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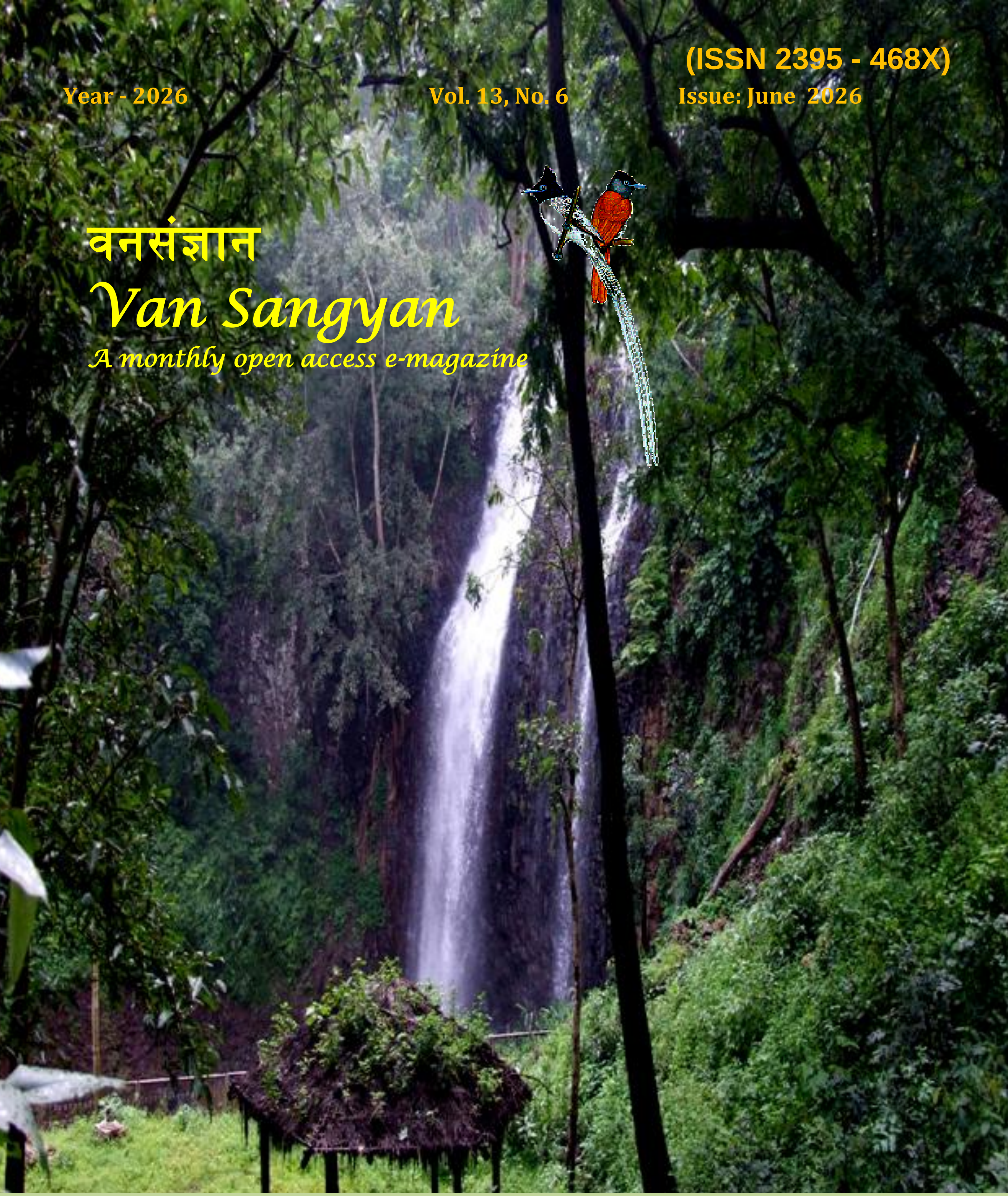

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Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

From the Editor's desk

The question of whether trees communicate has moved from the realm of ecological curiosity to a serious scientific field of investigation. Trees do not communicate through language in the human sense, yet they possess sophisticated mechanisms for transmitting and responding to information. Through chemical signaling, volatile organic compounds (VOCs), root exudates, mycorrhizal fungal networks, electrical signals, and hydraulic cues, trees can detect environmental changes and alter their physiology accordingly. When attacked by herbivores or pathogens, for example, damaged plants may release airborne chemical compounds that can induce defensive responses in neighboring plants. Belowground interactions are equally intriguing: roots and their associated mycorrhizal fungi can facilitate the movement of nutrients and chemical signals among plants, although popular descriptions of a universal "wood-wide web" sometimes go beyond what experimental evidence currently demonstrates. Trees also respond to signals generated by drought, shading, temperature fluctuations, and mechanical stress, modifying stomatal conductance, root growth, secondary metabolism, and defense chemistry. The emerging picture is therefore not one of trees "talking" as animals do, but of information exchange within complex plant–plant–microbe networks. This perspective challenges the traditional image of forests as collections of independent organisms and instead presents forests as dynamic, interconnected biological systems in which communication-like processes contribute to resilience, competition, cooperation, and adaptation. Understanding these mechanisms could have important implications for forest ecology, climate-change resilience, restoration science, and sustainable forest management.

In line with the above this issue of Van Sangyan contains an article on Do trees communicate? There are also useful articles viz. Molecular docking in drug discovery: Principles, applications, and advances in natural product research, Dynamics of forest area and carbon stocks in India: A long-term biomass and soil carbon analysis, गोंद, रेजिन, टैनिन और प्राकृतिक रंगों की व्यापारिक गतिशीलता और क्षमता, Nilgai-Induced Crop Losses in India: Ecology, Impacts and Management Options, Neem tree: Value in the summer, Hidden architects of forest recovery: The role of native mycorrhizal networks in restoring Telangana's forests, First record of the bracket fungus, Laetiporus sulphureus (Bull.) Murrill (1920), from the urban landscape of Nagpur, Maharashtra and श्री अन्न - पोषण सुरक्षा का आधार.

Looking forward to meet you allthrough forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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Do trees communicate?

Aruri Manoj and Shalini Mudalkar
Department of Forest Biology and Tree Improvement
Forest College and Research Institute, Mulugu, Siddipet, Telangana - 502279
E-mail: manojaruri198@gmail.com

Abstract

Trees were once considered isolated organisms, but modern research shows that forests function as interconnected communities through complex communication systems. Trees communicate underground through mycorrhizal fungal networks, often called the "Wood Wide Web," which connect roots and enable the transfer of nutrients, water, carbon, and chemical signals between neighbouring plants. Mature trees support seedlings and stressed plants through these networks. Trees also release airborne volatile organic compounds during herbivore attacks or environmental stress, warning nearby trees to activate defence responses. Electrical signals within vascular tissues coordinate physiological activities such as wound healing and hormone production, while root exudates influence soil microbes and neighbouring plants. Although tree communication is not conscious like animal communication, these signalling systems are highly evolved adaptive mechanisms that improve forest resilience, biodiversity, and ecosystem stability. Understanding these hidden networks has important implications for forest conservation, restoration, and climate adaptation, highlighting forests as cooperative and interconnected ecological systems.

Keywords: Tree Communication, Mycorrhizal Networks, Wood Wide Web, Volatile Organic Compounds, Forest Resilience, Ecosystem Stability.

Introduction

For a long time, trees were viewed as solitary organisms, silent and disconnected from one another. However, recent scientific research has revealed that forests function as highly interconnected and interactive ecosystems. Trees communicate through biochemical, electrical, and ecological networks that allow them to exchange nutrients, transmit warning signals, and coordinate responses to environmental stress. Underground mycorrhizal fungal networks, often called the "Wood Wide Web," connect tree roots and facilitate the transfer of water, carbon, and chemical signals between neighbouring plants (Smith and Read, 2008; Simard *et al.*, 1997). Trees also release airborne volatile organic compounds during herbivore attack or environmental stress, enabling nearby plants to activate defence responses (Heil and Karban, 2010). Electrical signalling within vascular tissues and chemical interactions through root exudates further regulate physiological responses and microbial associations (Fromm and Lautner, 2007; Bais *et al.*, 2006). Although trees do not communicate consciously like animals, these evolved signalling systems enhance forest resilience, biodiversity, cooperation, and ecosystem stability under changing environmental conditions.

Underground communication: The Mycorrhizal Network

One of the most fascinating discoveries in plant ecology is the existence of extensive underground fungal networks, popularly called the "Wood Wide Web." Mycorrhizal fungi form symbiotic relationships with tree roots, creating microscopic channels (hyphae) that connect multiple trees across a forest (Smith and Read, 2008). Through these fungal networks, trees exchange nutrients, water, and chemical messages.

Research by Simard and colleagues demonstrated that trees connected by ectomycorrhizal fungi can transfer carbon and other nutrients between individuals (Simard *et al.,* 1997). Mature trees, often referred to as "mother trees," can send carbon, nitrogen and phosphorus to younger seedlings growing in shaded or nutrient-poor environments, thereby improving seedling survival and establishment (Gorzelak*et al.,* 2015). The same network also functions as an information pathway: when a tree experiences herbivore attack or environmental stress, warning signals can travel through fungal networks, preparing neighbouring plants to activate defence responses (Song *et al.*, 2015).

This underground communication is not random. Trees frequently show species-specific cooperation, providing more resources to genetically related individuals. These interactions highlight that forest communities operate less like collections of isolated organisms and more like interconnected systems supporting collective stability.

Airborne chemical signals (Volatile organic compounds)

Trees also communicate above ground using airborne chemicals known as volatile organic compounds (VOCs). When a tree is wounded - due to herbivores, pathogens, or drought - it releases a unique blend of VOCs into the air(Heil and Karban, 2010). Nearby trees detect these molecules through their leaves and activate internal defence pathways.

A classic example comes from African acacia species. When herbivores such as giraffes feed on acacia leaves, the trees release ethylene gas, which serves as a warning signal to neighbouring trees. In response, nearby acacias increase tannin concentrations in their leaves, making them less palatable to herbivores (Baldwin and Schultz, 1983).

Additionally, VOCs also serve ecological functions such as attracting predators of herbivores. For instance, a caterpillar-chewed tree may release chemicals that draw parasitic wasps, indirectly protecting itself (Heil and Ton, 2008).

Electrical signalling within trees

Trees are also capable of generating electrical signals that travel through their vascular tissues. Although these signals move much more slowly than animal nerve impulses, they play a critical role in coordinating internal plant responses (Fromm and Lautner, 2007).

When plant tissues are damaged, electrical signals propagate through the phloem and trigger the synthesis of defensive hormones such as jasmonic acid. These signals help coordinate physiological responses including wound healing, defence compound production, and regulation of stomatal activity (Fromm and Lautner, 2007).

Some plants, such as *Mimosa pudica*, exhibit visible electrical responses where leaves fold upon mechanical stimulation, demonstrating the ability of plants to transmit and respond to electrical stimuli.

Communication through soil chemistry and root exudates

Beyond fungi and electrical signals, trees release a variety of chemical compounds into the soil - sugars, amino acids, organic acids, hormones, and secondary metabolites(Bais *et al.,* 2006).

These root exudates influence neighbouring plants by altering growth patterns, boosting resistance or sometimes inhibiting competitors. Trees under stress may modify their exudate profiles to influence the microbial community, increasing the abundance of beneficial bacteria or fungi that help in nutrient uptake or disease resistance (Bais *et al.,* 2006).

This soil-based communication is essential for maintaining healthy forest microbiomes and ensuring resilience against changing environmental conditions.

Is tree communication conscious?

While trees clearly share information, redirect resources, and coordinate responses, it is important to clarify that tree communication is not conscious. Trees do not think or intend to communicate. Instead, their signalling systems are the product of millions of years of evolution, allowing them to survive in complex ecosystems where cooperation can be as important as competition (Karban, 2008).

Their communication resembles chemical and ecological feedback systems rather than deliberate messaging. Yet the effects are remarkable: through these systems, forests behave like integrated, adaptive communities.

Ecological importance of tree communication

The communication abilities of trees contribute to the overall health of forest ecosystems. They help:

- Improve survival of seedlings through resource sharing.
- Provide early warnings about pests, pathogens and drought.
- Balance competition and cooperation in complex plant communities.
- Stabilise ecosystems, making them more resilient to disturbances.
- Maintain biodiversity by supporting interactions between trees, fungi and microbes(Gorzelak*et al.*, 2015; Karban, 2008)

Understanding these processes has major implications for forest conservation, restoration and climate adaptation.

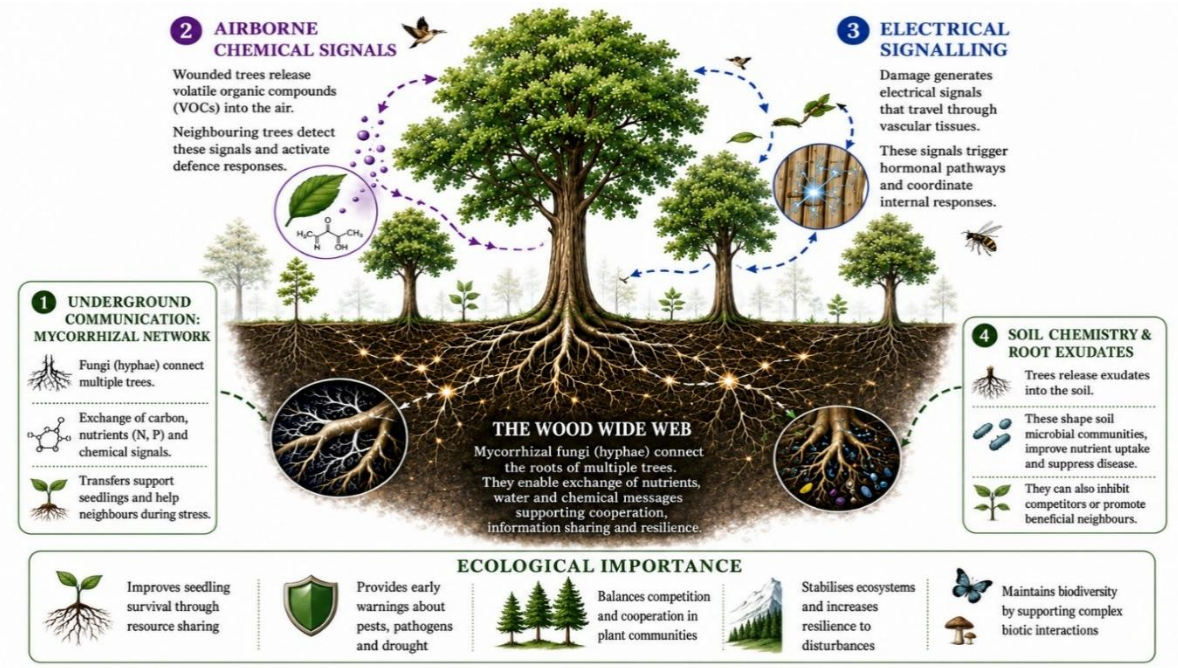

Fig: Interconnected Forests- Signalling Pathways in Trees

Conclusion

Trees do communicate through underground fungal networks, airborne chemical signals, electrical impulses, and soil chemistry. Their communication systems allow them to respond collectively to environmental challenges, support vulnerable neighbours and maintain the stability of forest ecosystems. Although this communication is not conscious, it is sophisticated and vital to the survival of forests. As we continue to learn more about these hidden networks, it becomes increasingly clear that forests are not merely collections of trees but interconnected communities, thriving through cooperation and subtle continuous communication (Simard *et al.*, 1997; Karban, 2008)

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Molecular docking in drug discovery: Principles, applications, and advances in natural product research

Akkenapally Snehanjali*, RohithRavula, Shalini Mudalkar and Burugula Akhila
Forest College and Research Institute, Mulugu, Siddipet, India
E-mail: akkanapallysnehanjali1234@gmail.com

Introduction

Molecular docking is a structure-based drug design approach that predicts the interaction, binding mode, and binding affinity between receptors and ligands at the atomic level (Morris and Lim-Wilby, 2008). It is a computational technique used to simulate the interaction between small molecules and target proteins and has become an important component of modern drug discovery and development (Sahoo *et al.*, 2022). In recent years, molecular docking has gained significant importance in pharmaceutical and medicinal chemistry research due to its ability to rapidly screen large compound databases for potential pharmacophores. This approach not only facilitates the identification of promising therapeutic compounds but also reduces the time, cost, and experimental effort involved in conventional drug discovery. Furthermore, the development of reverse molecular docking techniques has significantly enhanced the prediction of potential drug targets and improved the understanding of molecular mechanisms associated with diseases (Chen and Zhi, 2001).

Considerable efforts have been directed towards evaluating plant-derived secondary metabolites as potential inhibitors of the COVID-19 main protease (Mpro/3CLpro) using molecular docking studies. Several phytochemicals, including kaempferol, quercetin, luteolin-7-glucoside, demethoxycurcumin, naringenin, apigenin-7-glucoside, oleuropein, curcumin, catechin, and epicatechin gallate, were reported to exhibit promising inhibitory activity against the SARS-CoV-2 main protease through strong binding affinity and stable protein–ligand interactions (Khaerunnisa*et al.*, 2020). Similarly, docking analysis of 27 bioactive ligands commonly found in Indian and other traditional cuisines demonstrated significant binding affinity toward COVID-19 proteases 6LU7 and 6Y2E, indicating their potential use in developing natural-product-based therapeutic agents against viral infections.

The advancement in understanding the molecular basis of carcinogenesis has also promoted the discovery of selective and less toxic chemotherapeutic agents. Molecular docking studies have been extensively used to investigate naturally occurring compounds against important cancer-related molecular targets. Although many natural compounds have demonstrated anticancer properties, their exact mechanisms of action remain insufficiently understood. Docking simulations have therefore been performed against several proteins involved in cell cycle regulation, cell growth, apoptosis, angiogenesis, and DNA replication, including cyclin-dependent protein kinases 2 and 6 (CDK-2 and CDK-6), DNA topoisomerases I and II, B-cell lymphoma 2 (Bcl-2), vascular endothelial growth factor receptor-2 (VEGFR-2), and telomeric G-quadruplex structures.

Parasitic protozoal diseases continue to cause significant morbidity and mortality, particularly in developing countries, thereby necessitating the development of novel chemotherapeutic agents. Natural products provide an important source of compounds for virtual screening against drug targets associated with parasitic diseases (Harvey *et al.*, 2015). Molecular docking studies have identified several phytochemicals with strong binding affinity toward proteins associated with *Trypanosoma brucei*, *Leishmania* spp., and *Plasmodium falciparum*, thereby supporting the potential application of phytochemicals in antiparasitic drug development.

The incidence of Diabetes Mellitus (DM) is increasing globally across all populations. Although several synthetic antidiabetic drugs such as meglitinides, biguanides, sulfonylureas, thiazolidinediones, α-glucosidase inhibitors, and dipeptidyl peptidase-IV inhibitors are currently available, these medications are often associated with side effects and therapeutic limitations (Sangeetha *et al.*, 2017). Consequently, researchers are increasingly focusing on the identification of effective, safe, and low-toxicity therapeutic agents from natural sources. Molecular docking has emerged as an efficient computational approach for evaluating the interaction of phytochemicals with diabetes-associated molecular targets and predicting their therapeutic potential.

Molecular docking is fundamentally a computational technique used to estimate the affinity and interaction between molecules such as ligand–protein and protein–protein complexes. The technique has become indispensable in modern drug discovery because it also assists in predicting potential side effects and toxicological properties of compounds. Conventional drugs such as chloroquine, hydroxychloroquine, and remdesivir have demonstrated therapeutic activity against COVID-19 under laboratory conditions; however, their clinical efficacy and associated toxicity remain major concerns. The absence of highly effective and specific treatments for COVID-19 encouraged researchers worldwide to explore medicinal plants and ethnopharmacological resources as potential antiviral agents.

Basic Theory of Molecular Docking

Molecular docking is based on the principle of molecular recognition, where receptors and ligands interact through structural and energetic complementarity to achieve the most stable conformation (Morris *et al.*, 2008). The earliest concept explaining ligand–receptor interaction was the “lock-and-key” model, which described the rigid fitting of ligands into receptor binding sites based on geometric complementarity (Morrison *et al.*, 2006). However, biological systems exhibit substantial flexibility, and therefore the “induced-fit” model was later proposed, suggesting that both receptors and ligands undergo conformational changes during binding to achieve optimal interaction (Koshland, 1995).

In addition to geometric complementarity, molecular docking also depends on energy complementarity and molecular pre-organization, which enable the receptor–ligand complex to attain the lowest free energy state and maximum structural stability (Audie and Scarlata, 2007). Molecular docking software employs advanced search algorithms and scoring functions to predict the optimal ligand orientation, binding affinity, and interaction patterns. Widely used docking tools such as AutoDock Vina enable researchers to analyze protein–ligand and protein–DNA interactions effectively (Trott and Olson, 2010).

Significance of Molecular Docking

- Molecular docking aims to predict the formation and stability of ligand–receptor complexes through computational methods (Jain, 2004).
- It plays an important role in medicinal chemistry and drug discovery by providing insights into molecular recognition and interaction mechanisms.

- Docking has become an integral part of Computer-Aided Drug Design and Discovery (CADDD).
- Advanced docking approaches consider solvation effects, entropy, and receptor flexibility to improve the accuracy of drug–receptor interaction studies.

Applications of molecular docking

Virtual screening and lead identification

Virtual screening is widely used to identify hit compounds and lead molecules from large molecular databases based on scoring functions and binding affinity predictions. This approach has greatly improved the efficiency of lead discovery and drug development (Kitchen *et al.*, 2004).

Prediction of potential drug targets

Reverse molecular docking techniques are employed to identify novel drug targets by docking a single ligand against multiple receptors to detect potential binding cavities and predict target specificity (Chen and Zhi, 2001).

In silico analysis of phytochemicals

In silico molecular docking is an important bioinformatics approach for visualizing and understanding the biological activities of plant secondary metabolites. It enables the identification of molecular targets, analysis of ligand orientation, prediction of stable protein–ligand complexes, and evaluation of binding affinity toward disease-associated proteins (Singh *et al.*, 2019).

Bioremediation

Molecular docking is also applied in bioremediation studies to predict the interaction of environmental pollutants with enzymes involved in their degradation. Docking studies assist in designing inhibitors or activators that enhance the efficiency of pollutant degradation processes (Suresh *et al.*, 2008).

ADMET prediction

Docking approaches are frequently integrated with ADMET analysis to predict the Absorption, Distribution, Metabolism, Excretion, and Toxicity properties of small molecules. These predictions help eliminate compounds with undesirable pharmacokinetic and toxicological characteristics during the early stages of drug discovery (Das *et al.*, 2020).

Molecular dynamics simulation

Molecular docking is often combined with molecular dynamics simulations to evaluate the dynamic behavior, conformational stability, and interaction patterns of protein–ligand complexes over time (Dhanik *et al.*, 2013).

Structure elucidation

Docking techniques are also useful in elucidating the structures of proteins with unknown conformations and in understanding their interaction mechanisms with ligands (Ferreira *et al.*, 2015).

Research advances in molecular docking

Molecular docking has become a cost-effective and reliable method for studying protein–ligand interactions and prioritizing compounds during lead discovery and development. It serves as an important complement to experimental techniques such as X-ray crystallography and Nuclear Magnetic Resonance (NMR) spectroscopy by providing detailed insights into ligand binding poses and interaction mechanisms. Docking studies involving phytochemicals have demonstrated the potential of natural compounds to function as therapeutic agents, lead molecules for chemical optimization, or structural templates for novel drug synthesis. Several investigations have identified selective interactions between phytochemicals and protozoan drug targets. For instance, an in silico screening study on antiprotozoal medicinal plants from West Africa revealed several phytochemicals with strong docking affinity toward

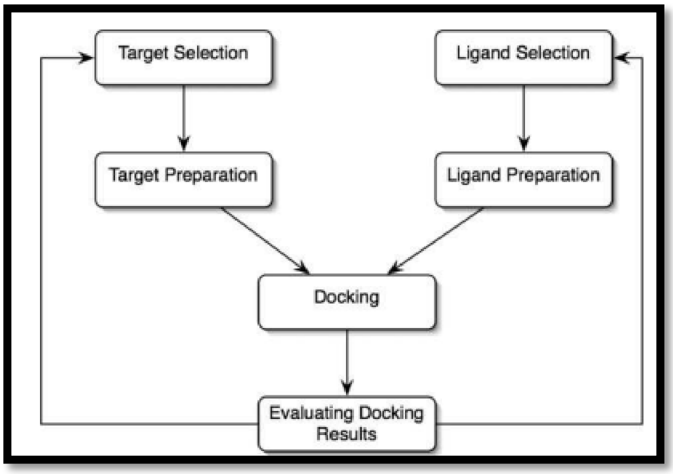
Trypanosoma brucei protein targets (Setzer and Ogungbe, 2012).

Trypanothione reductase has been extensively investigated as a potential target in several parasitic protozoa, including *Leishmania* spp., *T. brucei*, and *T. cruzi* (Krauth-Siegel and Inhoff, 2003). The flavonoid taxifolin demonstrated significant docking affinity toward the active site of *Leishmania infantum* trypanothione reductase (Gundampati and Jagannadham, 2012). Similarly, tomatidine was reported to interfere with sterol biosynthesis and induce mitochondrial dysfunction in promastigotes of *Leishmania amazonensis* (Lavie *et al.*, 2001).

A molecular docking study employing a homology model of *Leishmania donovani* PTR1 suggested that piperlongumide may act as a potential inhibitor of this protein target. In another study, alkaloids such as N-methyl tetra hydro palmatine, nordomesticine, and sarachine showed preferential docking toward *Trypanosoma cruzi* pteridine reductase (McCulley and Setzer, 2014).

Molecular docking studies using AutoDock further revealed that curcumin interacts with the homology-modeled *Plasmodium falciparum* tubulin dimer at the colchicine-binding site rather than at the paclitaxel or vinblastine-binding regions (Chakrabarti *et al.*, 2013). Additionally, (+)-usnic acid, a secondary metabolite derived from lichens, was identified as a selective inhibitor of the liver-stage form of *Plasmodium berghei* (Lauinger *et al.*, 2013). Based on docking and subsequent in vitro validation, celastrol was identified as a potent inhibitor of PfENR (Tallorin*et al.*, 2014). Furthermore, homology modeling approaches have been used to construct mitogen-activated protein kinases (MAPKs) of *Leishmania mexicana*, *Plasmodium falciparum*, and *Trypanosoma brucei* for docking-based therapeutic investigations (Gupta *et al.*, 2016).

Overall, molecular docking has emerged as a powerful interdisciplinary tool integrating computational biology, medicinal chemistry, structural biology, and pharmacology. Its capability to predict molecular interactions efficiently and economically continues to accelerate the discovery and development of novel therapeutic agents against infectious diseases, cancer, metabolic disorders, and other human ailments.



Docking workflow

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Dynamics of forest area and carbon stocks in India: A long-term biomass and soil carbon analysis

Arnab Roy[1], Kapil Choudhry[1], Vikas Kumar[1], K.N. Singh[1], Ananya Baidya[2] and Soumya Mohapatra[3]
[1]ICAR-Indian Agricultural Statistics Research Institute (IASRI), New Delhi -110012, India
[2]ICAR-Central Soil Salinity Research Institute, Karnal – 132001, India
[3]ICAR-Central Institute of Post Harvest Engineering & Technology
ORCID: 0000-0003-4855-5753
E-mail: royarnab_94@rediffmail.com

Abstract
This study evaluates long-term changes in forest biomass, carbon pools, and land-use dynamics in India during 1990–2025 using descriptive statistics, and trend analysis. The results reveal a substantial increase in above-ground biomass (37.65%), below-ground biomass (35.75%), and carbon stored in forest biomass, reflecting improved forest productivity and enhanced carbon sequestration potential. Forest area increased by 13.76%, while other wooded land and remaining land area declined, indicating land-use transition toward denser forest ecosystems. Strong positive interrelationships among biomass, forest area, and carbon stock variables demonstrate that forest expansion and vegetation recovery significantly contribute to ecosystem carbon storage. Temporal analysis further highlights steady growth in dead wood carbon, suggesting increasing forest maturity, whereas slight declines in soil and litter carbon indicate ecological pressures on below-ground carbon dynamics. From a policy perspective, the findings emphasize the need to strengthen afforestation, REDD+, community forestry, and climate-smart land-use policies to enhance carbon sequestration, restore degraded ecosystems, and support India's commitments under the Paris Agreement and net-zero climate goals.

Keywords: Forest biomass; Carbon sequestration; Land-use change; Soil carbon; India

Introduction

Climate change caused by rising greenhouse gas (GHG) emissions due tonatural and anthropogenic disruption activities, principally driven bycarbon dioxide (CO^2)has arisen as a major problem worldwide(IPCC, 2018). Forests are the primary element of the global carbon cycle that act as a carbon sink, playing a crucial role in mitigating climate change by storing carbon, reducing atmospheric carbon dioxide (CO^2)(Forest Survey of India, 2021).The role of species composition inforests in carbon storage and sequestration has become especially significant in the present climate scenario and takes center stage in climate change mitigation strategies and research. India has a total forest cover of 80.9 million hectares, making up 24.62% of the nation's total geographical area (FAO, 2025).Forests play a key role in site rehabilitationacross the globe to restore degraded land and maintain forest cover. The global forest cover has declined by about 100 million ha during the period of between 2000 and 2020, and degraded land had increased by 11.3–15.5 % between 2015 and 2019 (FAO, 2025). As reported in FRA-2020, the plantation area in India has expanded from 5.72 million ha to 13.27 million ha in 2020, while the forest area has increased only by 0.6 % (Dar & Parthasarathy, 2022). Empirical study revealed that planted forests can store a significant amount of carbon into its biomass and soil. However, there is a limited understanding of how different variables affect biomass and soil carbon stock in planted forests in India.The analysis revealed that, as of 2021, the status of carbon stock in Indian forests reveals dynamic changes in carbon storage across various components. The total forest carbon stock improved by 79.4 million tonnes between2019 to 2021, indicating a positive trend in carbon sequestration capacity (Food and Agriculture Organization, 2020; Manhas *et al.*, 2006). Carbon stocks may be affected by edaphic, climatic, biotic, topographic conditions, and anthropogenic disturbances.Accordingly, the study aimed to assessing Forest Area Change and Carbon Pool Dynamics in India.

Methodology

Data Source and Variable Selection

The study utilized secondary time-series data on forest biomass, carbon pools, and land-use indicators for India covering the period 1990–2025. The dataset comprised variables related to forest area, other wooded land, remaining land area, above-ground biomass, below-ground biomass, dead wood, and different forest carbon pools including carbon in above-ground biomass, below-ground biomass, litter, dead wood, and soil carbon. These indicators were measured in either thousand hectares (1000 ha) or tonnes per hectare (tonnes/ha). The data were compiled from internationally recognized forestry and environmental databases such as the Food and Agriculture Organization Forest Resources Assessment and national forest statistics of India.

Statistical Analysis

Descriptive statistical techniques were employed to summarize the temporal characteristics of forest biomass and carbon variables during 1990–2025. The analysis included estimation of, Mean, Standard deviation (SD), Coefficient of variation (CV %), and Percentage growth between 1990 and 2025. The coefficient of variation was used to assess the degree of temporal variability in each variable.The descriptive statistics provided insights into long-term changes, variability, and growth patterns in India's forest biomass and carbon stocks.

Trend Analysis

To evaluate temporal changes in forest biomass, carbon pools, and land-use variables, a linear trend model was estimated for each variable using ordinary least squares (OLS) regression. The trend model was specified as:

$$Y_t = \beta_0 + \beta_1 t + \varepsilon_t$$

Where,Y_t = value of the variable at time t,t = time period,β_0 = intercept,β_1 = slope coefficient representing temporal trend,ε_t = error term

Positive slope coefficients indicated increasing trends, while negative coefficients represented declining trends over time. Scatter plots with fitted regression lines were generated to visually examine temporal trajectories of the variables.

Correlation Analysis and Correlogram

Pearson correlation analysis was conducted to examine the interrelationships among forest biomass, carbon pools, and land-use variables. The Pearson correlation coefficient was calculated as:

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum (x_i - \bar{x})^2 \sum (y_i - \bar{y})^2}}$$

where, r = correlation coefficient,x_i and y_i = observed values of variables,$\bar{x}$ and $\bar{y}$ = mean values

Statistical Software and Visualization

All statistical analyses, graphical visualizations, and correlogram generation were performed using RStudio. High-resolution figures were generated for publication-quality visualization of temporal trends and correlation structures among forest ecosystem variables.

Results and discussion

The summary statistics presented in table 1 indicate substantial changes in India's forest biomass and carbon dynamics during 1990–2025. Above-ground biomass and below-ground biomass increased by

37.65% and 35.75%, respectively, reflecting improved forest productivity and vegetation density over time. Similarly, carbon stored in above-ground and below-ground biomass showed notable growth, indicating enhanced carbon sequestration potential of Indian forests (Tewari, 2016). The relatively low coefficient of variation (CV) for these variables suggests stable long-term growth patterns. Forest area also expanded by 13.76%, highlighting the positive effects of afforestation programmes, social forestry, and conservation initiatives implemented in India over recent decades. In contrast, "other wooded land" declined by nearly 20%, suggesting conversion of low-density wooded ecosystems into either dense forests or alternative land uses (Murthy *et al.*, 2023). The decline in remaining land area further reflects growing land-use transformation associated with urbanization, agricultural expansion, and infrastructure development. Soil carbon showed very low variability and a slight decline, implying that soil carbon pools remain relatively stable but may be vulnerable to degradation and land-use disturbance (Kaul *et al.*, 2022. The exceptionally high growth rates observed in dead wood and carbon in dead wood indicate increasing biomass accumulation and natural forest maturation processes. However, the sharp decline in carbon in litter may reflect changes in decomposition dynamics, forest management practices, or climatic influences affecting litter turnover.

In the broader Asian and global context, these findings are consistent with ongoing efforts toward forest restoration and climate mitigation through nature-based solutions. Many Asian countries, particularly China and India, have expanded afforestation and ecological restoration programmes to combat land degradation and increase terrestrial carbon sinks. Globally, the positive trends in biomass carbon stocks support international climate commitments under the Paris Agreement and REDD+ initiatives aimed at reducing emissions from deforestation and forest degradation. From a policy perspective, the results emphasize the need for integrated forest management strategies that simultaneously enhance biomass productivity, conserve soil carbon, and maintain ecological resilience. India's Green India Mission, agroforestry policies, and community-based forest governance can play a crucial role in sustaining these gains. Policymakers should prioritize restoration of degraded lands, protection of natural forests, and long-term carbon monitoring systems to strengthen climate adaptation and mitigation efforts. Additionally, strengthening forest carbon accounting and incentivizing sustainable forest-based livelihoods could improve both ecological sustainability and rural economic development across tropical and subtropical regions.

Table 1: Summary Statistics of Forest Biomass, Carbon Pools, and Land-Use Variables in India during 1990–2025

Variable	Mean	SD	CV (%)	Growth 1990–2025 (%)
Above-ground biomass (tonnes/ha)	69.75	7.53	10.80	37.65
Below-ground biomass (tonnes/ha)	21.74	2.23	10.26	35.75
Carbon in above-ground biomass (tonnes/ha)	31.51	2.85	9.03	32.42
Carbon in below-ground biomass (tonnes/ha)	9.81	0.82	8.38	29.88
Carbon in dead wood (tonnes/ha)	0.59	0.32	54.73	195.00

Carbon in litter (tonnes/ha)	1.46	0.51	35.26	-50.00
Dead wood (tonnes/ha)	1.25	0.67	53.46	188.37

As depicted in figure 1, the correlogram reveals a strong positive association among forest biomass and carbon stock variables, indicating that increases in above-ground biomass are closely linked with higher below-ground biomass and greater carbon sequestration potential. High positive correlations among variables such as forest area, above-ground biomass, and carbon in biomass suggest that forest expansion and improved vegetation density contribute substantially to ecosystem carbon storage. Similar trends have been reported in India, where afforestation programmes, joint forest management, and agroforestry expansion have enhanced biomass accumulation and carbon retention over the last three decades. Across Asia, rapidly growing plantation forestry and restoration initiatives in countries such as China, India, and Vietnam have also strengthened biomass–carbon linkages. At the global level, these findings align with evidence from tropical and subtropical forests showing that biomass-rich ecosystems act as major terrestrial carbon sinks that help mitigate climate change. The strong negative correlations between remaining land area and biomass/carbon-related indicators indicate land-use transitions from degraded or open lands toward forested landscapes. Negative associations involving dead wood or disturbance-related variables may reflect ecological degradation, forest extraction, or biomass loss due to anthropogenic pressure.

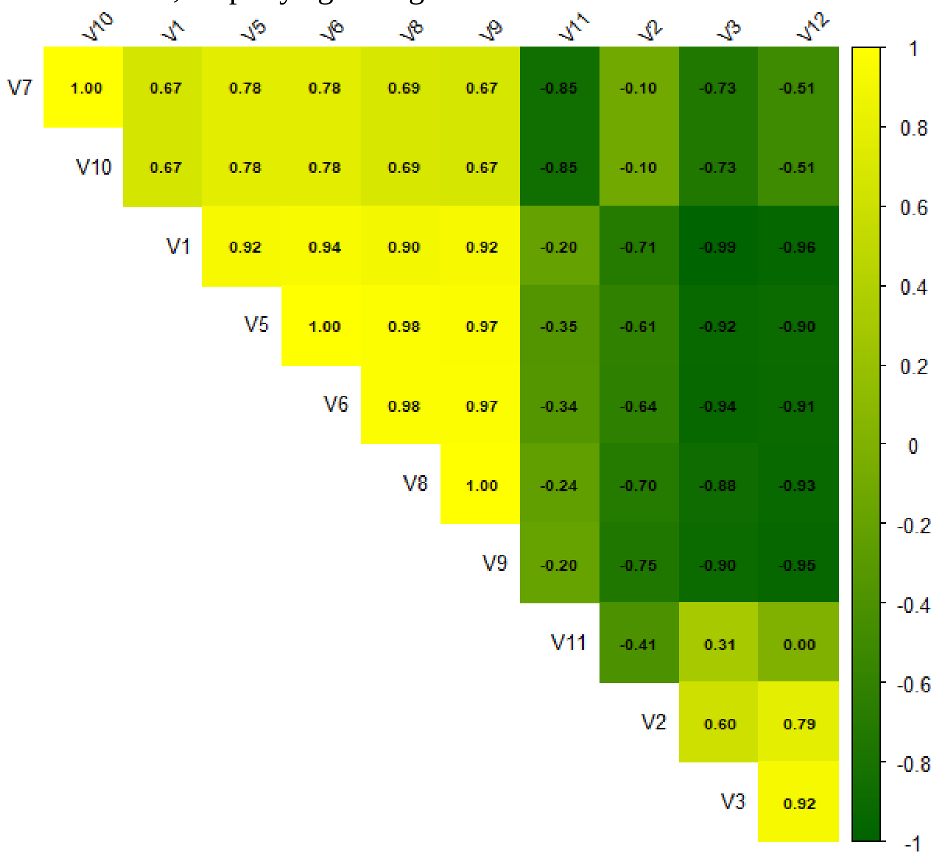

Fig. 1: Interrelationship among Forest Area, Biomass, and Carbon Pools in India during 1990–2025

From a policy perspective, the findings emphasize the importance of integrated forest conservation and carbon management strategies in India and other developing economies. Strengthening afforestation, community forestry, REDD+ implementation, and climate-smart land-use policies can significantly improve carbon sequestration capacity while supporting biodiversity conservation. India's National Mission for a Green India and commitments under the Paris Agreement can benefit from such evidence by prioritizing biomass restoration in degraded landscapes. In the broader Asian context, sustainable forest governance and transboundary ecological cooperation are necessary to balance economic development with environmental sustainability.

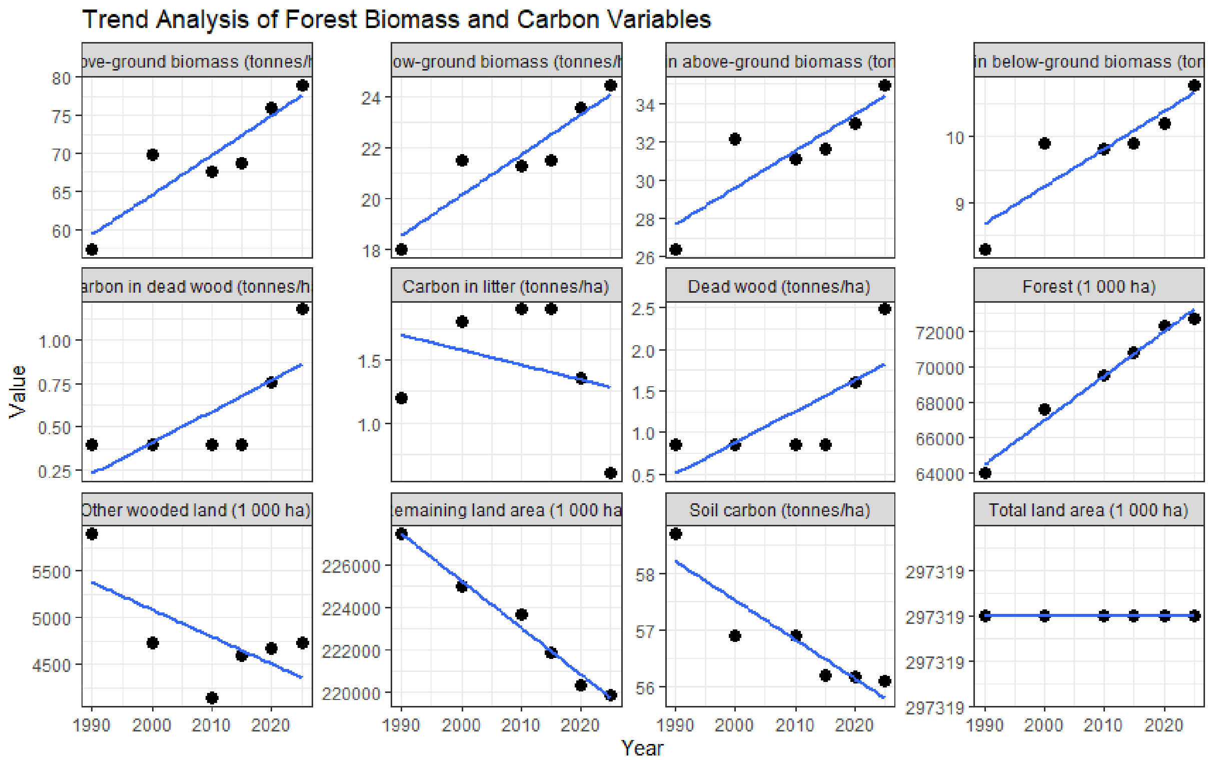

Fig. 2: Temporal trends in forest biomass and carbon stock variables in India (1990–2025)

Trend analysis of India's forest carbon (1990–2025)

The trend analysisis reported inFigure 2reveals a consistent increase in forest biomass and carbon-related variables in India during 1990–2025, indicating improving forest productivity and carbon sequestration capacity (FAO, 2025). Above-ground biomass (AGB) and below-ground biomass (BGB) display strong positive linear trends, suggesting enhanced forest growth and ecosystem recovery over time. Similarly, carbon stored in AGB and BGB increased steadily, reflecting the growing contribution of Indian forests to climate change mitigation through carbon accumulation (FSI, 2021). Forest area also expanded continuously, indicating the positive impact of afforestation programmes, forest conservation policies, and restoration initiatives like the Green India Mission (Ravindranath et al., 2022).

In contrast, "other wooded land" and "remaining land area" exhibited declining trends, implying land-use conversion toward denser forest cover and increasing developmental pressures such as urbanization (UN-Habitat, 2022). Soil organic carbon (SOC) demonstrated a slight downward trend despite increases in biomass carbon; research indicates that the conversion of natural forests to plantations can lead to significant reductions in SOC stocks. Carbon in litter also declined moderately, potentially reflecting faster decomposition processes associated with rising temperatures and altered forest management practices (IPCC, 2022). Dead wood and carbon in dead wood showed strong upward trends, suggesting increasing biomass maturity and natural forest ageing processes.

In the Indian and broader Asian context, these findings align with regional efforts toward ecological restoration and climate adaptation. Similar patterns have been observed across Asia, particularly in China, where large-scale reforestation has significantly expanded mangrove and terrestrial forest extent. Globally, the increasing trends in biomass support international climate goals under the Paris Agreement and the REDD+ framework aimed at reducing emissions from deforestation (FAO, 2025). However, the declining trends in soil and litter carbon highlight the need for ecosystem-based management that prioritizes below-ground ecological processes alongside above-ground growth (Kaul et al., 2022).

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गोंद, रेजिन, टैनिन और प्राकृतिक रंगों की व्यापारिक गतिशीलता और क्षमता

मनीष कुमार मानकुर एवं सुषमा केरकेट्टा

प्रक्षेत्र वानिकी विभाग, विश्वविद्यालय शिक्षण विभाग, संत गहिरा गुरु विश्वविद्यालय, अंबिकापुर, छत्तीसगढ़, भारत

अनुरूपी लेखक: manishmankur7@gmail.com

परिचय

पृथ्वी की प्राकृतिक प्रक्रियाओं को संतुलित रखने और जीवन को बनाए रखने के लिए प्राकृतिक संसाधन आवश्यक हैं। वन, पृथ्वी पर मौजूद नवीकरणीय प्राकृतिक संसाधन होने के कारण, विभिन्न प्राकृतिक संसाधनों में एक अद्वितीय स्थान रखते हैं क्योंकि वे कई तरीकों से पृथ्वी पर जीवन का समर्थन करते हैं और उनकी सेवाओं का कोई विकल्प नहीं है। साथ ही, विश्व के सभी प्राकृतिक संसाधनों में, वन शायद सबसे उपेक्षित हैं और अभूतपूर्व और चिंताजनक दर से कम होते जा रहे हैं। ऐतिहासिक काल से भी पहले, वनों ने आदिवासी लोगों की अर्थव्यवस्था में महत्वपूर्ण भूमिका निभाई है। भारत जैसे विकासशील देश में, लोगों की वनों पर निर्भरता अपरिहार्य है। भारत में वन पारिस्थितिकी तंत्र की मांग सबसे अधिक है, जहां मानव निर्भरता अत्यधिक है और विशाल मानव जनसंख्या, पशुधन और औद्योगिक मांगों के कारण तेजी से बढ़ रही है। वन उत्पादों (अनवंचित वन उत्पाद) में राल और गोंद का विशेष महत्व है और ये अनादिकाल से मानव जाति के लिए ज्ञात हैं। भोजन, पशु आहार और औषधि के रूप में सीधे उपयोग की जाने वाली वस्तुओं के अलावा, ये संभवतः सबसे व्यापक रूप से उपयोग किए जाने वाले और व्यापार किए जाने वाले वन उत्पाद हैं। घरेलू उपयोग और नकद आय के लिए गोंद और राल का उपयोग वनवासियों, विशेष रूप से भारत के आदिवासी क्षेत्रों में बहुत आम है। मध्य और पश्चिमी भारतीय राज्यों में हजारों वनवासी आय के एक प्रमुख स्रोत के रूप में गोंद और राल पर निर्भर हैं। टैनिन कार्बनिक यौगिक होते हैं, जो मुख्यतः ग्लूकोसोइडल प्रकृति के होते हैं, अम्लीय अभिक्रिया करते हैं और बहुत कसैले होते हैं। ये कोशिका रस में घुलित अवस्था में पाए जाते हैं और पौधों के सभी भागों में मौजूद होते हैं। कुछ पौधों की छाल, लकड़ी, जड़, पत्तियां, फूल, फल और बीजों से रंग प्राप्त किए जाते हैं। कई प्रकार की छाल और लकड़ी के अर्क का उपयोग रंगाई के लिए भी किया जाता है। कुछ रंग देने वाले पौधों का उपयोग अन्य पौधों से प्राप्त रंगों को स्थिर करने के लिए मोर्डेंट के रूप में किया जाता है।

गोंद की विशेषताएं इस प्रकार हैं:

- ये पॉलीसेकेराइड या उनके व्युत्पन्न पदार्थों से बने होते हैं।
- ये पानी में घुलनशील होते हैं या कम से कम पानी में मिलाने पर नरम और फूल जाते हैं। हालांकि, ये अल्कोहल और अन्य कार्बनिक विलायकों में अघुलनशील होते हैं।
- गर्म करने पर ये पिघले बिना पूरी तरह से विघटित हो जाते हैं और जलकर राख हो जाते हैं।
- अधिकांश गोंद पौधों से तरल रूप में निकलते हैं। हवा के संपर्क में आने पर ये सूखकर पारदर्शी, अनियमित आकार के, आंसू के आकार के पिंड या परत बन जाते हैं।

गोंद के प्रकार

वास्तविक गोंद

वास्तविक गोंद से तात्पर्य पानी में घुलनशील, गैर-क्रिस्टलीय पादप स्रावों से है जो पादप ऊतकों के रोग संबंधी टूटने (गमोसिस) के माध्यम से बनते हैं।

व्यापारिक नाम	वैज्ञानिक नाम
भारतीय गोंद अरेबिक	*Acacia Arabica*
वास्तविक गोंद अरेबिक	*Acacia Senegal*
भंगुर गोंद या झिंगन गोंद	*Macaranga beltata*
लैनिया गोंद	*Lannea corromandelica*
अंबर गोंद	*Azadirachta indica*
खैर गोंद	*Acacia catechu*
धावड़ा गोंद	*Anogeissus latifolia*
लाल भूरा गोंद	*Aegle occidentale*
एनाकार्डियम गोंद	*Anacardium*

	occidentale
फेरोनिया गोंद	*Feronia limonia*

छद्म गोंद

ऐसे गोंद जो पानी में घुलनशील नहीं होते, लेकिन आसानी से पानी सोख लेते हैं और फूलकर जेली जैसा गाढ़ा पदार्थ बन जाते हैं।

व्यापारिक नाम	वैज्ञानिक नाम
कुल्लू गोंद	*स्ट्रेकुलिया यूरेंस*
गहरा भूरा गोंद	*बॉम्बेक्स सीबा*
सफेद गोंद	*मोरिंगा ओलिफेरा*
सफेद गोंद	*कोक्लोस्पर्मम रिलिजियोसम*
पेक्टिन गोंद	*सैकोपेटालम टोमेंटोसम*

गम एस्ट्रिंजेंट

गम एस्ट्रिंजेंट (जिसे गम पेंट भी कहा जाता है) एक सामयिक दंत औषधि है जिसका उपयोग मसूड़ों की सूजन, मसूड़ों से खून आना, स्पंजी मसूड़े और मुंह के छालों के इलाज के लिए किया जाता है।

व्यापारिक नाम	**वैज्ञानिक नाम**
गोंद कीनो	*कोक्लोस्पर्मम रिलिजियोसम*
बंगाल कीनो	*सैकोपेटालम टोमेंटोसम*

रेजिन की विशेषताएं:

- ये पानी में अघुलनशील होते हैं।
- ये अल्कोहल, ईथर और तारपीन जैसे सामान्य विलायकों में घुलनशील होते हैं।
- ये भंगुर, अनाकार और पारदर्शी या अर्ध-पारदर्शी होते हैं।
- इनमें एक विशिष्ट चमक होती है, ये आमतौर पर गलनीय होते हैं और प्रज्वलित होने पर रेजिन धुएँ वाली लौ के साथ जलते हैं।

रेजिन के प्रकार

व्यापार में, रेजिन को अक्सर गोंद कहा जाता है, जबकि वार्निश रेजिन, कठोर रेजिन, स्पिरिट वार्निश, बाल्सम, गोंद रेजिन, डामर रेजिन, नरम रेजिन और कई अन्य शब्दों का प्रयोग काफी हद तक अंधाधुंध किया जाता है। विभिन्न समूहों के बीच रासायनिक अंतर कहीं अधिक स्पष्ट हैं। इस खंड में, कठोर रेजिन, ओलियोरेजिन और गोंद रेजिन नामक तीन समूहों का भेद किया जाएगा।

कठोर रेजिन

इनमें आवश्यक तेल बहुत कम या न के बराबर होता है। ये आमतौर पर ठोस, लगभग पारदर्शी, भंगुर पदार्थ होते हैं जिनमें कोई विशेष गंध या स्वाद नहीं होता है। ये आसानी से गल जाते हैं और हवा में धुएँ वाली लौ के साथ जलते हैं। ये अवाष्पशील होते हैं और विद्युत के बहुत खराब चालक होते हैं। कोपल और डामर जैसे सबसे महत्वपूर्ण व्यावसायिक रेजिन इसी समूह से संबंधित हैं। कठोर रेजिन का उपयोग पेंट, स्याही, प्लास्टिक, साइजिंग, चिपकने वाले पदार्थ, आतिशबाजी और अन्य उत्पादों में भी किया जाता है।

उदाहरण: एम्बर, बालसम, बोसवेलिया, प्रोटियम कोपल और हाइमेनिया कौरबारिल वृक्षों से प्राप्त कोपल, डिप्टेरोकार्पेसी कुल के वृक्षों से प्राप्त डामर गोंद, ड्रैगन वृक्षों (ड्रैसेना प्रजाति) से प्राप्त ड्रैगन ब्लड, एलेमी, बोसवेलिया सैकरा से प्राप्त लोबान।

तारपीन

ये ओलियोरेसिन हैं जो लगभग विशेष रूप से शंकुधारी वृक्षों से प्राप्त होते हैं। ये गाढ़े, शहद जैसे तरल पदार्थ या नरम और भंगुर ठोस पदार्थ होते हैं। राल कैम्बियम परत के पास की नलिकाओं में स्रावित और संग्रहित होता है और प्राकृतिक रूप से एक नरम, चिपचिपे पदार्थ के रूप में निकलता है, जिसे अक्सर पिच कहा जाता है। व्यावसायिक उपयोग के लिए, वृक्षों से राल निकालकर कच्चा तारपीन प्राप्त किया जाता है।

उदाहरण: चीड़, *डिप्टेरोकार्पस टर्बिनाटस, बोसवेलिया सेराटा*

गोंद राल

गोंद राल, वास्तविक गोंद और राल दोनों का मिश्रण होते हैं और प्राकृतिक रूप से दोनों समूहों के गुणों को संयोजित करते हैं। इनमें अक्सर आवश्यक तेलों की थोड़ी मात्रा और रंगद्रव्य के अंश पाए जाते हैं। गोंद प्राकृतिक रूप से दूधिया स्राव के रूप में पाया जाता है और आँसुओं या अनियमित पिंडों के रूप में एकत्रित होता है। पौधों को चोट पहुँचाने या उन्हें थपथपाने से भी ये उत्पन्न होते हैं। ये अधिकतर शुष्क, बंजर क्षेत्रों के पौधों से प्राप्त होते हैं, विशेषकर अम्बेलिफेरी और बर्सेरेसी कुल की प्रजातियों से।

उदाहरण: *गार्सिनिया मोरेला, कमिफोरा मुकुल, सी. रॉक्सबर्गी*

राल पैदा करने वाले पौधों के उदाहरण:

व्यापारिक नाम	वैज्ञानिक नाम
सफ़ेद डम्मर	*वेटेरिया इंडिका*
ब्लैक डम्मर	*कैनारियम स्ट्रिक्टम*
चिर पाइन	*पीनस रॉक्सबर्गी*
ब्लू पाइन	*पीनस वालिचियाना*
डिकामाली	*गार्डेनिया रेजिनफेरा*
साल	*शोरिया रोबस्टा*
चिलगोजा	*पीनस जेरार्डियाना*
खासी पाइन	*पीनस केसिया*

टैनिन

टैनिन कार्बनिक यौगिक होते हैं, जो मुख्यतः ग्लूकोसोइडल प्रकृति के होते हैं, अम्लीय अभिक्रिया करते हैं और अत्यधिक कसैले होते हैं। ये कोशिका रस में घुलित अवस्था में पाए जाते हैं और पौधों के सभी भागों में मौजूद होते हैं (मुख्यतः पैरेन्काइमेटस ऊतकों जैसे छाल, युवा लकड़ी, कुछ फलों और पत्तियों में और कभी-कभी पत्तियों पर बनने वाली गांठों में), लेकिन इनकी मात्रा बहुत परिवर्तनशील होती है। कुछ ही पौधे ऐसे हैं जिनमें ये प्रचुर मात्रा में पाए जाते हैं। टैनिन आर्थिक दृष्टि से महत्वपूर्ण हैं क्योंकि इनमें एल्ब्यूमिन और जिलेटिन (जैसे कि पशुओं की खाल में पाए जाने वाले पदार्थ) के साथ मिलकर एक अघुलनशील यौगिक बनाने की क्षमता होती है जो क्षय को रोकता है।

टैनिन के प्रकार

टैनिन को उस भाग के आधार पर वर्गीकृत किया जा सकता है जिससे वे प्राप्त होते हैं: टैनिन, फल टैनिन और पत्ती टैनिन-

(क) छाल टैनिन

सामान्य नाम	**वैज्ञानिक नाम**
काला वॉटल	*Acacia mearnsii*
हरा वॉटल	*Acacia decurrens*
रजत वॉटल	*Acacia dealbata*
सुनहरा वॉटल	*Acacia pycnantha*
सुनहरा रेन ट्री	*Casia fistula*
बबूल	*Acacia arabica*
साल	*Shorea robusta*
अर्जुन वृक्ष	*Terminalia arjuna*

कुछ पेड़ों के फलों का उपयोग टैनिंग उद्देश्यों के लिए किया जाता है जिनमें से सबसे महत्वपूर्ण हैं

सामान्य नाम	वैज्ञानिक नाम
चेबुलिक हरड़	*टर्मिनलिया चेबुला*
बेलेरिक मायराबोलन	*टर्मिनलिया बेलेरिका*
एम्ब्लिक हरड़	*एम्ब्लिका ऑफसिनैलिस*
भारतीय तुरही फूल	*ओरोक्सिलम इंडिकम*
दिवि-दिवि	*कैसलपिनिया कोरियारिया*
भारतीय ख़ुरमा	*डायोस्पायरस पेरेग्रीन*
कैथ बेर	*ज़िज़िफस प्लाबेरिमा*

पत्तियों से टैनिंग

पत्तियाँ टैनिंग के लिए मुख्य एजेंट नहीं हैं। हालाँकि, कुछ पौधों की पत्तियों का उपयोग टैनिंग के लिए किया जा सकता है।

सामान्य नाम	वैज्ञानिक नाम
एक्सल वुड ट्री	*एनोजिसस लैंजलिया*
करोंदा	*कैरिसा स्पिनारियम*

रंग

रंग कुछ पौधों की छाल, लकड़ी, जड़ों, पत्तियों, फूलों, फलों और बीजों से प्राप्त होते हैं। कई प्रकार की छाल और लकड़ी के अर्क का उपयोग भी रंगाई के लिए किया जाता है। कुछ रंग देने वाले पौधों का उपयोग अन्य पौधों से प्राप्त रंगों को स्थायी बनाने के लिए मोर्डेंट के रूप में किया जाता है।

रंग और उपयुक्त प्रजातियाँ

छाल के रंग	**लकड़ी के रंग**	**जड़ के रंग**
कैसिया अलाटा	पेरोकार्पस सैंटालिनस	मोरिंडा टिनक्टोरिया
लैनिया कोरोमंडेलिका	कैसलपिनिया सैप्पन	पुनिका ग्रैनटम
कैसुरीना इक्विसेटिफ़ोलिया	बबूल कैटेचू	ओल्डनलैंडिया अम्बेलेट
टर्मिनलिया टोमेंटोसा	आर्टोकार्पस हेटरोफिलस	मोरिंडा सिट्रिफ़ोलिया
फूलों के रंग	**पत्तों के रंग**	**फलों के रंग**
ब्यूटिया मोनोस्पर्मा	टर्मिनलिया कैटप्पा	मैलोटस फिलिपिनेसिस
सेड्रेला टूना	राइटिया टिनक्टोरिया	बिक्सा ओरेलाना

मिशेलिया चम्पाका	रिन्धटिया टिनक्टोरिया	

भारत में उत्पादन सांख्यिकी

2017-18 की तुलना में 2018-19 के दौरान प्राकृतिक नवीकरणीय ऊर्जा (एनआरजी) के उत्पादन में कमी देखी गई। यह गिरावट धौड़ा गोंद (10.0%), ग्वार गोंद (9.20%) और चीड़ राल (4.84%) के उत्पादन में देखी गई। परिणामस्वरूप, एनआरजी का कुल उत्पादन 2016-17 के 6,25,769.67 टन से घटकर 2018-19 में 6,03,369.0 टन हो गया। पिछले वर्ष की तुलना में एनआरजी के उत्पादन में लगभग 8.67% की गिरावट दर्ज की गई। झारखंड में लाख का कुल उत्पादन पिछले वर्ष की तुलना में लगभग 17.10% अधिक रहा। अन्य राल और गोंद के उत्पादन में 2018-19 में मामूली कमी आई। कुल मिलाकर, 2018-19 के दौरान एनआरजी का उत्पादन स्तर पिछले वर्ष की तुलना में अपेक्षाकृत कम रहने का अनुमान है। हालांकि, लाख और गोंद कराया के उत्पादन में क्रमशः 13.39% और 6.67% की वृद्धि हुई। 2018-19 में, भारत ने 5,13,211 टन ग्वार उत्पादों का निर्यात किया, जिसमें 3,62,902 टन ग्वार गोंद शामिल था, जिसका उपयोग तेल फ्रैकिंग और प्रसंस्कृत खाद्य पदार्थों में किया जाता है, और 1,50,309 टन ग्वार मील, जिसका उपयोग पशु आहार के रूप में किया जाता है। संयुक्त राष्ट्र कॉमट्रेड के आंकड़ों (2018 के दौरान सभी वस्तुओं के विश्व व्यापार का एकत्रीकरण) पर आधारित आईटीसी गणनाओं से पता चला कि विश्व के 130 निर्यातक देशों में से, भारत कुल विश्व निर्यात मूल्य में 1.74% हिस्सेदारी के साथ निर्यात में 19वें स्थान पर है। इसी प्रकार, विश्व के 130 आयातक देशों में से, भारत कुल विश्व आयात मूल्य में 2.71% हिस्सेदारी के साथ आयात में 9वें स्थान पर है। इन आंकड़ों में पुनर्निर्यात और पुनर्आयात को शामिल नहीं किया गया है। 2019-20 में 526,765.25 टन उत्पादन पिछले 2018-19 की तुलना में मामूली संकुचन, मजबूत घरेलू उपयोग के साथ शामिल था। भारत में रंगों के प्रमुख उपयोगकर्ता वस्त्र, कागज, प्लास्टिक, छपाई की स्याही और खाद्य पदार्थ हैं। वैश्विक स्तर पर पॉलिएस्टर और कपास की उच्च मांग के कारण वस्त्र क्षेत्र कुल उत्पादन का लगभग 80% उपभोग करता है। वर्तमान में, वैश्विक बाजार में भारत की हिस्सेदारी लगभग 6% है, जबकि चीन की हिस्सेदारी 25% है। उत्पादन और मांग, नियमों और ग्राहकों की बदलती प्राथमिकताओं से जुड़ी कई चुनौतियों का सामना करते हुए बाजार इस मुकाम तक पहुंचा है। रंग उद्योग विश्व के सबसे बड़े उद्योगों में से एक है और कई देशों, विशेष रूप से भारत और चीन की आर्थिक और सामाजिक स्थितियों पर इसके महत्वपूर्ण प्रभाव हैं। फाइबर की श्रेणी, रंग या औद्योगिक प्रक्रिया जैसे विभिन्न कारकों के आधार पर, कई ऐसे रंग पदार्थ हैं जो पर्यावरण में छोड़े जाने पर अत्यधिक प्रदूषणकारी हो सकते हैं। जलीय और वनस्पति जीवन को नुकसान पहुंचाने वाले खतरनाक पदार्थों से युक्त 50,000 टन से अधिक रंग प्रतिवर्ष अपशिष्ट के माध्यम से पर्यावरण में छोड़ा जाता है।

निष्कर्ष

प्राकृतिक गोंद और राल उद्योग का भविष्य अनिश्चित है, इसलिए राष्ट्रीय और अंतर्राष्ट्रीय व्यापार का गहन आर्थिक अध्ययन आवश्यक है। प्राकृतिक गोंद और राल की अनिश्चित आपूर्ति और लागत के कारण उद्योग में सिंथेटिक उत्पादों को प्राथमिकता दी जाती है। हालांकि, तेल की अस्थिर कीमतें, घटता उत्पादन और सिंथेटिक सामग्री की उच्च लागत प्राकृतिक गोंद और राल के लिए एक आशाजनक भविष्य का निर्माण करती हैं। सिंथेटिक उत्पादों से प्रतिस्पर्धा के बावजूद, कुछ उद्योगों में प्राकृतिक गोंद और राल को उनकी श्रेष्ठता के कारण प्राथमिकता दी जाती है। प्राकृतिक रंग सिंथेटिक रंगों की तुलना में बहुत ही अनोखे, सुखदायक और कोमल रंग उत्पन्न करते हैं। दूसरी ओर, सिंथेटिक रंग किफायती कीमत पर व्यापक रूप से उपलब्ध हैं और विभिन्न प्रकार के रंग उत्पन्न करते हैं; हालांकि, ये रंग त्वचा की एलर्जी, विषाक्त अपशिष्ट और मानव शरीर के लिए अन्य हानिकारक प्रभाव पैदा करते हैं। प्राकृतिक रंगों में न केवल रंगाई का गुण होता है, बल्कि उनमें औषधीय गुण भी प्रचुर मात्रा में होते हैं। प्राकृतिक रंगों पर किए गए कई शोधों में पाया गया है कि खरगोशों पर किए गए त्वचा जलन

परीक्षण में कई रंग त्वचा के लिए गैर-जलनशील हैं,
रंगे हुए कपड़ों में जीवाणुरोधी गतिविधि पाई गई है,
और वे देखने में आकर्षक और सुखद हैं।

Nilgai-Induced Crop Losses in India: Ecology, Impacts and Management Options

Anchal Sharma[1] and I. B. Maurya[2]
[1]Department of Wildlife Management
[2]College of Horticulture & Forestry, Jhalawar (Agriculture University, Kota)

Nilgai (*Boselaphus tragocamelus*), commonly known as the blue bull, is the largest antelope species in Asia and belongs to the family Bovidae. The species is native to the Indian subcontinent and is widely distributed across India, Pakistan, and parts of Nepal. The name "Nilgai" is derived from the Hindi words *nil* (blue) and *gai* (cow), referring to the bluish-grey coloration of adult males. Females and juveniles are generally brown in colour. Morphologically the species possesses a long neck, slender legsand a horse-like body structure. Both sexes exhibit distinctive white markings on the cheeks, throat, ears, belly, rump, and underside of the tail while adult males possess short conical horns.

Nilgai populations have increased considerably in several parts of India over the past few decades due to legal protection under the Wildlife Protection Act (WPA)-1972 reduced predation pressure, changes in land-use patterns, and the expansion of irrigated agriculture. Consequently, human–nilgai conflict has emerged as a major wildlife management issue, particularly in northern and western India.

Crop damage caused by nilgai has been reported from Rajasthan, Haryana, Punjab, Uttar Pradesh, Madhya Pradesh, Gujarat, Bihar, and other agricultural states. The species frequently forages in agricultural fields and causes substantial economic losses to farmers. Preferred crops include wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), chickpea (*Cicer arietinum*), mustard (*Brassica juncea*), pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), green gram (*Vigna radiata*), and cluster bean (*Cyamopsis tetragonoloba*).

Apart from direct consumption of crops, nilgai often cause extensive damage through trampling and movement within cultivated fields. Studies have shown that crop losses are frequently higher than the actual amount consumed because large herds can flatten standing crops while moving through agricultural lands. Such losses significantly affect agricultural productivity and farmer livelihoods.

Although nilgai are primarily diurnal under natural conditions, populations inhabiting humandominated areas often exhibit behavioural adaptations, including increased nocturnal activities. This behavioural shift is believed to reduce encounters with humans and enhance access to agricultural crops.

Several factors contribute to increasing crop depredation by nilgai, including:

- Expansion of agriculture into wildlife habitats.
- Fragmentation and degradation of natural forests and grasslands.
- Availability of highly nutritious cultivated crops.
- Reduction in natural predators.
- Legal restrictions on population control measures.
- Increased adaptability of nilgai to human-modified environments.

Mitigation Measures

Physical Barriers

Fencing remains one of the most effective methods for reducing crop damage. Solar-powered electric fencing and high-tensile wire fencing create physical barriers that discourage animal entry. Properly maintained fences can significantly reduce crop losses, although installation and maintenance costs may be high for smallholder farmers.

Solar-Powered Flashing Lights

Solar-powered flashing lights are increasingly being used to deter nocturnal crop-raiding wild animals. These devices emit intermittent flashes during the night, creating visual disturbances that may temporarily discourage nilgai from entering agricultural fields. Their effectiveness, however, often declines over time due to habituation.

Acoustic Deterrents

Motion-sensor-based sound devices generate alarm calls, predator sounds or other acoustic signals when animal movement is detected. Such systems may provide short-term protection but long-term effectiveness is often limited because animals can become accustomed to repeated sounds.

Habitat Management

Improvement and restoration of natural habitats can help reduce wildlife dependence on agricultural fields. Maintaining natural forage resources and wildlife corridors may reduce cropraiding behaviour in some landscapes.

Fertility Control

Wildlife managers have explored fertility control as a non-lethal population displayed a bright orange-yellow colour with distinct whitish margins (Figs. 2-3). The undersurface of the basidiocarps was poroid, bearing numerous minute pores. The bright orange-yellow brackets were the early stage soft and tender basidiocarps, which are considered edible. The older basidiocarps were dry, brittle, pale and brownish in appearance (Fig. 2). These features were consistent with the description of *L. sulphureus* by other authors (Alexopoulos *et al.*, 1996; Bernicchia, 2005; Phillips, 2006).

L. sulphureus was originally described as ***Boletus sulphureus*** by the French mycologist Jean-Baptiste Bulliard in 1789. American mycologist William Alphonso Murrill created the genus ***Laetiporus*** in

management strategy. However, large-scale implementation in free-ranging nilgai populations remains technically challenging, costly and largely experimental under Indian conditions.

Regulated Population Management

In exceptional circumstances involving severe agricultural losses, state governments may seek permission under Section 62 of the Wildlife (Protection) Act, 1972, to declare specific wildlife species as vermin in designated areas for a limited period. Such measures are highly regulated and remain controversial due to ecological and ethical considerations.

The increasing interaction between nilgai and agricultural systems has intensified human–wildlife conflict across many regions of India. Crop depredation by nilgai results in significant economic losses through both direct consumption and trampling of crops. Effective management requires an integrated approach combining habitat management, physical barriers, community participation, technological deterrents, compensation mechanisms, and science-based wildlife management policies. Long-term solutions should focus on balancing wildlife conservation objectives with the livelihood needs of farming communities.

1904, and in 1920, he moved *B. sulphureus* to the genus *Laetiporus* (Khatua *et al.*, 2017). This species is currently classified in Kingdom Fungi, Division Basidiomycota, Class Agaricomycetes, Order Polyporales, and Family Laetiporaceae. ***Laetiporus*** translates to "with bright pores", while ***sulphureus*** refers to its distinctive sulphur-yellow colour.

By decomposing woody substrates, *L.sulphureus* plays an important ecological role in nutrient recycling within forest ecosystems. The occurrence of *L.sulphureus* in Nagpur extends its known geographical range in India. Nagpur's high humidity during the monsoon provides a microclimate suitable for the fruiting of this bracket fungus. In the present study, the *L.sulphureus* specimen was found growing at the base of a living Gulmohar (*Delonix*) tree. Unlike temperate regions, where it favours Oak (*Quercus*) or Beech (*Fagus*), this record suggests adaptation to tropical trees. *L. sulphureus* serves as an efficient decomposer, recycling nutrients back to the soil, but its presence also signals the structural decline of the host tree due to the degradation of cellulose.

Conclusion

The occurrence of *L. sulphureus* in Nagpur adds to the Maharashtra biodiversity database. It also highlights the importance of trees in urban areas, for the survivalof fungal species that thrive on wood.

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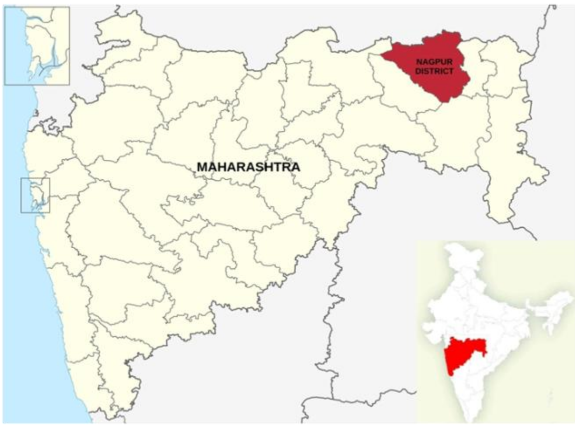

Fig 1. Map showing the location of Nagpur district in Maharashtra, India

Fig 2. Clusters of *Laetiporus sulphureus*

Fig 3. *L. sulphureus*mushroom

Neem tree: Value in the summer

Vinita Bisht
Banda University of Agriculture and Technology, Banda (U.P.)-210001
Mail id: jyotivinita89@gmail.com

Introduction

Neem is a fast-growing evergreen tree native to the Indian subcontinent. Its scientific name is *Azadirachta indica*. Neem is known as the "wonder tree" because of its numerous medicinal, environmental, and agricultural benefits. It can grow well in hot and dry climates, making it especially useful during the summer season. Every part of the neem tree, including its leaves, bark, flowers, fruits, and seeds, has important uses. Due to its ability to provide shade, purify the air, repel insects, and support human health, neem is considered one of the most valuable trees in India. Neem is one of the most valuable trees in tropical and subtropical regions, especially during the summer season. It is often called the "Village Pharmacy" because almost every part of the tree has practical uses.

The Neem is one of the most valuable trees during the summer season because it provides a wide range of environmental, health, and practical benefits. In hot weather, when temperatures rise sharply and air becomes dry and dusty, neem plays an important role in making the surroundings more comfortable and healthier.One of its main values in summertime is the cooling shade it provides. Its large and dense canopy blocks direct sunlight and helps reduce ground temperature, giving relief from extreme heat. The process of transpiration from its leaves also releases moisture into the air, which naturally cools the environment.

Neem is also valuable for improving air quality during summer. It absorbs carbon dioxide, releases oxygen, and traps dust and pollutants on its leaves. This helps reduce pollution levels, especially in dry and dusty conditions common in hot seasons.Another important value of neem is its ability to repel insects and mosquitoes. During summer, insect-borne diseases increase, and neem acts as a natural protective tree due to its antibacterial and insect-repelling properties. Its leaves and oil are often used in homes for protection and hygiene.In addition, neem supports health and skin care in summer. Its medicinal properties help treat skin problems like rashes, itching, and infections caused by heat and sweating. Neem-based products are widely used in traditional remedies for maintaining cleanliness and wellness.The tree is also highly drought-resistant, meaning it can survive in very hot and dry conditions with little water. This makes it extremely useful in maintaining greenery and ecological balance during harsh summer climates.

Overall, the neem tree is highly valuable in summertime because it provides shade, cools the air, purifies the environment, protects health, and survives extreme heat, making it one of the most important trees for both people and nature.

Provides Cooling Shade

One of the most important benefits of the Neem tree during the summer season is its ability to provide cooling shade. The tree has a broad and dense canopy of leaves that blocks direct sunlight and reduces the temperature underneath it. As a result, people and animals can rest comfortably in its shade during hot afternoons. Neem also cools the surrounding air through a natural process called transpiration, in which water vapor is released from its leaves. This helps create a cooler and more pleasant environment, making the neem tree especially valuable in regions that experience extremely high summer temperatures. During summer, temperatures can become extremely high. Neem trees have a wide, dense canopy that:

- Blocks direct sunlight.
- Reduces ground temperature beneath the tree.
- Creates a comfortable resting place for people and animals.
- Helps cool the surrounding environment through transpiration (release of water vapor from leaves).

A mature neem tree can significantly lower the temperature in its immediate surroundings.

Improves Air Quality

The Neem tree plays an important role in improving air quality. It absorbs carbon dioxide from the atmosphere and releases oxygen through the process of photosynthesis, helping to maintain a healthy balance of gases in the air. Its dense foliage can also trap dust, smoke, and other harmful pollutants, reducing air pollution in the surrounding area. By cleaning the air and increasing oxygen levels, the neem tree contributes to a healthier environment and helps people breathe cleaner, fresher air, especially during the hot and dusty summer season.

Neem trees act as natural air purifiers by:

- Absorbing carbon dioxide (CO_2).
- Releasing oxygen.
- Trapping dust and airborne particles on their leaves.
- Helping reduce pollution levels in urban and rural areas.

This is especially beneficial during hot, dry summer months when dust levels are often high.

3. Natural Insect and Mosquito Repellent

Neem contains natural compounds such as azadirachtin that repel many insects.

Benefits include:

- Reducing mosquito populations.
- Protecting crops from pests.
- Decreasing the need for chemical pesticides.
- Helping maintain a healthier environment.

Neem leaves are sometimes placed in homes or stored with grains to discourage insects.

Medicinal Importance

Neem has been used in traditional medicine for centuries.

Leaves

- Used for skin problems such as acne and rashes.
- Possess antibacterial and antifungal properties.
- Sometimes used in herbal remedies for boosting general health.

Bark

- Traditionally used for dental and oral hygiene.

Seeds and Oil

- Neem oil is used in skin-care products and agricultural pest control.

Twigs

- Traditionally used as natural toothbrushes (datun).

Protects skin during summer

The Neem tree is well known for its skin-protecting properties, especially during the summer season. Hot weather and excessive sweating can cause skin problems such as heat rashes, itching, acne, and irritation. Neem leaves contain natural antibacterial, antifungal, and anti-inflammatory compounds that help keep the skin clean and healthy. Neem-based products such as soaps, creams, and oils are commonly used to soothe skin irritation and prevent infections. Because of these beneficial properties, neem is widely used in traditional medicine and skincare to protect and maintain healthy skin during the hot summer months. The hot weather of summer can lead to:

- Heat rashes
- Skin irritation
- Excessive sweating

Neem-based products are commonly used because they may help soothe skin and support hygiene due to their antimicrobial properties.

Drought Resistance

The Neem tree is highly drought-resistant, making it well suited to hot and dry climates. It can survive for long periods with very little water because of its deep root system, which helps it access moisture from deeper layers of the soil. Unlike many other trees, neem continues to grow and remain healthy even during prolonged dry seasons and high temperatures. This ability makes it an ideal choice for areas that experience water scarcity or frequent droughts. Its resilience helps maintain green cover, protect the environment, and provide shade even under harsh summer conditions.

Neem is highly tolerant of:

- High temperatures
- Low rainfall
- Dry soil conditions

This makes it an ideal tree for regions that experience harsh summers and water scarcity.

Conclusion

The Neem tree is especially important during the summer season because it offers numerous benefits to people, animals, and the environment. Its broad and dense canopy provides cooling shade, helping to reduce temperatures and create a comfortable place for rest during hot days. The tree also improves air quality by absorbing carbon dioxide, releasing oxygen, and trapping dust and pollutants from the atmosphere. Neem is widely known for its natural insect-repelling properties, which help protect homes, crops, and communities from mosquitoes and other harmful pests. In addition, its leaves, bark, seeds, and oil have been used for centuries in traditional medicine to support health and treat various skin and hygiene-related problems. During summer, neem products are often used to help prevent heat rashes, skin infections, and irritation caused by excessive heat and sweating.

Hidden architects of forest recovery: The role of native mycorrhizal networks in restoring Telangana's forests

[1]Deepika Ande and [2]Jagadeesh Bathula
[1]Department of Forest Resource Management, Forest College and Research Institute, SKLTGHU, Mulugu-502279, Telangana
[2]Department of Forest Resource Management, Forest College and Research Institute, SKLTGHU, Mulugu-502279, Telangana

Beneath the forest floor lays nature's internet

When we walk through a healthy forest, our attention is naturally drawn to towering trees, flowering plants, birds, and wildlife. However, one of the most important components of a forest ecosystem remains invisible beneath our feet—a vast underground network of beneficial fungi known as mycorrhizae. These microscopic partners form intimate associations with plant roots, creating living networks that facilitate nutrient exchange, improve plant growth, enhance stress tolerance, and contribute significantly to ecosystem resilience (Smith and Read, 2008; van der Heijden*et al.*, 2015).

Mycorrhizae, often referred to as the "wood wide web," connect plants through underground fungal hyphae, enabling the transfer of nutrients, water, and even chemical signals among plants (Simard *et al.*, 1997; Simard *et al.*, 2021). Such networks play a critical role in forest regeneration and restoration, particularly in degraded ecosystems where soil fertility and microbial diversity have been compromised.

Why Native Mycorrhizae Matter

Forest restoration efforts traditionally focus on planting trees and protecting habitats. However, successful restoration requires rebuilding the entire ecosystem, including the soil microbial communities that sustain plant growth. Native mycorrhizal fungi are especially valuable because they have evolved alongside local tree species and are well adapted to regional environmental conditions (Brundrett and Tedersoo, 2018).

Research has shown that native mycorrhizal associations improve seedling establishment, nutrient uptake, drought tolerance, disease resistance, and overall survival in restoration sites (van der Heijden*et al.*, 2015; Begum *et al.*, 2019). Unlike introduced microbial inoculants, native species are already adapted to local soils, climate, and vegetation, making them more effective and ecologically sustainable for restoration programs.

In tropical dry deciduous forests, where nutrient availability is often limited and climatic stresses are significant, these fungal partners become indispensable for maintaining ecosystem productivity and biodiversity.

Exploring the Underground Biodiversity of Kawal Tiger Reserve

Recognizing the importance of native mycorrhizal communities, a research project has been initiated to isolate, identify, and mass multiply indigenous mycorrhizal fungi from the forests of Telangana. The study is being conducted in the ecologically rich landscapes of the KawalTiger Reserve, one of India's largest tiger reserves and a significant biodiversity hotspot of the Deccan Plateau.

As part of the ongoing investigation, rhizospheric soil samples were collected from several dominant forest tree species, including: *Bamboo*, *Anogeissuslatifolia*, *Tectonagrandis (Teak)*, *Wrightiatinctoria*, *Mitragynaparvifolia*, *Terminalia arjuna*, *Terminalia tomentosa*, *Lagerstroemia parviflora*, *Cleistanthus collinus*, *Butea* *monosperma*. Detailed laboratory investigations have successfully led to the isolation of ten distinct species of arbuscular mycorrhizal fungi (AMF), also known as endomycorrhizae. These fungi belong to a group that penetrates root cortical cells and forms specialized structures called arbuscules, through which nutrients are exchanged between plants and fungi (Smith and Smith, 2011).The discovery highlights the remarkable hidden biodiversity present within Telangana's forest soils and provides a valuable foundation for developing region-specific bioinoculants for forest restoration initiatives.

From isolation to mass multiplication

The next phase of the project focuses on the mass multiplication of these native mycorrhizal species. Mass production involves culturing fungal propagules using suitable host plants under controlled conditions to generate inoculum containing spores, colonized root fragments, and fungal hyphae.Once multiplied, these native inoculants can be integrated into forest nurseries and restoration programs. Seedlings inoculated with native mycorrhizae often exhibit improved growth, higher nutrient acquisition, better root development, and enhanced field survival compared to uninoculated plants (Begum *et al.*, 2019).The use of indigenous fungal inoculants also reduces dependence on chemical fertilizers, promotes soil health, and contributes to long-term ecological sustainability.

Building climate-resilient forests

Climate change poses unprecedented challenges to forest ecosystems through rising temperatures, prolonged droughts, altered rainfall patterns, and increased incidence of pests and diseases. Mycorrhizal fungi can help forests adapt to these changing conditions by improving water-use efficiency, enhancing nutrient acquisition, and increasing plant tolerance to environmental stresses (Averill *et al.*, 2014; van der Heijden*et al.*, 2015).Moreover, mycorrhizal networks contribute to soil carbon storage by stabilizing organic matter and supporting belowground carbon sequestration processes, making them important allies in climate change mitigation efforts (Averill *et al.*, 2014).

A new frontier for forest restoration in Telangana

The isolation of native mycorrhizal fungi from the forests of Kawal Tiger Reserve represents an important step toward scientifically informed restoration practices in Telangana. By harnessing the natural symbiosis between trees and fungi, restoration programs can move beyond simply planting trees to rebuilding self-sustaining forest ecosystems.The ongoing project aims to create a repository of native mycorrhizal diversity, develop efficient multiplication protocols, and promote the use of indigenous bioinoculants in forest nurseries and degraded land restoration programs. Such efforts will not only improve plantation success but also help conserve the rich microbial heritage hidden beneath Telangana's forests.

As forest restoration gains momentum across India, the tiny fungi living underground may prove to be among the most powerful partners in rebuilding resilient, biodiverse, and climate-smart ecosystems for future generations.

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First record of the bracket fungus, *Laetiporus sulphureus* (Bull.) Murrill (1920), from the urban landscape of Nagpur, Maharashtra

Pawan U. Gajbe, Vaishali H. Badiye
Department of Zoology, Shri Mathuradas Mohota College of Science,
Nagpur - 440024, Maharashtra
Corresponding author Email: pgajbe884@gmail.com

Abstract
Laetiporus sulphureus, commonly known as Chicken of the Woods, is a globally recognized bracket fungus known for its vibrant colouration and edible properties. While documented in various parts of India, its presence in the hot, tropical climate of the Deccan Plateau, specifically Nagpur, remains poorly documented. This paper reports the first formal record of *L. sulphureus* in Nagpur, Maharashtra, detailing its morphological characteristics, host association, and the ecological implications of its presence in an urban tropical environment. This record also contributes to the macrofungal diversity of the Vidarbha region of Maharashtra.
Keywords: Bracket fungi, edible mushroom, fungal diversity, sulphur polypore.

Introduction
Laetiporussulphureus is a parasitic and saprobic fungus growing typically in large clusters on decaying logs, stumps and trunks of many deciduous and coniferous tree species, and is widely distributed in Europe, Asia, and North America (Pleszczyńska *et al*., 2012). It is known by different common names such as crab-of-the-woods, sulphur polypore, sulphur shelf, and chicken of the woods. Acting as both a parasite and a saprobe, it causes a reddish brown cubical heart rot, with thin areas of white mycelium visible in the cracks of wood (Gilbertson & Ryvarden, 1986). Due to its unique fragrance and texture, ***L. sulphureus*** has been used as nutritional food for a long time (Adamska, 2023). Itstaste has been compared to that of crab or lobster (Patocka, 2019). Besides food, ***L. sulphureus is also*** a source of bioactive compounds (Khatua *et al*., 2017; Olennikov, 2008). Although, ***L.*** sulphureus is known to thrive naturally only, efforts have been made to grow it on an artificial substrate (Pleszczyńska et al., 2012).
L. sulphureus has been reported from diverse regions of India such as Sonmarg, Kashmir; Jabalpur, Madhya Pradesh; Toglo Hills, Sikkim; Nadia, West Bengal (Erande *et al*., 2024; Verma *et al*., 2019). Nagpur city is located in central India, and experiences a tropical hot and dry climate. The discovery of this species in such a high-temperature zone is significant for mycological mapping in the Vidarbha region of Maharashtra, where Nagpur is situated.

Methodology
Nagpur city (*C*. 21.1498°N 79.0806°E) is located in Maharashtra state of India (Fig. 1). The ***L. sulphureus*** specimen was discovered in an urban area of Nagpur, specifically, the campus garden of Mohota Science College. The fungus was closely observed growing on the base of a living Gulmohar tree (*Delonix regia*). The observations were made during the monsoon period (late August) of 2025. Macroscopic features such as colour, texture, pore surface were recorded, and photographs were taken. Identification of the species was done with the help of scientific literature.

Results and Discussion
The specimen observed possessed characteristic features of*L. sulphureus* such as large size, fleshy texture, and vivid colouration. It had overlapping clusters of fruiting bodies laterally attached to the wood, with each bracket being

semicircular or fan-shaped in appearance, creating a shelf-like arrangement on the wood surface. The smooth to wrinkled upper surface of the brackets displayed a bright orange-yellow colour with distinct whitish margins (Figs. 2-3). The undersurface of the basidiocarps was poroid, bearing numerous minute pores. The bright orange-yellow brackets were the early stage soft and tender basidiocarps, which are considered edible. The older basidiocarps were dry, brittle, pale and brownish in appearance (Fig. 2). These features were consistent with the description of *L. sulphureus* by other authors (Alexopoulos *et al.*, 1996; Bernicchia, 2005; Phillips, 2006).

L. sulphureus was originally described as *Boletus sulphureus* by the French mycologist Jean-Baptiste Bulliard in 1789. American mycologist William Alphonso Murrill created the genus *Laetiporus* in 1904, and in 1920, he moved *B. sulphureus* to the genus *Laetiporus* (Khatua *et al.*, 2017). This species is currently classified in Kingdom Fungi, Division Basidiomycota, Class Agaricomycetes, Order Polyporales, and Family Laetiporaceae. *Laetiporus* translates to "with bright pores", while *sulphureus* refers to its distinctive sulphur-yellow colour.

By decomposing woody substrates, *L.sulphureus* plays an important ecological role in nutrient recycling within forest ecosystems. The occurrence of *L.sulphureus* in Nagpur extends its known geographical range in India. Nagpur’s high humidity during the monsoon provides a microclimate suitable for the fruiting of this bracket fungus. In the present study, the *L.sulphureus* specimen was found growing at the base of a living Gulmohar (*Delonix*) tree. Unlike temperate regions, where it favours Oak (*Quercus*) or Beech (*Fagus*), this record suggests adaptation to tropical trees. *L. sulphureus* serves as an efficient decomposer, recycling nutrients back to the soil, but its presence also signals the structural decline of the host tree due to the degradation of cellulose.

Conclusion

The occurrence of *L. sulphureus* in Nagpur adds to the Maharashtra biodiversity database. It also highlights the importance of trees in urban areas, for the survivalof fungal species that thrive on wood.

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श्री अन्न - पोषण सुरक्षा का आधार

विकास पाटीदार[1], गजेन्द्र यादव[2], भावना बाबल[3]

[1] भा. कृ. अनु. प– भारतीय कृषि अनुसंधान संस्थान, करनाल (हरियाणा)

[2] भा. कृ. अनु. प–केन्द्रीय मृदा लवणता अनुसंधान संस्थान, करनाल (हरियाणा)

[3] भा. कृ. अनु. प–केन्द्रीय मृदा लवणता अनुसंधान संस्थान, करनाल (हरियाणा)

परिचय

श्री अन्न भारत की एक परंपरा रही है। एक पुरानी कहावत है कि "जैसा खाय वैसा पाय" यह वर्तमान समय में भी सही लगती है, अर्थात संतुलित व पौष्टिक आहार, उत्तम स्वास्थ्य का मूल मंत्र है। कुछ समय से लोग स्वस्थ जीवनशैली के लिए संतुलित एवं पौष्टिक आहार ग्रहण करने हेतु जागरूक हो रहे हैं। श्री अन्न मानव जाति को ज्ञात सबसे पुराना खाद्य पदार्थ है, इनके लिए यह अनुमान है कि इनकी खेती 8000 ई.पू. से की जा रही है। श्री अन्न परंपरागत रूप से विश्व के शुष्क और अर्द्धशुष्क उष्णकटिबंधीय क्षेत्रों के लोगों के लिए आय, आहारीय ऊर्जा (प्रमुख भोजन के रूप में), तथा प्रोटीन का मुख्य स्रोत रहे हैं। श्री अन्न के प्रमुख प्रकारों में ज्वार, बाजरा, रागी तथा छोटे पौष्टिक धान्य में कंगनी, कुटकी, कोदो, चेना, तथा सांवा शामिल है।

यद्यपि श्री अन्न को अपने भरपूर पोषक तत्वों, पानी और कृषि निविष्टियों की न्यूनतम आवश्यकता और जलवायु प्रतिरोध-क्षमता के कारण कई शताब्दियों से भारत में उगाया जा रहा है, 1980 के बाद से श्री अन्न के फसल क्षेत्र में काफी कमी आई है, जिसके चलते किसानों ने बाजार मांग का अनुसरण किया और इस प्रकार गेहूँ तथा चावल का मार्ग प्रशस्त हुआ। श्री अन्न की कठोर प्रकृति, स्वास्थ्य के लिए लाभ, पोषण सघनता और भारतीय स्वाद और थाली के प्रति उनकी अनुकूलता को पहचानते हुए भारत सरकार कुछ वर्षों से श्री अन्न की खेती को प्रोत्साहित कर रही है। अप्रैल, 2018 में भारत ने पोषण से भरपूर श्री अन्न को 'पोषक-अनाज (न्यूट्रीसिरीयल्स)' के रूप में रिब्रांड किया और वर्ष 2018 को "राष्ट्रीय श्री अन्न वर्ष" के रूप में घोषित किया। भारत ने वर्ष 2023 को "अंतरराष्ट्रीय श्री अन्न वर्ष" (आईवाईएम) के रूप में घोषित करने के प्रस्ताव को प्रायोजित किया, जिसे संयुक्त राष्ट्र महासभा ने स्वीकार किया। तब से भारत आईवाईएम 2023 को केंद्र में रखते हुए एक 'लोक आंदोलन' के सृजन में प्रमुख भूमिका निभा रहा है और साथ ही स्वयं को श्री अन्न के वैश्विक हब के रूप में स्थापित कर रहा है। वर्ष 2024 के केंद्रीय बजट में मिलेट को 'श्री अन्न' या महाखाद्य (सुपर फूड) (जिसका शाब्दिक अर्थ 'सर्वोत्तम खाद्यान्न' है) कहा गया है। वर्ष 2025 आईसीएआर-भारतीय कदन्न अनुसंधान संस्थान, हैदराबाद का नाम परिवर्तन कर आईसीएआर-भारतीय श्री अन्न (बाजरा) अनुसंधान संस्थान, हैदराबाद कर दिया गया।

श्री अन्न के पोषक तत्व

श्री अन्न (मिलेट्स) गरीब किसानों के लिए भोजन और पशु-चारे का अहम स्रोत है तथा देश की पारिस्थितिक व आर्थिक सुरक्षा में सहायक है। इन्हें "मोटा अनाज" या "गरीबों का अनाज" भी कहा जाता है। गेहूँ-चावल की तुलना में ये अधिक पौष्टिक हैं क्योंकि इनमें प्रोटीन, विटामिन और खनिज प्रचुर मात्रा में पाए जाते हैं (तालिका 1)। साथ ही, ये ग्लूटेन-मुक्त और निम्न ग्लाइसेमिक इंडेक्स वाले होते हैं, जिससे ये मधुमेह और सीलिएक रोगियों के लिए उपयुक्त खाद्य हैं।

तालिका 1: श्री अन्न की पोषण संरचना

मोटे अनाज	कार्बोहाइड्रेट (g)	प्रोटीन (g)	डाइटरी	कैल्शियम (mg)	मैग्नीशियम (mg)	थायमिन (mg)	रिब्लोफ्लेविन (mg)	नियासिन (mg)

			फाइबर (g)					
ज्वार	67.68	9.97	102	27.6	133	0.35	0.14	21
बाजरा	61.8	10.96	11.49	27.4	124	0.25	0.2	0.86
रागी	66.82	7.2	11.18	364	146	0.37	0.17	1.3
कोदो	66.19	8.92	6.39	15.27	122	0.29	0.2	1.49
चेना	70.4	12.5	-	14	153	0.41	0.28	4.5
कंगनी	60.10	12.3	-	31	61	0.59	0.11	3.2
कुटकी	65.55	10.13	7.72	16.1	91.41	0.26	0.05	1.29
सावा	65.50	6.2	-	20	82	0.33	0.1	4.2

Source- https://idronline.org/article/agriculture/millet-cultivation-history-and-trends/

श्री अन्न (मिलेट्स) से लाभः

- श्री अन्न पारिस्थितिक परिस्थितियों की एक व्यापक श्रृंखला के लिए अत्यधिक अनुकूल है तथा ये फसलें वर्षा-सिंचित क्षेत्र में अच्छी तरह से पनपती है।
- इन फसलों के लिए शुष्क जलवायु उपयुक्त है तथा पानी, उर्वरकों और कीटनाशकों की न्यूनतम आवश्यकता होती है।
- स्वास्थ्यवर्धक पौष्टिकता से भरपूर इन फसलों में अन्य अनाजों की तुलना में इसमें बेहतर सूक्ष्म पोषक तत्व एवं बायोएक्टिव फ्लेवोनोइड पाए जाते हैं।
- श्री अन्न में निम्न ग्लाइसेमिक इंडेक्स होता है तथा यह मधुमेह की रोकथाम से भी जुड़ा होता है।
- यह आयरन, जिंक तथा कैल्शियम जैसे खनिजों का उपयुक्त स्रोत है।
- यह ग्लूटेन-मुक्त होता है इसका सीलिएक रोग के रोगियों द्वारा सेवन भी किया जा सकता है।
- इसका हाइपरलिपिडिमिया के प्रबंधन और रोकथाम और सीवीडी के जोखिम पर लाभकारी प्रभाव पड़ता है।
- श्री अन्न वजन घटाने, बीएमआई और उच्च रक्तचाप में सहायक पाया गया है।
- भारत में श्री अन्न का सेवन आम तौर पर फलियों के साथ किया जाता है, जो प्रोटीन का परस्पर पूरक बनाता है तथा अमीनो एसिड सामग्री को बढ़ाता है, एवं प्रोटीन की समग्र पाचनशक्ति में सुधार करता है।
- पकाने के लिए तैयार, खाने के लिए तैयार श्रेणी में श्री अन्न आधारित मूल्य वर्धित उत्पाद शहरी आबादी को आसानी से सुलभ और सुविधाजनक रूप से प्राप्त है।
- इनका उपयोग खाद्य पदार्थ के साथ-साथ पशु-चारे के रूप में दोहरे प्रयोजन के लिए भी किया जाता है,

जो इनकी खेती को अधिक कुशल बनाता है।

- श्री अन्न की खेती कार्बन फुटप्रिंट को कम करने में सहायता प्रदान करती है।

भारत में श्री अन्न की माँग

भारत में श्री अन्न की खेती की पूरी क्षमता को उपयोग में लाने के लिए केवल आपूर्ति पक्ष का संवर्धन ही पर्याप्त नहप होगा। वित्तीय वर्ष 2012 में भारत में श्री अन्न की अनुमानित खपत 16.1 मिलियन टन थी, जो 2022 में 17.8 मिलियन टन से 1% दशकीय कम्पाउंडेड एनुअल ग्रोथ रेट (सीएजीआर) से बढ़ी। भारत में श्री अन्न की प्रति व्यक्ति खपत 1960 में 30.9 किग्रा प्रतिवर्ष से 2022 में 3.9 किग्रा तक उल्लेखनीय रूप से घटी है। स्थिर उत्पादन के साथ बढ़ती हुई जनसंख्या से श्री अन्न की प्रति व्यक्ति खपत में गिरावट देखी गई है तथापि, युवाओं में स्वास्थ्य के प्रति बढ़ती जागरूकता से श्री अन्न में उपभोक्ताओं की रुचि बढ़ रही है। श्री अन्न के उपभोग सम्बंधी व्यवहार पर 2021 में किए गए एक सर्वेक्षण-आधारित अनुसंधान अध्ययन ने यह दिखाया है कि सर्वेक्षण के 28% सहभागियों ने स्वास्थ्य-सम्बंधी कारणों से श्री अन्न का सेवन शुरू किया है, जबकि 15% सहभागियों ने वज़न घटाने के लिए श्री अन्न खाना शुरू किया है। इस अध्ययन में यह भी पाया गया है कि 40% सहभागी इसलिए श्री अन्न नहप खाते हैं क्योंकि श्री अन्न उनके रोज़मर्रा के आहार का भाग नहप है। इस अध्ययन से यह भी निष्कर्ष निकला है कि अन्य बातों के साथ-साथ, श्री अन्न के लाभों के बारे में जागरूकता की वृद्धि से अधिक माँग उत्पन्न की जा सकती है। मनुष्य द्वारा सीधी खपत के अलावा, पशुचारे, खाद्य प्रसंस्करण उद्योग, एथनॉल उत्पादन, डिस्टिलरियों इत्यादि के लिए भी श्री अन्न की माँग में वृद्धि अपेक्षित है। श्री अन्न के स्वास्थ्य सम्बंधी लाभों के बारे में जागरूकता फैलाने के साथ-साथ बेहतर पहुँच के लिए बेहतर ब्रांडिंग जैसे नीतिगत सहयोगों के माध्यम से भी श्री अन्न के लिए माँग उत्पन्न की जा सकती है। विभिन्न देशों में श्री अन्न के प्रति बढ़ती रुचि, आने वाले वर्षों में इस बाज़ार की विकासात्मक संभावनाओं को दर्शाती है। प्राकृतिक सामग्रियों के उपयोग की ओर बदलती उपभोक्ता धारणाओं और जई, और किनुआ जैसे अधिक प्रोटीन वाले अनाजों की बढ़ती मांग से यह अपेक्षित है कि इससे उत्पादन के विविधीकरण और उद्योग के विस्तार के लिए अधिक अवसर प्राप्त होंगे।

श्री अन्न उत्पादक राज्य

भारत मोटे अनाजों यानि श्री अन्न का सबसे बड़ा उत्पादक है। राजस्थान, महाराष्ट्र, कर्नाटक, आंध्र प्रदेश, मध्य प्रदेश आदि जैसे प्रमुख मोटा अनाज उगाने वाले राज्यों में उत्पादित मोटे अनाजों की एक व्यापक श्रृंखला से देश समृद्ध है। भारत ने 17.96 मिलियन मीट्रिक टन मोटे अनाजों का उत्पादन किया। भारत में उगाए जाने वाले मोटे अनाजों में बाजरा, ज्वार, रागी और प्रोसो मिलेट, कोदो मिलेट, छोटा मिलेट, कंगनी मिलेट, ब्राउनटॉप मिलेट, बार्नयार्ड मिलेट, चौलाई और बकवीट जैसे गौण मोटे अनाज आदि शामिल हैं। भारत सरकार भी अपने राष्ट्रीय खाद्य सुरक्षा मिशन के हिस्से के रूप में मोटे अनाजों के उत्पादन को बढ़ावा दे रही है। इन कारकों के परिणामस्वरूप, आने वाले वर्षों में भारत में मोटे अनाजों का उत्पादन बढ़ने की उम्मीद है।

श्री अन्न का सतत कृषि में महत्त्व

हरित क्रांति ने भारत को खाद्यान्न उत्पादन में आत्मनिर्भर बनाया, लेकिन रासायनिक उर्वरकों और कीटनाशकों के अत्यधिक प्रयोग से भूमि की उर्वरता घटी, जल स्रोत प्रदूषित हुए और खेती योग्य क्षेत्र नष्ट होने लगे। जलवायु परिवर्तन ने समस्या को और गम्भीर बना दिया है- हीट वेव, सूखा और अनियमित वर्षा के कारण अनेक राज्यों में फसलें नष्ट हो रही हैं। ऐसे समय में जैविक खेती और श्री अन्न (मिलेट्स) टिकाऊ विकल्प हैं।

ये कम पानी में उगते हैं, जलवायु परिवर्तन के प्रति सहनशील हैं और किसानों की आजीविका तथा देश की खाद्य सुरक्षा सुनिश्चित करते हैं।

बनारस हिंदू विश्वविद्यालय के फार्म में जैविक बाजरा उत्पादन

भारत में श्री अन्न की खपत और संभावनाएँ

भारत में श्री अन्न की खपत 2012 में 16.1 मिलियन टन से 2022 में 17.8 मिलियन टन तक केवल 1% की दर से बढ़ी है, जबकि प्रति व्यक्ति खपत 1960 के 30.9 किग्रा से घटकर 3.9 किग्रा रह गई है। उत्पादन स्थिर रहने और जनसंख्या बढ़ने से यह गिरावट हुई, लेकिन युवाओं में स्वास्थ्य जागरूकता से मांग बढ़ रही है। एक अध्ययन के अनुसार, 28% लोग स्वास्थ्य कारणों और 15% लोग वजन घटाने के लिए श्री अन्न खाने लगे, जबकि 40% इसे अपने नियमित आहार का हिस्सा नहप मानते। भविष्य में जागरूकता, ब्रांडिंग और उद्योगों (पशुचारा, खाद्य प्रसंस्करण, एथनॉल) में उपयोग से श्री अन्न की मांग और अवसर दोनों बढ़ेंगे।

श्री अन्न से बनने वाले उत्पाद

इडली, डोसा, इडियप्पम, रोटी, पुट्टू, उपमा, दलिया, चपाती, पैनकेक, वर्मिसेली उपमा, पास्ता, नूडल्स, मैक्रोनी, सूजी, मूसली, इंस्टेंट मिक्स नाश्ते की सामग्री के रूप में मुड्डे, हलवा, अधिरसम, केसरी, पौष्टिक गेंद, मिठाई के रूप में पायसम/खीर, वड़ा, पकौड़ा, मुरुक्कू, भेलपुरी, बोली, पापड़, रेडी टू ईट मिक्स, फ्लेक्स, पफ, बाजरे के लड्डू, मोटे अनाज के रस्क स्नैक्स के रूप में और कुछ बेकरी उत्पाद जैसे ब्रेड, केक, कुकीज, सूप स्टिक, खाद्य बिस्कुट कप, हेल्थ बार, स्प्रेड, मफिन, आदि जैसे मोटे अनाज के साथ बहुत सारे वैल्यू एडेड उत्पाद बनाए गए हैं। बीयर, सूप, माल्टेड बाजरा आधारित पेय, अंकुरित रागी ड्रिंक मिक्स, मल्टीग्रेन ड्रिंक मिक्स, रेडी टू ड्रिंक पेय जैसे पेय पदार्थ मोटे अनाजों के साथ भी बनाए गए हैं। इनके अतिरिक्त, मोटे अनाजों से बने कुछ अन्य खाद्य पदार्थों में बिरयानी, वीनिंग फूड/शिशु आहार, चाट मिक्स आदि शामिल हैं।

श्री अन्न से समृद्धि की ओर किसान

जिस तरह से देश में मोटे अनाजों की मांग बढ़ी है साथ ही स्टार्टअप्स से हर आयु वर्ग को ध्यान में रखते हुए वैल्यू ऐड प्रोडक्ट बना रही है, उससे आने वाले दिनों में मोटे अनाज का बाजार और बढ़ने वाला है। साथ ही मोटे अनाजों के प्रचार-प्रसार की यात्रा ने मोटे अनाजों के निर्यात में तेजी प्रदर्शित करते हुए सकारात्मक प्रभाव डाला है। भारत को मोटे अनाजों के प्रमुख उत्पादक से अग्रणी निर्यातक देश के रूप में ले जाने, देश भर में लाखों भारतीय किसानों के लिए एक समृद्ध

भविष्य की दिशा में योगदान देने और खाद्य तथा पोषण सम्बंधी सुरक्षा अर्जित करने के लिए मूल्यवान योगदान देने की पूरी तैयारी की जा रही है। भारतीय मोटे अनाजों के गुणों को वैश्विक उपभोक्ताओं तक पहुंचाने के लिए यात्रा अभी आरंभ हुई है।

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(Indian Council of Forestry Research & Education)
(Anautonomous 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
Visitusat: http://tfri.icfre.org or http://tfri.icfre.gov.in