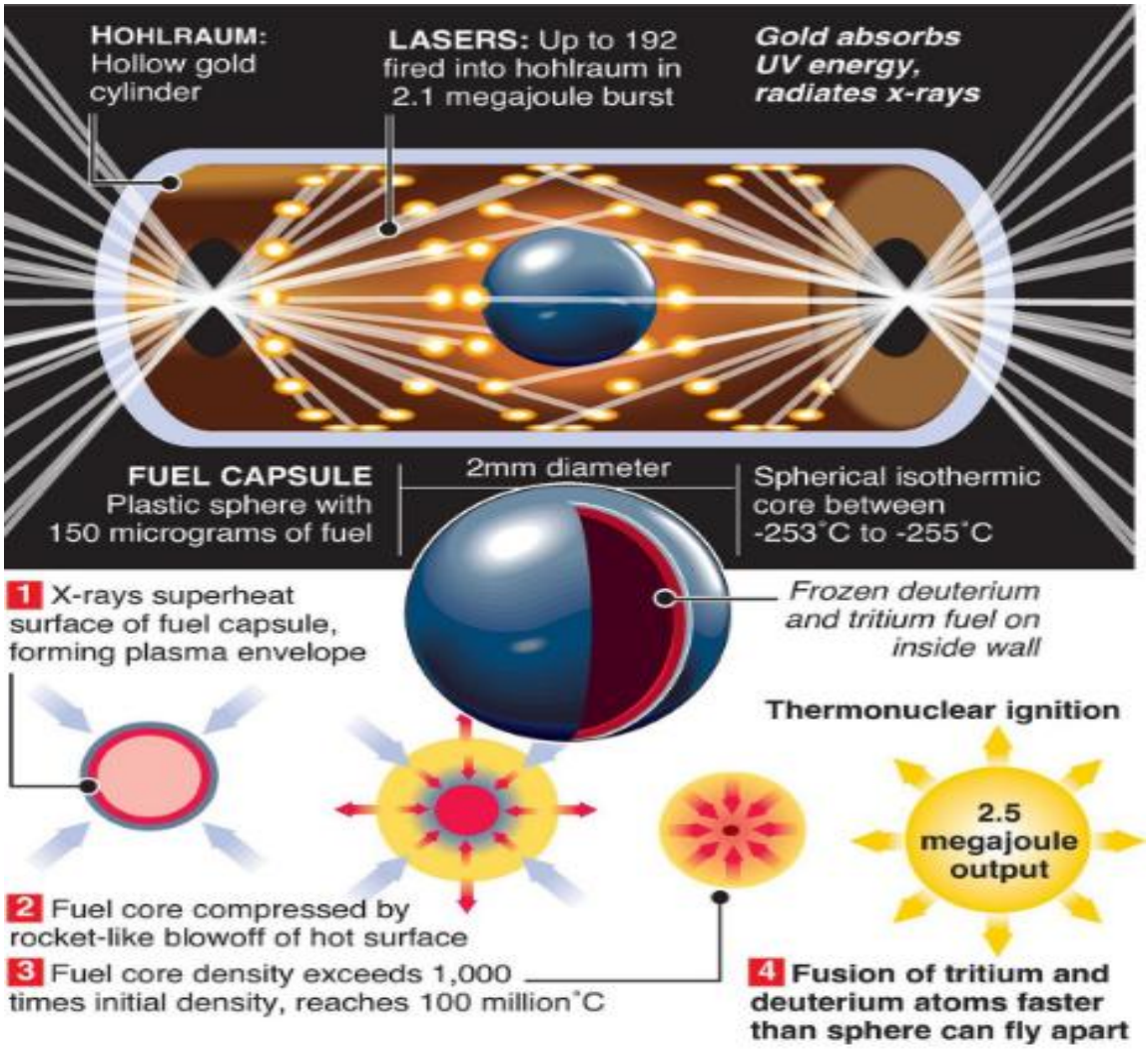
The reaction of tritium (T) with deuterium (D) in 50:50 mixture requires lower temperature (1/10 that for D-D reaction) and the reaction rate is up by a factor of 110. Tritium will obtain in reactor in blanket by the bombardment of fast neutrons.

$Li^{6} + {}_{0}n^{1} \longrightarrow {}^{3}H (T) + {}^{4}He + 4.5Mev$

During the fusion reaction the deuterium atoms must collide with another deuterium atom with energy of around 45 keV. For this, it required temperatures around 5 x 10^{8} ^{o}C. This temperature is five times greater than that in the interior of the sun. At this high temperature, the deuterium atoms are ionised, which is why they are charged positively as the electron is stripped off. Being positively charged, the deuterium ions repel each other, these ions containing the stripped electrons at very high temperature. This is the fourth stage of matter, called the plasma state. Due to the very high temperature, formidable problems arise. The plasma density N and the time for which plasma is contained t should be such that $Nt > 10^{14}$ per cm^3 sec. This is called the Lorsan criteria. Strong Magnetic Fields have been used to contain the plasma and achieve high temperatures. In the equation $Nt>10^{14}$ t is large and N is small It means the deuterium atoms which must collide with another deuterium atom with an energy of around 45 keV. For this, it required temperatures around 5 x 10^{8} ^{o}C. This temperature is five times greater than that in the interior of the sun. At this high temperature, the deuterium atoms are ionised, which is why they are charged positively as the electron is stripped off. Being positively charged, the deuterium ions repel each other. these ions Containing the stripped electrons at very high temperature. There is considerable research being carried out to use laser rays to achieve the high temperatures required for the D-T fusion reaction. In this case, N is large and t is small. Controlled fusion reaction experiments have been conducted in the USA, Russia, China, and France, etc., but has not been successful. Tokomac, Stelletor, Magnetic Mirror, Laser fusion etc. have been used to achieve high temperatures. Fusion reactors have more advantages than fission reactors. But the problem is which type of material will be used to withstand such high temperatures.



Nuclear Fusion

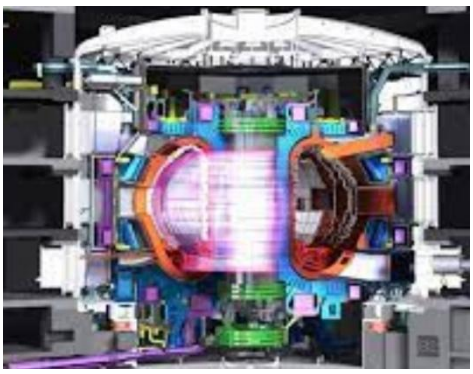


Laser Fusion

The reaction of tritium (T) with deuterium (D) in a 50:50 mixture requires a lower temperature (1/10 that for the D-D reaction), and the reaction rate is up by a factor of 110. Tritium will be obtained in the reactor by bombardment with fast neutrons.

This is way to generate tritium in a D-T reactor i.e. fission reactor where the fast neutrons 15MeV neutrons can react with a 1meter thick layer of lithium mixed with beryllium surrounding the DT plasma. This is very complicated job for scientists. For this challange scientists are try to make tokamak. The tokamak is an experimental machine designed to harness the energy of prapose fusion reactor, but the machine won't be equipped to produce electricity due to very high temperatures to start the fusion reaction.

Today, nuclear energy plays a vital role in electricity power production, but the drawback of this type of power production is waste generation, how to store it that is radioactive, and nuclear fuel consumption, which is consumable. One day, if nuclear fuel ores vanish all around the earth, at this stage, for all countries, electricity power energy is essential, and one type of reactor, i.e., a fusion reactor, will be the boon for nuclear energy. Experiments for fusion reactor are going on, and designed by ITER (International Thermonuclear Experimental Research Project) The ambitious ITER will be able to generate commercially viable electrical energy through fusion reactor by 2050. The ITER scientific installation is taking shape, as buildings rise and machine and plant components are delivered from factories on three continents to the ITER site in southern France. Thousands of nuclear Scientists, Physicists, and Technicians are participating in construction, assembly and installation activities plan and conduct scientific experiments and studies to test the theories of fusion reaction and control and to discover the high temperature sustained matter for reactor vessel and its energy.



ITER in France

Initially, it will produce 500 MW of electrical power from Fusion. This information is given in CERN curian news. On the basis of this news "ITER is technically ready with machine devices that only have to be put together, and the first wall material for plasma operation is expected in 2025". By 2035–40, it will be in the experimental stage and will be able to produce electrical energy by 2050. India is the partner of the ITER project, which has contributions from seven countries. For fusion fuel like D &T pallet, first wall material, reaction feasibility, plasma control, superconductivity material for reactor core, design and quality control, etc. The participated seven countries for this project are India, USA, Russia, Japan, South Korea, and European Union & China. It is situated in Cadache, France. So, the first fusion reactor will be technically feasible in France by 2050. In another experiment in South Korea, the Superconducting Tokamak Advanced Research (KSTAR) device recently set a world record by maintaining and controlling its plasma with an ion temperature of over 120 million degrees Celsius for 25 seconds. According to a report by Engadget, no previous fusion machine lasted for more than 10 seconds in those conditions. KSTAR had managed to hold out for just 8 seconds. The report adds that it is an important step towards improving the internal transport barrier (ITB), which helps with plasma confinement and stability. Fusion, the nuclear reaction that powers the Sun is a promising long-term option for sustainable global energy supply. Joining fusion's power is the goal of ITER, which has been designed as the key experimental step between today's fusion research machines and tomorrow's fusion power plants will be commissioned and operational.

The main goal for KSTAR is to run for five minutes at a stretch at extreme temperatures by 2035, and the breakthrough is an important step in that direction. It could prove to be vital if fusion reactors became a reality.

Indeed, power generation of this type of nuclear energy is economically & safety.

Advantages of a fusion reactor

- The amount of fuel required for the reactor is very small. Normally, one gram of deuterium is sufficient for criticality.
- This type of reactor can never explode because the reaction is not self-maintaining.
- Zero greenhouse gas emissions and no radioactive waste except tritium, which is comparable to fission products.
- This reactor (~GW) much more energy (1 GW) than a fission reactor.
- No separate plant is required like heavy water, Waste storage Plant, Irradiation plant for fusion reactor comparable to fission products.
- A large scale of energy production in the energy scarce world is critical.
- Fusion in ITER will require two elements: deuterium and tritium. Deuterium can be distilled from all forms of water, while tritium will be produced during the fusion reaction as fusion neutrons interact with lithium. (Terrestrial reserves of lithium would permit the operation of fusion power plants

for more than 1,000 years, while sea-based reserves of lithium, used in a fusion reactor in its Li-6 isotope form, would fulfil needs for millions of years). A critical challenge is how to breed and recover tritium reliably in a fusion device.

No CO_2

Fusion doesn't emit harmful substances like carbon dioxide or other greenhouse gases into the atmosphere. Its major by-product is helium: an inert, non-toxic gas.

No long-lived radioactive waste

Nuclear fusion reactors produce no high activity, long-lived nuclear waste. The activation of components in a fusion reactor is anticipated to be low enough for the materials to be recycled or reused within 100 years, depending on the materials used in the "first-wall" facing the plasma.

Limited risk of proliferation

Fusion doesn't employ fissile materials like uranium and plutonium. (Radioactive tritium is neither a fissile nor a fissionable material.) There are no enriched materials in a fusion reactor like ITER that could be exploited to make nuclear weapons.

Disadvantages

- The lack of radioisotopes like Ir-192, Co-60, Tc - 99m, Cs-137etc etc. is useful in the fields of medicine for cancer treatment, industrial radiography, hydrology, agriculture, space science, and radiation-based (alpha emitter) batteries.
- Fusion requires high temperatures to initiate a thermonuclear reaction, which has a very expensive initial electric power cost.
- It design is a very complex process. How it controls which vessel reaction takes place and how it sustains and resists the high temperature
- If nuclear fusion can be successfully recreated on Earth, it holds out the potential of virtually unlimited supplies of low-carbon, low-radiation green energy in which a very low amount of nuclear fuel burns.

Multipurpose tree species (MPTs) and their characteristics suitable for agroforestry

BheemreddyvallaVenkateshwar Reddy[1*], Mhaiskar Priya Rajendra[2], MilkuriChiranjeeva Reddy[1], Yerrawada Naveen[1], Ravula Rohit[1], Katikala Anish[1] and Bestha Ashwitha[1]

[1]Department of Silviculture and Agroforestry, Forest College and Research Institute, Mulugu, Hyderabad, (TG) - 502 279
[2]Department of Forest Ecology and Climate Science, Forest College and Research Institute, Mulugu, Hyderabad, (TG) - 502 279
*E-mail: bvreddy12121@gmail.com

Introduction

In the face of increasing global challenges such as climate change, land degradation and food insecurity, it is important to prioritize the adoption of sustainable agricultural practices (Mbow *et al*., 2019). The United Nations predicts that the world's population will increase from 8 billion to 9.7 billion by 2050. To meet food demand by then, production will have to increase by more than 60%. Among sustainable agricultural practices, agroforestry stands out as a promising solution.

Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence. These systems promote both ecological and economic interactions between their components. They are dynamic, ecologically orientated natural resource management systems that aim to diversify and sustain production and increase social, economic and environmental benefits for land users at all levels. By integrating trees and shrubs into agricultural landscapes, agroforestry represents a promising solution that utilises the multiple benefits of trees to strengthen the resilience, productivity and sustainability of ecosystems (Russo, 2023). At the heart of successful agroforestry systems, are the multipurpose tree species that are endowed with a variety of characteristics which make them indispensable allies in the pursuit of sustainable land use.

Multipurpose Tree Species (MPTs)

Multipurpose tree species (MTPs) are tree species deliberately cultivated to provide two or more significant benefits or products (Fig 1). These benefits include i.e., soil conservation, shade, fuelwood, timber, fodder, food, medicine etc. The importance of multipurpose tree species in agroforestry cannot be overstated (Nair *et al*., 2022). Unlike single-purpose tree plantations that prioritize timber production at the expense of other ecosystem services, multipurpose trees serve as versatile and capable of delivering a wide range of benefits simultaneously. They contribute to nitrogen fixation, improve soil quality, carbon sequestration, and empower local economies. In the face of the complex challenges that modern agriculture encounters, these trees offer a

multifaceted toolkit for sustainable and resilient farming practices (Lelamo, 2021). In this article, we delve into the world of multipurpose tree species, exploring their characteristics, functions, and contributions to agroforestry.

Fig 1: Various benefits of multipurpose tree species

Characteristics of MPTs suitable for Agroforestry

Multipurpose Tree Species (MPTs) are the key foundation of successful agroforestry systems, offering a diverse array of attributes that make them invaluable assets in sustainable land management (Tscharntke *et al.*, 2011). These species possess a unique combination of characteristics that enable them to fulfill multiple functions and provide a wide range of benefits to agroecosystems. Understanding the key characteristics of MPTs is essential for selecting suitable species and designing resilient and productive agroforestry systems (Nair *et al.*, 2021; Chundawat and Gautam, 2020).

Fast growth rate

One of the important characteristics of MPTs is their ability to grow rapidly under diverse environmental conditions. Fast-growing species can quickly establish themselves in agroforestry systems, providing early benefits such as shade, erosion control, and habitat for beneficial organisms. Rapid growth also allows MPTs to compete effectively with weeds and other vegetation, helping to suppress weed growth and reduce the need for herbicides.E.g:- Eucalyptus spp., *Acacia nilotica*, Casuarina spp., *Moringa oleifera*, *Poplar deltoides*, *Leucaena leucocephala* etc.

Nitrogen fixation

Numerous MPTs, particularly leguminous species, possess the unique ability to capture atmospheric nitrogen by forming symbiotic relationships with nitrogen-fixing bacteria in their root nodules. This process not only provides a readily available source of nitrogen for plant growth but also improves soil fertility and reduces the need for synthetic nitrogen fertilizers. Nitrogen-fixing MPTs play a crucial role in enhancing soil health, supporting crop productivity, and promoting sustainable agricultural practices.E.g:-*Casuarina equisetifolia*, *Gliricidiasepium*, *Leucaena leucocephala*, *Faidherbia albida*, *Albizzia lebbeck*, *Albizia falcataria*, *Sesbania grandiflora*, *Acacia mangium*etc.

Deep root systems

MPTs are known for their deep and extensive root systems that enable them to access water and nutrients from deeper soil layers. These deep rootsplay a crucial role in enhancing soil structure, promoting water infiltration, and preventing soil erosion by binding soil particles together (Solanki *et al.*, 2024). Additionally, deep-rooted MPTs also contribute to soil carbon sequestration by transporting carbon-rich organic matter from the surface to deeper soil layers, thereby promoting long-term soil fertility and resilience.E.g:-*Casuarina*

equisetifolia, *Prosopis juliflora*, *Acacia nilotica*, *Gliricidiasepium*etc.

Drought tolerance

Many MPTs exhibit a high degree of drought tolerance, enabling them to thrive in arid and semi-arid environments where water availability is limited. Drought-tolerant species can withstand periods of water stress and continue to provide valuable ecosystem services such as shade, windbreak, and soil stabilization during dry periods. By selecting drought-tolerant MPTs, farmers can enhance the resilience of agroforestry systems to climate variability and reduce the risk of crop failure during droughts. *E.g:-Prosopis juliflora*, *Acacia Senegal*, *Eucalyptus camaldulensis* etc.

Pest and disease resistance

In agroforestry systems, the careful selection of tree species with natural pest and disease resistance is essential for maintaining ecosystem health, minimizing the dependence on chemical pesticides, and ensuring the long-term sustainability of agricultural production. Multipurpose tree species (MPTs) that possess innate resistance to pests and diseases provide farmers with various benefits, including reduced management costs, increased resilience to environmental stressors, and improved yields. *E.g:-Azadirachta indica*, *Robinia pseudoacacia*, *Salix alba*, *Juglans nigra* etc.

Nutrient content

MPTs play a pivotal role in enhancing soil fertility, increasing crop productivity, and fulfilling the nutritional requirements of livestock. Their rich nutrient content is essential for the overall health and resilience of agroecosystems. Additionally, these tree species offer valuable resources for both human and animal consumption, making them integral to sustainable agricultural practices. *E.g:-Moringa oleifera*, *Leucaena leucocephala*, *Calliandra calothyrsus*, *Albizia lebbeck*, *Sesbania seban etc.*

Nutrient cycling & bio-remediation

Multipurpose tree species (MPTs) are integral for bio-remediation in agroforestry, extracting, degrading, or immobilizing pollutants from soil, water, or air through phytoremediation. They enhance nutrient cycling by efficiently capturing and recycling nutrients, improving soil fertility and reducing pollution. MPTs stabilize soil, preventing erosion and sedimentation, and can immobilize contaminants through phytostabilization, protecting ecosystems. Additionally, they promote biodiversity, providing habitat and promoting ecological resilience. Overall, MPTs play a vital role in mitigating environmental pollution, improving soil quality, and enhancing ecosystem health in agroforestry systems, supporting sustainable land management practices and long-term productivity. *E.g:-Moringa olifera*, *Acacia nilotica*, *Prosopis laevigata*, *Prosopis juliflora*, *Acacia auriculiformis*, etc.

Adaptability to various soil types and climates

MPTs exhibit a wide range of adaptability to different soil types and climatic conditions, making them suitable for a variety of agroforestry applications. MPTs can thrive in diverse environments (From tropical rainforests to temperate grasslands) and contribute to the resilience and productivity of agricultural landscapes. By carefully selecting species

that are well-suited to local soil and climatic conditions, farmers can maximize the success of agroforestry interventions and ensure the long-term sustainability of their land-use practices.*E.g:-Acacia mangium, Albizia saman, Cassia siamea, Prospopiscineraraia,* etc.

Conclusion

In conclusion we can say that, the characteristics of MPTs make them indispensable components of agroforestry systems, offering a versatile toolkit for addressing the complex challenges facing modern agriculture. By selecting and incorporating suitable MPTs into agroforestry designs, farmers can enhance the resilience, productivity, and sustainability of their land-use practices while reaping a multitude of economic, social, and environmental benefits.

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नाग छतरी (ट्रिलियम गोवैनियनम): हिमालय की एक लुप्तप्राय औषधीय जड़ी बूटी

नीरज संख्यान[1], संजीव कुमार[1], नेहा ठाकुर[2], नितिन शर्मा[1], शिवानी चौहान[3]

[1]मूल विज्ञान विभाग, कॉलेज ऑफ़ फॉरेस्ट्री, डॉ वाई.ऐस.परमार.यूनिवर्सिटी ऑफ़ हॉर्टिकल्चर एंड फॉरेस्ट्री, नौनी, सोलन (हि.प्र.)

[2]बायोसाइंस विभाग, हिमाचल प्रदेश विश्वविद्यालय, शिमला (हि.प्र.)

[3]मृदा विज्ञान विभाग, कॉलेज ऑफ़ हॉर्टिकल्चर एंड फॉरेस्ट्री नेरी, हमीरपुर (हि.प्र.)

ई-मेल: neerajsankhyan80@gmail.com

सार

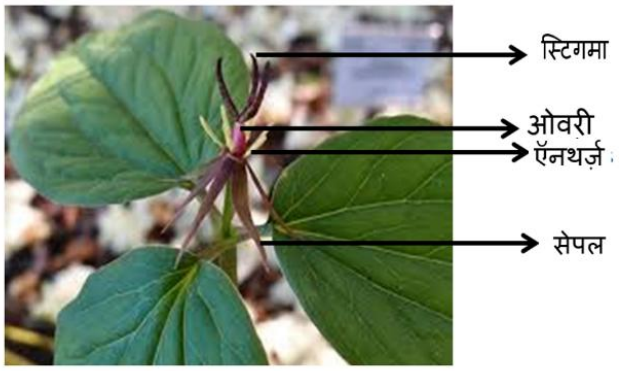
नाग छतरी भारत के हिमालयी क्षेत्र का एक लुप्तप्राय पौधा है जिसका औषधीय महत्व बहुत अधिक है। इसके अत्यधिक औषधीय महत्व, छोटी आबादी, सीमित क्षेत्र, बीज की कम निर्धारित दर, गैर-जिम्मेदार संग्रह और बढ़ती औद्योगिक मांगों के कारण, नागछतरी को आईयूसीएन द्वारा लुप्तप्राय औषधीय पौधों की प्रजातियों के रूप में सूचीबद्ध किया गया है। हाल के दिनों में इसके बढ़ते अवैध व्यापार के कारण यह प्रजाति भारी दबाव में आ गई है जिसका एक कारण अन्य राज्यों में इसका बढ़ता संग्रह और व्यापार है। कथित तौर पर जड़ी-बूटी का कारोबार 2500-4000 रूपए प्रति किलोग्राम की मौजूदा कीमत पर किया जा रहा है। अतः नागछतरी को संरक्षण की सख्त जरूरत है क्योंकि इसकी प्राकृतिक पुनर्जनन क्षमता इसके अवैध निष्कर्षण से बहुत पीछे है जिससे यह प्रजाति बहुत जल्द प्रकृति से विलुप्त हो सकती है।

भूमिका

वर्तमान दवाओं में, पौधे या तो सीधे दवा के रूप में उपयोग किए जाते हैं या सैमी-सिंथेटिक दवाओं के लिए बायोएक्टिव योजिक प्रदान करते हैं, या नए बायोएक्टिव योजिकों की खोज के लिए मार्कर के रूप में उपयोग किए जाते हैं। डब्लू.एच.ओ (विश्व स्वास्थ्य संगठन) के अनुमान के अनुसार, संयंत्र-आधारित कच्चे माल की वर्तमान मांग 15- 25% वार्षिक वृद्धि के साथ प्रतिवर्ष लगभग 14 बिलियन अमेरिकी डॉलर है। भारत औषधीय पौधों के लिए कच्चे माल का दूसरा प्रमुख आपूर्तिकर्ता (केवल चीन के बाद) है। भारत में, औषधीय पौधों से संबंधित व्यापार प्रतिवर्ष 1 बिलियन अमेरिकी डॉलर होने का अनुमान है।

नागछतरी को हिमालयन ट्रिलियम के नाम से भी जाना जाता है। अपनी विशाल औषधीय क्षमता के कारण इसने हाल ही में भारतीय हर्बल बाजार में लोकप्रियता हासिल की है। यह ट्रिलियासी परिवार की एक बारहमासी शाकाहारी प्रजाति है, जिसमें एशिया की 11 प्रजातियाँ शामिल हैं और 53 प्रजातियाँ दुनिया भर में जानी जाती हैं। भारत में, ट्रिलियम गोवैनियनम और ट्रिलियमत्स चोनोस्की अब तक हिमालय से रिपोर्ट किए गए हैं, जिनमें से पहला हिमालय के लिए स्थानिक है। नागछतरी शंकुधारी जंगलों और नम, छायादार स्थानों में उगनेवाली एक छोटी (10-30 सेमी ऊंचाई) औषधीय जड़ी बूटी है। पौधे की विशेषता एक भूमिगत राइजोम से निकला हुआ सीधा और अशाखित तना है जिसमे की तीन एपिकल पत्तियां व बीच से एकल टर्मिनल डंठलवाला फूल निकलता है। नागछतरी, हिमालय क्षेत्र में उगनेवाला पौधा है जो सिक्किम, दार्जिलिंग और हिमाचल प्रदेश से लेकर कश्मीर तक भौगोलिक वितरण के साथ समुद्र तल से 2,700-4,000 मीटर की ऊंचाई पर पाया जाता है। यह प्रजाति

निकटवर्ती देशों, यानी नेपाल, भूटान, चीन, अफगानिस्तान, पाकिस्तान और तिब्बत में भी पाइ जाती है । इस प्रजाति को नागछतरी, हिमालयन ट्रिलियम, छोटा सत्व, शीथकर, ट्राइफ्लॉवर, मटरजेला, बर्थ रूट और सतवा के नाम से जाना जाता है । नागछतरी में समृद्ध औषधीय क्षमता है और इसका उपयोग पारंपरिक भारतीय, चीनी और पाकिस्तानी चिकित्सा प्रणालियों में किया जाता है । इसमें मई से जून तक फूल आते हैं और जुलाई से अक्टूबर में फल लगते हैं और पत्तियों झड़ने लगती हैं । पत्तिओं और तने के जीर्ण होने के बाद, सर्दियों में बर्फबारी से पहले इसका प्रकंद निष्क्रिय हो जाता है । प्रजातियों का प्रसार मुख्य रूप से यौन प्रजनन द्वारा होता है।



नाग छतरी के विभिन्न भाग

नाग छतरी का पौधा

नाग छतरी प्रकंद पर प्रारंभिक फाइटोकेमिकल (गुणात्मक) परीक्षणों से ट्रिलारिन (स्टेरॉयडल ग्लाइकोसाइड्स), टैनिन, स्टेरोल्स और फ्लेवोनोइड्स जैसे माध्यमिक मेटाबोलाइट्स की उपस्थिति का पता चला । नाग छतरी का प्रकंद आवश्यक फाइटो केमिकल्स जैसे स्टेरॉयड और कई अन्य यौगिकों जैसे डायोसजेनिन और ट्रिलारिन से समृद्ध है । माना जाता है कि "राइज़ोम" ट्रिलारिन के यौगिक का उपयोग सेक्स हार्मोन, कोर्टिसोन और मासिक धर्म प्रवाह विनियमन और पेट की समस्याओं को ठीक करने में में किया जाता है । एक अन्य यौगिक, 'डायोसजेनिन' में कैंसर रोधी और बुढ़ापा रोधी गुण बताए गए हैं । इसके अतिरिक्त, इस पदार्थ का उपयोग कई स्टेरायडल दवाओंके संश्लेषण के लिए एक क्रिया धार के रूप में किया जाता है। अन्य औषधीय पौधों की तुलना में इसमें डायोसजेनिन की लगभग तिगुनी मात्रा जमा होती है । राइज़ोम में एंटी-बैक्टीरियल, एंटी-इंफ्लेमेटरी, रेडिकल स्केवेंजिंग, एंटी-कैंसर, एनाल्जेसिक और β-ग्लुकुरोनिडेज़ निरोधात्मक गतिविधियाँ भी होती हैं । साइटोलॉजिकल रूप से, इस प्रजाति को पूर्वी हिमालय से गुण सूत्र संख्या ***2n=20*** और कश्मीर हिमालय *से* **2n=20 + (0-2B)** के रूप में जाना जाता है । नाग छतरी में गुण सूत्र बहुरूपता पहली बार मेहरा और सचदेवा द्वारा गुलमर्ग, कश्मीर, भारत से एकत्रित एक पौधे में देखी गई थी ।

नाग छतरी के उपयोग

इस पौधे के प्रकंदों (राइजोम) का उपयोग पारंपरिक दवाओं में कैंसर, न्यूरस्थेनिया, उच्च रक्तचाप, गठिया, चक्कर आना, सूजन, प्रजनन संबंधी विकार और पेचिश जैसी बीमारीओं के

इलाज के लिए किया जाता है । साथ ही इसका प्रयोग एक एंटीसेप्टिक के रूप में, मासिक धर्म और यौन विकारों व गुर्दे के इलाज में भी किया जाता है । भारत के कश्मीर हिमालय के कुछ क्षेत्रों में ताजा प्रकंद के नमूनों को खाने योग्य बताया गया है । प्रांत के निवासी विभिन्न बीमारियों जैसे पेट, घाव और एक एंटीसेप्टिक के इलाज के लिए नाग छतरी की जड़ इकट्ठा करते हैं । जम्मू-कश्मीर के राजौरी और पुंछ जिलों के आदिवासी लोगों ने खुलासा किया कि 3-4 दिनों तक 10 ग्राम जड़ों से बनी चाय का एक बार सेवन सिर दर्द से राहत दिलाने में मदद करता है । इसकी ऊंची कीमत (2,000- 4,000 किलोग्राम) के कारण नाग छतरी के अनियंत्रित संग्रह और तस्करी ने इसे हिमालय में अत्यधिक औषधीय मूल्यवाली जड़ी बूटी बना दिया है । इसके प्राकृतिक रूप से उगनेवाले क्षेत्रों से अंधाधुंध दोहन इस प्रजाति के शीघ्र विलुप्त होने का कारण बन सकता हैं । नाग छतरी अपने औषधीय गुणों के कारण घरेलू और विदेशी बाजारों में औषधीय उपयोग के लिए अत्यधिक मांग में है । वर्ष 2010 के बाद से इस प्रजाति के हिमाचलप्रदेश और उत्तराखंड में अवैध वाणिज्यिक व्यापार में वृद्धि देखी गई है । अवैध व्यापार और प्रकंद नमूनों की तस्करी के परिणामस्वरूप भारतीय हिमालय (खतरेवाली प्रजाति के रूप में वर्गीकृत) से नाग छतरी की आबादी कम हो गई है, और बाजार की कीमतें भी यू.एस.डॉलर 50-315 प्रति किलोग्राम तक बढ़ गई हैं ।

संरक्षण

पारंपरिक (प्रकंद के माध्यम से वानस्पतिक प्रसार) और इन विट्रो दोनों तरीकों को नाग छतरी के तेजी से बड़े पैमाने पर प्रसार के लिए आवश्यक माना जाता है l ये तरीके इस पौधे को खतरे की स्थिति से उभारने की संभावनाएं प्रदान करते हैं जिससे इसके विलुप्त होने का खतरा कम हो जाएगा । इस औषधीय पौधे के विशाल संग्रह के कारण जंगल में इसकी उपलब्धता में गिरावट देखी गई है । इसकी संकुचित पारिस्थितिक सीमा के कारण, यह निश्चित नहीं है कि प्रजाति एक्स-सीटू परिस्थितियों में अच्छा प्रदर्शन कर सकती है । इसलिए, इन-सीटू संरक्षण बेहतर विकल्प है l इसकी ऊंचाई सीमा के भीतर आसपास के गांवों में लुप्तप्राय औषधीय पौधों की खेती की जानी चाहिए, जिससे जंगली आबादी पर दबाव कम हो जाएगा । गुणवत्तापूर्ण रोपण सामग्री का उत्पादन करने के लिए टिशूकल्चर तकनीक जैसी बड़े पैमाने पर गुणन विधियों का उपयोग किया जा सकता है । औषधीय पौधों के संरक्षण और सतत उपयोग के लिए शैक्षिक और जागरूकता कार्यक्रम शुरू करने की आवश्यकता हैं l

निष्कर्ष

नागछतरी, भारतीय हिमालय के कम उपयोग में लाये जानेवाले औषधीय पौधों में से एक है । पारंपरिक चिकित्सा में कई बीमारियों के इलाज और ग्रामीण परिवारों के लिए आय पैदा करने के लिए इसका बहुत महत्व है । क्योंकि यह केवल समशीतोष्ण और उप-अल्पाइन प्राकृतिक जंगलों में ही मिलता है अतः इसके प्रकंद का संग्रह और विपणन कठिन है l पौधों की जीव विज्ञान और पहचान, कटाई, गुणवत्ता वाले उत्पादों, उचित बाजार और कीमत पर जागरूकता बढ़ाने का एक बड़ा प्रयास जरूरी है । मांग अधिक और उपलब्धता कम होने के कारण मिलावट का खतरा बहुत रहता है । चूंकि इस प्रजाति की बाजार में बहुत ऊंची कीमत मिलती है, जो रुपये 2000-4000 प्रति किलोग्राम तक होती है, अधिक उपज देने वाले जीनोटाइप की खेती को यदि बढ़ावा दिया जाए तो भारत सरकार के "किसानों की आय दो गुनी करने के मिशन" हेतु किसानों की आय में अवश्य ही वृद्धि होगी ।

ओज़ोन क्षति रोकने हेतु अंतर्राष्ट्रीय प्रयास

संजय गोस्वामी

एसोसिएट एडीटर
ग्रामीण विकास संदेश
सोसायटी ऑफ बायोलॉजिकल साइंस एंड रूरल डेवलपमेंट
यमुना जी/13, अणुशक्ति नगर, मुंबई-94

प्रस्तावना

ओजोन रिक्तीकरण के कारण पराबैंगनी विकिरण की बढ़ी हुई मात्रा पृथ्वी तक पहुंच सकती है जिससे त्वचा कैंसर, मोतियाबिंद और कमजोर प्रतिरक्षा प्रणाली के अधिक मामले हो सकते हैं। ऐसा माना जाता है कि यूवी के बहुत अधिक संपर्क से मेलेनोमा में वृद्धि हो रही है, जो सभी त्वचा कैंसरों में सबसे घातक है। ओजोन परत की खोज सबसे पहले 1913 में फ्रांसीसी भौतिकविदों चार्ल्स फैब्री और हेनरी बुइसन ने की थी। पृथ्वी का वायुमंडल विभिन्न परतों या क्षेत्रों में विभाजित है। उदाहरण के लिए, क्षोभमंडल (0-12 किमी), समताप मंडल (12-50 किमी), मध्यमंडल (50-80 किमी) आदि। लगभग 90% ओजोन समताप मंडल में पाया जाता है। इसलिए, समताप मंडल को ओजोन क्षेत्र या ओजोन परत भी कहा जाता है। ओजोन परत वास्तव में ओजोन गैस की 20 किमी लंबी परत है। एक मोटी परत होती है. यह परत भूमध्य रेखा पर पतली तथा ध्रुवों पर मोटी होती है। यह परत पृथ्वी के चारों ओर मौजूद है जो सूर्य के लिए फिल्टर का काम करती है। यह सूर्य की अधिकांश पराबैंगनी विकिरणों (यूवी) को अवशोषित करता है।

समताप मंडल में ओजोन की सांद्रता उसी परत में मौजूद अन्य गैसों की तुलना में बहुत कम है। ओजोन परत में ओजोन की मात्रा 10 पी.पी.एम. है। (प्रति मिलियन भाग) से थोड़ा कम लेकिन कुल मिलाकर पृथ्वी के वायुमंडल में ओजोन की औसत सांद्रता लगभग 0.3 पीपीएम है। ओजोन परत पृथ्वी से लगभग 15 किमी ऊपर है। से 35 कि.मी. यह मुख्यतः समताप मंडल के निचले हिस्से में पाया जाता है, हालाँकि इसकी मोटाई मौसम और भौगोलिक दृष्टि से बदलती रहती है। ओजोन परत की मोटाई दुनिया भर में एक समान नहीं है और आमतौर पर भूमध्य रेखा के पास पतली और ध्रुवों के पास मोटी होती है।

ओजोन छिद्र क्या है और इसकी खोज कब हुई

परिभाषा के अनुसार ओजोन छिद्र ऐसा कोई छिद्र नहीं है जहां ओजोन मौजूद न हो। यह वास्तव में अंटार्कटिक महासागर के ऊपर समताप मंडल में असामान्य रूप से क्षीण ओजोन का एक क्षेत्र है, जहां यह दक्षिणी गोलार्ध वसंत (अगस्त-अक्टूबर) की शुरुआत में होता है।

"ओजोन छिद्र" वास्तव में समताप मंडल में पृथ्वी के ऊपर ओजोन की सांद्रता में कमी है। इसे भौगोलिक रूप से उस क्षेत्र के रूप में परिभाषित किया गया है जिसमें ओजोन की कुल मात्रा 220 डॉब्सन इकाइयों से कम है। एक डीयू 0.01 मिमी शुद्ध ओजोन है। एक मोटी परत बनाने के लिए आवश्यक ओजोन अणुओं की मात्रा का प्रतिनिधित्व करता है। ओजोन छिद्र एक बार तस्मानिया के दक्षिण में और ऑस्ट्रेलियाई मुख्य भूमि पर देखा गया है। मध्य अक्षांश क्षेत्र यानी ऑस्ट्रेलिया पर ओजोन परत के पतले होने के कारण अधिक पराबैंगनी विकिरण पृथ्वी पर पहुंचने लगा।

1970 में पॉल कर्जन ने खाद और सुपरसोनिक विमानों में मौजूद नाइट्रोजन ऑक्साइड से ओजोन परत को नुकसान पहुंचने की आशंका जताई थी । इसके बाद ब्रिटिश अंटार्कटिक सर्वे के वैज्ञानिक जो फ़ार्मन, ब्रायन गार्डिनर और जोनाथन शैंकलिन ने मई 1985 में "नेचर" पत्रिका में अपना शोध पत्र प्रकाशित किया। इस शोध पत्र में बताया गया कि समताप मंडल में पाई जाने वाली ओजोन गैस लगातार कम हो रही है जिसके कारण पृथ्वी की ओजोन परत में एक छेद हो गया है. इस खोज ने वैज्ञानिक समुदाय को तब चौंका दिया जब उन्हें पता चला कि ध्रुवीय ओजोन में देखी गई कमी अनुमानित आंकड़ों से कहीं अधिक बड़ी थी और यह छेद लगभग पूरे यूरोप के क्षेत्रफल के बराबर था।

ओजोन परत के नष्ट होने के कारण

वायुमंडलीय डेटा दर्शाता है कि ओजोन क्षयकारी पदार्थ समताप मंडल में ओजोन को नष्ट कर रहे हैं और इस प्रकार ओजोन परत की मोटाई कम कर रहे हैं। ओजोन क्षयकारी पदार्थ ऐसे रसायन हैं जिनमें क्लोरोफ्लोरो कार्बन (सीएफसी), हेलोन्स, कार्बन टेट्राक्लोराइड (सीसीएल4), मिथाइल क्लोरोफॉर्म (सीएच3सीसीएल3), हाइड्रो ब्रोमोफ्लोरो कार्बन (एचबीएफसी), हाइड्रोक्लोरोफ्लोरो कार्बन (एचसीएफसी), मिथाइल ब्रोमाइड (सीएच3बीआर) और ब्रोमो-क्लोरो मीथेन शामिल हैं। इन्हें रेफ्रिजरेटर, एयरोसोल प्रणोदक, एयर कंडीशनिंग संयंत्र, इलेक्ट्रॉनिक उद्योग, ऑप्टिकल उद्योग, प्लास्टिक और फार्मेसी उद्योगों में रेफ्रिजरेंट के रूप में व्यापक रूप से उपयोग किया जाता है। आधुनिकता की दौड़ में कई विकसित और विकासशील देश बिना सोचे-समझे औद्योगिक क्रांति में लगे हुए हैं। कई कारखाने, उद्योग और रासायनिक संयंत्र गैसों और प्रदूषित हवा का उत्सर्जन करते हैं जिनमें क्लोरीन, फ्लोरीन, ब्रोमीन और कार्बन तत्व प्रचुर मात्रा में होते हैं।

ओजोन परत में ओजोन क्षरण के ज्ञात कारणों में सबसे अधिक जिम्मेदार क्लोरोफ्लोरोकार्बन (सीएफसी) वर्ग के मानव निर्मित रसायनों का उत्पादन है। सी.एफ.सी. इसमें कार्बन से जुड़े हाइड्रोजन, क्लोरीन और फ्लोरीन के परमाणु होते हैं। जब यह वायुमंडल की ऊपरी सतह यानि पृथ्वी की सतह से 15-50 कि.मी. ऊपर होता है। एम। जब सीएफसी शीर्ष पर पहुंचता है तो पराबैंगनी किरणों के प्रभाव में अणु क्लोरीन, फ्लोरीन और ब्रोमीन में विघटित हो जाते हैं।

ओजोन रिक्तीकरण से पर्यावरण पर प्रभाव

ओजोन परत के नष्ट होने से पर्यावरण पर व्यापक प्रभाव पड़ने की संभावना है। लगभग 90% सौर विकिरण ओजोन परत द्वारा अवशोषित होता है, इसलिए केवल 10% ही पृथ्वी तक पहुँच पाता है। जब ओजोन परत नष्ट हो जाएगी तो सूर्य से घातक विकिरण पृथ्वी के वायुमंडल तक पहुंच जाएगा। इन विकिरणों में पराबैंगनी और कॉस्मिक किरणें प्रमुख हैं। इस परत के नष्ट होने से दुनिया भर के जीवित प्राणियों यानी मनुष्य, पशु, पक्षी, समुद्र पर व्यापक प्रभाव पड़ सकता है। जीव-जन्तु, पौधे एवं जलवायु जिनका विस्तृत विवरण नीचे दिया गया है।

मानव स्वास्थ्य पर प्रभाव

मानव स्वास्थ्य पर ओजोन परत के क्षरण का प्रभाव विभिन्न रूपों में दिखाई देता है। सूर्य के प्रकाश के प्रति उदासीनता मानव ऊतकों को नुकसान पहुंचाती है और वातावरण में ओजोन की कम मात्रा त्वचा और नेत्र रोगों की घटनाओं को बढ़ाती है। इनमें प्रमुख हैं त्वचा कैंसर और मोतियाबिंद।

1998 में, संयुक्त राष्ट्र पर्यावरण कार्यक्रम विभाग ने ओजोन परत की कमी के कारण त्वचा कैंसर की घटनाओं में उल्लेखनीय वृद्धि की सूचना दी।

महामारी विज्ञानी भी सौर विकिरण को त्वचा कैंसर का कारण मानते हैं। इनमें स्क्वैमस सेल कार्सिनोमा, बेसल सेल कार्सिनोमा और घातक ट्यूमर प्रमुख हैं और गोरी त्वचा वाले लोगों में इसका खतरा अधिक होता है। त्वचा कैंसर का अधिक खतरा यूवी-बी के संपर्क में आने के कारण होता है। इसमें कोई संदेह नहीं है, पराबैंगनी विकिरणों के अत्यधिक संपर्क के परिणामस्वरूप, हमारी त्वचा पर अन्य सभी प्रभाव जैसे कि धूप के धब्बे, झुर्रियाँ, केराटोसिस, इलास्टोसिस, असमान रंजकता आदि होते हैं। बढ़ोतरी देखने को मिलेगी। आपतित यूवीए (315-400 एनएम) किरणों का लगभग 50% और यूवीबी (280-315 एनएम) किरणों का 3% कॉर्निया, आंख की पारदर्शी बाहरी परत में प्रवेश करती है। इनमें से 1% UVB हमारे जलीय हास्य द्वारा अवशोषित होता है और शेष पराबैंगनी विकिरण (UVA और UVB) आंखों के लेंस द्वारा अवशोषित होता है। इसका तात्पर्य यह है कि सूर्य के प्रकाश के प्रति उदासीनता आम आंखों की समस्याओं से जुड़ी है। यूवी विकिरण के उच्च स्तर पर आंखों का तीव्र संपर्क, विशेष रूप से उन क्षेत्रों से जहां प्रकाश बर्फ, पानी और रेत से परिलक्षित होता है, कॉर्निया और कंजंक्टिवा की सूजन का कारण बन सकता है। इसके अतिरिक्त, सूर्य की पराबैंगनी विकिरण के लंबे समय तक हमारी आंखों के संपर्क में रहने से केराटोपैथी, पेटीगियम, मोतियाबिंद, तीव्र सौर रेटिनोपैथी और मैक्यूलर डीजेनरेशन जैसी अन्य बीमारियां हो सकती हैं। मैक्यूलर डिजनरेशन होने की संभावना बढ़ जाती है।

जानवरों पर प्रभाव

घातक यूवी विकिरण से जुड़े कई गंभीर स्वास्थ्य जोखिमों का सामना मनुष्यों और जानवरों दोनों को करना पड़ता है। जंगली जानवर, जो खुद को ऐसे घातक विकिरण से बचाने में असमर्थ हैं, वे यूवी विकिरण के प्रति अधिक संवेदनशील होते हैं। जिन जलीय जंतुओं में सुरक्षात्मक कोटिंग की कमी होती है, वे विकास के शुरुआती चरणों के दौरान भी बढ़ते यूवी विकिरण के संपर्क से खुद को बचाने में असमर्थ होते हैं।

ओजोन परत के क्षरण के कारण बिल्लियों, मवेशियों, भेड़ों और घोड़ों के खुले और बिना रंग वाले हिस्सों पर स्क्वैमस सेल कार्सिनोमा का खतरा होता है। कुत्तों में Uberreiter रोग के लक्षण दिखाई देने लगते हैं। पराबैंगनी विकिरण के घातक प्रभाव के कारण तालाबों और नदियों में मछलियाँ मोतियाबिंद और त्वचा के घावों का शिकार हो जाती हैं।

त्वचा कैंसर लगभग सभी जानवरों जैसे मवेशी, बकरी, भेड़, बिल्ली, कुत्ते, गिनी सूअर और चूहों में पाया जाता है। घने बालों से ढके शरीर के अंगों पर यूवी-बी विकिरण का प्रभाव नगण्य होता है। फिर भी, बालों वाले जानवरों की नंगी त्वचा आमतौर पर मुंह और नाक के पास और कभी-कभी शरीर के अन्य हिस्सों पर पाई जाती है। शरीर के ऐसे हिस्से, यदि भारी रंजित न हों, तो विकिरण द्वारा नष्ट हो सकते हैं।

पेड़-पौधों और वनों पर प्रभाव

पृथ्वी पर वनस्पति की उपस्थिति मनुष्य और पशु दोनों के लिए आवश्यक है। यहां तक कि सबसे छोटे जानवर भी पौधों के अस्तित्व के बिना जीवित नहीं रह सकते हैं, जिसका हमारी खाद्य श्रृंखला पर भारी प्रभाव पड़ सकता है। ओजोन परत में बढ़ते छेद के कारण वनस्पति पर पड़ने वाले प्रभाव को जानने के लिए शोध और कई प्रयोग किए गए हैं। वनस्पति पर यूवी-बी विकिरण के प्रभाव की प्राकृतिक घटना को प्रयोगशाला में सटीक रूप से दोहराना मुश्किल है क्योंकि कृत्रिम यूवी प्रकाश सौर यूवी से अलग है।

हम अपनी नग्न आंखों से पौधों पर अत्यधिक पराबैंगनी स्तर के प्रभाव को नहीं देख सकते हैं, लेकिन हम उन्हें महसूस कर सकते हैं। पौधों की

वृद्धि के साथ-साथ उसकी सभी कार्यात्मक एवं विकासात्मक प्रक्रियाओं पर नकारात्मक प्रभाव पड़ता है। इनमें पौधे के निर्माण की प्रक्रिया, उसके विकास और वृद्धि का समय, पौधों में पोषक तत्वों का वितरण और चयापचय आदि शामिल हैं। इन परिवर्तनों का पौधों के प्रतिस्पर्धी संतुलन पर महत्वपूर्ण प्रभाव पड़ता है।

अत्यधिक यूवी विकिरण लगभग सभी हरे पौधों की विकास प्रक्रिया में बाधा डालता है। पृथ्वी पर हर जगह चिंता है कि ओजोन की कमी कई पौधों की प्रजातियों को नुकसान पहुंचा सकती है और वैश्विक खाद्य आपूर्ति को कम कर सकती है। पौधे स्थलीय खाद्य श्रृंखला का आधार बनते हैं और मिट्टी के कटाव और पानी के नुकसान को रोकते हैं। वे ऑक्सीजन के प्रमुख उत्पादक हैं और CO2 जैसी ग्रीनहाउस गैसों के लिए प्राथमिक निष्कासन सिंक हैं।

यूवी विकिरण के संपर्क में आने से स्थलीय पौधों के जीवन पर नाटकीय प्रभाव पड़ता है, हालांकि इसके प्रभावों को वर्तमान में बहुत कम समझा जाता है। पराबैंगनी विकिरण का अवशोषण एक जीव से दूसरे जीव में व्यापक रूप से भिन्न होता है। सामान्य तौर पर, पराबैंगनी विकिरण पत्तियों के आकार को कम करके और प्रकाश संश्लेषण के दौरान ऊर्जा ग्रहण के लिए उपलब्ध क्षेत्र को सीमित करके पौधों की वृद्धि को प्रभावित करता है। बौनापन और समग्र शुष्क वजन में कमी विशेष रूप से यूवी-विकिरणित पौधों में देखी जाती है। पोषक तत्वों की मात्रा में कमी और पौधों, विशेषकर मटर और पत्तागोभी की धीमी वृद्धि देखी गई है।

Thinning as a stand management tool: Enhancing forest health and productivity

Yerrawada Naveen[1*], Mhaiskar Priya Rajendra[2], MilkuriChiranjeeva Reddy[1], BheemreddyvallaVenkateshwar Reddy[1], Rohith Ravula[1]and Katikala Anish[1]

[1] Department of Silviculture and Agroforestry, Forest College and Research Institute, Mulugu, Telangana
[2]Department of Forest Ecology & Climate Science, Forest College and Research Institute, Mulugu, Telangana
E-mail: naveenyerrawada@gmail.com

Introduction

Forests are not simply clusters of trees; they are complex and varied ecosystems that support diverse life forms and provide countless benefits to both the planet and its inhabitants. These ecosystems are known for their ecological functions, such as storing carbon, purifying waterand offering habitats for numerous species (Biswas, 2003). Forests also provide essential resources like timber, fueland other products that support industries and communities globally (Sizer *et al.*, 2005).To ensure that our forests stay healthy and provide us with the benefits we need; we need to manage them properly (Marchi *et al.*, 2018). Thinning is an essential way to manage forests. It involves removing some trees from a forest so that the remaining trees can be healthy and productive. This can help the forest grow better, be more diverse and be healthier overall (Kerr & Haufe, 2011). Thinning forests involves carefully assessing their condition and planning removal of trees by trained foresters. It applies to both natural and plantation forests (Oliveira *et al.*, 2021and Duchateau *et al.*, 2020). The aim is to improve the health, structureand diversity of the forest stand by removing selected trees (Pang *et al.*, 2023; Rajeev *et al.*, 2023 and Zhang *et al.*, 2020). As forests mature, they become more crowded due to tree growth and competition for resources (McMahon *et al.*, 2010). This overcrowding leads to reduced growth, disease and vulnerability to wildfires (Balandier *et al.*, 2006).Thinning involves removing specific trees to alleviate these problems. By reducing competition, thinning allows the remaining trees to grow and flourish (Zhang *et al.*, 2024). Thinning forests offers a major benefit by improving their health. When trees are thinned out, it allows more air to circulate and sunlight to reach the remaining trees. This improves their overall strength and resistance to pests and diseases, making the forest more resilient and healthier (Aussenac, 2000).

Objectives of thinning

The objectives of thinning are multifaceted and vary based on the specific characteristics of the forest ecosystem and the management objectives in place. Some common objectives include:

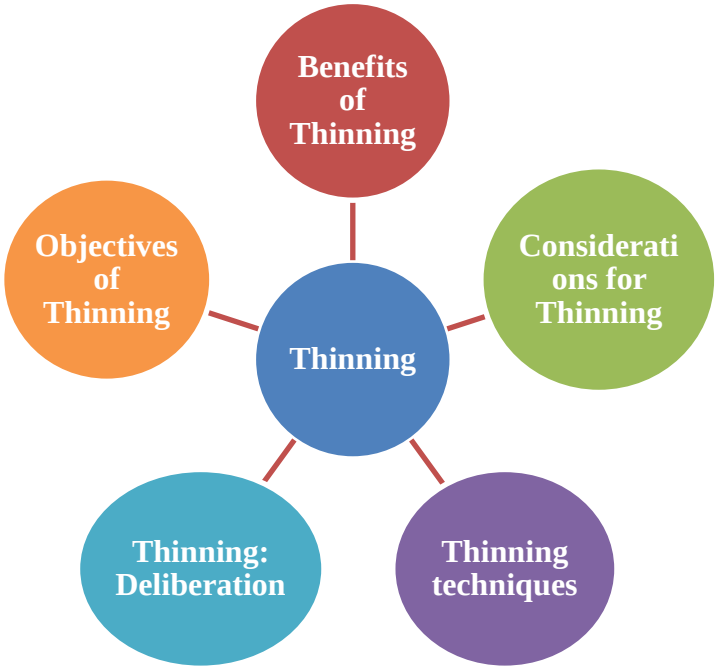
Enhancing Growth

Thinning involves removing some trees to lessen the competition between them for vital resources like sunlight, water, and nutrients. This helps the remaining trees benefit from these resources more efficiently, which in turn enhances their

growth and overall health (Qu *et al.*, 2022).

Improving stand structure

Thinning is a process where trees that are unhealthy, overcrowded, or damaged are removed. This helps improve the condition of the remaining trees by giving them more space, light, and nutrients. As a result, the forest becomes stronger and more resistant to disturbances like wildfires or pests (Roberts *et al.*, 2020).



Regulating stand density

Thinning is vital for managing the density of trees in a forest. It helps keep overcrowding in check, which reduces the likelihood of pest infestations, diseases, and wildfires. This promotes the health and well-being of the forest, ensuring it stays balanced and sustainable over time (Onyekwelu *et al.*, 2011).

Promoting biodiversity

Removing trees (thinning) makes spaces in the top layer of the forest (canopy). This helps plants grow underneath the canopy (understory vegetation). By making more spaces, it gives different types of plants and animals more places to live in the forest (Davis & Puettmann, 2009).

Benefits of thinning

Thinning presents numerous benefits to both the forest ecosystem and forest management practices. Some key advantages include:

Increased timber quality and value

When trees are thinned out, the ones left behind can focus more of their energy on growing wider. This leads to wood that is stronger, has fewer knot holes, and is overall better quality. As a result, the lumber harvested from these trees is worth more money (Liziniewicz, 2014).

Enhanced carbon sequestration

Thinning improves tree growth rates,

leading to increased carbon dioxide uptake and storage in the forest ecosystem. This contributes to mitigating climate change by reducing atmospheric carbon levels (Nunes *et al.*, 2020).

Reduced risk of pest and disease outbreaks

Removing excess trees (thinning) allows the remaining trees to thrive by reducing stress and improving their overall well-being. This makes them more resistant to pests and diseases. Furthermore, thinning improves airflow, which helps prevent the growth of harmful fungi (Roberts *et al.*, 2020).

Improved wildlife habitat

By selectively removing trees, thinning creates a varied landscape with different forest types. These varied forest structures provide diverse living environments that cater to a wide array of animal species. This diversity fosters a healthy ecosystem, making it more resistant to disturbances and able to adapt to changing conditions (Carey, 2003).

Increased recreational opportunities

Thinning forests can enhance their visual appeal and make them easier to navigate, increasing their popularity for activities such as hiking and watching birds (Paudyal *et al.*, 2018).

Considerations for thinning (Kerr, & Haufe., 2011)

Thinning requires careful planning and consideration of various factors to ensure successful implementation. Some key considerations include:

Silvicultural prescription

Forest thinning should be planned carefully based on a set of instructions that take into account the intended goals, type of forest, tree species, location, and any environmental limitations. These instructions determine which trees will be removed and how dense the remaining trees should be.

Timing and frequency

The schedule and regularity of tree thinning depend on how quickly the trees grow their natural life span, and the goals of management. Thinning can occur during various stages of a tree stand's development, including the early, middle, and mature phase.

Tree Selection Criteria

Trees to be removed should be chosen based on clear rules. These rules should prioritize trees that are stunted, hurt, or sick because they block the growth of healthy trees. Elective thinning promotes the retention of high-quality, dominant and genetically superior trees.

Logging and utilization

Careful logging practices should be employed during thinning operations to minimize soil disturbance, protect residual treesand ensure efficient utilization of harvested wood products. Sustainable harvesting techniques, such as reduced-impact logging, should be employed to minimize ecological impacts.

Monitoring and adaptive management

Regular monitoring of thinned stands is essential to assess the effectiveness of the thinning operation and make necessary adjustments. Adaptive management allows for continuous learning and improvement in stand management practices.

Thinning techniques

Thinning can be implemented using various techniques, depending on the forest type, management objectivesand available resources. Some common thinning techniques include:

Selective thinning

This involves the removal of individual trees or small groups of trees to create gaps in the canopy and promote the growth of desired species.

Crop tree thinning

This technique focuses on the selection and promotion of high-quality, dominant trees with desirable characteristics for timber production.

Thinning from below

This technique involves the removal of smaller, suppressed trees from the lower canopy to reduce competition and promote the growth of larger, more valuable trees.

Thinning from above

This technique targets the removal of larger, overtopping trees to reduce shading and allow morelight to reach the understory.

Variable density thinning

This approach involves the creation of varying levels of tree density across the stand to mimic natural forest dynamics and promote biodiversity.

Thinning: Deliberation

Thinning necessitates meticulous planning and consideration of several factors to ensure its successful execution (Yoshimoto*et al.*, 2016). Key considerations include:

Silvicultural prescription

Thinning should adhere to a well-defined silvicultural prescription tailored to specific objectives, forest type, tree species, site conditions and ecological constraints. This prescription guides decisions regarding tree selection and desired residual stand density.

Timing and frequency

Thinning operations timing and frequency hinge on tree species growth rates, life cycle characteristics and management objectives. Thinning may occur at different stages of stand development, such as early, intermediateand mature stages.

Tree selection criteria

The selection of trees for removal should adhere to predetermined criteria, prioritizing suppressed, damaged or diseased trees hindering the growth and development of the remaining trees. Selective thinning emphasizes retaining high-quality, dominantand genetically superior trees.

Logging and utilization

Thinning necessitates careful logging practices to minimize soil disturbance, protect residual treesand ensure efficient utilization of harvested wood products. Sustainable harvesting techniques, like reduced-impact logging, should be employed to minimize ecological impacts.

Monitoring and adaptive management

Regular monitoring of thinned stands is crucial for assessing thinning operation effectiveness and making necessary adjustments. Adaptive management facilitates continuous learning and improvement in stand management practices.

Conclusion

Thinning in forests is a valuable technique that boosts forest well-being, productivity, and diversity. It helps trees grow better, keeps the forest canopy balanced and spaced out, and encourages a wide range of plant and animal life. By thinning, we can support both the environment and the economy. But it's important to plan carefully, think about all the different things that can affect the forest, and follow the right forestry guidelines to make

thinning successful. To ensure the desired results and address unexpected issues, it is crucial to track and adapt forest management practices. When thinning is done properly, it can help forests remain sustainable over the long term, guaranteeing that they provide important ecosystem services and resources for future generations.

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Promising properties of transparent wood for various applications

Chutturi Mahesh[1*], Kapil Sihag [1], Sumith Yadav[1]

[1]Department of Forest products and utilization
FCRI, Mulugu, 502279, Hyderabad, Telangana, India
E-mail: chutturimahesh789@gmail.com

Abstract

Environmental uncertainty and emissions from non-renewable resources have driven mankind to develop environmentally friendly and energy-efficient materials. Wood is one of the most abundant and versatile bio-based structural material. There are several promising and significant benefits of wood, such as its high toughness, high strength, high Young's modulus, low density, low thermal conductivity, biodegradability, and non-toxic nature. Moreover, while wood has several structural and ecological advantages, it falls short of satisfying the need of optical transparency. Transparent wood, which is fabrication of wood channel template filled with resins, exhibited acceptable environmental friendliness as well as high transparency and haze, offering immense potential applications in a variety of important industries.

Keywords: Transparent wood, Synthesis, Physical properties, Mechanical properties, Optical properties, applications

Introduction

The rapid depletion of fossil fuel resources has prompted a surge in interest in the development of renewable energy alternatives (Pang et al. 2020). Trees are the oldest living beings on the planet, and also the largest and most predominant living things with distinct biomaterials. Wood, mankind's original source of energy, remains the most important single source of renewable energy, accounting for around 6% of the world's total primary energy supply. The inherent complexity and variability of wood's biological structure, as well as the availability of a variety of technological advancements that allow for more efficient use of this resource have expanded the scope of this bio-based material.

Wood is a primary supportive organ essential for producing firm structures since it is a porous and fibrous hard structured stem that also contains the secondary xylem of the vascular tissue made of cellulose, hemicellulose, and lignin (Jin et al. 2017).

Transparent wood has recently experienced a surge in popularity because to its fascinating optical, mechanical, energy-efficient building material, and eco-friendly features (Montanari et al. 2021). Transparent wood enables direct sunlight in, requiring less coal-based electricity, and hence has huge significance in the gradual replacement of fossil fuels with bio-based products. In light of the global energy and environmental crisis, transparent wood is now considered as a significant boon and a

major achievement in innovation toward a circular economy.

Synthesis strategies of transparent wood

Wood is fabricated into transparent one generally in two steps. Firstly, chemical bleaching helps remove the light-absorbing lignin and chromophores along with coloured tannins, and other polyphenols. This process is known as decolourization/delignification which is shown in Fig.1. Secondly, the pores/voids created due to delignification tend to increase specific surface area, without affecting the anisotropic wood structure and can be filled in using a matrix polymer of the same refractive index and this process is referred to as polymerization. Some of the different Delignifiation and polymerization methods are shown in table 1.

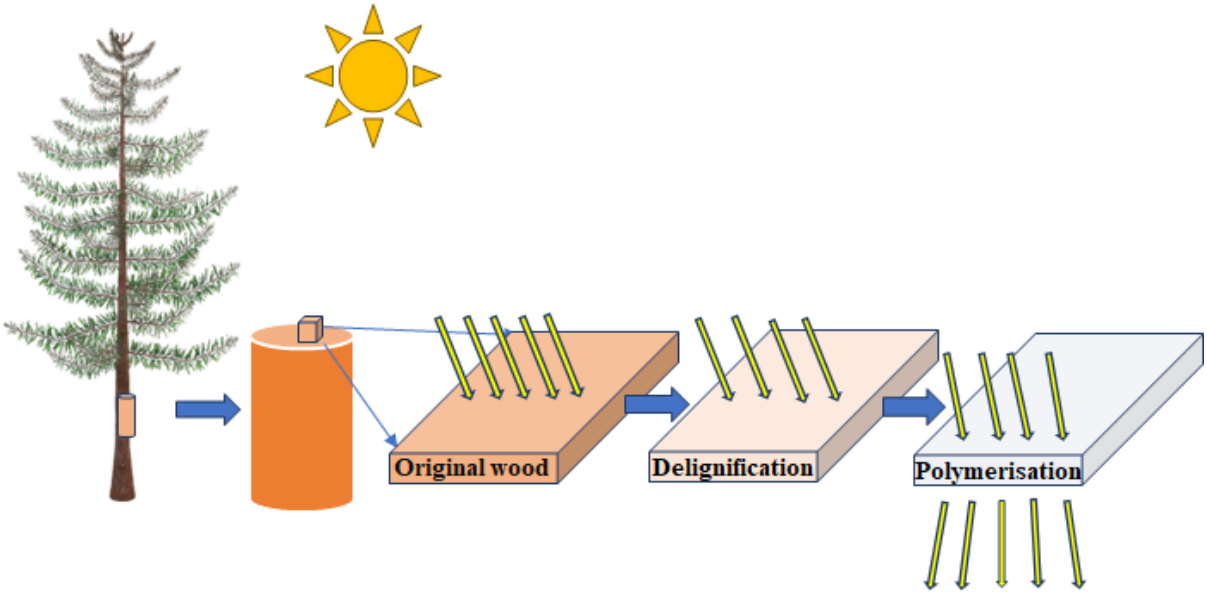

Fig.1 Schematic illustration of the preparation of transparent wood

Table 1: Different delignification treatments and polymers used in the preparation of transparent wood

Wood	Chemical treatment (Delignification)	Effect	Polymer	Reference (s)
Balsa wood	H_2O_2 at 70°C sodium silicate, NaOH+ magnesium sulfate + DTPA	Samples turned visibly white	Mixtures of thiol and all monomers of PETMP & TATATO	Samanta et al. 2021
Balsa, Alder, Birch, Beech	Peracetic acid	Samples colour changed to white.	PLIMA	Montanari et al. 2021

Pine and bass	NaClO, CH_3COOH, ethanol 90°C/90min	Improved colour of wood	MMA	Wu et al. 2021(b)
Balsa veneer	acetate buffer containing sodium chlorite at 80^0c	White colour	Thiol−ene polymers	Höglund et al. 2021

* PETMP- Pentaerythritoltrakis (3-mercaptopropionate), TATAO- 1,3,5-triallyl-1,3,5-triazine-2,4,6 (1H, 3H, 5H)-trione, MMA- Methylmethacrylate, PLIMA- Poly limonene acrylate.

Physical and mechanical properties

The performance of transparent wood is generally depending on physical and the mechanical characteristics such as density, young modulus, tensile properties and elastic modulus. These evaluations are crucial to determining material ability, especially under critical and extreme conditions, which are directly connected to structural and functional performance. The mechanical properties of transparent wood prepared from different species are discussed in Table 2.

Table 2: Physical and mechanical properties of transparent wood prepared from different wood

Wood sample	Length x width x thickness (mm^3)	Density ($kg/m^{3)}$	Young's modulus E (GPa)	Tensile strength σ (MPa)	Elongation at break ε (%)	Reference (s)
Balsa	15 ×15 × 1.1	170−200	2.2	46	14	Samantha et al.2021
Balsa	20 × 40 × 0.8	172	-	143	-	Mi et al. 2020
Poplar	60 × 20 × 1.0	380	1.51	39.9	-	Rao et al. 2019
Birch	20 × 5.0 × 1.2	593	10.6	174	1.2	Montanari et al. 2021

Samanta et al. (2021) evaluated the transmittance and haze properties of a transparent wood thiol-ene monomer sample (1.1 mm thick) under UV. with a UV torch operating at 550 nmr showed a transmittance of 87 ± 2% and haze of 47 ± 2%. Mi et al. (2020) evaluated the transmittance of the Douglas fir wood at radial direction using UV–vis Spectrometer Lambda 35 and noted average transmittance of 80% at 600 nm and a haze value of 93%. While at longitudinal direction (0.6 mm thick)) noticed a transmittance of 87% and optical haze of 65% at 600 nm. Montanari et al. (2021) evaluated the optical properties of transparent succinylated balsa wood of 1.2mm thickness showed transmittance of 90% and haze of 30%. Hogland et al. (2020) evaluated the low haze transparent balsawood bleached sample of 1.2 mm thickness using spectrometer of wavelength at 550 nm according to ASTM D1003-13 standard and noted transmittance 90 ± 0.1 % and haze 36 ± 0.4 % respectively are presented in Table 4.

Table 4 Optical and thermal properties of transparent wood prepared from different wood

Wood	Thickness (millimeters)	Transparency (%)	Haze (%) at 550 nm	Thermal conductivity (W m−1 K−1)	Reference (s)
Balsa	1.1	87	47	-	Samanta et al. 2021
Balsa	1.2	90	36	-	Hogland et al. 2020
Balsa	0.8	80	93	-	Mi et al. 2020
Balsa	-	-	-	0.24	Mi et al. 2020b

Applications

The applications of transparent wood are ample, ranging from smart windows to smartphone screens, rooftops to interior aesthetic panels. Transparent wood building material can contribute to less indoor fossil fuel energy consumption by replacing it with thermally insulating material for promoting effective sunlight harvesting in place of artificial lights (Samanta et al. 2021). Gan et al. (2017) prepared Magnetic transparent wood by incorporating ferromagnetic (Fe_3O_4) nanoparticles. Demir et al. (2011) fabricated Luminescent transparent wood with improved diffused luminescence by incorporating Si and CdSe/ZnS core/shell quantum with the luminescence diffusivity tunable by the light scattering of transparent wood.

Fu et al. (2017) used nanoclay impregnation into the cell wall for fire retardancy and Bisht et al. (2021) developed a UV resistant transparent wood for outdoor application by incorporating epoxy resin doped with a UV absorber (2-(2H-Benzotriazol-2-yl)-4, 6-di-tera-

pentylphenol) (conc. 1.0 and 1.75% w/v) respectively) are illustrated in Fig 15. Mi et al. (2020) reported aesthetic transparent wood for glass ceilings, rooftops, transparent decorations, and indoor panels along with energy-efficient functions of low thermal conductivity (0.24 W m−1 K−1) are shown in Fig. 2.

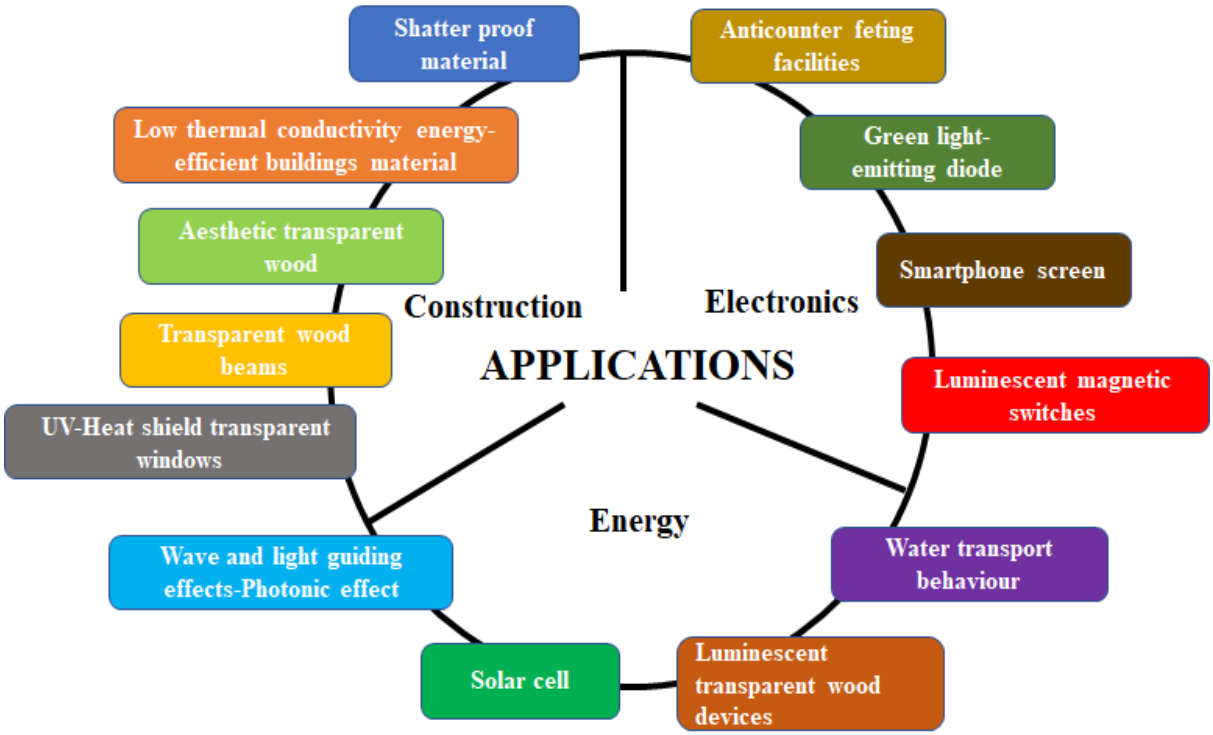

Fig. 2 Illustration of different application of transparent wood

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Role of *Patidoi* or *Pati-Bet* in livelihood generation

Ankur Jyoti Saikia and Prodip Kumar Hazarika

Silviculture and Forest Management Division
ICFRE-Rain Forest Research Institute, Jorhat, Assam
E-mail: ankurj.saikia05@gmail.com

Patidoi or *Pati-Bet* is a perennial shrub growing in the wetlands of India (especially, Assam and West Bengal) and Bangladesh. The scientific name of this shrub under the Marantaceae family is *Schumannianthus dichotomus* (Roxb.) Gagnep. It is also known by other names, including *'Murta'*, *'Mustak'*, *'Pati Pata'* and *'Pati Jang'*. It is a major raw material source not only as a support to the rural cottage industry prevalent in the North-Eastern regions but also in various states of Cooch Behar (West Bengal) and Bangladesh in India.

'Pati', used as raw material, is a long strip obtained from the bark of the mature stalk of *Pati bet*. Patti is processed to make a variety of handicrafts; in which important reference is made to *'Sital Pati'* – which is a durable, well-furnished and biodegradable mat. Processing of *pati* to make various household use items is a cumbersome effort carried out through a series of rigorous activities based on indigenous knowledge along three parameters (technology, skill and craftsmanship). *Sital Pati*, which is very popular for its use in daily rural and semi-urban life, is a craft that suits the hot and humid climate of the prevailing areas.

The weaving and dyeing techniques of *Pati* are listed below:-

(a) Harvesting of *Pati Bet* – Cutting the stalk (stem in bushes) from the base.

(b) Processing of *Pati Bet* – Soaking and drying in water for 10-15 days depending on the maturity as well as the quality of the bark, followed by sun drying for one hour.

(c) Division of *Pati Bet* – The individual bet is divided in length into two equal parts (chitto).

(d) Division of the medulla – The medulla is separated from the inner medulla by lengthwise division.

(e) Division of *Pati* – *Pati* is processed into three sections from outside to inside depending on the thickness.

(f) Boiling of *Pati* - To bring out the colour, it is boiled in water for one hour using the following methods:

a. Boiled with water (to develop red colour);

b. Mixing the *pati* with the juice of boiled rice and boiling it with mango and tamarind leaves (to develop ivory colour);

c. Boiling the paste with magenta dye (to develop the reddish-pink colour); And

d. Wrapped in mango bark and kept in soil for seven days (to develop black colour).

(g) Drying of *Pati*

(h) Weaving –

a. Grading – The mat is finally graded and cut as required to produce a specific mat.

b. Twilling – The joining process involves plaiting a large sized box

c. following the method of twill/check pattern.

The method of cultivation and harvesting of *Patidoi* is written in detail below. Swampy wetlands with shady environment are favourable for plant growth. Saplings are planted after ploughing; the distance between the two lines is kept at 60-75 cm. Pre-monsoon season is most suitable for plantation and monsoon months are favourable for normal growth of the plant. A plant is nurtured for three years to reach harvestable size and then replaced with new plants. A mature plant can produce about 24 plants covering a 30-45 cm radius. Its cultivation does not require much care or any specific agricultural practice. During harvesting, a mature stalk is cut at the base with the help of a sickle. The size of a cut stalk can be 90–150 cm long, and 300–400 such stalks are used to make a bundle. About 550 bundles are produced from one *bigha* land i.e. 1333 square meter area, which costs Rs. 65,000-75,000 (US$ 1030-1090).

Livelihood is one of the important parameters in socio-economic analyses which needs to be studied in detail. It is anticipated that forestry researchers will focus upon and provide a detailed study and review on this subject; thereby conveying the usefulness of *Patidoi* to the people in an opportunity for economic progress.

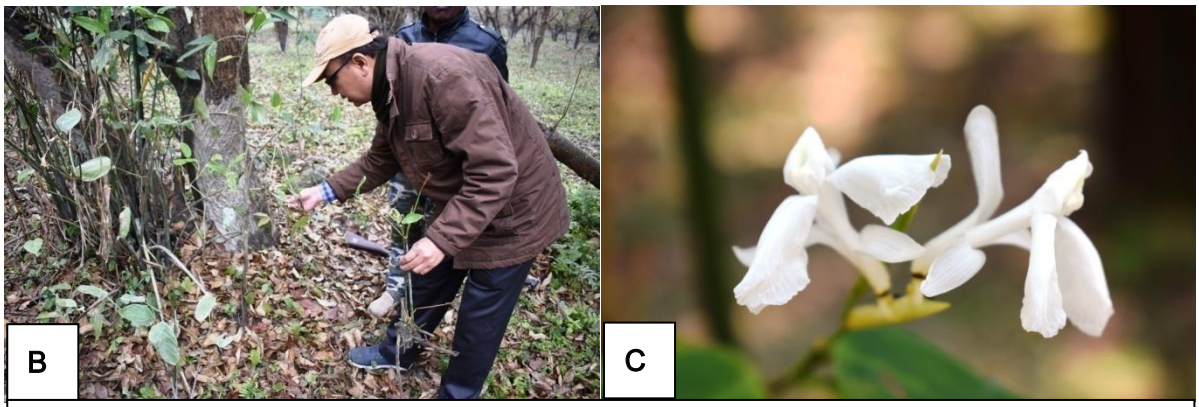

Plate: *Patidoi* or *Pati-Bet* [*Schumannianthus dichotomus* (Roxb.) Gagnep.]: (a) – Few plants in natural habitat, (b) – Author collecting germplasm, (c) – Two flowers in an inflorescence.

Empowering smallholder farmers: The role of agroforestry in India's agricultural landscape

Sindhu Xaxa[1], Ekta Singh[1] and Animesh Shukla[2]

[1]Department of Forestry, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh
[2]Department of Forestry, Wildlife & Environmental Science, Guru GhasidasVishwavidyalaya, Bilaspur, Chhattisgarh
Email: sindhuxaxa97@gmail.com

Introduction

Agroforestry, essentially a mixed cropping system, implies co-existence of farm and forests which can achieve both natural resources and socio-economic sustainability (Bhatt and Misra, 2003). It improves the well-being of the rural poor to meet a diverse range of livelihood securities including food, nutrition, environment, fodder, energy and income (Kumar *et al*., 2004). Agroforestry as a traditional land-use system potentially support livelihood improvement through simultaneous production of food, fodder, fuel wood and timber as well as mitigation of the impact of climate change. Despite, magnificent contribution to social, economic and ecological functions, the adoption level of agroforestry systems in small holder farmers is inadequate. To promote well-being of the small holder farmers, adoption of agroforestry needs to be strengthened by strategic motivation.In India, agroforestry practices in rainfed agriculture have been used to manage scatteredtrees on farm lands, trees on farm bunds, wood lots as block plantations,trees on range lands, and vegetative live hedges for ecological, social, andeconomic functions. To enhance rural livelihood security among thedryland farmers, several improved agroforestry systems, commercialplantations and biofuels and bioenergy systems came into being foradoption. Agroforestry plantation-based success stories reveal livelihoodsecurity of small, marginal, and landless farmers. Steps to promote basicand promotional agroforestry research in dryland agriculture and appropriate policy responses with extension outreach may potentially deliverbetter results in rainfed agriculture. Rainfed agroforestry for livelihoodsecurity reflects the positive way in utilization of rainfed area resources.

Agroforestry systems: Opportunities and challenges in India

Small holder agriculture faces many challenges including low productivity, high dependence on rain-fed agriculture, insecurity of the traditional land tenure system and environmental degradation due to unsustainable agricultural practices in rural India (Kumar *et al*., 1999). Today, Indian agriculture faces diverse challenges and constraint due to growing demographic pressure, increasing food, feed and fodder needs, natural resource degradation and climate change (Dhyani *et al.* 2013) therefore a management system needs to be devised that is capable of producing food from marginal agricultural land and is also capable of maintaining and improving quality of producing environment (Dobriyal, 2014).

Major Agroforestry systems followed in India

Agroforestry systems	Agroecological region adaptations
Agrisilvicultural Systems	
Shifting Cultivation	In tropicalforest areas
Taungya	In all regions
Plantation-based cropping system	Mainly humid tropical regions
Scattered trees on farms, parklands	All regions, especially semiarid and arid regions
Shelterbelts and windbreaks	In wind-prone areas, especially coastal, arid and alpine regions
Boundary planting and live hedges	In all regions
Woodlots for soil conservation	In hilly areas, along sea coast and ravine lands
Industrial plantations with crops	Intensively cropped area in northern India
Silvo-pastoral systems	
Silvipastures	Sub tropics and tropics with bio- edaphic sub- climaxes
Horti-pastoral	In hilly orchards for soil conservation
Plantation crops with pastures	Mostly humid & sub- humid regions of south regions of south East Asia and South with less grazing pressure on plantation lands
Seasonal Forestry Grazing	Semi-arid and mountainous ecosystem
Agro-silvo-pastoral system	
Home gardens	Mainly tropical region
Others	
Aqua forestry	Low Lands
Apiculture with trees	In all regions

Source: (Dagar *et al*. 2014 and Puri and Nair, 2004)

Agroforestry benefits

Increased crop yield

Trees in agroforestry systems can improve soil fertility by cycling nutrients. Tree roots can access nutrients deeper in the soil profile, which are then brought to the surface and made available to crops. As a result, crops grown in agroforestry systems often have access to a more abundant and diverse supply of nutrients, leading to increased yields

Diversified Income Streams

Agroforestry involves growing trees alongside crops or livestock, providing farmers with multiple products to sell. These can include fruits, nuts, timber, fodder, and medicinal plants, among others. Different trees and crops in agroforestry systems often have varying

maturity rates, leading to staggered harvests throughout the year. This helps in maintaining a continuous income flow rather than relying on a single seasonal harvest.

Improved land productivity

Agroforestry systems often incorporate trees that fix nitrogen, such as legumes, which enrich the soil with this essential nutrient. Additionally, fallen leaves and organic matter from trees help build soil organic carbon, improving soil structure and fertility. The presence of trees in agroforestry systems helps prevent soil erosion by providing ground cover and reducing the impact of rainfall on the soil surface.

Enhanced carbon sequestration

Carbon sequestration was estimated both in plant biomass and soil in two pasture systems (*Cenchrus ciliaris*and *Cenchrus setigerus*), two tree systems (*Acacia tortilis*and *Azadirachta indica*), and four silvopastoral systems (combination of one tree and on grass) on moderately alkaline soils (pH 8.36 to 8.41) in Kachchh, Gujarat, northwestern India (Mangalassery *et. al.,* 2014).

Strategies for Implementing Agroforestry in India

Choice of appropriate species

Choose tree species that offer multiple benefits, such as providing timber, fruits, fodder, medicinal products, or nitrogen fixation. Multipurpose species maximize the benefits of agroforestry systems and enhance their economic viability. Some of the agroforestry system with bamboo being adopted in the country is:

- Soybean with *D. strictus.*
- Pigeon pea with *Bambusabambos.*
- Soybean with *Bambusabambos.*
- Ginger with *Bambusabambos.*
- Turmeric with *Bambusabambos.*
- Soybean with *Melocannabaccifera.*
- Soybean with *D. longispathus*

Management practices

Species Selection, Agroforestry Design, Spacing and Arrangement, Crop Management, Soil Management, Water Management, Pruning and Thinning, Monitoring and Evaluation. By implementing these management practices, farmers can harness the multiple benefits of agroforestry systems, including increased resilience to climate change, enhanced biodiversity, improved soil and water conservation, and diversified income streams.

Motivation- key instrument for agroforestry adoption

A motive is some inner drive, impulse,intension *etc*. that causes a person to act in a certain way to achieve a goal he or she considers to be important at a particular time within their cultural environment Motivation among people can be originatedfrom specific needs, wants, desires, motives, incentives or urges (Pant, 2011) such as:

Need for security

Economic, social, psychological and spiritual security.

Need for affection or response

Companionship, gregariousness and social mindedness.

Need for recognition

Status, prestige and achievement.

Future of Agroforestry in India

The future goals in the agroforestry should be toward to enhance biomass productivity per unit area and time through agroforestry interventions; Tree improvement, post-harvest & value addition; environmental

amelioration, resource conservation, mitigation of climate change effects and management of stresses; and Participatory development of agroforestry models, HRD, refinement and transfer of technology (CAFRI, 2015). The promotion of sustainable agroforestry practices on a large scale in future only possible through amalgamation of proactive farmer policies of government, involvement of the industries, support services from NGOs and willingness of farmers (Verma*et al.* 2017). A major role for agroforestry in the near future will be to give environmental service such as climate change mitigation (carbon sequestration), phytoremediation, watershed protection and biodiversity conservation. However, this will need the development of mechanism to reward the rural poor for the environmental services that they provide to society (CAFRI 2015).

Land use statistics and Agroforestry area in the past, present and in 2050 in India {Million ha}

S. N.	Land use classes	Year		
		1999	**2013**	**2050**
1.	**Forests**	63.72	69.20	69.63
2.	**Cultivated land**	140.86	140.86	142.60
	A. Irrigated areas			
	1.Pure cropping area with scattered trees on bunds/fields	59.09	55.29	51.03
	2.Agroforestry	3.20	7.00	13.00
	Sub total	**62.29**	**62.29**	**64.03**
	B. Rainfed areas			
	1.Pure cropping area with scattered trees on bunds/fields	67.79	65.57	57.07
	2.Agroforestry	10.78	13.00	21.50
	Sub total	**78.57**	**78.57**	**78.57**
3.	**Other miscellaneous land**			
	1.Fallows/cultivable wastes/pastures/groves etc.	51.57	49.86	34.94
	2.Agroforestry	3.61	5.32	18.82
	Sub total	**55.18**	**55.18**	**53.44**
	Total Reported Geographic Area (TRGA)	305.67	305.67	305.67
	Total Agroforestry area	17.59	25.32	53.32
	Agroforestry as % of TRGA	5.75	8.28	17.57

Source: Director of Economics and Statistics, Ministry of Agriculture, Govt. of India. Forest survey of India, State Forest Report, 2011.

Conclusion

Agroforestry offers a holistic approach to empowering smallholder farmers in India, aligning environmental conservation with socioeconomic development. By harnessing the potential of agroforestry, India can create resilient, inclusive, and sustainable agricultural systems that benefit both farmers and the environment.Agroforestry fosters community engagement and knowledge sharing, as farmers collaborate on tree planting initiatives and adopt innovative techniques. This strengthens social cohesion and empowers farmers to collectively tackle challenges such as

access to markets, resources, and information.

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ICFRE-Tropical Forest Research Institute
(Indian Council of Forestry Research & Education)
(An autonomous council under Ministry of Environmnet, Forests and Climate Change)
P.O. RFRC, Mandla Road
Jabalpur – 482021, M.P. India
Phone: 91-761-2840484
Fax: 91-761-2840484
E-mail: vansangyan_tfri@icfre.gov.in, vansangyan@gmail.com
Visit us at: http://tfri.icfre.org or http://tfri.icfre.gov.in