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Management of Pests & Diseases of Important Timber Trees

Vol. 5, Issue 3, October - December 2024

ICFRE-INSTITUTE OF WOOD SCIENCE AND TECHNOLOGY, BENGALURU

Indian Council of Forestry Research and Education

(An Autonomous Body Under Ministry of Environment, Forest & Climate Change)

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PREFACE

Forests are one of our most vital natural resources, sustaining biodiversity, livelihoods, and our nation's timber needs. The health of our forests is intrinsically linked to the prosperity of our forestry sector, and in turn, the wellbeing of millions who depend on it. Among the numerous challenges faced by our valuable timber resources, pests and diseases pose some of the most persistent and formidable threats.

In India, commercially important timber species such as teak, sal, sandalwood, rosewood etc have long been prized for their exceptional qualities. However, these species are increasingly vulnerable to a wide range of pests and pathogens that threaten not only tree health but also the sustainability of timber production and the economic returns for communities and industries alike.

At the Indian Council of Forestry Research and Education – Institute of Wood Science and Technology (ICFRE-IWST), we have long recognized the critical need for research, monitoring, and the development of sustainable management strategies to tackle these threats. Through focused studies on forest entomology, pathology, and integrated pest management, our scientists continue to contribute valuable knowledge and practical solutions to safeguard our timber resources.

This special issue of Wood is Good magazine, dedicated to Management of Pests and Diseases of Important Timber Trees, is both timely and significant. It brings together recent research insights, practical case studies, and expert perspectives that will benefit foresters, researchers, students, policymakers, and all stakeholders invested in the healthy future of our forests.

I congratulate the editorial team for their thoughtful curation of this issue and extend my best wishes to the contributors and readers. May this edition serve as a catalyst for further awareness, collaboration, and innovation in the management of forest pests and diseases, ensuring that our precious timber resources continue to thrive for generations to come.

Dated: 04-08-2025

(Rajesh S. Kallaje)

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INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION

(An Autonomous Council of Ministry of Environment Forest and Climate Change, Government of India)

VISION

To achieve long-term ecological stability, sustainable development and economic security through conservation and scientific management of forest ecosystems

MISSION

To generate, advance and disseminate scientific knowledge and technologies for ecological security, improved productivity, livelihoods enhancement and sustainable use of forest resources through forestry research and education

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- A new wood preservative which is comparable to CCA.
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Varieties/ Clones developed

- Developed improved germplasm of many forest tree species.
- Released 47 high performing and disease resistant clones of *Eucalyptus, Casuarina, Shisham, Melia* and *Sarpagandha* with a envisaged production gain of more than 20%. The developed germplasm are being made available to the State Forest Departments and farmers for use in plantations.

High performing and disease resistant clone of *Melia* sp.

CYCUS v. 1.0

- Casuarina Yield Calculator Utility Software (CYCUS v1.0) software has been developed to facilitate the farmer and other user agencies in yield estimation which requires only observations on girth of 100 sample trees per acre of plantation.

Wood Welding

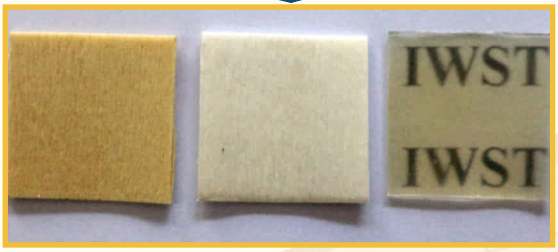
Wood welding is new to our country. In this technique wood joints can be made without using nails and adhesives making them more natural and chemical free. A wood welding machine has been designed and fabricated at Forest Research Institute, Dehradun. Success has been achieved in spin welding of wood pieces of few species.

Wood Welding Machine

Indian Council of Forestry Research and Education

New Initiatives

- Transparent wood- a flexible and biodegradable transparent wood has been fabricated using poplar wood veneer and water soluble polymer- polyvinyl alcohol. The transparent wood exhibited high optical transmittance, high haze and light diffusing property.



Natural wood (Left most), Lignin modified wood (middle) and Transparent wood (right most) placed on a paper with letters "IWST"

Heat storage based modified Solar Kiln

- Solar heat storage system based solar kiln has been developed by Forest Research Institute, Dehradun for timber drying. The solar heat is trapped using suitable phase change material (PCM). The New solar kiln is able to trap 39 % more heat in winters as compared to traditional green-house based traditional FRI solar kiln developed during 1970.

Head based storage Solar Kiln

Xylarium

- Collection of authentic wood samples both from India and other countries, depicting wood biodiversity of the country like lightest, heaviest, sweet-smelling, foul smelling, smoothest, streaked, variegated wood and wood of different colours, etc. The collection of wood cross sectional discs depicting variation in sapwood and heartwood colour is a unique feature of the xylarium.
- Wood identification services.

Xylarium- Collection of Authentic wood samples

Tree hollowness detection technique based on ultrasonic waves

- Forest Research Institute, Dehradun has developed ultrasonic techniques (Non-destructive testing) to detect the location and magnitude of the hollowness of the standing tree. This will help to remove the potential human hazards by way of falling down of such trees during a high wind regime in Urban Forestry.

Measurement of hollowness in a tree using ultrasonic detector

Agroforestry models

- Various agroforestry models (Poplar, Eucalyptus, Melia, Casuarina and Babool) have been developed to improve green cover, enhance farmers income and to mitigate climate change .

Poplar based agroforestry model with wheat

Innovative Bamboo Bottles

- Techniques for making bamboo bottles by using Bamboo Treatment Technologies of ICFRE. Most suitable bamboo species for making bottles are Shil Barak (*Bambusa salarkhanii*) & Barak (*Bambusa balcooa*). One full bamboo is sufficient for making 21 full size bottles and 12 small bottles.

Bamboo bottles

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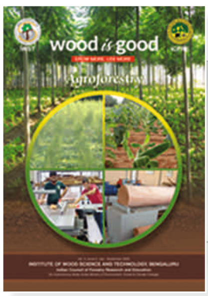

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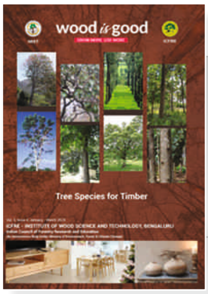

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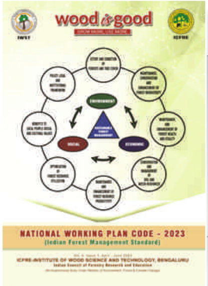

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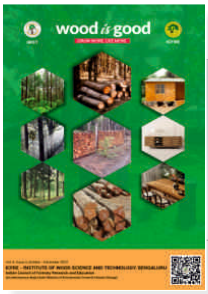

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Kandla Timber Association

Association of Timber Imorters, Traders, Saw Mill Owners, Plywood & Veneer Manufacturers

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Activities of ICFRE-IWST during October – December 2024

Forestry Training and Capacity Building: Training of Other Stakeholders on Sandalwood Cultivation and its Prospects

ICFRE-IWST organized three days training on "Sandalwood Cultivation and its Prospects" during 27 - 29 November 2024 to sensitize and educate stakeholders. The training was well received by 34 participants from various backgrounds like academicians, NGOs, homemakers, social activists, students, farmers, etc. The training was sponsored by Ministry of Environment, Forest and Climate Change under the Umbrella Scheme: Forestry Training and Capacity Building - Training to Other Stakeholders.

The training program was inaugurated on 27th November 2024. About eleven lectures were scheduled over three days covering sandalwood nursery technology, agroforestry, management of pest & diseases, policy and marketing. The in house resource persons included IFS officers and scientists from IWST who are working in the field of sandalwood research. Two external resource persons were also invited for the training. A half day field exposure visit was arranged to provide first-hand field information, directly interact and hear about the experience on growing sandalwood along with various combinations of trees and plants. The trainees visited Thapovan located in Baradhi village, Nelamangala, Rural Bangalore. On field, they learnt about various hosts, growing of sandalwood in trenches as a measure to save the root stock from theft. They also visited the Karnataka Soaps and Detergents Limited and got firsthand information related to the process of making world famous Mysore Sandal Soap. The participants were also provided information related to purchasing process of sandalwood by KSDL.

Three days Regional Training on Sustainable Land Management

ICFRE-IWST, Bangalore organized three days regional training on "Sustainable Land Management" from 16th to 18th Dec 2024 sponsored by Centre of Excellence, ICFRE. A total of 17 officials from forest departments, agriculture & horticulture departments, academicians of forestry colleges, KVK officials & others were part of this training.

The training covered aspects such as Land Degradation Neutrality (LDN) as a means to achieve Sustainable Development Goals; Framework on National Action Plan for achieving Land Degradation Neutrality; Integrated farming system approach for livelihood security; Addressing Land Degradation challenges within the UNCCD framework; Climate-resilient agriculture for sustainability and increased productivity; Soil and water conservation measures; Reclamation and management of saline and other problematic soils; Coastal Restoration; Grassland Restoration and Reclamation of Mined Out Areas. Resource persons for the training program were from Forest Research Institute, Dehradun; Himalayan Forest Research Institute, Shimla; University of Agricultural Sciences, Bangalore; The Ashoka Trust For Research In Ecology and the Environment (ATREE), Bengaluru and IWST.

Forestry Training and Capacity Building: Training of Other Stakeholders on Know your Plywood and Panel Composites

ICFRE-IWST, B'lore organized Three days training on “Know your Plywood and Panel Composites” under the MOEFCC sponsored Umbrella Scheme “Forestry Training and Capacity Building -Training of other Stakeholders from 18th to 20th December 2024. 25 members from across the country participated in the Training.

The resource persons for the training program were scientists and officers from ICFRE-IWST and Lectures from resource persons were scheduled over three days covering various aspects of professional knowledge with regard to processing technologies for efficient utilization of wood and its conversion into Plywood and a variety of panel products viz. particleboard, fibre board, block board and flush door etc.; Topics covered during course were Overview of Panel composites, Manufacturing process of Panel Composites: Plywood, Particle board. MDF etc, Wood Plastic Composites, Testing of panel Composites, Adhesives and its importance in panel Composites technology, Preservation against termite borer, fungus, mold of wood based panel Composites. Hands on session and demonstration of processing and product manufacturing were also made on pilot scale at chemical, mechanical, wood identification and protection laboratories. The participants were taken on one-day trip to provide exposure on industrial production of plywood, block board and flush door. The industry was supported by Karnataka State Forest Industries Corporation (KSFIC), Bangalore and M/s. Maruthi Gold Ply, Dasanapura, Bangalore.

Memorandum of Understanding Signed

Memorandum of Understanding was signed between Shri. Rajesh S. Kallaje, IFS, In-Charge Director, ICFRE-IWST and ITC Limited, Andhra Pradesh on 20 November 2024 with a vision of research, advocacy, skilling, implementation and sectorial development in nature-based solutions, socio-economic and cultural development in timber, bamboo and forest-based products.

Gandhi Jayanthi

ICFRE- IWST celebrated 155th Gandhi Jayanthi on 02 October 2024. Shri. Rajesh S. Kallaje, IFS In-Charge Director, ICFRE-IWST together with staff and students of the institute paid homage to Mahatma Gandhi. In recognition of the hard work and services rendered, the casual daily workers were felicitated. Further, prizes were distributed to the winners of painting competition.

Wildlife Week

ICFRE-IWST, Bengaluru celebrated Wildlife Week. Shri. Krupaka and Shri. Senani Wildlife photographers, Karnataka delivered the lecture on “Wild life Conservation through co-existence” on 03.10.2024. The lively and enlightening talk was well received and appreciated by all the participating officers and staff of the institute.

Vigilance Awareness Week

Vigilance Awareness Week was observed by ICFRE- IWST, Bangalore and Kolkata Field station from 28th October 2024. Shri. Rajesh S. Kallaje, IFS, In-Charge Director ICFRE-IWST along with officers, scientists, staff & students took the Integrity Pledge. An awareness program on Process of procurement through GEM Portal by Mrs. V Bhanumathy, UDC, Purchase Section was organized on 29th October 2024. Poster and elocution completions on the theme "Culture of Integrity for Nation's Prosperity" were organized for staff and students.

The institute concluded Vigilance Awareness Week on 5th November 2024. Shri Rajesh S. Kallaje, IFS, I/C Director said that the word integrity evolved from the Latin adjective integer, meaning whole or complete. In this context, integrity is the inner sense of "wholeness" deriving from qualities such as honesty and consistency of character. Further, The Chief Guest of the occasion, Shri Vikas Agarwal, ITS (1997), Chief Vigilance Officer, HMT Ltd. addressed the gathering. He highlighted that vigilance plays a vital role and is the backbone of any Govt. organization He stressed that, honesty, transparency, accountability are the faces of Integrity. While appreciating the vigilance report of IWST, he opined that scientific integrity aids Nation's Prosperity. The program ended with distribution of prizes to winners of competitions.

Kannada Rajyotsava

IWST, Bangalore observed State Formation Day - Kannada Rajyotsava on 1st Nov 2025 with hoisting of the Karnataka Flag by Shri Rajesh S. Kallaje, In-Charge Director, ICFRE-IWST. He wished the employees on the occasion. Dr. D. V. Guruprasad. IPS, Director General of Police (Retd.) was the chief Guest of the Rajyotsava celebration on 8th November 2025. The colorful celebration was highlighted by cultural extravaganza by staff & students of the institute.

Maha Parinirvan Diwas

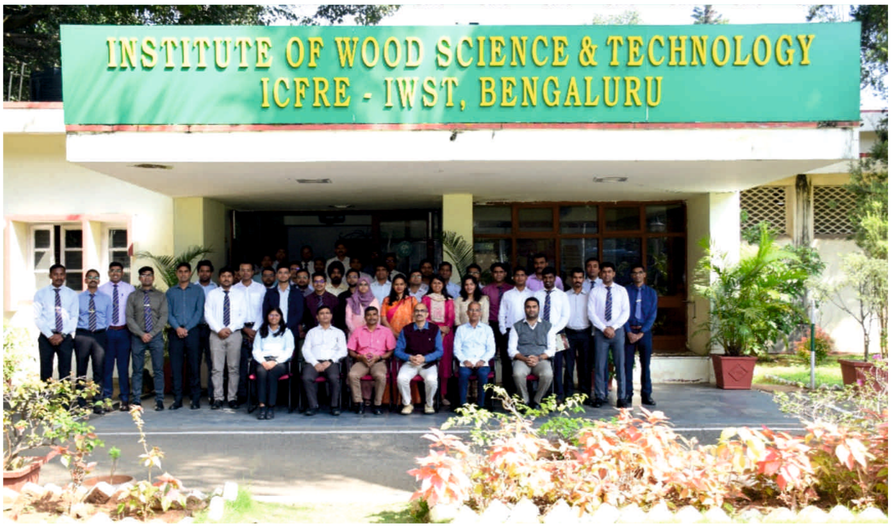
ICFRE-IWST observed Maha Parinirvan Diwas on 6th December 2024. Shri Rajesh S. Kallaje, In charge Director, ICFRE-IWST lead the team of scientists and staff in celebrating the event by offering floral tribute to Dr. B. R. Ambedkar on his 67th Death Anniversary.

Training on HS code of wood and wood products

ICFRE- IWST organized training on HS code of wood and wood products covering classification and duty structure by Sri. Devasish Paul, Deputy Commissioner, Airport and Air Cargo complex, NASIN, Bangalore on 26.11.2024. All HOD's /Officers/ Staff and students attended.

Janjatiya Guarav Diwas

ICFRE- IWST organized a talk on "Tribal Communities: Biodiversity Conservation and Livelihood with Special Reference to Soligas in Karnataka" by Sri. Siddappa Setty R., Sr. Fellow & Convenor, from ATREE, Bangalore on 27.11.2024 on occasion of Janjatiya Guarav Diwas. All HOD's/Officers/ Staff and students attended.



Visit of IFS Probationary Officers

Shri. Rajesh S. Kallaje, IFS In-Charge Director, ICFRE-IWST addressed two batches each of 54 Indian Forest Service (IFS) Probationers of 2023 -25 batch from Indira Gandhi National Forest Academy, Dehradun during their visit to the institute on 28 November and 16 December 2024. The officers were given an overview about the research activities of the institute. They interacted with Director and his team of scientists. This was followed by talk on Trends in Wood Utilization by Dr. Shakti Singh Chauhan, Scientist G and Head, WPP Division.

Visit of trainees from Forest Academies and others

A total of 72 Range Forest Officer trainees from Telangana State Forest Academy and Himachal Pradesh Forest Academy, Surendranagar visited the laboratories, workshops and other facilities like Xylarium, Advanced Wood working Training Centre, Wood Museum and Technology Demonstarion Centr at the institute. Also, five Forest Officers from Manipur Forest Department visited the Plant Tissue Culture and Molecular Biology Laboratory of ICFRE-IWST. About 25 farmers from Krishni Vigyan Kendra, Kaneri, Kolhapur enhanced their knowledge at the laboratories and facilities of the institute.

Visit of students under Prakriti program of ICFRE

An overview of research activities carried out at ICFRE-IWST is given to visiting students of different age groups and disciplines from universities, colleges & schools as part of Prakriti program of ICFRE. According to their curriculum needs, interests and education level, students are taken to various facilities like Tissue Culture lab, Molecular Biology lab, Pathology lab, Chemistry lab, Plant Nursery, Xylarium, Wood workshop and Advance Woodworking Training Centre, Wood Museum and Technology Demonstration Centre. Few students batches visit the IWST-IPIRTI Campus to get exposed and to enhance their knowledge at Adhesive Technology lab, Plywood pilot plant, Particle Board pilot plant, Fire door testing facility, Bamboo Processing units and Coir Composite centre. Students and faculty are sentisized about Mission LiFE Activity and Pledge is also administered.

Students from PM Shri Kendriya Vidyalaya, Malleshwaram; Sharada School, T.G. Halli, Bangalore and Bunts Sangha RNS Vidhyaniketan, Bangalore visited the institute. Few colleges and university that visited ICFRE-IWST are The American College, Madurai, Tamil Nadu; KLE Society's Nijalingappa College, Bangalore; SJR College, Race course Road, Bangalore; FRI Deemed University, Dehradun; Dyananda Sagara University, Bangalore; Forestry College, Ponnampet; MES College, Bangalore; Reva University, Bangalore ;Cotton University, Guwahati; Alliance University, Bangalore; University of Agriculture, GKVK, Bangalore; College of Horticultural and Forestry , Rani Lakshmi Bai Central Agricultural University, Jhansi; Forest College and Research Institute, Mulugu, Hyderabad and Dr. Y S Parmar University of Horticulture & Forestry, Nauni, Himachal Pradesh.

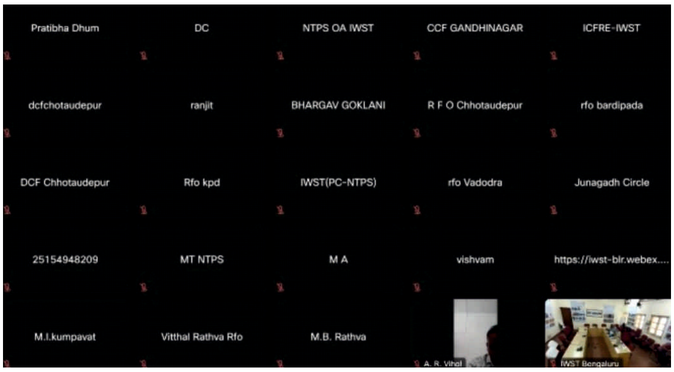
National Transit Pass System (NTPS) Trainings Conducted by ICFRE-IWST (October–December 2024)

National Transit Pass System cell of ICFRE-IWST successfully conducted 11 training programs during the period October-December 2024 to Forest Department officials and other key stakeholders of 7 States (Goa, Gujarat, Kerala, Maharashtra, Mizoram, Tripura, Uttarakhand) and for smooth roll out and implementation of National Transit Pass System.

Training for Goa SFD

Training for Mizoram SFD

Training for Kerala SFD



Training for Gujarat SFD

Pests of Teak (*Tectona grandis*): A Threat to Sustainable Timber Production

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Introduction :

Teak (*Tectona grandis L.*) is a prominent hardwood species of tropical countries. It is native to south and south-east Asia but in recent days it's been naturalized via plantation forestry in many countries. Although relatively unimportant in terms of the volume of world timber production, because of its strength and aesthetic features, teak is in most demand and considered as symbol of "luxury". It is widely planted across the globe for it's highly durable, strong, water and decay resistance timber which favors the high demand for manufacturing furniture, housing materials, handicrafts, ships and many other wooden products. Huge requirement of the Teak wood has created wide opportunities for farmers to involve the timber species in agroforestry. Industrial producers employs different varieties of teak, based on their end purpose like Teak wood from Godavari (Andhra Pradesh) region, is renowned for its ornamental figuring and been used in making furniture and cabinets whereas, Teakwood from Western Ghats are mainly preferred and used in constructing boats, bridges because of its highly durability feature (Athulya et al., 2024). With vast applicability, Teak provides good financial returns. However, teak cultivation faces serious challenges due to various pests like root feeders, stem borers, sap suckers, defoliators, seed feeders, fruit borers and gall inducers at various stages of its growth, which can significantly reduce tree growth, timber quality and plantation profitability. Many of these insects are minor or occasional pests and few are considered as major pests, due to economical threats they pose.

Major insect pests of Teak

Major insect pests of teak include defoliators, leaf skeletonizers, seed pests, root feeders and wood borers are reported widely due to their vast impact. Knowledge on these pests and their management is essential for sustainable teak forestry.

I) Defoliators

Defoliation is a serious and recurring issue that can be highly destructive to host plants. This phenomenon is primarily caused by insect herbivory, where various insect species feed on the leaves and tender parts of the plant, adversely affecting its growth and fruit set. Among the key contributors to defoliation are leaf skeletonizers, which consume the lamina of the leaf, leaving behind only the skeletal structure. Both types of feeding activities can lead to significant damage, especially when left untreated, and in some cases, this damage can be severe. *Hyblaea puera* and *Eutectona machaeralis* are recognized as major pests in this category, causing extensive defoliation and threatening the health of teak and other host plants.

Fig.1 : Teak trees affected by defoliating insect pests

a) *Hyblaea puera* (Lepidoptera:Hyblaeidae)

Hyblaea puera, commonly known as the teak defoliator, is a major pest responsible for widespread defoliation in teak across plantations, natural forests, and nurseries. Outbreaks typically occur during the monsoon season, particularly between June and August, and have been documented to cause significant losses, up to 44.1% reduction in timber volume in teak plantations across India.

Fig 2: Larvae of *Hyblaea puera* enclosed within an infested leaf roll

Due to the substantial impact of *H. puera o*n timber production, effective pest management is essential. Silvicultural practices and biological control strategies are widely recommended for sustainable management. Among biological control agents, egg parasitoids such as *Trichogramma* spp. have shown considerable success in suppressing pest populations (Joshi et al., 2005).Additionally, various entomopathogens affecting *H. puera* have been documented (Rouchoudary et al., 2010). One of the most promising tools in biological control is the use of *Hyblaea puera* nucleopolyhedrovirus (HpNPV), a baculovirus known for its high specificity and environmental safety.

b) *Eutectona machaeralis* (Lepidoptera: Crambidae)

Commonly referred to as the "teak leaf skeletonizer," *Eutectona machaeralis* is one of the most serious pests of teak. The larvae predominantly feed on soft, tender leaves, consuming the entire leaf tissue while leaving behind the network of veins, thereby giving the leaf a characteristic "skeletonized" appearance. Severe infestations, particularly in young plantations, can lead to dieback of the apical shoots, causing undesirable forking and structural deformities in saplings. In addition to defoliation, the pest has also been reported to attack teak inflorescences, adversely affecting seed formation and reducing seed set during epidemic outbreaks. Although chemical insecticides are commonly used to manage the pest, these provide only short-term control and pose significant environmental risks. Biological control offers a more sustainable solution. Notably, the egg parasitoid Trichogramma *raoi* has been found effective against *E. machaeralis*, providing an ecologically safer alternative for pest management (Joshi et al., 2005).

ii) Sap sucking insects

Teak is susceptible to several sap-sucking insect pests that adversely affect its growth and productivity. Among the major sap-sucking insects are aphids (*Aphis* spp.), whiteflies (*Bemisia tabaci*), scale insects (*Coccus* spp. and Aspidiotus spp.), and mealybugs (*Planococcus* spp.). These pests feed on the sap of tender shoots, leaves, and stems, causing symptoms such as leaf yellowing, curling, wilting, and stunted growth. Their feeding also weakens the plant, reduces photosynthetic efficiency, and can lead to secondary fungal infections due to the honeydew they excrete.

Fig 3: Various sucking insect pests of teak

iii) Root feeders

Some insects feed on root and rootlets and cause negative impact on growth of teak.

a) Holotrichia spp. (Coleoptera - Scarabaeidae)

Holotrichia spp., commonly referred to as white grubs or June beetles, are soil-dwelling beetles that feed on the roots and rootlets of teak seedlings, posing a serious threat during the nursery stage. Prominent species include *Holotrichia consanguinea, H. insularis, H. fissa, H. serrata,* and *H. problematica.* These pests typically emerge as major concerns 4–5 years after nursery

Fig 4 : *Holotrichia* spp. white grubs infesting roots of teak

establishment. Infestations often occur in patches, with affected seedlings exhibiting wilting symptoms followed by eventual death. After undergoing several molts, the larvae develop into adult beetles also known as chafer beetles, which feed on the foliage, inflorescences, and fruits of teak plants, causing further damage.In Kerala, white grubs have been reported to cause 20–30% mortality in teak seedlings across various nurseries. As part of integrated pest management strategies, light traps are commonly employed to capture adult beetles and reduce their population (Roychoudhury and Mishra, 2021).

Apart from the above, other pests like white grubs of the scarab beetle, *Schizonycha ruficollis* (Fabricius) is also reported with 14%-52% damage in teak nursery at Ramdongari, Nagpur, India (Kulkarni et al., 2007).

iv) Stem borers

Stem-boring insects are among the most destructive pests affecting commercial timber species such as teak. Larvae of various moths and beetles feed within the stems during their immature stages, creating tunnels that damage the plant's vascular tissues. This internal feeding disrupts the transport of water and nutrients, leading to symptoms such as branch dieback, structural instability, and, in severe cases, the death of the affected trees. Additionally, the wounds created by boring activity often serve as entry points for secondary pathogens, compounding the damage and accelerating decay. Some of the major stem-boring insect pests of teak include:

Fig 5 : Stem borer, *S .malbaricus* within a infested tree (left) and Pupa (right)

a) *Sahyadrassus malbaricus* (Lepidoptera: Hepialidae)

Sahyadrassus malabaricus, commonly known as the Phassus borer or stem borer, primarily affects saplings of various tree species preferably teak, by boring into the stem. Infestation is readily identified by a dome-shaped mass of woody particles at the entry point, indicating larval activity. The young larva bores a vertical tunnel downwards through the stem, extending to the root zone, often leaving an exit hole. The feeding area on the sapwood is typically concealed under a layer of frass. The stem borer targets the basal region of the main stem in newly established trees. Infested saplings often exhibit wilting and may ultimately die as a result of compounded pest pressures. Although the overall impact of this pest is generally considered minor, severe infestations can occasionally lead to stem breakage, compromising tree stability and growth.

b) *Alcterogystia cadambae* (Lepidoptera: Cossidae)

It is ccommonly referred as the teak trunk borer, typically affects teak trees between the ages of 15 and 25 years. Infestation results in the formation of irregular tunnels and internal hollowness within the heartwood, significantly reducing the commercial value of the timber. It is estimated that approximately 20% of teak timber arriving at depots is damaged due to borer activity. The pest primarily targets weakened or mechanically injured trees. Eggs are laid in small bark crevices, and upon hatching, the larvae begin feeding on callus tissue and the outer bark.

As the larvae progress, they bore tunnels approximately 6–7 cm into the sapwood, following a zig-zag path that eventually extends into the heartwood. One of the early signs of infestation is the girdling of side shoots, leading to dieback. During the rainy season, water infiltrates the damaged sites, creating favorable conditions for saprophytic fungi. These fungi accelerate the decay of the heartwood, rendering the timber structurally compromised and commercially unusable. The presence of borer holes further diminishes the market value of the wood. Management strategies include the adoption of agro-silvicultural practices, deployment of resistant clones, use of trapping methods, and application of entomopathogenic nematodes for biological control.

e) *Hypsipyla robusta* (Lepidoptera: Pyralidae)

The shoot borer, *Hyblaea robusta*, is one of the most serious pests affecting teak. It is widely distributed across tropical and subtropical regions. The female moth lays eggs on leaves and young shoots, and the emerging caterpillars bore into the tips and shoots of the plant. During larval development, a single individual may infest multiple shoots. This damage typically results in the destruction of the apical shoot, prompting the tree to produce several lateral branches and often leading to a deformed trunk, both of which significantly reduce the commercial value of the timber.

Fig 6: Larvae of shoot borer, *Hypsiphyla robusta*

Natural enemies of H. robusta include several predators such as the common myna (*Acridotheres tristis*), the praying mantis (*Amorphoscelis indica*), and members of the family Carabidae, as well as entomopathogenic fungi like *Beauveria bassiana*. In addition to biological control strategies, integrated pest management (IPM), silvicultural practices, and tree improvement techniques are recommended for effective and sustainable management (Athulya et al., 2024).

v) Gall formers

The growth of teak is frequently compromised by gall-forming insects, particularly in young plantations by gall forming insects like *Asphondylia tectonae* Mani (Diptera: Itonididae), which induces gall formation or swellings on plant tissues that disrupt normal plant development and negatively impact both timber quality and yield (Mani, 1959). Other significant gall-inducing pests include the leaf gall midge (*Cecidomyia tectonae*) and the stem gall insect (*Apsylla cistellata*), both of which contribute to similar detrimental effects. Additionally, although less common, gall-like symptoms may sometimes result from secondary infections or pathogen-induced hypertrophy, complicating diagnosis and management.

Fig 7: Leaf galls on teak

v) Timber pests

Timber of teak is resistant to most of the borer attacks due to presence of certain phenolic compounds such as tectoquinone and lapachol. However, certain insects like longhorn beetles (*Xystrocera globosa*, *Stromatium barbatum*), termites (*Odontotermes obesus*, *Coptotermes heimi*), powder post beetles (*Lyctus africanus*, *L. brunneus*) and several wood wasps pose damage to wood either in standing tree (pre-harvest) or after felling (post-harvest) (Tewari, 1992; Joshi and Namdeo, 1990). These pests can significantly reduce the commercial value of teak wood.

Conclusion

Teak been a commercial crop found to be susceptible to several pests attack. While most of these pests cause minimal damage individually, their impact can become significant when populations are high. In addition to reducing yield, these pests can degrade timber quality, further diminishing the economic value of the crop. Although several pest management strategies are currently in use, many of them pose environmental and ecological risks, limiting their long-term viability. Therefore, greater emphasis should be placed on the development and implementation of biological control methods. These environmentally friendly approaches offer a sustainable alternative and are well-suited for adoption in large-scale forest systems.

References :

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Defoliation by *Patialus tecomella* in Marwar Teak: its Biology, Symptoms, and Management Strategies

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1. Introduction

Tecomella undulata, commonly known as Marwar Teak or Rohida, is a vital tree species native to the arid and semi-arid regions of Rajasthan, India. This species holds significant ecological, economic, and cultural value, serving as a source of timber, medicinal products, and playing a crucial role in soil conservation (Bhoi et al., 2024). It thrives in the harsh climatic conditions of the desert, making it an indispensable part of the flora in Rajasthan's arid landscape. The tree's wood is of high commercial value due to its durability, strength, and fine grain, which makes it highly sought after for construction, furniture making, and other timber-based industries. Furthermore, it is prized in traditional medicine, where its bark, leaves, and roots are used to treat a variety of ailments, adding to its importance in local practices. Beyond its timber and medicinal uses, T. undulata also plays a significant role in ecological functions, such as preventing soil erosion, improving soil fertility, and providing vital shelter for wildlife. This multifunctional importance has made it a keystone species in Rajasthan's desert ecosystem.

However, despite its importance, it faces several challenges, primarily from pest infestations. Among the most significant pests is *Patialus tecomella* Pajni, Kumar and Rose (1990) a leaf-eating defoliator that attacks the foliage of T. undulata. The larvae of this pest feed on the leaves, causing extensive defoliation, which results in a reduction in the tree's photosynthetic ability. Over time, this damage can lead to stunted growth, reduced seedling survival, and, in severe cases, tree death. This not only affects the health of the trees but also has detrimental effects on the timber yield and quality, impacting the commercial value of the species. *P. tecomella* has become a major pest of T. undulata, particularly in Rajasthan's arid regions where the tree is a key timber resource. The pest's feeding habits can lead to the loss of a significant portion of the tree's canopy, which can severely limit its ability to regenerate and grow effectively (Govindasamy et al., 2025).

Despite the critical role of T. undulata and the threats posed by P. *tecomella*, there is a lack of extensive research focused specifically on the biology and management of this pest. Pest management in desert tree species is an area of general interest, research on P. *tecomella* and its impact on *T. undulata* has been limited. Understanding the biology, life cycle, and feeding behavior of *P. tecomella* is crucial for developing effective control strategies. Furthermore, the environmental factors that influence the spread of this pest need to be better understood, as well as the specific impacts on timber production. This article aims to explore the biology, symptoms, and management strategies of *P. tecomella* by highlighting the importance of this species and the threats it faces, the article emphasizes the urgent need for research and the development of effective management strategies to safeguard one of Rajasthan's most valuable resources (Govindasamy et al., 2025).

2. Taxonomic position

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta
Order: Coleoptera
Superfamily: Curculionoidea
Family: Curculionidae (Weevils)
Subfamily: Cioninae
Genus: *Patialus*
Species: *tecomella*

3. Identification mark of Rohida defoliator

Weevil specimens collected from *T. undulata* at ICFRE–AFRI, Jodhpur, Rajasthan and identified with the help of ICAR-NBAIR, Bengaluru. Specimens were preserved in 70% ethanol, mounted, and examined using a Leica M205A stereozoom microscope with

Automontage software (v4.12). Identification followed Pajni et al. (1991), with updated morphological and morphometric data. Key characters include a large, coarsely punctate head with ovate eyes (0.50–0.58 mm), a rostrum shorter than the pronotum, and antennae inserted at the apical third. The prothorax is transverse (1.42–1.68 mm) with a bisinuate basal margin, and elytra are oblong with broad interstriae. Femora bear a sharp tooth; tarsal claws are equal in both sexes. The prosternal channel reaches the mesosternum base; abdominal ventrite 1 is longer than ventrites 2 and 3 combined. Male genitalia feature penis apodemes equal in length to the penis body, a sclerotized endophallus, and a tegmen with distinct parameres. Female genitalia show tubular coxites and a spermatheca with distinct collum and ramus (Govindasamy et al., 2025).

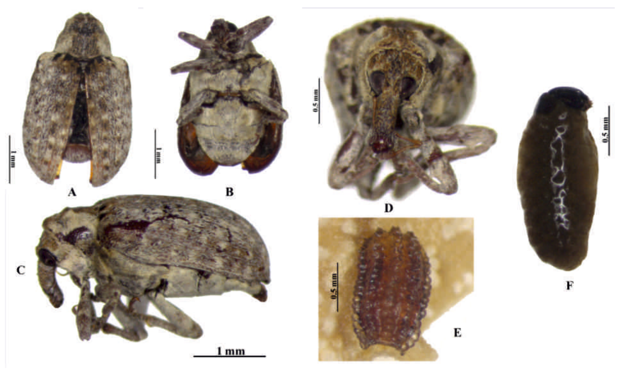

Figure 1. General morphology of *P. tecomella* a) Dorsal view of the adult, b) Ventral view of the adult, c) Lateral view of the adult, d) Front view of the adult, e) Ootheca, f) Larvae of *P. tecomella*.

4. Biology

The study on the biology of P. *tecomella* was conducted under controlled laboratory conditions at a temperature of 27 ± 2°C and relative humidity of 75–85%. Egg cases (oothecae) of *P. tecomella* were collected from the research plots of ICFRE–Arid Forest Research Institute (ICFRE-AFRI), Jodhpur, Rajasthan, and incubated until grub emergence. Newly hatched grubs (neonates) were individually placed in separate petri dishes containing fresh leaves of Tecomella undulata. Various developmental stages were closely monitored and recorded. Key parameters included the incubation period, number of larvae hatched per ootheca, duration of the grub stage, pupation period, and adult longevity. One grub was released per petri dish with three replications in a completely randomized design. The average egg incubation period was 4–6 days, with 8–12 larvae hatching per ootheca. The ectophagous larvae had a developmental period of 10–12 days, followed by a pupal stage within a cocoon lasting 3–6 days. Adults emerged after 11–13 days. The total life cycle spanned 28–37 days. Characteristic damage symptoms caused by the pest were also documented (Figure 2) (Govindasamy et al., 2025).

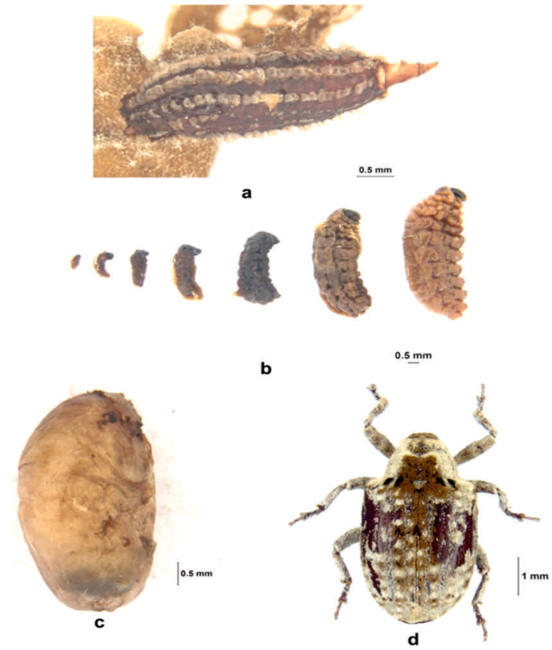

Figure 2. *Patialus tecomella* developmental stages a) Egg, b) Different instars of the larval stage, c) Pupae, d) Adult.

5. Damage symptoms

The defoliation caused by *P. tecomella* significantly impacts the photosynthetic efficiency of *Tecomella undulata* (Rohida) trees. As the larvae feed voraciously on the leaves, large portions of the tree's canopy are stripped away, reducing the surface area available for photosynthesis. This impairment in photosynthetic activity leads to decreased production of carbohydrates, which are vital for the tree's growth, development, and overall health. The skeletonization of leaves, where only the veins remain, further reduces the tree's ability to perform efficient photosynthesis, as the remaining leaf tissue is insufficient for energy production. The damage also hinders the tree's capacity to store nutrients and sustain vital processes such as flowering, fruiting, and regeneration (Figure 3). Furthermore, the loss of leaves weakens the tree, making it more vulnerable to environmental stressors, such as drought, pests, and diseases. Over time, if defoliation persists or occurs over multiple seasons, the reduced photosynthetic output may lead to stunted growth, slower timber production, and even tree mortality. In commercial forestry contexts, this decline in tree health results in reduced timber yield, as trees may not reach their optimal growth or marketable size. The cumulative effect of repeated defoliation by *P. tecomella* can thus have severe economic consequences for timber industries relying on *T. undulata* for high-quality wood production (Govindasamy et al., 2025).

Figure 3. Damage symptoms caused by *P. tecomella*. Defoliation of *Tecomella* undulata due to larval feeding, skeletonized leaves with onl veins remaining, and the presence of frass and larvae on the tree.

6. Integrated Pest Management (IPM)

The management of this pest, requires an integrated pest management (IPM) approach that combines biological, cultural, mechanical, and chemical control strategies.

6.1. Cultural Control

- **Pruning and Sanitation:** Regular pruning of infested branches helps reduce the pest population. Infested plant material should be destroyed away from the trees to prevent reinfection. Additionally, maintaining a clean environment around trees reduces the risk of fungal and bacterial pathogens that could further weaken trees already stressed by *P. tecomella* infestation.
- **Optimizing tree health:** Fertilizing trees with balanced nutrients enhances overall vigor, which improves resistance to both pests and diseases. Healthy trees are more capable of recovering from pest damage and disease infections, reducing the overall impact of *P. tecomella* infestation.

6.2. Biological Control

- **Natural predators:** Encouraging natural enemies such as birds and spiders helps keep the *P. tecomella* population in check. These organisms reduce pest numbers without disrupting the natural ecosystem.
- **Entomopathogenic fungi:** Fungi like *Beauveria bassiana* or Metarhizium anisopliae are effective against *P. tecomella* larvae and pupae. These fungi can be applied as biocontrol agents and help to combat secondary fungal infections that may arise from open wounds caused by feeding larvae.
- **Microbial disease control:** Utilizing bacteria like *Bacillus* thuringiensis (Bt) or *Paenibacillus* spp. can help in controlling both pests and suppressing diseases that affect the tree's foliage and vascular systems.

6.3. Mechanical Control

- **Hand-picking and removal:** Manually removing larvae and egg cases from trees can reduce infestations and prevent the introduction of diseases into the plant. This method also removes any frass that could harbor disease-causing organisms.
- **Trapping:** Using pheromone traps to capture adult weevils can reduce their population and prevent further egg-laying, indirectly limiting the chance of disease spread caused by larvae feeding and causing plant damage.

6.4. Chemical Control

- **Targeted Pesticide Use:** In cases of high infestation, insecticides like *chlorpyrifos* (2-2.5 ml per liter of water for foliar spray) or *imidacloprid* (1 ml per liter of water for foliar spray) can be used to control *P. tecomella.* It is important to apply these chemicals at the appropriate developmental stage (e.g., larvae or pupae) to minimize impact on natural predators and disease resistance.

6.5. Monitoring and early detection

- **Regular monitoring:** Monitoring for signs of *P.tecomella* infestation, such as defoliation, skeletonized leaves, and frass presence, is critical for early intervention.
- **Pheromone traps and disease surveillance:** Setting up pheromone traps for adults can help detect the timing of pest emergence.

6.6. Resistant Varieties

- **Breeding for Resistance:** Developing pest-resistant varieties of *T. undulata* that are also resistant to diseases will help reduce pest damage. This can be achieved through traditional breeding techniques or genetic engineering, enabling the trees to withstand attacks by *P. tecomella* and minimize the need for chemical interventions. Meena and Kant (2022) utilized ISSR (Inter-Simple Sequence Repeat) markers to evaluate genetic diversity and assign genotypes to T. undulata populations across Rajasthan, India. The study revealed moderate genetic diversity among populations, with higher diversity observed in the Jodhpur and Barmer regions compared to other areas. Genetic clustering analysis identified distinct groups, reflecting geographical and ecological adaptations. The authors attributed reduced diversity to habitat fragmentation, overexploitation, and limited gene flow. They emphasized the urgency of conserving region-specific germplasm and integrating molecular markers into breeding programs to enhance genetic resilience. This work provides a foundation for selecting diverse genotypes for pest-resistant variety development, such as against *P. tecomella*, by prioritizing genetically robust individuals for propagation and hybridization. In the context of pest management, this genetic understanding can be linked with the development of pest-resistant varieties. Breeding efforts that aim to enhance resilience to pests like *P. tecomella* could play a crucial role in the future of conservation and timber production. By developing pest-resistant varieties, either through traditional breeding techniques or molecular genetics approach, these trees can be better equipped to withstand the damage caused by such pests, reducing the need for chemical interventions and ensuring long-term survival and productivity.

7. Road Ahead: molecular tools for developing resistant varieties of T. undulata against *P. tecomella*

The increasing threat of *P. tecomella* defoliation in T. undulata calls for some innovative approaches to develop resistant varieties. Molecular tools offer promising strategies to enhance resistance by identifying and incorporating pest-resistant traits into the host plant. These approaches, combined with traditional breeding, offer a sustainable solution to mitigate defoliation and ensure the conservation of Marwar Teak in arid ecosystems.

a. Genetic markers and QTL mapping:

Molecular markers such as SSRs (Simple Sequence Repeats) and SNPs (Single Nucleotide Polymorphisms) can be used to identify genetic loci associated with resistance to *P. tecomella*. Quantitative Trait Loci (QTL) mapping can help pinpoint genomic regions responsible for defense mechanisms, such as secondary metabolite production or physical leaf toughness, that deter the pest.

b. Marker-Assisted Selection (MAS) for breeding programs:

Molecular markers linked to resistance traits can accelerate conventional breeding programs through Marker-Assisted Selection (MAS). This allows for the rapid development of *T. undulata* varieties with enhanced resistance while maintaining desirable agronomic traits.

c. Transcriptomics and proteomics for resistance gene discovery:

RNA-Seq and microarray-based transcriptomic studies can compare gene expression profiles between resistant and susceptible *T. undulata* varieties under pest infestation. Key genes involved in jasmonic acid signaling, protease inhibitors, or defensive compound biosynthesis (terpenoids, phenolics) can be identified. Similarly, proteomic approaches can reveal pest-induced protein changes, aiding in the selection of resistance-related proteins.

d. CRISPR-Cas9 genome editing for enhanced resistance:

Once resistance-associated genes are identified, CRISPR-Cas9-mediated genome editing can be employed to enhance their expression or introduce mutations that confer resistance. For instance, editing genes responsible for leaf trichome density (a physical barrier) or anti-herbivory compounds could reduce *P. tecomella* feeding efficiency.

e. RNA Interference (RNAi) for pest-specific defense:
Host-Induced Gene Silencing (HIGS) can be utilized to express double-stranded RNA (dsRNA) targeting essential genes in *P. tecomella*, such as digestive enzymes or molting-related genes. When ingested, these RNA molecules disrupt pest metabolism, reducing larval survival and leaf damage.

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Integrated Analysis of Teak Pathologies: Nursery Management and Field Syndromes

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Introduction

Healthy Teak

Teak (*Tectona grandis L.f*)

Teak (*Tectona grandis* L.f.), a cornerstone of the country's forestry sector and a globally valuable tropical hardwood, faces persistent and multidimensional disease pressures across its growth cycle. Thriving in Tamil Nadu, Kerala, and Karnataka, the species contributes significantly (more than 18% of India's production annually) yet remains susceptible to disease threats exacerbated by regional climatic variability. Nurseries combat established fungal pathogens, while plantations encounter emergent syndromes linked to abiotic stressors. This report synthesizes data from the Institute of Forest Genetics and Tree Breeding (ICFRE), Institute of Wood Science and Technology (IWST), University of Agricultural Sciences (UAS) campuses, Karnataka Forest Department (KFD), and field surveys, providing a holistic analysis of teak health challenges.

Nursery Pathogen Complex: Etiology and Management Strategies

Teak nurseries, influenced by specific climatic conditions, grapple with a distinct disease complex.

Leaf rust (*Olivia tectonae*) exhibits peak incidence (August–February), particularly in dryland nurseries of Southern India. Urediniospore colonization severely reduces photosynthesis by 40–60%, leading to documented seedling mortality rates of 40-60% in unmanaged outbreaks (IWST, 2019). Rising temperatures (>35°C) in regions like Haveri further accelerate sporulation by 30% (KFD, 2021).

Leaf Rust Symptom

Leaf Rust Symptom

Leaf blight (*Colletotrichum gloeosporioides*) proliferates under water stress, notably in overcrowded polybag nurseries such as those in Bhadravati, causing up to 70% seedling mortality. Biocontrol trials by UAS Dharwad demonstrate the efficacy of *Trichoderma viride*; application at 10 ml/seedling to the root zone induces systemic resistance, achieving 95% recovery within 30 days as infected foliage withers and new growth emerges.

Leaf Blight Infected Saplings

Treated Saplings

Root rot (*Fusarium oxysporum*), prevalent in waterlogged soils of Shimoga and Chikkamagaluru where poor drainage or excessive watering causes root decay and leaf desiccation, is mitigated by carbendazim (0.1%), reducing incidence by 80%.

Foliage Symptoms of Infected Saplings by Root Rot Pathogen

Leaf spot (*primarily Phomopsis spp.*, also *Colletotrichum*) and powdery mildew (*Uncinula tectonae*), characterized by irregular white patches of mycelium and conidia, peak during monsoon transitions and post-monsoon humidity (notably November-December). Sulfur-based sprays (0.1% or 1 ml/100ml water) and dust effectively suppress sporulation by 75% and control these diseases (ICFRE, 2020; IWST protocols).

Leaf Spot Symptom

Dandeli Field Syndrome: Abiotic-Biotic Interplay & Symptomatology

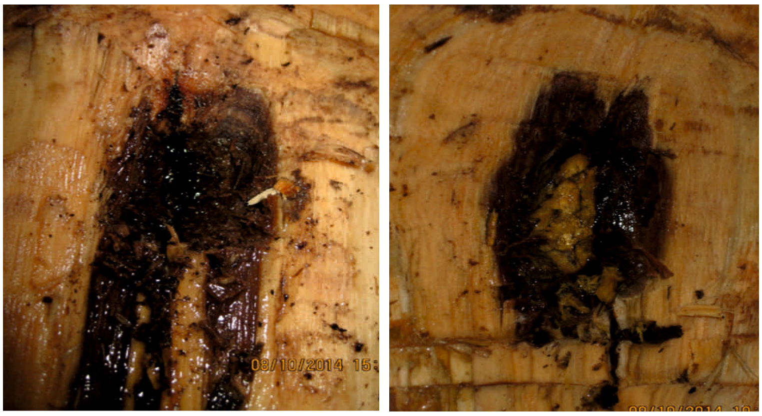
Field surveys, notably a 2014 study in a 25-hectare plantation at Dandeli (Ref: A2/BGT/IWST/CR/13-14), documented anomalous symptoms diverging significantly from common nursery pathologies.

Initial manifestations included the development of brown-black vertical grooves on tree trunks exuding viscous fluid. X-ray diffraction (XRD) analysis of this fluid confirmed high calcium oxalate crystallinity (68–72%), indicating a physiological stress response (Kumar et al., 2020).

Advanced stages featured the accumulation of calcareous crust deposits on darkened bark surfaces. Crucially, bubble emergence from lesions suggested anaerobic microbial activity (e.g., potential involvement of *Clostridium* spp.), though definitive metagenomic profiling remains pending. Internal examination revealed significant heartwood discoloration in 32% of sampled trees – a symptom previously unreported in Karnataka's teak. IWST's longitudinal study (2018–2023) correlated these symptoms with a 15–20% reduction in lignin synthesis, compromising structural integrity.

Calcareous Crust Deposits

Cross-species implications emerged as parallel symptoms were observed in adjacent red sanders (*Pterocarpus santalinus*) plantations. Underlying abiotic factors implicated include soil alkalinity (pH 8.2–8.6) and micronutrient imbalances, particularly zinc deficiency (Kumar et al., 2020; Journal of Tropical Forestry, 2020). The precise etiology of this syndrome remains unidentified, representing a critical research gap.



Discolouration of the Internal Heart Wood

Regional Research Advancements and Management Implications - Karnataka-specific research provides critical insights for management:

- **Genotype Resistance:** Pathogen-inoculation trials at UAS Raichur indicate Teli and Nilambur teak varieties exhibit approximately 40% lower susceptibility to *Colletotrichum* leaf blight compared to common stock.
- **Soil Interventions:** Field trials targeting abiotic stressors, such as gypsum amendment (500 kg/ha) in Dandeli to counter soil alkalinity, demonstrated a 45% reduction in bark exudation within two seasons.
- **Climate-Pathogen Nexus:** Documented acceleration of Olivia *tectonae* sporulation under rising temperatures (>35°C) underscores the need for climate-resilient strategies (KFD, 2021).

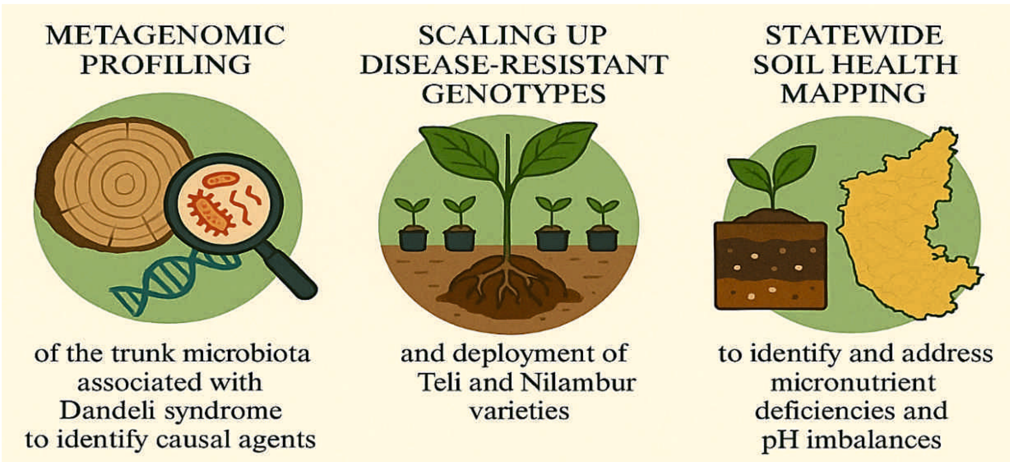
Integrated Management Framework:

Proven strategies include:

- **Nurseries:** Employing *Trichoderma*-amended potting media coupled with rigorous drainage optimization, cutting seedling losses by up to 65%. Sanitation practices are also essential.
- **Plantations:** Exploring interventions like trunk-injected tetracycline (targeting potential bacterial associates in syndromes like Dandeli's) and micronutrient foliar sprays (e.g., zinc sulfate 0.5%).
- **Surveillance:** The Karnataka Forest Department's mobile application "TeakHealth" enables real-time symptom reporting, enhancing surveillance coverage (12,000 ha since 2022).

Conclusion and Recommendations

Teak diseases in Karnataka necessitate a dual-pronged approach: conventional fungicides and biocontrol agents remain effective for managing well-characterized nursery pathogens, while complex field syndromes like the Dandeli trunk disorder demand investigation and management focused on the soil-plant-atmosphere continuum (SPAC).



Sustaining Teak Plantation Productivity - Integrated Intervention - Urgent Priorities

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Neem (*Azadirachta indica*) - Ecological Challenges and Conservation Strategies

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Abstract

Neem (*Azadirachta indica*), a versatile tree revered for its medicinal, agricultural, and ecological value, faces significant threats from insect pests and pathogenic diseases despite its inherent pesticidal properties. This article observes the global challenges posed by biotic stressors such as the Tea Mosquito Bug (*Helopeltis spp*.), Oriental Scale (*Aonidiella orientalis*), and defoliators like the Geometrid Moth (*Cleora cornaria*), alongside fungal and bacterial pathogens causing damping off, leaf blight, and dieback. Compounding these threats are abiotic stressors, including human activities like urban concretization, improper pruning, and climate change, which exacerbate tree vulnerability. The article details mitigation strategies, ranging from chemical treatments and cultural practices to policy-driven initiatives such as India's Neem Coated Urea Policy and afforestation programs under the National Mission for a Green India. Emerging technologies, particularly machine learning and deep learning, are highlighted for their transformative potential in early disease detection and precision management. By integrating traditional knowledge, conservation policies, and cutting-edge research, this review emphasizes the urgency of adopting multidisciplinary approaches to safeguard neem, a species critical to sustainable agriculture, healthcare, and biodiversity. The synthesis emphasizes the need for global collaboration to address these challenges, ensuring the preservation and sustainable utilization of this "Tree of the 21st Century."

Keywords: Neem, Disease, Insect pest, Mortality

Origin and distribution of Neem:

Neem, scientifically known as *Azadirachta indica* (commonly referred to as margosa or Indian lilac), belongs to the mahogany family, Meliaceae. Indigenous to the Indian subcontinent, it thrives in arid and semi-arid regions. The species has been introduced globally to diverse regions, including South and Southeast Asia, such as Sri Lanka, Thailand, Malaysia, Indonesia, and Pakistan, as well as Africa, the Caribbean, and parts of Central and South America, Australia, and the Pacific Islands [*National Research Council (US) Panel on Neem, 1992*]. It is valued primarily for its applications in agroforestry and traditional medicine. Figure 1 illustrates its worldwide distribution, with yellow highlights indicating its presence across these regions.

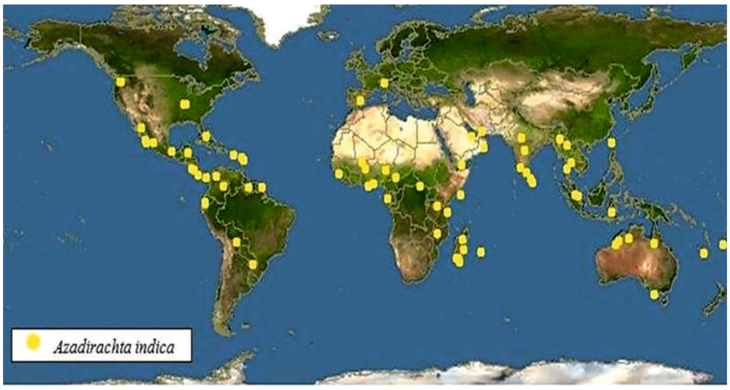

Figure 1: Distribution of Neem [*Shellikeri at al., 2018*]

The neem tree is widely distributed across India, thriving in tropical and subtropical regions from the southern tip of Kerala to the Himalayan foothills. It is found in various states, including Uttar Pradesh, Bihar, West Bengal, Odisha, Maharashtra, Karnataka, Kerala, Tamil Nadu, and Andhra Pradesh [*National Research Council (US) Panel on Neem, 1992*]. A healthy neem tree is illustrated in Figure 2.

Figure 2: Healthy Neem

Importance of Neem:

The neem tree, a multifaceted medicinal plant, serves as a source of remedies for numerous ailments and extends its utility beyond disease treatment to natural fertilizers and pesticides. Renowned for its diverse therapeutic properties, neem exhibits antioxidant, antibacterial, antimalarial, antiviral, antidiabetic, and anticancer effects, among others, as illustrated in Figure 3 [*Mohammad A. Alzohairy, 2016*]. The World Health Organization (WHO) estimates that approximately 80% of the global population relies on traditional medicine for primary healthcare [*Eid / Ahmad, et al., 2017*]. Often regarded as a "natural drugstore," neem holds profound cultural, agricultural, and environmental significance in India. Its leaves are traditionally used as air purifiers, and the tree is deeply intertwined with festivals and religious practices. Recognized globally, the United Nations has designated neem as the "Tree of the 21st Century." Beyond India, countries such as China, Indonesia, Nigeria, Pakistan, Bangladesh, Myanmar, Thailand, nations across the African subcontinent, and regions in South and Central America also utilize neem for medicinal purposes, emphasizing its worldwide relevance.

The neem tree, celebrated for its bioactive compounds, has been pivotal in Ayurvedic medicine for centuries, addressing ailments such as skin disorders, diabetes, infections, and liver issues, alongside demonstrating anticancer potential. Its applications span agriculture as a natural pesticide and soil-enhancing fertilizer, with drought resistance enabling its use in urban greening to improve air quality and provide shade. Table 1 [*Jose Francisco Islas et al., 2020*] systematically details the medicinal properties of its parts (leaves, bark, seeds, etc.), while Table 2 [*Jose Francisco Islas et al., 2020, National Research Council (US) Panel on Neem, 1992, & Reddy et al., 2020*] outlines traditional Ayurvedic uses, including treatments for fever, oral health, and skin ailments. Supported by scientific validation, neem's eco-friendly role in sustainable agriculture and global adoption aligns with rising demand for organic alternatives to chemical pesticides [Jose Francisco Islas et al., 2020, & Reddy et al., 2020].

India is a major producer and exporter of neem products, playing a pivotal role in meeting global demand. The import and export details of neem products in India are outlined in Figure 4. The international significance of neem is deeply rooted in

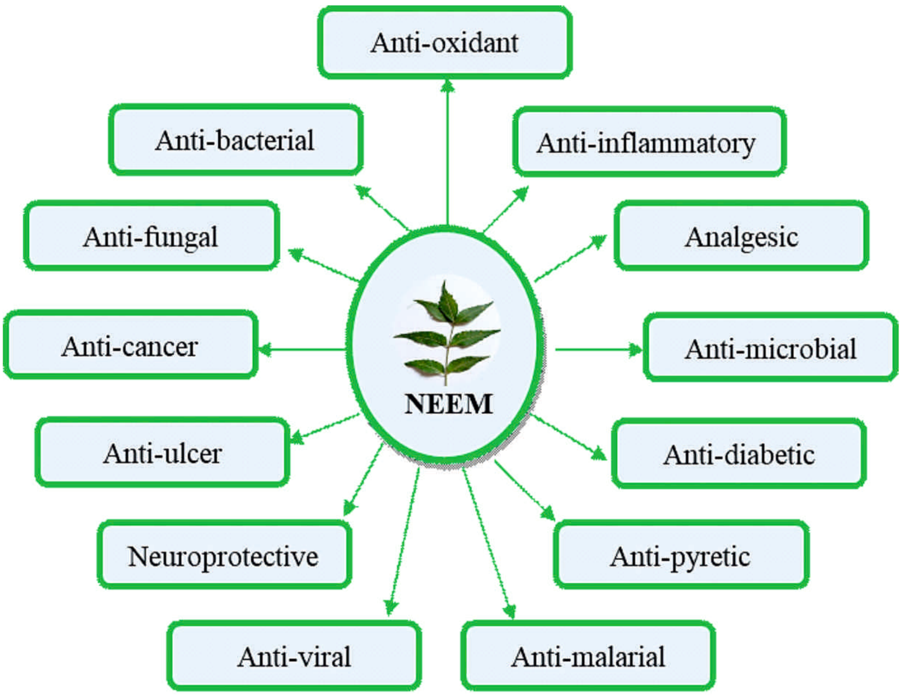

Figure 3: Therapeutic values of Neem

Table 1: Parts of Neem and Medicinal Values

Part of the Neem	Uses
Bark	Astringent, Anti-inflammatory, Anti-diabetic.
Leaf	Anti-inflammatory, Cytotoxic, Anti-diabetic, Blood purifier, Anti-proliferative, Chemo-protective effects (associated with oxidation prevention including DNA damage), Reduces immune toxic effect, Decreases tumor incidence in colorectal cancer.
Seed	Cytotoxic, Anti-cancer, Anti-inflammatory.
Root	Anti-diabetic.

Source: *Jose Francisco Islas et al., 2020*

Table 2: Ayurvedic Usage of Neem

Ayurvedic Use / Property	Description and Applications
Anti-inflammatory	Reduces inflammation and pain in conditions like arthritis.
Antimicrobial	Effective against bacteria, fungi, and viruses. Used for skin infections and oral hygiene.
Antioxidant	Scavenges free radicals, protecting cells from damage. Contributes to overall health and aging.
Anti-cancerous	Components inhibit cancer cell proliferation.
Anti-viral	Nimbin and nimbidin exhibit antiviral activity.
Blood Purifier	Detoxifies blood, promoting healthy skin and internal organ function.
Skin Disorders	Treats eczema, psoriasis, acne, and ringworm via antiseptic and anti inflammatory properties.
Wound Healing	Promotes faster healing of wounds and ulcers.
Dental	HealthTwigs used as toothbrushes; extracts in toothpaste / mouthwash prevent cavities and gum disease.
Fever Reducer	(Antipyretic)Traditionally used to reduce fever.
Anthelmintic	Expels intestinal worms.
Immunity Booster	Strengthens the immune system.
Diabetes Management	May help regulate blood sugar levels (as suggested by studies).

Source: National Research Council (US) Panel on Neem, 1992, & Reddy et al., 2020, Jose Francisco Islas et al., 2020

India's traditions, agricultural wisdom, and scientific advancements. Recognized as a versatile tree, neem is now globally utilized across diverse sectors such as medicine, agriculture, cosmetics, and environmental conservation. Its widespread application emphasizes India's enduring legacy in harnessing natural resources for sustainable and innovative solutions.

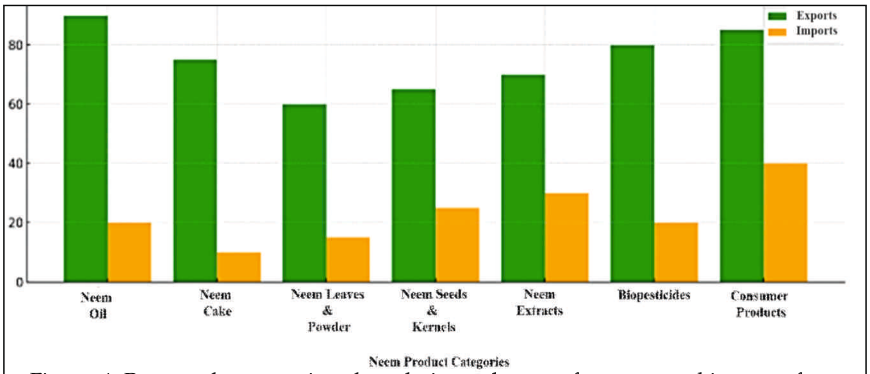

Figure 4: Bar graph comparing the relative volumes of exports and imports for various Neem product categories in India (2024), visually highlights that exports significantly outweigh imports across most categories, particularly in Neem oil, biopesticides, and consumer products.

Neem as Wood:

One of the abundant but under-utilized species in the tropics in wood industries is the neem, found both in the forest and off-reserve areas. The main mechanical properties at 12% moisture content includes; density - 740 kg/m³, Modulus of Rupture (MOR) - 54.07 MPa (bending strength), Modulus of Elasticity (MOE) - 8,317 MPa (stiffness), Compressive Strength (parallel to grain) - 39.82 MPa, and Shear Strength (parallel to grain) - 17 MPa (*Quartey et al., 2021*). While its compressive strength is comparable, neem's MOR is 30% lower than odum (*Milicia excels*), though ~2% higher than oak, and its MOE is 39% lower than odum and 43% lower than oak (*Quartey et al., 2021*). The shrinkage values are (Tangential shrinkage - 12.74%, Radial shrinkage - 6.26%, and Longitudinal shrinkage - 1.15%), comparable to Sterculia rhinopetala, a tropical hardwood tree native to India and Sri Lanka. However, its volumetric shrinkage (19.12%) is higher than many commercial timbers (e.g., teak, mahogany) (*Akpan, 2007*). These properties make neem wood a structural element to augment the demand in the timber industry.

Conservation of Neem:

The Government of India has undertaken a multi-faceted approach to conserve the neem tree, recognizing its ecological, medicinal, and agricultural importance, despite it not being an endangered species. The Ministry of Environment, Forest & Climate Change (MoEF&CC) integrates neem into its National Afforestation Programme (NAP), promoting its inclusion in medicinal-value plantation models and afforestation activities [*MoEF&CC, 2018*]. Concurrently, the National Mission for a Green India (GIM) under MoEF&CC supports mixed indigenous species plantations, including neem, across multiple states [*MoEF&CC, 2018*]. Complementing these efforts, the National Medicinal Plant Board (NMPB) and the Ministry of Ayush implement a Central Sector Scheme prioritizing neem among 140 medicinal plants, offering a 30% subsidy for its conservation and sustainable management [*MoEF&CC, 2018*]. The NMPB further drives cultivation through the National Ayush Mission (NAM), emphasizing medicinal plant propagation [*MoEF&CC, 2018*].

In agriculture, the Neem Coated Urea (NCU) Policy mandates neem-coated urea production and imports, enhancing nitrogen efficiency, regulating fertilizer use, and improving soil health, thereby indirectly promoting neem utilization [*Min. of IB, GoI*]. At the state level, Gujarat Narmada Valley Fertilizers and Chemicals Ltd (GNFC), under the Gujarat government, incentivizes neem conservation by procuring seeds from marginalized communities, particularly women, fostering socio-economic empowerment. GNFC also promotes neem cake as organic fertilizer, targets planting one million neem trees, and raises environmental awareness [*GNFC, 2015*].

Disease and insect pest in Neem: Neem trees in India face significant pressure from pathogens, and insect pests like Phomoposis sp., Fusarium sp., the Tea Mosquito Bug (Helopeltis spp.), defoliating caterpillars, and scale insects, including the globally emerging Oriental Scale (*Aonidiella orientalis*). These pests cause extensive damage (Figure 5), highlighting the dynamic and evolving nature of biotic threats to neem worldwide (Table 3). Effective management strategies are essential to safeguard this ecologically and economically vital tree species [*TNAU*].

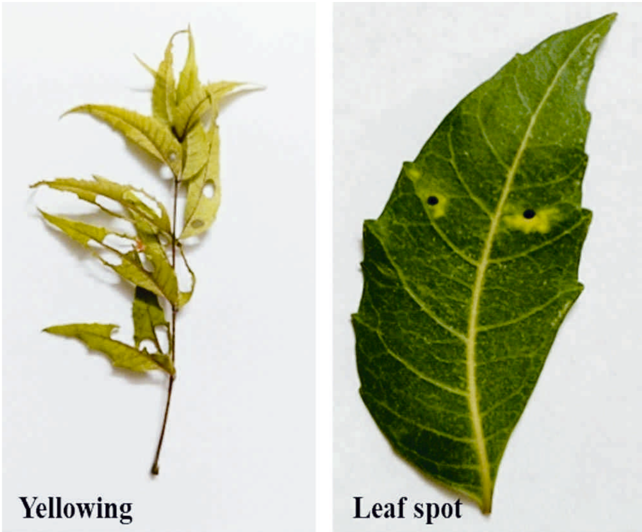

Figure 5: Common foliar symptoms in Neem

Despite its well-known insecticidal properties, the neem tree is susceptible to several insect pests (Figure 6 & 7). These pests can affect various parts of the tree, including leaves, shoots, roots, and seedlings (*Sheetal Anand and Barish E. James, 2023*).

Table 3: Major Diseases

Disease	Causal Organism	Symptoms	Control Measures
Damping off	Pythium, Phytophthora, Fusarium, Rhizoctonia	Seedlings fail to emerge, collapse, water-soaked stem base	Fungicide (e.g., Bavistin), seed dressing, formalin
Leaf web blight	*Rhizoctonia solani*	Gray-brown blotches, leaves webbed together, premature detachment	Sanitation, cultural practices, Bavistin 0.1%)
Colletotrichum leaf spot	*Colletotrichum gloeosporioides*	Expanding spots, leaf blight, premature defoliation	Blitox (0.2%) twice/week
Alternaria leaf spot	*Alternaria alternata*	Brown spots with white patches, grayish conidia, premature leaf fall	Blitox (0.2%) fortnightly
Pseudocercospora leaf spot	*Pseudocercospora subsessilis*	Brown spots with white patches, conidia underside,premature leaf shedding	--
Powderly Mildew	*Oidium azadirachtae*	Grey-white patches on leaves, entire leaf covered, premature defoliation	Bavistin spray (0.01%)
Other foliar diseases	Xanthomonas, Pseudomonas, Colletotrichum, Sclerotium, Phomopsis, Fusarium, Phoma	Bacterial spots, dieback, seedling wilt, twig canker, root rot	Depends on disease; general sanitation + fungicides

Figure 6: Dieback and termite infestation in Neem

Figure 7: Common insect-pest in Neem (Image Source: TNAU, CABI, CDFA, INSECTA.pro, WIKI)

Table 4: Major insect pests reported

Pest Name	Scientific Name	Type of Damage	Region/Remarks
Tea Mosquito Bugs	*Helopeltis theivora, H. antonii*	Feeding causes burnt appearance on shoots and leaves; gum exudation	South India
Oriental Scale	*Aonidiella orientalis*	Causes yellowing, stunted growth, and possible death	Parts of Africa
Lesser Snow Scale	*Pinnaspis strachani*	Affects photosynthesis and weakens tree	Common in tropical regions
Macropulvinaria	*Macropulvinaria jacksoni*	Sap-sucking, yellowing of leaves	Previously significant in India
Geometrid Moth	*Cleora cornaria*	Major defoliator; voracious leaf feeder	North India
Giant Looper Moth	*Ascotis selenaria*	Defoliator; larvae feed on tender leaves and shoots	Various regions
Peacock Moth	*Macaria notata*	Defoliator; leaves consumed except midrib	Various regions
Looper Moth	*Boarmia variegata*	Defoliator and leaf feeder	Common in nurseries
Weevils	*Myllocerus spp.*	Adults eat leaves (except midrib); larvae bore roots	Affects seedlings
Termites	–	Attack weakened or young trees; structural damage	Common in various regions
Subterranean Bug	*Scaptocoris castanea*	Attacks radicles; causes yellowing, wilting, drying of seedlings	Damaging to young plants

Way Forward:

Neem, a keystone species with immense ecological and medicinal value, faces escalating mortality from biotic threats like fungal pathogens (*Phomopsis azadirachtae, Rhizoctonia solani*) and pests (e.g., Tea Mosquito Bug, Oriental Scale), alongside abiotic stressors such as climate-induced droughts, urbanization [*Turner-Skoff, Jessica & Cavender, Nicole, 2019*], and improper cultural practices (especially pruning). Southern India reports a ~15% rise in dieback-related mortality [*Prasad, Rajendra & Prasad, Samendra, 2018*], driven by pathogens like Phomopsis spp. [*Kavi Sidharthan V, and A Muthu Kumar, 2024*] and root damage from unsustainable practices. Emerging AI/ML tools achieve >90% accuracy in early disease detection through leaf imagery [*Sladojevic et al., 2016*], aiding mitigation efforts that include chemical treatments (e.g., Systemic/ BS FC) and policy interventions like India's Neem Coated Urea Policy to improve soil health [*Nowak et al., 2001*]. Conservation strategies emphasize urban tree buffer zones [*Nowak et al., 2001*], community-driven afforestation, genetic diversity preservation via seed banks [*Singh et al., 2021*], and genotype-environment studies to enhance resilience. A multidisciplinary approach integrating policymakers, scientists, and communities is critical to safeguarding this "Tree of the 21st Century" and its global sustainability contributions.

Acknowledgement:

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References : contact author at vidya.ha@gmail.com

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Insect Pests of Malabar Neem (*Melia dubia*): Identification, Impact and Integrated Management Approaches

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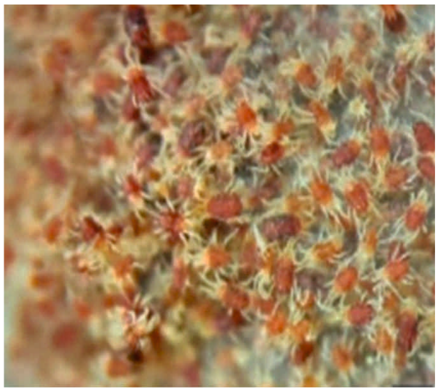
Introduction

Melia dubia popularly known as Malabar Neem is a promising multipurpose tree highly suitable for farm forestry and agro forestry for generating higher income per unit area. It has the potential to be an alternative timber crop in a wood deficient country like India. It grows almost in all soil types and can even sustain low water supply which is the plus point of this crop but, pests are one of the major threats of this species at seedling stage in nurseries and young plantations. Pest spectrum of Malabar Neem covers wide range of sap suckers such as mealy bugs, scales, thrips, hoppers, mites and leaf miners, defoliators and wood borders etc, seasonal outbreak of these pests causing mortality of the plants. Large scale plantation programmes have been initiated by State Forest Departments and tree growing farmers in Tamil Nadu and Karnataka. *M. dubia* is reported to be free from termites. However, large scale raising of seedlings in nursery and plantations revealed incidence of various pests and diseases. Therefore, periodical monitoring, documentation and identification of pests and their timely management by eco-friendly cost-effective methods to increase the productivity for the sake of farmers income is the main purpose. The paper reports the management measures for key insect pests' infestation on *M. dubia* in nursery and plantation.

Congregation of *T. urticae*



Infestation of T. *urticae*

1. Red spider mite, *Tetranychus urticae* (Tetranychidae)

A sporadic pest feeding on plant sap. Adults are caramine red colour mites occurring underneath the leaves. Presence of chlorotic spots which coalesce into pale patches indicates the presence of mite infestation. There will be extensive webbing underneath the leaves. Leaves start drying from the edges and slowly wither away. Occurrence is from June to November.

Managernent: Infested leaves can be hand plucked and destroyed if the pest is at low to medium level.

Web formation of *T. urticae* with chloratic patches on *M. dubia* leaves

Application of 10% neem oil and soap solution emulsion pointed towards the underside of the leaves can reduce the population level. Oberon^{TN} Spiromesifen 240 SC 22.9% ww 1ml/ litre of water can be applied during severe infestation. Application of Wettable sulphur 1 g/lit of water can also control the mites.

2. Mealy bug, *Ferrisia virgate* (Hemiptera: Pseudococcidae)

The mealy bug is very small elongate, oval shaped. The adult female is covered with powdery white wax and has a pair of purplish dorsal stripes along the back. Long, glossy white wax threads extend from the body and there are two long wax tails. The mealy bugs are often tended by ants and the ants act to keep other insects away from the mealy bug. The mealy bugs suck the sap of the leaves and tender shoots in the nurseries and in young plantations. The severely attacked plants show wilting and gradual die-back symptoms. The damage by this pest on the young seedlings is serious during the months of February to May.

Mealy bug, *Ferrisia virgata* infestation on *M. dubia*

Management: During low level infestations the scales can be scrapped off manually with a pair of sticks. Management, measures are application of Neem oil and tobacco leaf extract mixture directed towards the underside of the leaves or spray Tafgor Dimethoate 30% EC 1 ml/litre or Acetamiprid @ 0.3 g/1.

3. Scale insect, *Parlatoria ziziphi.* (Hemiptera: Diaspiedae)

This scale attacks the young plants all above ground parts of the trees particularly the bark of the stem and leaves. Severity of this pest leads to drying up of the plants. The female are 1.25 - 1.5 mm long and 0.5 to 0.7mm wide; sub rectangular with rounded corners, slightly membranous, elongate and oval whereas the males are red and winged. Occurs from February to April.

Scale Insect Infestation

Management: For low-level infestations, scales can be manually scraped off using sticks. During severe infestation Movento^{TN} (Spirotetramat 11.01% + Imidacloprid 11.01% w/w SC (240 SC) 1 ml/litre can be sprayed.

4. Leafhoppers, *Empoasca* sp. (Hemiptera: Cicadellidae)

Nymphs and adults suck the sap of the leaves resulting in chlorosis or discoloration of leaves. Nymphs and adults rest closely pressed to the surface of leaves. Occurrence is from February to April.

Scale insect infestation

Management: Light trap or sticky traps can be used to attract and kill the nymphs and adults. Application of 10% neem oil and soap solution emulsion, targeted towards the underside of leaves, can help reduce leafhopper populations. Spraying of Areva^{TN} Thiamethoxam 25% WG 0.2g/litre at fortnight interval.

5. Thrips, *Dolichothrips indicus* (Phleothripidae: Thysanoptera)

It is regular pest, occurring throughout the year, both adults and nymphs feed on the sap and scrap off tissue of unfolding young leaves leading to curling and chlorosis of young terminal leaves. A single adult individual usually settles down in an unopened tender, terminal leaf bud. It lays eggs and a colony of hundreds of individuals is developed within a short span of time. Though the tender leaf grows in size, the leaf remains
25 folded due to the continuous feeding of thrips. The folded leaf provides an ideal shelter for the thrips to survive. The infestation of this insect can be recognized by the typical nature of leaf folding. Feeding by thrips results in twisting and curling of young leaves and the affected leaves ultimately fall. The damaged leaves are also characterized by numerous, irregular, yellowish mottled areas with total absence of chlorophyll leading to leaf drying and shedding or stunted growth of seedlings.

Upward curling of leaf due to Thrips infestation

Management: Regular monitoring throughout the raising period is required. Avoid overhead watering, as it can create conditions favourable for thrips. Use yellow sticky traps to capture adult thrips. Application of 5% NSKE every 10 -15 days interval is effective. Suitable microbial formulations of *Verticillium lecanii* can be applied to bring down the population. Tracer^{TN} Spinosad 45% SC 0.3 ml/litre can be sprayed.

6. Leaf miner, *Liriomyza* spp. (Diptera: Agromyzidae)

Seasonal pest, larva is a leaf minor and cause white zigzag lines on leaf during January to February. The larva lives between the two epidermal layers of the leaf inside the tunnel resulting in premature shedding of the leaves slow or stunted growth, loss of leaves, partial or complete drying of seedlings. Adult is a minute moth and silvery grey in colour.


Liriomyza

Management: Once the white patches start appearing on leaves of the seedlings, such leaves could be hand collected and destroyed by burning with debris or dried leaves. Tafgor™ Dimethoate 30% EC 1 ml/litre or Danitol™ (Fenpropathrin 10% EC) 1 ml/litre can be given as a prophylactic spray. If new leaves show the patches or blotch, spraying can be repeated after 15 days of first treatment.

7. Defoliator, *Bormia variegata* (Lepidoptera: Geometridae)

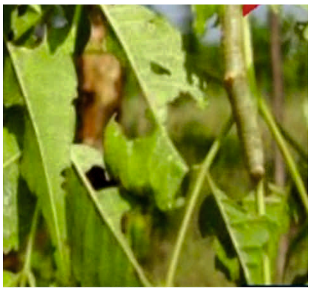
The Moth is whitish-grey or pale in colour. Caterpillar is a looper with two pairs of sucker feet on the last abdominal segments, naked, occurs in two colour forms, green with dark lines or pale yellowish brown, full size of 2 to 2.5 inches. Pupa is reddish brown in colour. Young larvae feed gregariously. The larvae consume the leaf completely only leaving the mid vein and some basal portion of leaf. This pest is more active during April to September.


Defoliator B. *variegata* infestation

Management: Small number of larvae can be hand collected and destroyed if the population is at low to medium level. Application of Intrepid™ (Chlorfenapyr 10% SC) 1 ml/litre or Danitol™ (Fenpropathrin 10% EC) 1 ml/litre can be sprayed.

8. Myllocerus weevil, *Myllocerus tenuicornis* (Coleoptera: Curculionidae)

Adult weevils are metallic green in colour. Males have pointed abdominal end whereas females have rounded end. Larvae and adult feed on the leaves. Severe feeding results in partial defoliation in tender foliage of young seedlings and saplings. This pest is more serious during May to September.




Myllocerus weevil infestation

Management: Application of 10% neem oil emulsion when adults are first observed in seedlings can limit the damage on leaves. Spraying of Karate™ (Lambda-cyhalothrin 5% EC) 2 ml/litre can bring down the population.

Conclusion

Effective insect pest management in *Melia dubia* is essential to ensure optimal growth, timber quality, and economic returns. Integrated Pest Management (IPM) strategies combining cultural, mechanical, biological and chemical methods are the most sustainable and environmentally sound approaches. Regular monitoring and early detection are critical for timely intervention, especially against key pests like defoliators, stem borers, and sap-sucking insects. Promoting natural predators, adopting resistant varieties, and maintaining plantation hygiene can significantly reduce pest incidence. Therefore, a well-planned and adaptive pest management program is vital for the long-term health and productivity of *Melia dubia* plantations.

References : Contact author at ashrithkn@icfre.org

Polyphagozerra coffeae Nietner (Lepidoptera: Cossidae) Infesting Sandalwood in Southern India: Incidence, Damage, and Management

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Abstract

Once considered a minor pest of sandalwood, *Polyphagozerra coffeae* has become a major pest in agroforestry plantation settings. Extensive surveys were conducted across 45 locations in 28 districts of five states in Southern India, representing Semi-arid, Tropical wet and dry, and Tropical wet climatic conditions. Results revealed an average percentage incidence of *P. coffeae* of 5.61%, with a minimum incidence of 1% and a maximum of 22%. The incidence of stem borer attack was significantly higher in pruned plants (6.92%) than in unpruned plants (3.55%). Climate did not significantly impact the incidence of attack. A "t"-test showed no significant difference in incidence between the Semi-arid region and the Tropical wet and dry region.

Introduction

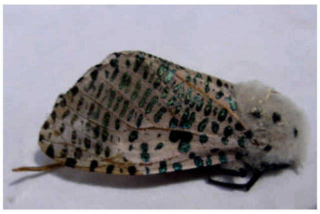
Polyphagozerra coffeae Nietner (Lepidoptera: Cossidae), a moth described by John Nietner in 1861, is widely distributed across the Asian continent. This polyphagous stem borer feeds on a wide variety of species, including tea, cotton, cocoa, kapok, eucalyptus, and teak (Beeson, 1941; Waller et al., 2007; Ahmed et al., 2017; Sundararaj et al., 2019; Tavares et al., 2020; Suheri et al., 2022). The species was historically a major pest of coffee, reported from India, Sri Lanka, Myanmar, China, Vietnam, Taiwan, the Philippines, Malaysia, Indonesia, Java, Sumatra, West Irian, and Papua New Guinea, and a minor pest of teak (Varma et al., 2007), Eucalyptus (Suheri et al., 2022), and almond (Ahmed et al., 2017). However, in India over the last decade, this species has become a major pest of Indian Sandalwood (*Santalum album L.*: Santalaceae), the "royal tree" of the Indian subcontinent (Chavan et al., 2024). Sandalwood agroforestry began in India around 2000 when most state governments relaxed stringent, monopolistic rules and permitted commoners to grow the species on their land. As sandalwood plantations expanded in major South Indian states, localized populations of *P. coffeae*, previously inhabiting coffee in the cooler hilly regions of Tamil Nadu and Karnataka, widened their range into the central lands of the Deccan Plateau (states of Andhra Pradesh, Telangana, and Maharashtra), characterized by semi-arid and tropical climates.

Infestation Pattern

Extensive surveys were conducted in 2 to 5-year-old sandalwood plantations across South India from 2022 to 2024. A total of 45 locations from 28 districts in five states, representing Semi-arid, Tropical wet and dry, and Tropical wet climatic conditions, were surveyed. Results revealed an average percentage incidence of *P. coffeae* of 5.61%, with the lowest incidence at 1% and the highest at 22%. The incidence of stem borer attack was significantly higher in pruned plants (6.92%) than in unpruned plants (3.55%). This indicates that pruning sandalwood plants acts as a predisposing factor for *P. coffeae* infestation, as pruned areas provide sites for egg deposition and serve as weaker points of entry for larvae. A "t"-test comparing infestation between pruned and unpruned sandalwood plantations showed significant variation (df=43, critical value=2.015, t=3.29).

Damage and Symptom

Damage to sandalwood plants was highly age-specific, primarily infesting plants up to 4 years old. Symptoms of *P. coffeae* damage included initial wilting of the shoot tip, resulting in the gradual drying of the entire twig, which eventually becomes brittle and breaks off easily. Active larvae inside the plant caused the ejection of yellowish or reddish, gummy, rice grain-shaped pellets from exit holes. During larval development, the inner stem tissue is completely consumed and hollowed. Larvae were frequently found residing and actively feeding within the stem. Mortality was higher in pruned plantations, as the insect attacked the main branch directly in the absence of side branches. In unpruned plants, attacks were mostly confined to side branches, leaving the main bole intact.



Adult P. coffeae,

Larva of P. coffeae

Pupal Stage of P. coffeae

Initial infestation symptoms

Faecal palates excreted by the larva of P.coffeae,

side branch infestation in Unpruned sandalwood tree

Stem borer *P. coffeae* is a major pest of sandalwood (Chen and Wang, 2018). Sundararaj et al. (2019) identified active borer complexes in sandalwood plantations and predicted *P. coffeae*'s potential to become a major pest. Five years later, *P. coffeae* is now a major threat to sandalwood plantation establishment. The higher attack rate in pruned plants aligns with findings by Rai et al. (2004) for Gmelina arborea, where stem borers entered through pruning wounds. Similarly, Gramaje et al. (2014), Barbour et al. (2010), and Burgess and Steel (2018) demonstrated that pruning points serve as entry points for rot fungi in *S. album* grown in Western Australia. This results in significant economic loss through impeded tree growth, hindered heartwood formation, and ultimately reduced oil production.

Management

Given the findings, adopting integrated pest management (IPM) strategies tailored to sandalwood ecosystems is critical. Key recommendations are outlined below.

- **Monitoring and Early Detection:** remain essential tools for identifying and regulating this insect. Regular field inspections, especially in younger plantations, are crucial for the localized management of infestations.

- **Pest-Specific Silvicultural Practices:** Data revealed higher mortality in pruned plantations, as insects directly attack the main bole in the absence of side branches. Therefore, pruning should be avoided or minimized. If necessary, it must be performed with utmost care, preferably during periods of low pest activity. Pruning wounds should be treated with protective agents to seal them and deter egg-laying.

- **Cultural and Mechanical Control:** Proper spacing, irrigation, and fertilization can enhance plant health, improving resistance to pests and diseases and reducing susceptibility. Infested branches should be promptly and effectively removed to limit pest spread.

- **Biological and Chemical Control:** Exploration and adoption of biological control agents, such as neem-based pesticides, parasitoids, or entomopathogenic fungi, can provide sustainable control options. Chemical controls should be used judiciously within an IPM framework.

Conclusion

Polyphagozerra coffeae, once a sporadic pest of coffee and other hosts, has emerged as a major threat to Indian sandalwood (*Santalum album* L.) plantations, particularly in southern India. The insect's host range expansion and increased prevalence in semi-arid and tropical regions underscore its adaptability and pest potential. Survey data from 2022 to 2024 revealed significant infestation rates, especially in pruned plantations, confirming pruning wounds as critical entry points for larvae. The pest causes age-specific damage, mainly targeting young plants (≤4 years), leading to stem hollowing, branch dieback, and plant death, particularly when main branches are compromised. These findings affirm that P. *coffeae* has transitioned from a predicted to a confirmed major pest, posing a serious threat to the sustainability and profitability of sandalwood agroforestry. Future management strategies must integrate silvicultural practices, especially careful pruning protocols, to mitigate infestation and preserve the economic viability of sandalwood cultivation.

The increasing prevalence of *P. coffeae* in sandalwood plantations poses serious economic and ecological implications. Sandalwood, a high-value tree prized for its aromatic heartwood and essential oil, which take years to develop, suffers from infestations that hamper growth, impede heartwood formation, and significantly reduce oil yield, thereby affecting commercial viability. Furthermore, the spread of *P. coffeae* into new geographic and climatic regions underscores its adaptability and highlights the vulnerability of monoculture sandalwood plantations to pest outbreaks.

References:

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Diseases of *Dalbergia sissoo* and Their Management

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Abstract

Dalbergia sissoo (Shisham) is a highly valued multipurpose tree species widely used in agroforestry and timber production across the Indian subcontinent. In recent years, its survival and productivity have declined significantly due to pathogenic infections. The most serious diseases include vascular wilt caused by *Fusarium solani f.* sp. *dalbergiae* and root rot caused by *Ganoderma lucidum*. These pathogens affect the vascular system and roots, leading to symptoms such as chlorosis, necrosis, dieback, and tree mortality. Management strategies involve uprooting infected stumps and deploying biocontrol agents like *Trichoderma* spp. Foliar diseases, including leaf spot and powdery mildew, also impact tree health, particularly in humid environments.

Keywords: *Dalbergia sissoo*, wilt, root rot, mortality, disease management.

Introduction

Dalbergia sissoo Roxb. ex DC. (commonly known as Shisham or Indian rosewood) is a nitrogen-fixing, multipurpose tree species extensively utilized for high-quality timber and ecological functions such as agroforestry, soil conservation, and afforestation across South Asia. Despite its socio-economic and ecological significance, *D. sissoo* has suffered widespread mortality and progressive decline in health, often without a single identifiable cause. Disease outbreaks have reached epidemic proportions in parts of South Asia, with mortality rates of up to 30% reported in Kasur, Pakistan (Khan et al., 2000), and 50–60% in districts like Basti, India (Kumar, 2014). In Bihar, mortality rates reached 80% in Araria and 35.4% in Darbhanga (Dayaram et al., 2003). Literature consistently identifies *Fusarium solani* as the primary pathogen responsible for large-scale mortality in Shisham-growing regions of India, Nepal, and Pakistan (Sharma et al., 2000; Kumar & Khurana, 2016). This mortality manifests as patchy canopy gaps, undermining forest health, timber economies, and ecosystem services. This paper reviews major diseases affecting *D. sissoo* and their management strategies.

Major Diseases of *Dalbergia sissoo*

Root Pathogens

Dalbergia sissoo is highly vulnerable to root pathogens causing wilting and root rot. Low genetic diversity may increase susceptibility to pathogens (Bakshi, 1954; Khan, 2000; Bhandari et al., 2014). The two primary pathogens are:

1. ***Ganoderma lucidum* (Root Rot)**

Ganoderma species cause root rot in woody plants, particularly affecting mature trees in natural forests and plantations (Bakshi, 1974). The pathogen infects roots through intact or wounded surfaces and spreads via root contact. Symptoms include leaf yellowing, root decay, and reddish fungal fruiting bodies (basidiocarps) at the trunk base (Khara & Singh, 1997).

Ganoderma Infection at the Root Collar of *Dalbergia sissoo*

Note: Earlier literature referred to this pathogen as Fomes lucidus (Troup, 1921; Khan & Bokhari, 1970), but Ganoderma lucidum is the currently accepted taxonomy

2. Fusarium *solani* f. sp. *dalbergiae* (Vascular Wilt)

This pathogen causes vascular wilt, the leading cause of *D. sissoo* mortality (Pandey et al., 2017). Early symptoms include leaf chlorosis, necrosis, premature shedding, and branch dieback. Asymmetric canopy thinning, stem cracks, cankers, and gummosis (gum exudation) occur in advanced stages (Shukla, 2011; Singh et al., 2019).

Drying / Decline of Peripheral Twigs

Gummosis Symptom

Minor Foliar Diseases

1. Leaf Spot

Causal organisms include Pestalotiopsis spp., *Cercospora* spp., and *Colletotrichum* spp. Symptoms involve dark necrotic spots, premature leaf drop, and reduced photosynthetic efficiency, exacerbated in humid conditions (Pandey et al., 2017).

2. Powdery Mildew

Caused by *Phyllactinia dalbergiae*, this disease produces dense, yellowish mycelial growth on leaf surfaces.

Integrated Disease Management:

Integrated disease management (IDM) for *Dalbergia sissoo* combines cultural, biological, and silvicultural strategies to address both root and foliar pathogens. For *Ganoderma* root rot, prompt removal and burning of infected stumps and roots are essential to eliminate inoculum sources, supplemented by avoiding replanting in infested sites for 1–2 years (Bakshi, 1974). *Fusarium* wilt is managed through biocontrol agents like *Trichoderma* spp. (applied as a 10 g/L suspension at 5 L/tree in root-zone trenches), which colonize roots and suppress pathogen growth through competition and mycoparasitism (Kumar & Khurana, 2016; Singh et al., 2019). Foliar diseases (leaf spot, powdery mildew) require sanitation practices, pruning infected branches and destroying fallen leaves, to break disease cycles, coupled with neem-based biofungicides or sulfur sprays in humid conditions (Pandey et al., 2017). Prophylactic measures include selecting disease-resistant clones, maintaining optimal tree spacing for air circulation, and avoiding mechanical root injuries during intercropping. Soil health enhancement via organic amendments (e.g., composted manure) and balanced irrigation further bolsters tree resilience against vascular pathogens (Shukla, 2011; Bhandari et al., 2014).

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Ganoderma Root Rot in *Dalbergia sissoo:* An Emerging Threat in the North-Western Himalayan Forests

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Introduction

A systematic disease survey was conducted across Himachal Pradesh and the Union Territory of Jammu & Kashmir to assess the severity of *Ganoderma*-associated root rot in *Dalbergia sissoo* populations. Sporocarps of *Ganoderma* spp. were collected from symptomatic trees, and pathogenic isolates were cultured on PDA and mass-multiplied on wheat grains for pathogenicity evaluation. Pathogenicity assays on 2-year-old saplings revealed variable virulence, with isolates GL04 and GL09, sourced from high-mortality zones, identified as the most virulent. These findings underscore the pressing need for integrated disease management strategies. While current methods offer limited short-term relief, future interventions must emphasize early detection, healthy planting stock, ecological balance, and biological control agents like *Trichoderma* spp. Sustainable, eco-sensitive approaches are essential to safeguard forest productivity and biodiversity.

Ecological, Economic, and Pathological Significance

Dalbergia sissoo, commonly known as Shisham, is a highly esteemed timber tree in India, valued for its robust, dense, and durable wood (Singh and Singh, 2003). Beyond its timber value, the species holds medicinal importance and serves as livestock fodder (Mukherjee et al., 1971; Hassan et al., 2016). It functions as a pioneer species in riverine ecosystems and fixes atmospheric nitrogen through symbiotic associations with root-inhabiting diazotrophic bacteria. Indigenous to the Himalayan foothills, Shisham occurs primarily in India, Nepal, and Pakistan. Within India, its distribution is concentrated in northern sub-Himalayan zones (900–1,500 masl). The tree is extensively used commercially for furniture, cabinets, veneers, plywood, and musical instruments (Sharma et al., 2000). Its hardwood is prized for its superior quality, rich hue, fine texture, smooth finish, and longevity (Bajwa et al., 2003). Traditional medicine utilizes its bark (anthelmintic), leaves (expectorant), and wood (febrifuge and abortifacient) (Shah et al., 2010). Ecologically, *D. sissoo* fixes nitrogen, tolerates drought, and rehabilitates sodic soils in woodlots (Mishra et al., 2002).

Despite these benefits, its productivity is declining due to soil salinity, prolonged droughts, nutrient exhaustion, and heightened disease susceptibility (Mishra et al., 2002; Alauddin and Quiggen, 2008). The steady reduction in Shisham populations over recent decades has raised global concern. Extensive mortality has been documented across India (Baghchee, 1945; Bakshi, 1954; Shukla, 2002; Dayaram et al., 2003; Negi et al., 2003), primarily attributed to root rot and wilt caused by *Ganoderma lucidum* and *Fusarium solani* (Bakshi and Singh, 1959; Mukerjee et al., 1971; Harsh et al., 2010; Sibounnavong et al., 2012; Bhatia et al., 2015; Pant et al., 2023). These fungi compromise vascular tissues, impair water transport, and cause desiccation. Disease progression begins with acropetal yellowing and wilting of leaves, culminating in dieback—a devastating condition for *D. sissoo.*

Ganoderma lucidum affects natural and plantation forests, spreading faster in light-textured soils than heavier soils (Bakshi, 1974). Early symptoms include wilting, stag-headed crowns, and sporocarps near the trunk base and exposed roots (Verma, 2014; Bhattarai et al., 2020). Transmission occurs via root-to-root contact, with symptoms typically emerging three years post-plantation (Bakshi et al., 1972). Advanced stages involve leaf shedding, branch dieback, and cambial invasion, disrupting water/nutrient transport and causing tree death (Bhattarai et al., 2020).

Case Study: Assessment of *Ganoderma*-Associated Root Rot in *D. sissoo*

Systematic surveys covered 64 locations in Himachal Pradesh (Bilaspur, Kangra, Hamirpur, Mandi, Shimla, Sirmaur, Solan, Una). Of these, 48 sites had healthy trees, while 16 showed moderate-to-high mortality due to Ganoderma. Infestation levels ranged from 5–20% in Kangra to 60% in Birplasi (Solan). Sirmaur and Una reported 11–22% incidence. Ganoderma was most frequent in Sirmaur, Bilaspur, Kangra, Una, and Solan, with the highest incidence in Sirmaur.

In Jammu & Kashmir (27 sites across Jammu, Samba, Kathua), 5 sites showed 7–18% infection. Disease presence varied significantly across low and mid-altitudes. During surveys, Ganoderma basidiocarps were observed on stumps, dead trees, diseased trees, and apparently healthy trees. Minimal infection was detected in Jammu & Kashmir. Ten Ganoderma isolates were collected from infected sites.

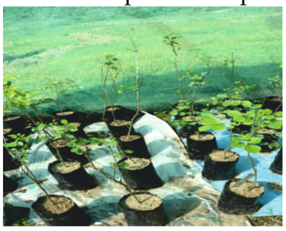
Diseased Trees (1^{st} three pictures) and Sporocarp

Pathogenicity Evaluation of *Ganoderma* spp.

Sporocarps were collected from infected living trees and stumps. Pure cultures were isolated on PDA and mass-multiplied on partially boiled wheat grains. Pathogenicity was assessed on two-year-old *D. sissoo* saplings in polybags under polyhouse conditions at Van Vigyan Kendra Nursery, Dharampur, Mandi (656 masl). Six saplings per isolate were inoculated, and disease progression was monitored. Isolates showed variable pathogenicity: GL04 (from Sirmaur) was most virulent, followed by GL09 (from Solan), both sourced from high-mortality zones. By 6 months post-inoculation, saplings exhibited mild defoliation and stag-headed crowns. Histological root sections confirmed *Ganoderma* colonization.

Basidiocarp on Stump

Ganoderma sp. culture on PDA



Inoculation of Saplings

Root Section with Symptom

Management Strategies for *D. sissoo* Mortality

Forest diseases receive less attention than cash crops, yet unchecked infections risk significant productivity losses. Current *Ganoderma* management focuses on delaying infection:

Preventive Measures:

- Use seeds from healthy trees for planting stock.
- Establish plantations in disease-free areas.
- Dig trenches around diseased trees to block root-to root transmission (Mawar and Ranganathan, 2023).
- Avoid monocultures, dense planting, flooded irrigation, and repeated ploughing (Sariah and Zakaria, 2000).

Curative Actions:

- Remove stumps and roots of infected trees.
- Prioritize early detection, as advanced stages are unmanageable (Javaid et al., 2004).

Chemical Control:

- Tridemorph, Bavistin, Mancozeb, and Propiconazole show efficacy (Bhaskaran, 1993; Nirwan et al., 2016; Timilsina et al., 2020; Mawar et al., 2021) but risk environmental harm.

Biological Control:

- Trichoderma viride, *T. koningii*, *T. harzianum*, and *Aspergillus* spp. exhibit antagonism (Bajwa et al., 2004; Bakshi, 1976).
- Eco-friendly botanicals and biocontrol agents are increasingly recommended (Tapwal et al., 2017;

Sheel et al., 2022; Kumari and Tapwal, 2023). A holistic approach—combining genetic improvement, ecological resilience, and companion species conservation—is vital for sustainability (Dangwal et al., 2014).

Conclusion and Future Perspectives

This study confirms significant *Ganoderma* incidence in *D. sissoo* across Himachal Pradesh and Jammu & Kashmir, with hotspots in Solan and Sirmaur at low-to-mid altitudes. Basidiocarps on symptomatic and asymptomatic trees indicate latent infections, emphasizing the need for early detection. Lower infection rates in Jammu & Kashmir may reflect earlier infestation stages or limited spread. The high virulence of isolates GL04 and GL09 from high-mortality zones necessitates integrated management. While trenching and stump removal offer short-term containment, and fungicides pose environmental risks, sustainable strategies must prioritize:

- Early detection systems.
- Disease-resistant planting stock.
- Ecological balance maintenance.
- Biological control agents.

International collaboration among scientists, policymakers, and forest managers is crucial. Long-term monitoring and research are essential to refine detection and mitigation, safeguarding *D. sissoo* productivity and biodiversity.

Referances:

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Xylotrechus smei: A Wood Boring Pest Threatening Red Sanders Cultivation and Conservation

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Importance of Red Sanders: Red sanders (*Pterocarpus santalinus*) are a timber-yielding tree species that is endemic to certain forest tracts of the Eastern Ghats, India. The tree is valued for its deep red coloured heartwood that mainly finds its use in making furniture and musical instruments. Besides, the heartwood contains santaline, which is generally used as a colorant in pharmaceutical and food preparations (*Kukrety et al., 2013*).Natural population of the species is dwindling in its native range, due mainly to the huge biotic pressure, reduced seed set and limited regeneration potential. Considering the drastic decline in wild population over three generations, the species was categorized as 'endangered' by the International Union for Conservation of Nature and Natural Resources (*Ahmedullah, 2021*). Cultivation of red sanders in private lands and public forestlands may help reduce the human pressure on wild populations (*Kukrety et al., 2013*).

Xylotrechus smei:

The longhorn beetle species-*Xylotrechus* smei (Laporte de Castelnau & Gory, 1841) was first described based on the specimen collected from India. The insect was documented in the Deccan region, Himachal Pradesh, Kashmir, Madhya Pradesh, the North Eastern India, Uttar Pradesh and West Bengal, of which the Deccan and the North Eastern regions are the major hotspots. The insect is a polyphagous pest infesting over 40 hosts including the economically important ones like Gmelina, mango, rosewood, sal, shisham and teak. Of the recorded hosts, the preferred ones for X. smei are Morus alba and Morus indica in the hot spot areas (***Kariyanna et al., 2019***). In recent times, the pest was intercepted in multiple entry ports in France and U.S. (***Roques et al., 2017; Wu et al., 2017***).

Infestation Spread in Indian Red Sanders:

In 2021, infestation of red sanders by the long horn beetle—*Xylotrechus smei* was observed in red sanders plantations in Khammam and Kothagudem districts, Telangana, with infestation percentage ranging from 0.6% to 2.5%. The age of infested trees ranged from 5 years to 20 years across plantations. Infested trees depicted crown drying and bark loosening from the main stem. Upon removal of the loosened bark, boreholes, mostly circular, and galleries were visible. However, obvious boreholes were not always visible from the wood exterior, probably because of the rough nature of red sander's bark. When the stem of infested trees was split open, creamy white grubs with well-developed broad head tapering towards apex and without legs were seen feeding the internal tissues, besides, galleries and frass. Pupa was exarate with spinules arranged on anterior 1/3rd of tergite 7. Adult beetles were 10.4 mm to 16.6 mm long with 1.3 time's wider prothorax than the head. Phylogenetic analysis based on *mt COI* gene sequences grouped the red sanders-infesting *X. smei* with the *X. smei* isolate intercepted in a port of entry in the United States (U.S.) and an X. Smei voucher specimen in the U.S. (*Sidharthan et al., 2022)*. In August 2023, occurrence of *X. smei* infestation in 2 to 16 year-old red sander plantations in Gujarat and Tamil Nadu was documented. Infestation percentage in these regions ranged from 2.2% to 10.9% (*Ashrith et al., 2024*). Considering the occurrence of the pest in atleast three states and the extent of damage the pest causes to red sanders, effective management strategies are to be devised for minimizing the pest damage.

> The tree is valued for its deep red coloured heartwood that mainly finds its use in making furniture and musical instruments.

Figure: Crown drying of infested trees (A), circular bore holes in drying trees(B), galleries in split-open wood (C), creamy white larva (D), pupa (E) and adult (F) of Xylotrechus smei infesting red sanders.

Acknowledgement:

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References:

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A Review on 'Sal Heartwood Borer (*Hoplocerambyx spinicornis*): A Devastating Invader to the Integrity of Central Indian Sal Forests'

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1. Abstract:

Shorea robusta Gaertn. f., commonly referred to as sal in India, is a prominent deciduous tree known for its resinous nature and attractive, glossy foliage. Among the pests infesting sal, The sal heartwood borer, *Hoplocerambyx spinicornis* Newman is considered to be the most destructive and notorious pest which is economically devastating the sal forests leading to the significant loss in terms of economy. Keeping in view the importance of sal in multiple dimensions, the present review was planned with a focus on the importance of sal, pest biology, mode of damage, host range, factors contributing to the outbreaks, preventive measures along with integrated management strategies which were discussed in detail.

1. Introduction:

Shorea robusta Gaertn. f., belonging to the family Dipterocarpaceae and commonly referred to as sal in India, is a prominent deciduous tree known for its resinous nature and attractive, glossy foliage (Anon, 1972). It is believed to have originated in India, with the northeastern region recognized as its native range (Kulkarni, 1956). Sal holds immense importance in the country, both as a keystone ecological species and a valuable source of timber (Tewari, 1995). Madhya Pradesh and Chhattisgarh, together, represent one of the largest sal-bearing regions in India, encompassing about 25,703 square kilometers, making up 16.54% of the total forested area (Anon, 2011). Major districts where sal forests dominate include Bastar, Raipur, Raigarh, Bilaspur, Surguja, Balaghat, Chhindwara, Mandla, Dindori, Anuppur, and Sidhi. These forests generate considerable forest produce annually, yielding around 2.5 lakh cubic meters of timber and 3 lakh metric tonnes of fuelwood. Moreover, the collection of sal seeds, a significant minor forest product in the region, reaches up to 50,000 tonnes per year, contributing an estimated 20 crores to the local economy (Anon, 1997). These forests are primarily concentrated in the eastern zones of these states and form a vital ecological zone in central and northern India, contributing significantly to local biodiversity and climate regulation.

Among the pests infesting sal, *Hoplocerambyx spinicornis* Newman (Coleoptera: Cerambycidae), widely recognized as the sal borer, is the sole Indian species within its genus and is considered one of the most destructive pests affecting sal forests. Its notoriety stems from the severe damage it inflicts on sal trees, making it a pest of major concern in forest management. The first report of this beetle as a serious pest came from a renowned forest entomologist, who documented its occurrence in the Singhbhum division of Chota Nagpur, Bihar (Stebbing, 1906). This species is oligophagous, with a strong preference for feeding on S. robusta (Stebbing, 1914; Beeson, 1941). Trees that are weak, stressed, or have diminished vitality are particularly susceptible to infestation and eventual death (Beeson, 1941). The interaction between the sal heartwood borer and its host tree has been more extensively studied than any other tree-insect relationship in India. The sal heartwood borer is known to cause widespread destruction in *S. robusta* forests by attacking both standing trees and freshly felled logs (Joshi *et al.*, 2002). This behaviour is strongly influenced by the kairomonal attraction exerted by sal tree sap (Roychoudhury, 1997; Kulkarni *et al.*, 2004).

A variety of biotic and abiotic stressors have been identified as contributing to the recurrent outbreaks of this pest (Joshi, 2009). The borer poses a threat to sal trees across all age classes, particularly those with a girth above 20 cm (Bhandari & Singh, 1988). However, trees with a girth range of 91–150 cm are the most frequently targeted, and the highest mortality has been recorded in trees with girths between 121–150 cm (Beeson, 1941; Roychoudhury *et al.*, 2004).

Outbreaks are considered epidemic when borer infestation exceeds the economic threshold level (ETL), which is defined as damage to more than 1% of the total tree population in a given area (Beeson, 1941). To date, over 21 major outbreaks have been documented in sal forests across various Indian states (Muir, 1929; Roonwal, 1952; Chatterjee & Thapa, 1964, 1970; Singh & Mishra, 1986; Bhandari & Singh, 1988; Bhandari & Rawat, 2001; Joshi et al., 2006; Roychoudhury, 2008). A significant epidemic occurred between 1997 and 2000 in the states of Madhya Pradesh and Chhattisgarh, affecting around 3 lakh hectares out of the total 16.84 lakh hectares of sal forests. The Mandla district was hit hardest, with an estimated 8 lakh trees damaged (Anon, 1997, 1998a, b). Additional reports have highlighted the presence and damage caused by the borer in Bastar Forest Division (Chhattisgarh) (Roychoudhury & Soni, 2009), and more recently in Dindori, East Mandla Forest Divisions, Kanha and Satpura Tiger Reserves (Madhya Pradesh), as well as Banhupratapur, Jagdalpur, and Kabirdham Forest Divisions (Chhattisgarh) (Roychoudhury & Kulkarni, 2012; Roychoudhury *et al.*, 2013a; Roychoudhury, 2015a).

Understanding the pest severity and devastating nature of these outbreaks, the current review was initiated to focus on the monitoring and early detection of *H. spinicornis*, identification of its natural enemies, evaluation of trap tree methods for beetle collection, and formulation of an integrated pest management (IPM) strategy for long-term control of this pest.

2. Review of Literature

The genus *Shorea* (Roxb. ex C.F. Gaertn.), part of the Dipterocarpaceae family, holds significant commercial value and is a dominant component of the lowland tropical rainforests across India, Indonesia, Malaysia, and the Philippines (Nair, 2007). Although the genus includes around 350 species (CABI, 2005), it has not been widely promoted for plantation forestry. Most planting efforts to date have been experimental, mainly focused on enrichment planting in degraded forest areas using naturally regenerated seedlings. However, since the 1950s, small-scale plantations of selected species have been developed in countries like Indonesia, Malaysia, and India.

In Indonesia, species such as *Shorea javanica, S. leprosula, S. parviflora, S. selanica,* and *S. smithiana* are known for their relatively faster growth and have been included in plantation programs (Cossalter and Nair, 2000). Malaysia has established plantations involving over a dozen species, including *S. leprosula* and *S. parviflora* (Appanah and Weinland, 1993). In India, Shorea robusta has been the primary species used in plantation forestry (Tewari, 1995). The Indian subcontinent is home to four native *Shorea species: S. assamica, S. robusta, S. talura,* and *S. tumbuggaia* (Troup, 1921; Anon, 1972).

2a. Tree profile

Shorea robusta Gaertn. f., a key member of the Dipterocarpaceae family, is widely distributed across more than 10 million hectares of forestland in central and northern India, spanning latitudes between 18°N and 32°N and reaching into the subtropical zone. Its natural range also includes the sub-Himalayan regions of Nepal, parts of Pakistan, and Bangladesh (Anon, 1972). The species is known for its gregarious growth habit and under optimal conditions, can grow up to 30 meters tall. It thrives in a broad elevation range, from near sea level (10 m) up to elevations exceeding 1500 m, and adapts well to annual rainfall between 1000 and 3000 mm. It is also tolerant of extreme temperatures, surviving both intense heat up to 45°C and cold down to 0°C.

The tree yields dense, durable timber that is highly valued in construction, especially for railway sleepers and mining supports. When damaged, it secretes a resin known as sal dammar, commonly used as incense. Traditionally, *S. robusta* has been managed using the shelter wood system, relying on natural regeneration. The species also exhibits strong coppicing ability, and coppice systems with rotations of 40, 60 or 80 years are commonly practiced, including scheduled thinning interventions.

2b. Overview of insect pests

Entomological studies on sal have been a focal point of forestry research in India since its early days (Stebbing, 1914; Beeson, 1941), largely due to the tree's susceptibility to a wide range of insect pests. Among forest tree species, sal hosts one of the highest diversities of insect fauna. Out of the approximately 346 insect species documented on sal, around 155 are associated with the living tree. These include primarily defoliators (108 species), followed by wood borers (20 species), seed feeders (17 species), and sap-sucking insects (4 species) (Stebbing, 1914; Beeson, 1941; Mathur and Singh, 1960; Browne, 1968; Srivastava *et al.*, 1984; Sen-Sarma and Thakur, 1994; Thakur, 2000; Nair, 2007; Roychoudhury et al., 2012, 2015b). The remaining insect species are associated with dead, felled, or decaying sal wood, including species that specialize in decomposing or rotten timber.

Despite this diversity, *S. robusta* in India does not generally face severe pest threats, with the exception of occasional outbreaks of the cerambycid trunk borer *H. spinicornis*, which remains the most significant insect pest of concern till date.

2c. Pest profile

Hoplocerambyx spinicornis Newman (Coleoptera: Polyphaga: Longicornia: Cerambycidae: Cerambycine), commonly known as sal heartwood borer, is a serious pest of S. robusta in India. It bores into the stem of sal trees and is the most notorious forest pest of India because of its periodic outbreaks, during which millions of sal trees are killed. The adult beetle is dark brown and variable in size, measuring 20-65 mm in length. In the male, the antennae are much longer than the body, whereas in female, the antennae are shorter than the body. The full-grown larva is large, measuring up to 9 cm in length. Pest exhibits clear sexual dimorphism (Fig. 1).

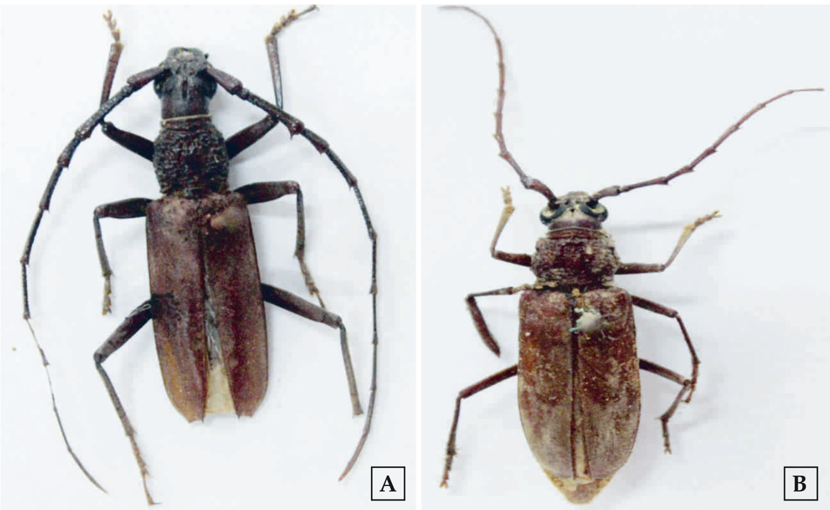

Fig. 1. (a). Male (b). Female

2d. Host range and geographical distribution of sal borer

The sal heartwood borer is recognized as the primary pest of *S. robusta*, with population outbreaks reported exclusively on this host. Nevertheless, it has also been observed to infest other species within the Dipterocarpaceae family, including *Anisoptera glabra*, *Dipterocarpus tuberculatus*, *Hopea odorata*, *Parashorea robusta*, *P. malaanonan*, *P. stellata*, *Pentacme suavis*, *Shorea assamica*, *S. obtusa*, *and S. siamensis.* Additionally, it has occasionally attacked trees outside this family, such as *Duabanga grandiflora* (Sonneratiaceae) and *Hevea brasiliensis* (Euphorbiaceae) (Beeson, 1941; Browne, 1968; Appanah and Turnbull, 1998; Thakur, 2000).

This species is broadly distributed across Central, South, and Southeast Asia. Its range includes countries such as eastern Afghanistan, Pakistan, India, Nepal, Bhutan, Bangladesh, Myanmar, China, Singapore, Thailand, Indonesia, Malaysia, and the Philippines (Beeson, 1941; Roonwal, 1978; Hutacharern and Tubtim, 1995; Appanah and Turnbull, 1998). Within India, the beetle's occurrence is largely restricted to the sal-dominated forests of the northern and northeastern regions.

2e. Life Cycle, Ecology, and Damage Caused by Sal Borer

The biology and control of the *H. spinicornis*, have been extensively studied since the early 20th century (Stebbing, 1906; Beeson and Chatterjee, 1925; Beeson and Bhatia, 1939; Beeson, 1941; Roonwal, 1978; Thakur, 2000; Bhandari and Rawat, 2001; Joshi et al., 2006). Adult beetles emerge annually following the onset of the southwest monsoon, typically in June or July. Successive showers over a two-month period trigger new waves of emergence, and by the end of this period, most beetles have exited from the host tree trunks (Fig. 2).

After emergence, adults mate quickly, and females begin ovipositing roughly a week later. Egg laying occurs in crevices, cuts, or natural wounds in the bark, often targeting trees that are recently dead or significantly weakened. However, during epidemic outbreaks, even healthy trees may become hosts. A single female can lay between 100 and 300 eggs during her month-long lifespan, although fecundity may reach up to 465 eggs under high relative humidity conditions (91%) (Beeson and Bhatia, 1939; Beeson, 1941).

Upon hatching, larvae begin feeding beneath the bark before progressing into the sapwood and eventually tunneling deep into the heartwood. Many larvae are naturally eliminated by the tree's resinous defenses, especially in healthy trees, where resin traps the young larvae. The survival and establishment of larvae depend on both tree vigour and larval density, which influence the host's capacity to resist attack. While over a thousand eggs may be deposited on a single tree, a large sal tree can typically support the development of approximately 300 beetles.

A distinct sign of infestation is the appearance of coarse wood dust ejected from the trunk, which forms noticeable mounds at the tree base (Fig.3). Larvae complete their development by around November and construct a pupal chamber within the heartwood, preparing an exit hole. Pupation occurs inside this chamber and by May or June, the adult beetles are fully formed but remain inactive until the onset of the next monsoon, resulting in an annual life cycle.

The larval galleries disrupt the vascular system by girdling the sapwood, which can cause partial or complete death of the tree. Although sal trees attempt to resist with heavy resin flow, mass larval attacks during outbreaks often overcome these defenses. Damage is not confined to the main trunk alone; crown branches are also affected. In heavily infested trees, around 60–70% of the borer population is found in the trunk and 30–40% in the crown branches (Beeson, 1941).

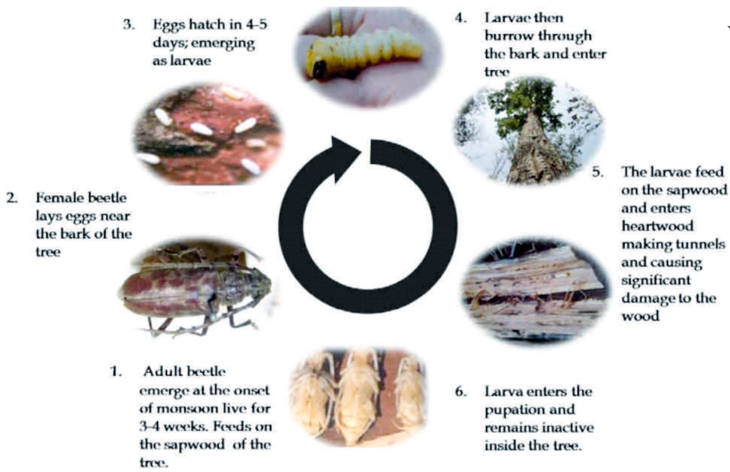

Fig. 2 (a). Life cycle of sal heartwood borer, *Hoplocerambyx spinicornis*

(b). Eggs, Newly hatched grub, Fully grown grub and Exarate pupa

Fig. 3. Typical symptoms of attack: Pile of coarse wood dust at the tree base (a); View of borer infested sal trees from a distance (b); Sal logs with galleries of sal borer (c).

2f. History, Impact, and Population Dynamics of Sal Borer Epidemics

The sal borer, *H. spinicornis* was first identified as a pest of sal in 1897 in the Chota Nagpur region of Bihar (Stebbing, 1914). Since then, several outbreaks of varying intensity have occurred across its geographical range in India. These ranged from localized, short-term infestations to prolonged epidemics lasting up to five years, resulting in the widespread death of sal trees. The first recorded epidemic, defined by damage to over 1% of the total sal stock, occurred in 1916 in the Thano forests of Dehradun, Uttarakhand. Here, adult beetles infested live trees, and their larvae tunneled into the sapwood, often girdling the tree and causing its death. By 1924, over 63,000 sal trees in a 3-acre area had been affected. In subsequent years, outbreaks were also recorded in Kalagarh, Ramganga Valley, and Timli and Lambirao ranges, with thousands of trees being felled to control the spread. Major epidemics occurred again in 1975–77 and between 1994–2000.

In Madhya Pradesh, sal borer infestations were first noted in Balaghat in 1905. Between 1914 and 1915, hundreds of trees were affected in Mandla division. An epidemic broke out in 1922–23 in Karanjia and adjoining ranges like Dindori and Banjar, leading to the felling of over 2.5 lakh trees by 1927–28. Although the situation stabilized for a time, repeated flare-ups occurred in the following decades, especially in Karanjia, Baihar, and Supkhar ranges.

Beeson and Bhatia (1939) documented sal borer infestations across diverse forest regions including the Garo Hills, Dambu Reserve, and Lakhimpur in Assam; Buxa, Jalpaiguri, Kalimpong, and Kurseong in West Bengal; Bonai and Sambalpur in Odisha; various ranges in Chhattisgarh, Jharkhand, and Madhya Pradesh; as well as parts of Uttar Pradesh, Uttarakhand, and Himachal Pradesh.

From 1949 onwards, trap tree operations were used as a preventive strategy. These involved felling healthy trees to lure beetles, which helped monitor and reduce borer populations. Despite such efforts, outbreaks resurfaced in the 1960s and again in 1976 in Pachmarhi. A particularly severe outbreak occurred from 1994 to 2000, beginning in the Dindori Forest Division. By 1996, the infestation had spread across more than 4,500 sq. km, impacting over 3 million trees in Madhya Pradesh and neighbouring Chhattisgarh.

During this outbreak, the population density of borer-infested trees increased significantly—from 8.64% in late 1996 to 22.07% in 1997. Management efforts such as beetle trapping and removal of affected trees were intensified from mid-1997. Favourable environmental conditions, including irregular rainfall and fluctuations in humidity and temperature, along with the activity of natural enemies, contributed to a significant decline in the pest population by 1998. By 2000, infestation levels had dropped below 1%..

In Jharkhand, early sightings of sal borer occurred in Singhbhum in 1899 and again in 1906, with subsequent outbreaks in Palamau. In Assam, Goalpara and Nowgong reported infestations in 1906 and 1961, respectively. In West Bengal, outbreaks were recorded in Kurseong (1931–34) and Rajabhatkhawa (1974), with thousands of trees affected. Himachal Pradesh experienced its first known outbreak between 1948 and 1954 in the Lahan region.

The frequency and duration of outbreaks have varied widely. For example, Mandla district in Madhya Pradesh experienced outbreaks during 1950–55, again in 1959–62, and then after a long gap in 1994–2000. The intervals between epidemics ranged from one to 32 years, and the outbreaks themselves lasted from one to eight years. Although control strategies such as trap tree operations and environmental factors played roles in regulating populations, the outbreak patterns remain unpredictable.

One of the most significant outbreaks (1994–2000) demonstrated how rapidly populations could escalate. Beginning around Chada in Dindori after the 1994 monsoon, borer numbers surged in the following years. In 1996, trap trees yielded 2.15 million beetles, increasing dramatically to 15 million by 1997, illustrating the explosive reproductive potential of this pest under conducive conditions.

3. Factors Contributing to Sal Borer Outbreaks

Sal forests have experienced tree mortality since the early 20th century (Troup, 1921). Observations from various regions indicate that several environmental and biological factors such as fire, overgrazing, drought, frost, insect infestation, fungal infections, and nutrient deficient soils contribute significantly to tree decline and vulnerability (Pandey, 1956; Boyce & Bakshi, 1959; Khan & Yadav, 1961).

Numerous researchers (Beeson, 1941; Roonwal, 1978; Tewari, 1995; Thakur, 2000; Bhandari & Rawat, 2001; Nair, 2007; Joshi, 2009; Joshi et al., 2013) have proposed the following key factors that drive the rapid multiplication and outbreak of the sal heartwood borer:

i. Tree Age and Health

Younger sal trees, typically below 9 meters in height, have smooth bark lacking fissures, which makes them less suitable for beetle egg-laying. As a result, these trees are generally avoided. In contrast, older, weakened, or diseased trees especially those affected by lopping, fire, frost, heart rot or over maturity are more susceptible (with stem girth >80cm are preferred). Pure stands of even-aged sal trees are more prone to borer infestation than mixed or uneven-aged stands with associated species.

ii. Site Conditions

Soil quality and other site-related factors are crucial for the healthy growth of sal trees. Vigorous trees growing in nutrient-rich soils are less likely to be attacked. Sal forests near human settlements often suffer more borer damage due to increased biotic pressure from grazing and human disturbances compared to remote forest areas.

iii. Climatic Conditions

The sal borer is endemic to sal-dominated forests across India. Annual rainfall plays a significant role in tree stress and susceptibility to borer attacks. Beetle emergence typically coincides with the onset of monsoon rains. Continuous light rain and overcast weather reduce temperatures and raise humidity conditions that favour beetle longevity, dispersal, and egg-laying. High humidity within larval and pupal tunnels enhances grub metabolism and leads to the emergence of robust, highly fecund adult beetles.

Field studies from June to July 1997 in Jagatpur (Madhya Pradesh) showed that consistent rainfall led to peak egg-laying. Conversely, abrupt heavy rains in mid-July 1998 disrupted humidity, causing a temporary halt in egg-laying and leading to some grub mortality due to desiccation. Similar rainfall patterns in August 1999 led to high egg and larval mortality, while reduced beetle trap catches in 2000 reflected lower population build-up.

iv. Forest Hygiene Practices

Monsoon-triggered emissions from freshly broken or damaged sal trees attract beetles from distant areas. These trees often become oviposition sites, resulting in heavy egg deposition. Therefore, prompt removal and disposal of such trees during winter is essential. Additionally, leftover lops and tops from felled trees should be cleared as they provide hiding spots for beetles and facilitate infestation.

v. Natural Enemies

While natural enemies do exist, their impact on controlling sal borer populations is limited. Grubs may sometimes be killed by fungal pathogens such as *Beauveria bassiana* and *Metarhizium anisopliae*. Parasitoid wasps like *Exobracon maculipennis*, *Disophrys dehraensis*, and *Iphiaulax immsi* have been documented to parasitize the larvae (Chatterjee & Misra, 1974). Predatory beetles like *Alaus* sordidus feed on grubs within tunnels (Kulkarni and Chander, 2022). In Central India, the golden-backed woodpecker (*Brachyptermas benghalensis*) preys on grubs and jungle crows (*Corvus macrorhynchos*) feed on adult beetles in forests and timber depots. However, these natural enemies typically fail to regulate borer populations during outbreaks due to their relatively slow population growth compared to the rapid reproductive potential of the pest.

4 Management of Sal Borer (*H. spinicornis*)

The sal borer is a chronic, endemic pest commonly found in sal forests, typically attacking weakened, fallen, or dying trees. Healthy, living trees are usually affected only during population outbreaks. A baseline infestation of about 1% of the growing stock approximately 2.5 trees per hectare is considered normal. Any population exceeding this threshold signals the onset of an outbreak. Management strategies are directed at two primary goals: (1) preventing outbreaks by maintaining infestation levels below the acceptable limit, and (2) implementing control measures during outbreaks to minimize damage.

To aid in decision-making, infested trees are categorized into seven types based on the severity of infestation (Beeson, 1941), with type 1 being nearly dead and type 7 showing early signs of attack. Forest management guidelines recommend felling trees classified as types 1, 2, 3, and 6 during control operations. Types 4 and 5 may be skipped in partial clean-up operations, while type 7 trees are not to be felled.

4a. Preventive Strategies

Prevention focuses on reducing susceptible trees through silvicultural practices and eliminating existing beetle populations. Key actions include:

- Regular winter patrols to detect and remove unhealthy, fallen, or infested trees, as indicated by resin exudation and wood dust.
- Timely thinning to prevent over-dense stands and harvesting trees once they reach commercial maturity, rather than prolonging their growth.
- Restricting felling to the period between October and March when adult beetles are inactive.
- Debarking all felled stems with a diameter above 20 cm to prevent larval development.

4b. Remedial Measures

Remedial actions include the felling and disposal of heavily infested trees and trapping adult beetles to suppress their reproduction and spread.

4c. Felling and Disposal:

Post-monsoon surveys are conducted to identify and classify infested trees by severity. Depending on the extent of infestation and available resources, felled trees may be processed on-site, stored, or burned. Debarking can eliminate larvae in early stages. Moderately infested logs are treated with insecticides and covered in polythene sheets to kill emerging beetles. Severely infested logs should be burnt efficiently with adequate ventilation and dry wood

4d. Trapping Beetles:

Adult beetles are highly attracted to fresh sap from sal bark. The 'trap tree' method exploits this behaviour. Undesirable or lightly infested trees are felled and cut into billets, with the bark loosened at both ends to encourage sap flow. Beetles gather in large numbers to feed on the sap and are then manually collected and destroyed. Trap billets are refreshed every few days to maintain attractiveness, and remain effective for 8–10 days. Local labour is often employed for beetle collection, paid per beetle head collected.

4e. Effectiveness and Research Insights

Both preventive and remedial measures can be effective if consistently implemented. Outbreaks may still occur due to lapses in preventive practices. Although outbreaks tend to subside naturally over time due to resource depletion, environmental factors, or predator buildup remedial actions like beetle trapping significantly reduce pest populations. For instance, during the 1994–2000 outbreak in Madhya Pradesh, around 63 million beetles were destroyed between 1996–2000, potentially preventing severe damage.

However, large-scale tree felling as a control method has faced criticism, particularly for its environmental implications. Some argue that felling may be as damaging as the pest itself. Dey (2001) observed that trees with dead crowns failed to recover, but 52–70% of trees with partially or fully live crowns survived the infestation. Interestingly, trees showing only resin exudation (without wood dust) often resisted the attack and harboured only dead larvae beneath the bark, indicating natural defense mechanisms.

5. Recent Studies and Future Directions

Regular monitoring and categorizing affected trees, identifying predators and parasitoids, evaluating trap tree efficacy, forest sanitation practices, kairomonal properties of sal bark, pesticide treatments, and entomopathogenic fungi is the need of the hour (Roychoudhury *et al.*, 2013b; Sharma and Joshi, 2004). Given the economic and ecological importance of *H. spinicornis*, continued research is essential on understanding important aspects of pest dynamics, insect-host interactions and the role of natural enemies which can help refine and improve integrated pest management approaches to safeguard sal forests from future insect threats and to protect the ecosystem stability.

6. Conclusion

The sal heartwood borer (*Hoplocerambyx spinicornis*) continues to pose a serious threat to the health and stability of sal forests in Central India. Its outbreaks are closely linked to factors such as tree age, poor site conditions, changing climate, and lapses in forest hygiene. While natural enemies and preventive measures can help reduce its impact, timely detection and integrated management practices remain critical. Strengthening forest health through silvicultural interventions, early removal of infested trees, and use of trap trees can significantly reduce sal borer populations. Continued research and monitoring are essential to refine management strategies and preserving the health and productivity of sal forests over time.

References:

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Insect-Pest Complex of Eucalyptus: Implications of Forest Health and Management Strategies

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Introduction

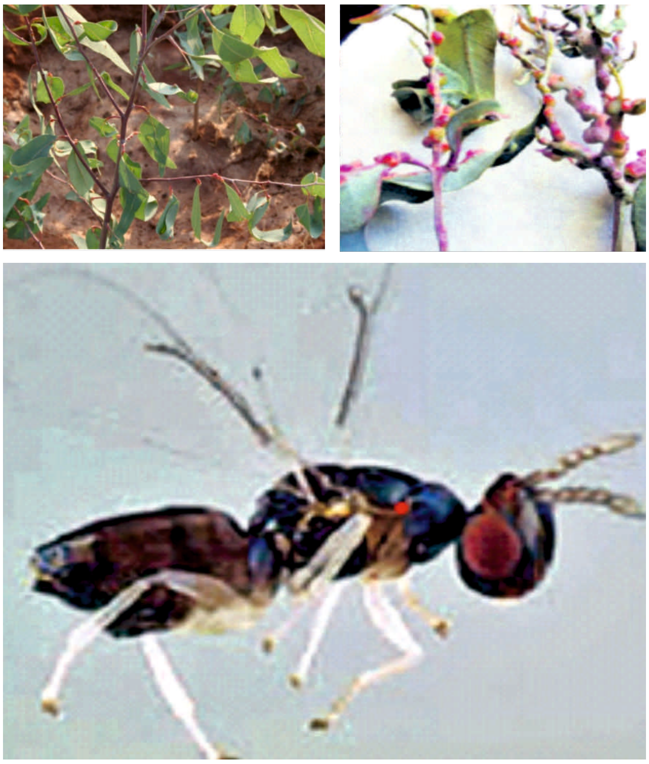
Eucalyptus is most successful world's exotic multipurpose fast grown tree species, which has already reached in more than 110 countries. Eucalyptus has a long history in India. It was first introduced around 1790 by Tippu Sultan, the ruler of Mysore, who received seeds from Australia and planted about 16 species in his palace garden on Nandi Hills near Bengaluru. (Sundar, 1984). Subsequent to the planting at Nandi Hills, the next significant introduction of Eucalyptus was in the Nilgiri hills, Tamil Nadu, in 1843. Regular plantations of *E. globulus* were raised since 1850s for meeting the demands for firewood, timber and pulpwood in various parts of the country. Species which are grown on plantation scale are *E. tereticornis, E. camaldulensis, E.pellita, E. globulus* and *E. grandis*.

Although Eucalyptus attracts a large number insect only few of them are serious pests of economic concern in India as well as in native land (Nair, 2007). Due to a prolonged ecological association with eucalyptus, some of the native phytophagous pestshave adopted eucalyptus as a favorable host. As a result, presently a number of insects have been found associated with different species of Eucalyptus in India causing debility/injury in varying degrees. Few among them are stem and root borer, *Celosterna scabrator*, Bark eating caterpillar,*Indarbela quadrinotata*, Gall wasp, *Leptocybe invasa* and termites, *Odontotermes* spp. The present paper explains the implication ofmanagement measures for key insect pestsofeucalyptus in the nurseries and plantations.

1. Blue gum chalcid or Gall wasp, *Leptocybe invasa* (Hymenoptera: Eulophidae)

Gall wasp damages seedlings at the nursery and saplings or young trees in the plantations. The main symptoms are galls formation on the mid-rib ofthe leaves, the leaf petioles and rarely in the stem. Succulent mass formation in the form of gall in the entire leaves makes the branches heavy and plants start bend. Severely infected branches or trees at the middle break causing economic loss.

Management: The adult wasps are very small and spread with wind. Movement of susceptible planting material along with infestation is the major caution for spreading of the insect. Hence efforts must be taken to prevent transportation of infected seedlings from nurseries to un-infested areas. Affected plant parts should be removed and burned along with fallen leaves.Use of yellow and green coloured sticky traps are effective to certain extent. Application of systemic insecticides Confidor[TN] Imidacloprid @ 1ml/lit or Tafgor[TN] Dimethoate @ 2ml/lit after every two weeks reduces the infestation in the nursery.



Infestation of gall wasp on eucalyptus leaves and leaf stalks (petioles)

2. Stem borer, *Celosterna scabrator* (Lamiidae: Coleoptera)

Adult attack the tender shoots of the plant, scarping and feeding the bark up to sap wood, killing the shoots or breaking them out right. Eggs are laid one each on 1-4 year old living plants, Grubs bores in stem and roots which are hallowed out. Waste materials comes out of the ejection holes. Attacked plants show wilting and yellowing. *E. citridora, E. tereticornis* and *E. grandisare* found to be susceptible for this pest. The Stem borer (*C. scabrator*) is widely distributed in India, Karnataka, Maharashtra, Tamil Nadu, Kerala and Andhra Pradesh.

Stem borer, *Celosterna scabrator*

Management: Clearing tunnels and application of insecticides, such as Danitol® - Fenpropathrin 10% EC @ 2ml/litre, or use fumigants chloroform or aluminium phosphide once in two months will be effective. Microbial agents Multiplex *Metarhizium anisopliae* (1x109 CFU's/ml) @10ml/lit of watercan also be used through spraying and stem smearing, or Spot application of Meothrin[TN] Fenpropathrin, 30% EC @2ml/litre.

3. Bark eating caterpillar, *Indarbela quadrinotata* (Lepidoptera: Cossidae)

The bark feeder has been found to feed on the bark and some sapwood. Poorly maintained plantations are more prone to this pest. Peak activity period of this pest is September to October.Infestation can lead to stunted growth, weakened tree trunk and increased with chance of wind break.

Management: Collect and burn the loose and damaged bark as well as affected branches. The caterpillars may be physically removed or killed by inserting an iron spike into the shelter holes on the first incidence once seen in few numbers. Clean the affected portion of the trunk and insert into the hole a swab of cotton wool soaked in fumigant like chloroform, petrol, Kerosine and plugging hole with mud. Spot application of Meothrin[TN] Fenpropathrin, 30% EC @2ml/litre or Danitol® - Fenpropathrin 10% EC @ 2ml/litre can control the further infestation.

4. Termite, *Microtermes* spp. & *Odontotermes* spp (Isoptera: Termitidae)

Eucalyptus trees are susceptible to termite infestations, particularly during the seedling and early growth stages, which can lead to significant damage and mortality. Termite attacks can sever the root system, leading to plant death, especially in young saplings (one year old plantation). *E. grandisis* prone to termite attack. Other species known to be susceptible are E. citriodora and E. robusta (Chatterjee *et al.*, 1967; Roonwal 1978).

Damaged tree trunk

Termite nibbled on the bark portion of eucalyptus

Management: Removing dead wood and plant debris in field: to minimizes termite infestation. Avoid water stress conditions. Destroy the termite mounds in the vicinity of plantation and treat the spot with Chlorpyriphos. Frequent watering can help manage termites in a field by making the soil less attractive to them. After the seedlings have become established in containers and before they are planted out, drench the seedlings with water emulsion of Dursban Chlorpyrifos 20% EC @ 2 ml/lit of water.

Conclusion

The insect-pest complex of Eucalyptus species presents ongoing challenges; effective forest management strategies can mitigate insect pests threats. By adopting a comprehensive, IPM-based approach that combines cultural, mechanical, biological control, sustainable pesticide use and legal control practices can improve the resilience of eucalyptus forests and ensure their long-term ecological and economic value. The integration of climate change considerations and continued research will be critical in adapting to future challenges and maintaining the health of these globally importanttree species.

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Major Insect Pests of Poplar in Agroforestry Systems and Their Management Strategies

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Abstract:

Poplar is fast-growing economically important agroforestry tree species extensively cultivated in north-western India. It has become integral to regional agroforestry due to its superior growth and timber yield. Clones G-3, G-48, and D-121 have been widely adopted for large-scale cultivation across states such as Punjab, Haryana, Uttar Pradesh, Uttarakhand, and Himachal Pradesh. Poplar cultivation provides substantial economic returns, supports diverse ecosystem services, and is extensively intercropped with agricultural crops. However, poplar plantations face significant challenges from insect pests, with several studies documenting a diverse pest complex. Among these, four species—*Clostera cupreata, Clostera fulgurita, Phalanta phalantha,* and *Apriona cinerea*—are recognized as major pests due to their wide distribution, high incidence, and severe damage. While *C. cupreata, C. fulgurita, and P. phalantha* primarily act as defoliators causing extensive leaf damage, *A. cinerea* is a destructive stem borer leading to structural damage and tree mortality. Understanding the pest dynamics is crucial for sustainable management and continued productivity of poplar-based agroforestry systems in north-western India.

Keywords: Poplar, agroforestry, insect pest, control, management POPLAR final-HFRI

Introduction

In early 1950s, exotic, fast-growing *Populus deltoides* commonly called Poplar was introduced in northwestern India (Mathur and Sharma, 1983), primarily to address the growing commercial demand for timber. Indigenous *Populus* taxa such as *P. ciliata* Wall. ex Royle, *P. gamblei* Dode, *P. jacquemontiana* Dode var. *glauca* (Haines), *P. alba* Linn., *P. nigra* Linn., and *P. euphratica* Oliv. were found to have limited ability in agroforestry systems within this region, largely due to their poor adaptability to local environmental conditions (Tiwari, 1993) and relatively slow growth performance compared to their exotic counterparts. Among the various P. *deltoides* clones evaluated, clones G-3, G-48, and D-121 were identified as the most productive in terms of growth performance and timber yield (Chaturvedi, 1981). Consequently, these clones were adopted for large-scale cultivation in the region.

Poplar plays a vital role in agroforestry systems across northwestern India, particularly in states such as Punjab, Haryana, Uttar Pradesh, and Uttarakhand and foot hills of Himachal Pradesh. Its fast growth, compatibility with agricultural crops, and high commercial value make it a preferred species among farmers. *P. deltoides* is cultivated in boundary plantings, blocks and rows of trees in cropped areas and also intercropped with annual crops throughout this region. Its timber is highly versatile and is used for a wide range of purposes, including matchwood, plywood, particle boards, cardboard, crates, pulp, packing materials, pallets, furniture, planks, and fuel wood. Poplars offer profit i.e., cash return to people and communities who are engaged in their cultivation and management. The estimated annual returns from its cultivation are up to 250,000 rupees per hectare per year (Kumar and Singh, 2012). It also provide various ecosystem services such as supplying food, offering habitat for number of fauna, and helps in protecting soil water and crops (Dhillon, 2020). About 2.7 lakh hectares of agroforestry systems in India are used for poplar production, which is an essential part of farm forestry and has substantial economic value. At an estimated Rs. 1.5 lakh per hectare annually, it offers farmers significant returns (Kumar et al., 1999). Despite its advantages, insect pests pose a serious threat to Populus species, as they are a key biotic factor limiting plantation productivity globally. Populus spp. have been linked to 164 insect pest species in India alone, with 65 of these species being particularly detrimental to Populus deltoides (Ahmad and Faisal, 2012; Kumar et al., 2022). As documented by Dickmann and Stuart (1983), Singh and Singh (1986), Coley et al. (2005), Kumar et al. (2022), only few of these pests are regarded as severe concerns that have the ability to drastically reduce tree growth and increase mortality rates.

Insect pests of Poplar

Poplar trees are susceptible to a range of insect pests that can significantly affect their health and productivity. Initialy, Mathur and Singh (1960) documented 42 insect species that cause damage to poplar trees and their timber. Later, Singh and Singh (1975) identified 17 species as important pests of poplars in India. Sen-Sarma and Gupta (1979) listed 33 insect pests of poplar, highlighting the significant impact of *Apriona cinerea* Chevrolat, *Clostera cupreata,* and *Clostera fulgurita*. These species were noted as major contributors to poplar damage. Rishi (1979) recorded 32 insect pests in the Kashmir Valley, emphasizing the seriousness of *Lymantria obfuscata* (Indian Gypsy Moth – a defoliator) and *Aeolesthes sarta* (Quetta Borer – a xylophagous insect) as major pests of hill poplars. Verma et al. (1980) reported 55 insect species affecting poplars in Himachal Pradesh. These included species from several orders: Lepidoptera (16), Coleoptera (13), Hemiptera (13), Isoptera (4), and nine species from other orders. Their study also provided details on the nature and extent of damage caused by these pests, as well as possible control measures. 16 insects were identified by Singh & Singh in 1986 which includes *Aeolesthes sarta, Macrotoma crenata, Quadraspidiotus perniciosus, Lymantria obfuscata, Neocerura wisei, Euproctis signata, Pyrausta diniaslis, Eucosma glaciata, Apriona cinerea, Plagiodera versicolora, Clostera cupreata, C. fulgurita, Malacosoma indica*. Grubs are significant from an economic standpoint as poplar pests in this region's nurseries, plantations, and wild stands. Singh et al., 2004 have identified eight insects as important insect pests namely *Clostera cupreata, C. fulgurita, Apriona cinerea, Acostis seleneria, Eucosma glaciata, Phalantha phalantha, Nodostoma waterhousie* and white grubs were identified as important pests.

Four species namely, *Clostera cupreata, Clostera fulgurita, Phalanta phalantha* and *Apriona cinerea* are designated as as major pests of *Populus deltoides* in north western India based on their widespread distribution, significant damage and high incidence in poplar based agroforestry in north-western India. *C. cupreata, C. fulgurita,* and *P. phalantha* are major defoliator insect pests of Populus deltoides, causing extensive damage to the foliage by feeding on the leaves. In contrast, *A. cinerea* is a stem borer, which damages the tree by boring into the trunk, leading to structural weakening and potentially causing tree mortality (figure 1).

C. fulgurita* and *C. cupreata are major defoliators of poplar trees, causing significant damage especially in the Tarai region of Uttarakhand. Epidemic defoliation events have been regularly reported in this area since 1966 (Seth, 1969), with *C. cupreata* identified as a key species responsible for large-scale infestations. These insects attack many poplar species, with *Populus deltoides* being the most heavily affected, experiencing nearly annual epidemic defoliation in certain locations. Additionally, *C. cupreata* also defoliates *P. ciliata* in Jammu and Kashmir (Singh and Singh, 1986). The infestation typically begins between March and April, when the female moth lays eggs in large groups of 200-300 on the leaf surfaces. The life cycle of *C. cupreata* completes within 19-20 days, allowing for 8 to 9 generations annually in the plains, which contributes to its rapid population build-up and severe damage to poplar foliage.

P. phalanta is a common butterfly species found on fast-growing poplar trees, particularly in the Tarai region of Uttarakhand. Its infestation on poplar was first reported by Rawat (1981). The larvae of *Phalanta phalanta* feed on the leaves of poplar trees, contributing to defoliation alongside other leaf-eating insects.

A. cinerea stem and root borer is the most common and economically significant xylophagous insect affecting poplar, especially in north-west India. This pest attacks a wide range of poplar clones and hybrids, including *Populus 'Casale', P. 'Robusta', P. nigra, P. x-euramericana, P. 'regenerata', and P. yunnanensis* (Sen-Sarma and Gupta, 1979). Adult beetles feed on the bark and young shoots, while the young larvae hatch and bore into the central pith region of the stem, tunneling downwards and ejecting frass, which accumulates at the base of the tree. The larva continues tunneling from the stem into the roots, eventually emerging as an adult beetle through a circular hole above ground. The life cycle of the stem and root borer spans approximately two years (Chatterjee and Sen-Sarma, 1968). Young poplar plants up to three years old are particularly vulnerable to attack, whereas mature trees are generally resistant. In sub-montane regions of Punjab, up to 5% of young trees have been reported as severely affected by this pest (Sohi, 1990). Infested trees weaken and become prone to breakage by wind. The beetle also has collateral hosts including apple, mulberry, fig, and willow (Chatterjee et al., 1969).

Although the majority of insect pests in poplar plantations are naturally regulated by existing natural enemies, certain species have the ability to multiply rapidly and exceed economic injury levels, particularly in the absence of effective natural enemies and under

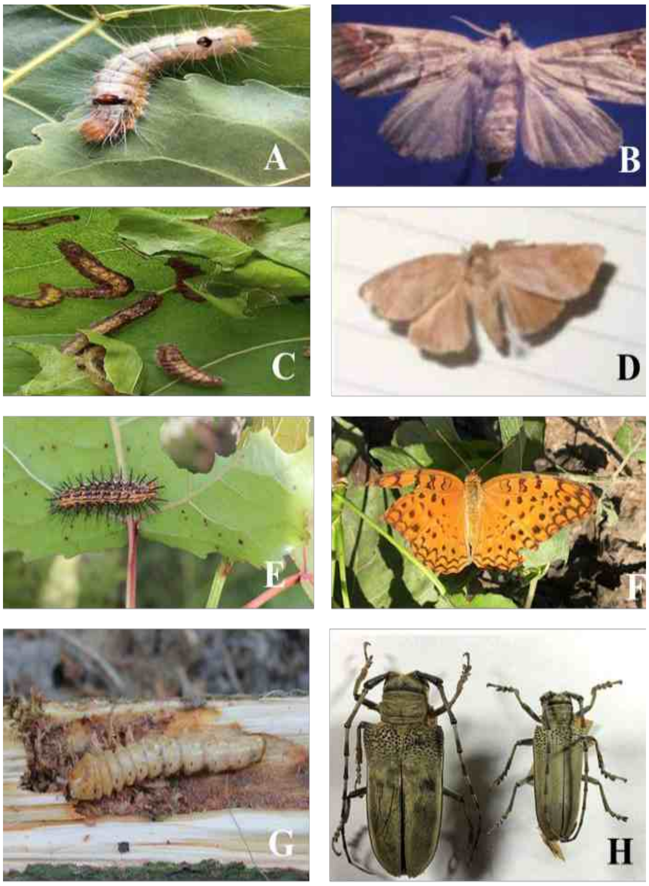

Figure 1:
A) Larvae of *C. fulgurita*, B) Adult of *C. fulgurita;*
C) Larvae of *C. cupreata*, D) Adult of *C. cupreata;*
E) Larvae of *Phalanta phalantha;*
F) Adult of *Phalanta phalantha;*
G) Larvae of *Apriona cinerea;*
H) Adult of *Apriona cinerea*

favourable climatic conditions. This highlights the need for proactive and integrated pest management strategies to prevent outbreaks and sustain plantation health. It has become essential to adopt integrated pest management (IPM) strategies. These strategies aim to maintain pest populations below economic injury levels (EIL), minimizing damage while reducing reliance on chemical inputs. Historically, various chemical insecticides have been used for managing insect pests in poplar plantations. Some of the commonly applied chemicals included: BHC (Benzene hexachloride), DDT (Dichlorodiphenyltrichloroethane), Lindane, Chlordane, Aldrin, Bidrin. Many of these insecticides are now banned or restricted due to their persistence in the environment, bioaccumulation, and toxic effects on non-target organisms, including humans. By integrating multiple control methods, IPM not only helps protect the health of the poplar ecosystem but also promotes sustainable and eco-friendly agroforestry practices. Given the environmental and health concerns associated with these chemicals, IPM in poplar agroforestry now emphasizes a holistic approach that includes: monitoring and surveillance of pest populations, biological control using natural enemies such as parasitoids and predators, cultural practices like proper spacing, sanitation, and pruning, mechanical control, e.g., removal of infested plant parts, botanical insecticides and microbial agents (e.g., *Bacillus thuringiensis*) and judicious and targeted use of safer, newer-generation insecticides when necessary.

The use of microorganisms for pest suppression is gaining importance as an eco-friendly alternative to chemical pesticides, which often have harmful environmental effects. In the case of *Clostera fulgurita*, a major defoliator of poplar, natural epizootics have been observed among its immature stages, indicating the presence of a biological control agent. Sen-Sarma and Ahmad (1984) isolated a disease-causing pathogen from infected larvae, identified as a nucleopolyhedrovirus (NPV) belonging to subgroup A of the genus *Baculovirus*. This virus is host-specific, making it a promising biological control agent. Infected larvae exhibited symptoms such as discoloration and rapid disintegration. The virus produced a high number of polyhedral inclusion bodies (PIBs), ranging from 0.37 × 10 to 2.92 × 10 PIBs per larva, indicating a strong potential for effective suppression of the pest population under natural and managed conditions.

Entomopathogenic nematodes (EPNs) have emerged as a prominent and promising tool in insect pest management. Recognized for their eco-friendly nature, host specificity, and broad spectrum efficacy, EPNs are increasingly being explored as a sustainable alternative to chemical pesticides. These insect-parasitic nematodes may offer an effective means of biological control against several major insect pests of *Populus deltoides.* Their ability to actively seek out and infect target insects, combined with their compatibility with integrated pest management (IPM) strategies, makes EPNs a valuable component in the sustainable management of poplar pests. These nematodes, primarily from the genera *Steinernema* and *Heterorhabditis*, actively seek out and infect insect hosts in the soil, releasing symbiotic bacteria (*Xenorhabdus spp.* or *Photorhabdus* spp.) that rapidly kill the insect through septicemia. EPNs offer several advantages in integrated pest management (IPM) programs: environmentally safe with minimal impact on non-target organisms, compatible with other biological agents and cultural practices, easy to apply using conventional spraying equipment, effective against soil-dwelling and concealed stages of insect pests. Their application in poplar plantations, especially against the pupal or soil-inhabiting stages of defoliators, can significantly reduce pest populations and contribute to the long-term health and productivity of *P. deltoides* under agroforestry systems.

Conclusion

Effective insect pest management is critical to ensuring the health, productivity, and sustainability of Poplar plantations, particularly under agroforestry systems in north western India. Major pests such as *Clostera cupreata*, *C. fulgurita*, and *Apriona cinerea* have caused widespread damage, necessitating a strategic and integrated approach to pest control. Adopting IPM not only reduces reliance on harmful chemicals but also promotes ecological balance, improves long-term pest suppression, and supports the resilience of poplar agroforestry systems. Continued research, farmer education, and field validation of biocontrol strategies will be key to achieving effective and sustainable pest management in poplar plantations.

References:

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Common Facility Centre at IWST

Common Facility Centre (CFC) has been established inside IWST campus during the year 2016. The CFC houses many modern wood working and bamboo processing machines. CFC extends wood and bamboo processing facilities to various stake holders, self-help groups, NGOs, wood based small scale/cottage industries and local artisans. All the machines can be used on payment basis during all working days (Monday to Friday) from 9:00 AM to 5:30 PM. The details of available wood working and bamboo machines and their description are given below.

A. List of Wood and Bamboo Working Machines

No.	Name of Machinery	Description
1	Surface Planer	Suitable for removing rough surface of the wood by planing.
2	Thickness Planer	Suitable for sizing the piece of wood in two dimensions
3	Sliding Table Panel Saw	Suitable to cut a wood lumber/panel board to the required sizes in different cutting like rip cut, & scoring for pre lamboard.
4	Small Table Circular Saw	Suitable for rip cutting, cross cutting, and chamfering of wood.
5	Multi Spindle boring	Suitable for multi boring on wood/panel boards like vertical, horizontal and angular bores.
6	Spindle Molder	Suitable for edge profiling and contouring.
7	Belt Sander	Suitable for sanding the surface
8	Finger Jointing Machine	Suitable for joining small solid wood pieces
9	Seasoning Kiln	Suitable for seasoning the wood(Capacity: 200 cft)
10	Bamboo Cross Cutting	Suitable for cross cutting of Bamboo culms.
11	Bamboo Semi Half Splitting	Suitable for splitting the bamboo culms to rectangular strips.
12	Bamboo Variable Size splitting	Suitable for splitting the bamboo culms to number of strips.
13	Bamboo External Knot Removing	Suitable for removing external knots of bamboo culms.
14	Bamboo Thickness Planning	Suitable for thickness planning of bamboo strips to variable size.
15	Bamboo Slat Gluing	Suitable for gluing the bamboo strips for making panel of different sizes.
16	Bamboo Panel Drier	Suitable for drying glues bamboo panels.

To use the facility and for further details, please contact:
Officer incharge of Common Facility Centre, **Institute of Wood Science and Technology**
18th Cross, Malleshwaram, Bangalore Ph:080 22190178, E Mail: cfc_iwst@icfre.org

Insect Pests of Selected Conifer Species (*Cedrus deodara and Juniperous polycarpos*) and their Ecofriendly Management

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Abstract

Insects constitute one of major biological destructive agents in tree seed productivity. All conifers are susceptible to different type of insect pest attacks. Cones and seeds of coniferous tree species are heavily attacked by coneworms, *Dioryctria abietella and Cateremna (Euzophera)* cedrella (Lepidoptera: Pyralidae) in western Himalaya (Thakur, 2000). *Dioryctria abietella* is responsible for causing economic losses in cones and seeds of various conifer species. Deodar (Cedrus deodara) and juniper (*Juniperus polycarpos*) are two important conifer species of North western Himalaya which provide multipurpose needs of the local inhabitants. Both trees have sacred values also. During the present investigation studies were conducted on insect pests of both the tree species and suitable ecofriendly management practices against serious insect pets were developed.

Key words: Insect pests, management, deodar, Juniper

Introduction

All conifers are susceptible to seed and cone insects. The increased emphasis on production forestry would necessitate the availability of seeds not only of good quality but also whenever it is needed. Long term storage is, therefore, inescapable. Many of regeneration failure in conifers have often been attributed to heavy insect attack during the period of flowering and seed formation and under storage conditions. The productivity of Indian forest is very low as compare to world average. Even the survival of plantations is very poor. The key factor for all these issues is quality of planting stock. The plantations in our country are generally driven by targets.

The most damaging seed and cone insects are two seed-bugs (*Leptoglossus corculus and Tetyra bipunctata*) and five species of coneworms in the genus *Dioryctria*. Other insect species that cause seed losses include the slash pine flower thrips (*Gnophothrips fuscus*), pine seedworms (*Cydia* spp.), pine conelet looper (*Nepytia semiclusaria*), cone borers (*Eucosma* spp.), cone beetles (*Conophthorus* spp.), and tip moths (*Rhyacionia* spp). Seed and cone insects occur throughout the known range of the hosts. Cone and seed insects limit the production of seed for nursery stock. Insect damage varies greatly between seed orchards, depending on age, tree species, location, and orchard insect control plan. On occasion, orchards may lose their entire seed crop. Without seed, there can be no seedlings, and without pest management expertise, seed crops are at risk to damage or destruction caused by insects and diseases. Such damage could result in repercussions for future production and revenue loss due to wasted time and effort spent on managing orchard cone crops or collecting infested natural stand cone crops.

Insects constitute one of major biological destructive agents in tree seed productivity. Cones and seeds of coniferous tree species are heavily attacked by coneworms, *Dioryctria abietella* and *Cateremna (Euzophera)* cedrella (Lepidoptera: Pyralidae) in western Himalaya (Thakur, 2000). *Dioryctria abietella* is responsible for causing economic losses in cones and seeds of various conifer species. In Chilgoja pine, Singh and Bhandari (1986) reported almost 100% attack at Kalpa, Himachal Pradesh. Pruthi and Singh (1950) published a comprehensive account on insect-pests of stored grains. In view of rising demand for quality forest tree seed for various aforestation, reforestation and social forestry programmes and in pursuance of recommendation of 8th Silvicultural conference (1951), Mathur et.al., (1958) prepared an inventory on nature of damage and habits of all forests insects associated with flowers, fruits and seeds of forest tree plants, weeds, horticultural forestry species. Conway, 1975 and Saxena, 1978 have made several studies on fruit, seed and cone pests and observed that incidence of damage even of a little lesser magnitude in seed orchards and seed production areas, need applications of direct control measure because of high stakes involved. Sen-Sharma et.al., (1988) and Singh & Bhandari (1986) and Bhandari (1992) have discussed the forest tree seed entomology in the field and under storage. According to Thakur (2000) *Dioryctria abietella* is responsible for causing economic losses in the cones and seeds of various coniferous species viz. Abies *pindrow* (1.5-5.4%) in Pakistan, *Cedrus deodara* (89.2%) and *Pinus wallichiana* (52.0%) in India.

Cutworms and white grubs are grouped in a major insect pest category which causes substantial damage to the nursery stock. Termites also cause considerable damage to the nursery stock. The damage to nursery stock by cockchafers (White grubs), cutworms and termites etc. is considerable, disrupting the plantation schedule. The rating of their damage is sometime very high, going upto 90% by some cutworms in Conifer nurseries in Himachal Pradesh and upto 93% by white grubs in Teak nurseries in Maharastra (Thakur, 2000). So these two categories of insects are classified as major pests of nurseries. Even other minor pests have potential to become major pests due to changing climatic conditions in the last decade especially in the Himalayan region. Four species of cutworms viz. *Agrotis ipsilon* Hufnagel, *A. flamata* Sciff. *A. segetum* Schiff. and A. spinifera pertaining to the family Noctuidae (Lepidoptera) attain epidemic status occasionally, causing losses of economic nature in forestry. The larvae of these species cut off seedlings of wide variety of young plantations. Among white grubs, principal pests are members of the subfamily Melolonthinae and Rutinae of the family Scarabaeidae (Coleoptera). Out of these Scarabaeds, *Granida albosparsa* Moser is one of the most common and largest cockchafer grub, which causes heavy damage to conifer nurseries (mainly *Cedrus deodara* and *Pinus*) at eleviation upto 3000m (amsl) in Himalayan region of India. *Holotrichea longipennis* Blanchard as adult feeds on *Q. leucotrichophora* and Rubus *laciocarpa* etc. whereas larva is reported to be injurious to seedlings of conifer nurseries. Larva of *Melolontha furcicauda* Ancey feed on the roots of deodar and other coniferous plants at nursery stage. Another deep blue color beetle *Papillia* cyanea Hope feeds on the roots of deodar seedlings in larval stage and adults survive on blossoms.

After pest damage is identified and quantified, cost-benefit and environmental impact analyses of pest management alternatives are needed to select the pest management strategy most economical and safest to the environment. Nursery pest management strategies include routine preventive practices as well as curative treatments after pest problems are detected, identified, and evaluated. High product values and high pest hazards in nurseries frequently make preventive practices such as soil fumigation and chemical sprays desirable. However, the most effective and efficient pest management procedures involve an integrated nursery pest management strategy. The primary objective of this strategy is to minimize potential pest losses and maximize production of high-quality, pest-free seedlings for improved survival and growth in field plantings.

Beeson (1941) reported infestation of white grub, *Granida albosparsa* Moser (Col.Scarabaedae), a largest cockchafer beetle in the seed beds and nurseries of deodar (Cedrus deodara) and pines upto the higher elevations upto 3000metres in the Himalayan ranges of India. He (1941) concluded that life cycle of this pest is of two years at higher altitudes beyond 2000 meters. Browne (1968) reported *Hamartus instabilis* (Coleoptera: Curculionidae), as a leafroller of nursery plantations. Larvae of this species roll inside the leaf and feed on the innersurface of leaf and overwinter as a pupa inside the leaf. He (1968) also observed severe defoliation by larvae of a geometrid moth (Lepidoptera) *Chrysocraspeda* olearia Guene. Hartlay and West (1979) reported increased nematodes activity in planting stock in forest nurseries which is attributed to monoculture plating practices. Kumar and Thakur (1989) reported rodent species *Nesokia indica* for the first time from the Satyanarayan Forest nursery, Dehradun. Thakur (2000) stated that larvae of *Agrotis ipsilon* (Lep. Noctuidae) are injurious to forest nurseries and young plantations of conifer in India and Pakistan. This wide spectrum cutworm is also serious pest of agriculture crops in the plains.

Results

All conifers are susceptible to different type of insect pest attacks. Deodar (*Cedrus deodara*) and juniper (*Juniperus polycarpos*) are two important conifer species of North western Himalaya which provide multipurpose needs of the local inhabitants. Both trees have sacred values also. During the present investigation studies were conducted on insect pests of both the tree species and suitable ecofriendly management practices against serious insect pets were developed.

Insect pests of Juniper

Juniper (*Juniperus polycarpos*) is important forest vegetation in Lahual valley in North-Western Himalaya. It is commonly known as "Himalayan Pencil Cedar". It is commonly found in the dry temperate regions of Himachal Pradesh and Jammu & Kashmir. Among the insect-pests problem of berries/seed borer is very common. Many of the regeneration problems in the conifers have been attributed to heavy insect-pest attack during the period of flowering and seed formation and under storage berries and seeds insects limit the production of seed for nursery stock. Long term storage is thus inescapable. *Homaloxestis cholopis* (Lepidopetra: Lecithoceridae) is identified as causative insect-pest (borer). Berries and seeds of Juniper were heavily attacked by this borer. It was recorded as a new report in natural and in stored berries of Juniper.

Natural Population of *J./polycarpos* in Kinnur, Himachal Pradesh

Pupatting Larvae of *H. cholopis*

Adult of *H. cholopis*

Habitat, life cycle and feeding habits of this pest was studied in detail.

Host Plant: *Juniperus polycarpos*

Name of Insect-Pest- *Homaloxestis cholopis* (Seed Borer)

Description

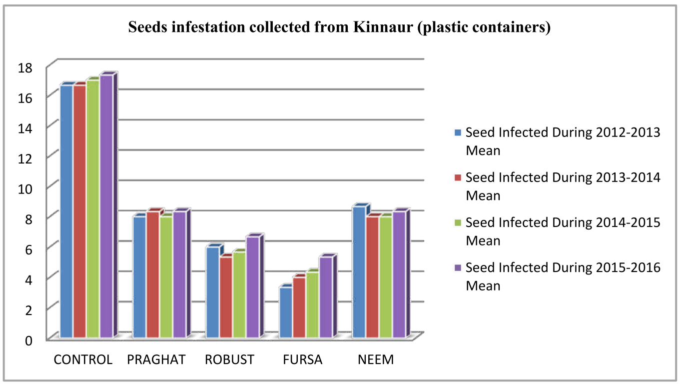
Homaloxestis cholopis is characterised by the forewing usually without any markings, sometimes having a pale orange or whitish band along the costa contrasting with the ground color.

Host Plant- *Juniperus polycarpos*

Type of attack-Borer, larvae of this pest heavily feed on the berries of Juniper in stored condition. Symptoms of this borer appear during the month of July and August, almost 50% of berries were found damaged when observed externally, damage by borer continues till December and 96% of berries were found damaged. After which no activity was recorded in stored berries.

Effective control measures developed by Institute

Seeds were treated with four bio - pesticides/Insecticides viz., Robust (0.05%), Fursa (1%), Praghat (2%), and Neem (2%). Freezing treatments were also applied for protection of seeds against the effect of seed borer.



Homaloxestis cholopis belonging to the order Lepidoptera were recorded for the first time infesting stored seeds of Juniper berries.

Light trap- It helps in collection of adults from affected site thus containing the attack in the initial stages.

It was found that Fursa treatment (causing 100% mortality) was most effective followed by Robust (92%), Praghat (70%), Neem (62%) and control (16.92) for the Juniper seeds/berries. The technology was disseminated to the frontline staff of State Forest Department, Himachal Pradesh by organizing trainings and demonstrations.

Insect Pests of Deodar (Cedrus deodara)

Several insect pests can affect deodar (Cedrus deodara) trees, with the most significant being the deodar looper, Ectropis deodarae, and the deodar weevil, Pissodes nemorensis. Other potential threats include various defoliators, bark beetles, and root rot pathogens. During the studies in last 5 years (2020 to 2025) it was observed that stem borer (Coleopteran species), scale insects and white grubs were most damging causing losses of the trees as well as nursery. Complete ecology of the insect pests was studies and various management practices were tested to mange the serious insect pests.

Effective control measures developed by the Institute

- **Light traps:** It helps in collection of adults from affected sites and is effective in managing this insect-pest during initial stage of insect attack.
- **Treatments of Methanol leaf extract of B. albiflora@ 1% and Angelhardia roxburghiana@**

2.5 % was found effective in controlling this insect pest causing mortality upto 78% after 72 hrs of application)

❖ **Horticulture Mineral Oils (HMOs) @ 2.3%** is an excellent antifeedant and effective to contain this insect pest below economic thresh hold level.

Mortality rate of insect pest of Nursery was observed at 1st, 3rd and 5th day after treatment at Himachal Pradesh. Mortality rate of larva differed significantly ($p \leq 0.05$) among the treatments. Sites have been finalised in the state of Punjab for testing of biopesticide. 72 hr of exposure C. serratus to Tree Pal @ 1% caused 45 % mortality and crawl clean @1% caused 20.33 % mortality in comparison to nimbicidine (53.33% mortality) and Imidacloprid @ 0.1% (93.33% mortality) at 72 hr.

References:

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Insect Pest Complexes affecting Mahogany plantations: Diversity, Impact, and Management

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Abstract

Mahogany (Swietenia spp.) is an economically valuable timber species renowned worldwide for its exceptional wood quality. However, its populations are increasingly threatened by insect pest infestataions, prompting significant concern for its conservation and sustainable management. A variety of insect pests have been reported to attack mahogany, with the severity of their impact varying across species and regions. Among these, the mahogany shoot borers *Hypsipyla* spp. (Lepidoptera: Pyralidae), particularly those affecting Swietenia species within the Meliaceae family, are considered the most economically damaging. Their feeding activity leads to the destruction of apical shoots, resulting in deformation, forked branching, and a marked decline in timber quality and market value. Following shoot borers, bark-boring beetles also pose a threat, though typically of lesser impact. Minor insect pests, including bark borers on both live and dead trees, ash weevils, and leaf-cutter bees, are generally not associated with significant damage. Differentiating between major and minor pests based on their economic and ecological impact is crucial for developing effective and targeted pest management strategies. This literature review focuses on compiling an updated list of insect pests both major and minor affecting *z*, with particular emphasis on their biological control and management across various developmental stages of the tree.

Key words: Mahogany; Top shoot borers; Defoliators; Borers; Managementas

Introduction

Mahogany, particularly Swietenia macrophylla (big-leaf mahogany), is a valuable timber species that faces a range of pest threats, especially in tropical plantation forestry. Among these, the Mahogany Shoot Borer (*Hypsipyla grandella*) stands out as the most destructive pest, is the overriding factor restricting the establishment and cultivation of many tropical members of the Meliaceae (Entwhistle, 1967; Whitmore, 1983) followed by other insect species that damage the foliage, seeds, and overall health of the tree. Mahoganies are the source of an exceptionally valuable cabinet wood, and are widely considered the most economically important tropical timber trees in the world. Thus, the insects that attack mahoganies are of considerable economic importance. True mahoganies include three species of Swietenia (family Meliaceae) that are native to the American Tropics. These are West Indies mahogany (S. *mahagoni* Jacquin), Honduras, or big-leaf, mahogany (S. *macrophylla* King), and Pacific mahogany (S. *humilis* Zuccarini).It is an important economic pest and has been the subject of concerted research efforts in several tropical countries. This paper provides an overview of the key pests affecting mahogany, their life cycles, the damage they cause, and strategies for their management.

A. Major Pests of Mahogany

The notable and most prominent pests that cause huge economic losses and the devastation of mahogany are top shoot borers, leaf miners, and wood boring beetles, as well as the evolving pests that have been reported recently on *Swietenia* sp., causing significant damage. (Table. 1)

1. Top shoot borers

1.1 Mahogany Shoot Borer (*Hypsipyla robusta*) (Moore); Order: Lepidoptera, Pyralidae.

The mahogany shoot borer, *Hypsipyla* robusta, reported above to attack several species of high quality timber in India, Indonesia and Thailand, has also been reported to cause damage in Australia, Bangladesh, Pakistan and Sri Lanka.

Nature of damage

The mahogany shoot borer, *Hypsipyla robusta* (Zeller), bores into the twigs and seed capsules of trees in the mahogany family (Meliaceae), especially mahogany species (Swietenia spp.) and cedro, known also as Spanish-cedar and tropical-cedar (*Cedrela* spp.). It is an important economic pest and has been the subject of concerted research efforts in several tropical countries. *H. grandella* and H. robusta are associated exclusively with the Meliaceae. Mahogany trees are susceptible to attack when they reach a height of 0.5 meter (1 ft 7 inch) (Griffiths, 2001). The pest is reported to attack nearly 40 percent of mahogany saplings in a plantation, causing a loss of 29 percent in total biomass production (Hossain *et al.*, 2004).

H. robusta bores to the apical shoot and cause shoot death. In early instar, the larvae move along several locations causing sap droplets and withered shoots. Larger larvae usually move to older stem which inflict damage to the main stem; continuous damage cause stunted tree and branching. Nuraeni and Nuroniah, 2020. *H. robusta* is a significant shoot borer that affects mahogany trees across all age groups, though its impact is particularly severe on younger plants. This pest has been a leading cause of failure in many mahogany plantations (Nair, 2007). Many authors have mentioned the damage to seeds by mahogany shoot borer, Monte (1933), Tillmanns (1964), and Becker (1976), but this has usually been regarded as unimportant or second in importance to the damage to the shoots. Being polyphagous, its infestation is most commonly observed during the monsoon season, coinciding with the emergence of new shoots. The species undergoes multiple overlapping generations typically between six and nine per year with each cycle lasting approximately 25 to 55 days (Wagner *et al.*, 2008).

Life Cycle: Adults: The adults of *Hypsipyla robusta* are brownish to grayish-brown in color with a wingspan measuring about 23 to 45 mm (1–1 ¾ in). The forewings are grey to brown with shades of dull rust red on the lower portion of the wing. The middle to outer areas of the forewings appear dusted with whitish scales with black dots toward the wing tips. Wing veins are distinctively overlaid with black. The hind wings are white to hyaline with dark coloured margins. The eggs are deposited during the early morning hours on leaf scars, new shoots, leaf veins, and fruits. They are generally laid singly but may sometimes be aggregated into clusters of three to four eggs in or near leaf-axils. The eggs of the mahogany shoot borer are oval and flattened the colour of the eggs changes from white to red within the first 12 hours after oviposition. The body of the early instar larva is tan to white in colour, becoming bluish in later instars. The head capsule is brown. Mature larvae are about 25 mm (1 in) long. The pupae of *Hypsipyla* robusta are brownish-black in colour and enclosed in a silken cocoon.

Management strategies: Cultural Control: Grow mahogany in mixed-species plantations to reduce the likelihood of infestation. Regular pruning of the terminal shoots can help reduce shoot borer impact.

Biological Control: Eco-friendly approaches like biological control are preferred over other control strategies. Twelve Chalcidoid species were found to parasitize both eggs and larvae of the pest and the list includes *Antrocephalus hakonensis, A. hypsiphylae, Brachymeria euploeae, B. hearseyi, B.tachardiae, Kriechbaumerella destructor* (Chalcididae), *Tetrastichus spirabilis, Trichospilus diatraeae* (Eulophidae), *Diomorus orientalis* (Torymidae) *and Trichogramma minutum, Trichogramma toideanana and T. robusta* (Trichogrammatidae) (Kazmi and Chauhan, 2003). Metarhizium anisopliae IWST-Ma7 strain (Balachander et al., 2012) and Beauveria bassiana (Mishra, 1993) are reported as effective entomopathogens of H. robusta at early instars. Supplementing this, weaver ants *Oecophyllas maragdina* (Mohanadas *et al.*, 2016) and resistant clones were mentioned as part of IPM against the pest (Wightman et al., 2008).The use of natural predators, such as parasitoid wasps, can help control borer populations. Biological insecticides, including *Bacillus thuringiensis* (Bt), show promise in controlling early-stage larvae.

Chemical Control: Systemic insecticides like imidacloprid can be used, particularly during early stages of infestation in nurseries or young plantations.

Figure 1: Damage symptoms caused by the attack of mahogany shoot borer,
A) Tip drying, exit holes filled with frass; B) Skeletanization ; C)& D) Leaves and tip drying

1.2 *Hypsiphyla grandella* (Zellar) reported from other parts of the country

The larvae of H. *grandella* reported to cause 71-100 percent damage on mahogany plantations (Delgado & Couturier, 2004). Its damage to *Swetenia* sp. is so intense that it can affect the establishment of commercial plantations by nipping them at the early stage itself. Destruction in seedlings and young trees, due to the entry and tunnelling of the larvae (Grijpma and Roberts, 1976).

2. Sapling borers

2.1.*Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae)

Xylosandrus compactus, commonly known as the mahogany sapling borer, is a polyphagous beetle that has recently emerged as a significant pest of mahogany. Female adults bore into mahogany saplings to construct chambers for oviposition and larval development. These chambers obstruct the flow of plant fluids, leading to necrosis of surrounding tissues. In severe infestations, seedling mortality has been observed. Even in cases of minor damage, seedlings often break at weakened, degenerated sites due to environmental stressors such as wind or mechanical disturbances. This damage can also stimulate the emergence of new sprouts, resulting in undesirable multi-branched growth.

The infestation predominantly affects the basal part of the plant (71.3%), followed by the middle (18.7%) and apical sections (9%), as reported by Delgado and Couturier (2010). As a prominent nursery pest more commonly encountered than wood borers, *X. compactus* thrives under conditions of high humidity, dense planting, and poor air circulation, as also observed in *Myrciaria dubia* (Delgado and Couturier, 2004).

Among its natural enemies, Formicid ants of the genus *Plagiolepis* have been noted for preying on all developmental stages of *X. compactus* (Egonyu et al., 2015). Additional predators include species of *Callimerus, Eupelmus, Cataulacus lujae, Tetraponera lepida, T. ophthalmica, Crematogaster impressa, C. impressiceps,* and *C. africana.* Parasitoids such as *Pyemotes herfsi, Pyemotes ventricosus, Prorops nasuta, Tetrastichus xylebororum,* and *Eurytoma* sp. have also been identified. Fungal pathogens, including Beauveria bassiana, *Hirsutella sp., Paecilomyces fumosoroseus,* and *Lecanicillium lecanii,* along with other natural enemies like *Asynapta* sp., contribute to the biological control of this pest (Balakrishnan *et al.*, 2011).

3. Defoliators

Defoliation is a serious and recurring problem that is destructive. Insect herbivory is the reason behind this, and the members of this category feed on leaves and tender parts of the plant affecting its growth and fruit setting. Leaf skeletonizers/leaf miners also contribute to this phenomenon; they consume the lamina parts, except the skeletal structure of the leaf. Both activities affect the host plant, and the damage can be severe (occasionally) if untreated.

3.1.Macalla *thyrsisalis* Walker (Lepidoptera:Pyralidae)

The mahogany webworm, Macalla *thyrsisalis,* is a defoliating pest reported on Swietenia species throughout the Americas. It primarily targets young mahogany trees in nurseries or neglected plantations, with infestations typically being short-lived. The larvae bind multiple leaves together with silk to form a protective web—hence the name "webworm"—and feed on the laminar tissue along the leaf margins, leaving the mid-veins intact. This feeding behavior reduces the plant's photosynthetic capacity and hinders overall growth.

Webworms show a preference for young, tender foliage, with infestations often coinciding with spring leaf flushes. In cases of high larval density, trees can be completely defoliated. Key natural enemies include the parasitic fly *Lespesia* sp. (Diptera: *Tachinidae*) and two parasitic wasps, *Habrobracon* sp. and *Apanteles* sp. (Hymenoptera: Braconidae). A decline in these natural enemy populations often leads to severe outbreaks of the pest.

In addition to natural enemies, botanical insecticides have shown effectiveness in managing webworm populations. Neem-based products, when sprayed on mahogany foliage, act as antifeedants on ants and prevent larvae from feeding, thereby protecting the plant.

4. Wood Borers

Wood-boring insects are the most destructive pests of commercial timber crops. Their feeding activities by tunnelling destroy the conducting tissues of the host, causing structural weakness in susceptible trees. Pest infestation sites also act as entry sources for secondary plant pathogens.

4.1. *Apate monachus* (Coleoptera: Bostrychidae)

A. monachus is commonly called the "black borer". It is reported as a potential pest on mahogany and other members of the Meliaceae. It is polyphagous and exhibits wood-boring activities in both live and dead trees. Adult beetles are involved in this process. The hole formed has a well-defined diameter and leads to a tunnel ranging from 25 to 60cm in length inside the host. These activities and the effects of pest damage weaken the structural integrity of the host plant. It also blocks vascular tissues, which are essential for tree growth, resulting in deformed trunks that are susceptible to breakage in high winds (Durai et al., 2017).

In biological control, natural enemies like *Sclerodermus* sp., and other braconid species closely related to the genus *Glyptocolastes* (Glyptodoryctes) are reported as parasites of this beetle (Rodriguez, 1975). Use of the entomopathogenic fungi, Metarhizium anisopliae or Beauveria bassiana helps to regulate sporadic infestations of the pest (Liu and Bauer 2008).

B. Other pests (Minor) Apart from the above mentioned pests, many other pests are associated with *S. macrophylla* and its relative species. Most of them are polyphagous and depend on host plants at different levels, but all are considered insignificant as long as they don't cause major economic damage. Minor pests include various species of ambrosia beetles that bore twigs and trunks, members of the Scrabaeidae that feed on foliage, scale insects like (Table 1.)*Conchaspis cordiae* (Mamet), mahogany bark weevils, *Copterus* floridanus (Fall), Ash weevils *Myllocerus* spp. An unidentified lepidopteran defoliator belonging to geomentridae, thrips causing leaf curl symptoms, and ladybird beetles predating on mites on the under surface of the leaf, and an unidentified grasshopper were recorded. In the natural habitats of mahoganies, there are undoubtedly numerous additional insect species associated with them that remain unstudied.

Conclusion

Pests pose significant challenges to mahogany cultivation, particularly the Mahogany Shoot Borer (*Hypsipyla robusta*), which remains the most destructive pest in mahogany plantations. Other bark boring beetles are gaining importance due to their serious damage both to dead and live mahogany. Pest impact in nurseries, thrips causing leaf curl and warrants heightened attention in forestry development, and control efforts should prioritize management strategies grounded in ecological principles. Integrated pest management (IPM) strategies that combine **cultural control, biological control, and chemical treatments** provide a comprehensive approach to minimizing pest damage. Long-term solutions may involve selecting resistant varieties of mahogany and using biological control agents to reduce pest populations without harming the environment.

References :

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Major Insect Pests of Casuarina and Their Management Strategies in Nurseries and Plantations

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Introduction

Casuarina is a fast growing, multipurpose tree species and adaptability to a wide range of climatic and edaphic conditions. Species have high economic importance with a variety of applications and is much preferred by the industries. Casuarina has short rotation and hence it has been a favourite species of farmers. Pest infestations pose a major threat to the large-scale cultivation of Casuarina, leading to substantial reductions in productivity. Nearly 40 species of insects belonging to Coleoptera and Lepidoptera have been recorded as pests of this tree in India. Among them, the bark eating caterpillar, stem borer, mealy bug is the most economically important pest, which causes significant damage to tree growth in clonal plantation. Information on the important pests and the extent of their damage are discussed below.

1. Bagworm, *Eumeta crameri* (Lepidoptera: Psychidae)

Bagworm is the most prevalent and important pest in Southern India. Regular incidence of this insect in plantations and nurseries and cause severe defoliation in plantations. Larvae construct small brown bags on the branches and needle-feeding.

Bagworm infestation on casuarina

Management: Removing infested branches, pruning, and maintaining healthy trees, Application of Intrepid^{TN} (Chlorfenapyr 10% SC) 1 ml/litre or Danitol^{TN} (Fenpropathrin 10% EC) 1 ml/litre can be sprayed.

2. Ambrosia beetle, *Xylosandrus* sp. (Coleoptera: Scolytinae)

Adult beetles are tiny and females bore into the main stem of Casuarina seedlings, they excavate tunnels in the stem, introduce ambrosia fungus and lay eggs to produce a brood. Eggs, larvae and pupae are found together. Infested seedlings often die from boring damage, ambrosia fungus, or infection by a secondary pathogen (Fig. 1). During the month of July, pest cause significant damage. Nearly 10 per cent mortality of seedlings was observed at the nursery.

Ambrosia beetle infestation on casuarina nursery

Management: Monitoring for ambrosia beetles in the nursery by using 70 % ethanol bait to attract and trap the adults. Heavily infested seedlings or plant parts should be removed and destroyed. Keep seedlings healthy and avoid any stress (drought, injury, nutrition, etc.). Application of pyrethroids such as Permethrin 25 % EC, Perkill^{TN} 2 ml per liter of water or Bifenthrin 10 % EC, Markar^{TN} @ 1.5 ml/l can be used and may have to be reapplied every two to three weeks while beetles are active.

3. Bark Eating Caterpillar, *Indarbela quadrinotata* (Lepidoptera: Cossidae)

The bark eating caterpillar is the most serious pest of Casuarina. The caterpillar feeds on the outer as well as inner bark of trees. It bores a short burrow downwards into the wood, which is used by the larva as a day shelter. The larva eats the bark during night, excavating broad irregular patches and paths. These portions are roofed with silk and fragments of bark and faecal pellets. Life cycle of the pest is annual, with moth emergence taking place during May – July and larval period from June – April. Infestation can lead to stunted growth, a weakened tree trunk, and increased susceptibility to wind damage. Nearly, 38-40 % of damage was observed in plantations grown in different agro-climatic zones of Tamil Nadu during 2021-22. The pest causes considerable loss to wood productivity and cause the 2-5 per cent of mortality in grownup plantations and 7.31 per cent loss in height increment annually (Sasidharan et al., 2014).

Management: Remove and burn dead and severely affected branches of the tree. Setup a light trap to attract adult moths in May and June month to avoid egg laying. Scraping the loose bark to prevent oviposition by adult moth. Remove the webbing and inject kerosene oil into the holes during September-October and again in January-February. Padding with Marshal (Carbosulfan) 25% EC @ 10 ml/lit/tree soaked in absorbent cotton.

4. Mealy bug, *Dysmicoccus brevipes* (Hemiptera: Pseudococcidae)

I.quadrinotata infestation on casuarina plantation

Mealy bugs suck sap from leaves and stems, weakening the trees and causing stunted growth, yellowing or deformation of needles and potentially defoliation. In severe cases, it can also cause plant decline and even death. The pest also secrete honeydew, which can support the growth of sooty mould, further affecting photosynthesis.

Management: Remove grasses and trim bunds in the main field. Avoid excessive nitrogen fertilizer application. Remove and destroy affected plant parts. Release the Australian ladybird beetle (*Cryptolaemus montrouzieri*) at a rate of 10 beetles per plant. If necessary, apply Tafgor 30EC at 1.5 ml/litre or a mixture of Triozophos 40 EC (2 ml) and neem oil (5 ml) per litre of water.

5. Seed Pest Bruchid, *Caryedon gonagra* (Coleoptera: Bruchidae)

Bruchids is the common pest affecting Casuarina seeds in India. The grubs, bore into the seeds and feeding on the contents, leading to reduced seed quality, germination, and overall yield. Studies have shown that bruchid can cause a weight loss of up to 39-40% in stored casuarinas seeds.

Mealy bug infestation on casuarina plants

Management: Treating seeds with 15% neem oil or neem formulation like Nimbecidine or dry neem seed powder before seed storage can control the pest. Pesticides like IntrepidTN (Chlorfenapyr 10% SC) @ 1 ml/litre can also be used.

6. Termite, *Odontotermes obesus* (Isoptera: Termitidae)

Termites cause wide spread damage to seedlings, cuttings of young plantations. The damage occurs below the ground level mainly in the upper 20 cm of the soil layer by hollowing out or severely ring barking the tap root which results in the death of the seedlings. The affected seedlings show sign of yellowing, wilting and finally resulting in die back.

Management: Drenching of mother beds or propagation chambers or polybags with a solution of chlorpyrifos 20 EC @ 2ml/lit would control the termites effectively.

Conclusion

Casuarina, a valuable multipurpose tree species, is vulnerable to several insect pests that can significantly impact its growth, productivity, and survival in both nursery and plantation settings. Key pests such as stem borers (*Indarbela quadrinotata*), sap-sucking insects like mealy bugs, defoliators and termites pose serious threats, particularly during early growth stages. Effective management of these pests requires an integrated approach combining cultural, mechanical, biological and chemical strategies. Emphasis should be placed on early detection, regular monitoring, and the promotion of biological control agents to minimize pesticide use and environmental impact. Implementing good nursery hygiene, selecting pest-resistant clones, and adopting integrated pest management (IPM) practices are crucial for sustaining healthy Casuarina plantations. Continued research and farmer education are essential to refine these strategies and ensure long-term productivity and ecological sustainability.

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Impact of Wood-Degrading Fungi on Stored Timber in Forest Depots: A Need for Strategic Action

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1. Abstract:

Wood-degrading fungi (WDF) such as *Polyporus, Ganoderma, Schizophyllum, Fomes, Serpula, Xylaria, Auricularia, Dacrymyces, Coniophora,* and *Trametes* species cause significant deterioration of stored timber in forest depots. These fungi lead to loss of structural integrity, reduced market value, and increased vulnerability to pests and fire. The level of damage is proportional to storage duration timber held for more than 12 months may incur more than 50% economic loss. This note highlights the urgency for preventive measures, including improved storage practices, regular monitoring, chemical treatments, and staff personnel training. Coordinated action at the forest department, research institute and industry levels are essential to protect valuable timber resources supplies.

Key words: Wood-degrading fungi, stored timber, forest depots, fungal infestation, wood deterioration and forest protection

Introduction

Timber stored in forest depots constitutes a valuable forest product that is particularly vulnerable to microbial colonisation, notably by wood-degrading fungi. These fungi flourish in damp and inadequately ventilated storage conditions, progressively decomposing wood fibres. In numerous forest depots, inadequate infrastructure for appropriate timber stacking and extended storage durations exacerbate fungal infection. The repercussions encompass not only economic detriment but also the structural degradation of timber products, along with heightened susceptibility to secondary pests and fire hazards (Vane et al., 2006). The advancement of fungal colonisation is affected by the duration and circumstances of wood storage. Extended storage duration, particularly in inadequately ventilated environments, correlates with an increased prevalence of deterioration and economic loss (Adamopoulos, 2012).

Figure 1.Timber stacking and prolonged storage in forest depot Impact on Stored Timber

Impact on Stored Timber

Fungal infestation in stored timber leads to various concrete losses:

- **Reduction of Structural Integrity:** The enzymatic breakdown of cellulose and lignin by WDF results in compromised lumber, rendering it inappropriate for industrial and construction applications (Figure 2) (Schilling & Jellison, 2005).
- **Market Value Decline:** Discoloured, cracked, or compromised timber has decreased commercial attractiveness, resulting in lower market prices and financial losses for forestry departments and dealers (Figure 2) (International Timber, 2023).
- **Fire Hazards:** Decomposed timber, exhibiting heightened porosity and desiccation, becomes exceedingly combustible, hence elevating fire hazards in storage facilities, particularly during arid seasons.

- **Attracts pests:** Fungal decay generates volatile organic compounds (VOCs) that lure wood-boring insects and termites, exacerbating timber deterioration (International Timber, 2023).

Figure 2. Reduction on market value of wood due to fungal infestations, degradation, and staining

Types and Mechanisms of Wood-Degrading Fungi

- **Brown Rot Fungi:** These fungi selectively degrade cellulose and hemi-cellulose, leaving lignin relatively intact. The result is a brittle, dark-brown wood with a cubical cracking appearance. *Serpula lacrymans* and *Coniophora puteana* are notorious examples, often responsible for rapid loss in mechanical strength (Schilling & Jellison, 2005; Adamopoulos, 2012).

- **White Rot Fungi:** Capable of decomposing all major wood components including lignin, these fungi leave the wood whitish and spongy. *Trametes versicolor* and *Phanerochaete chrysosporium* are effective lignin degraders, posing threats to hardwood and softwood alike (Vane et al., 2006).

- **Soft Rot Fungi:** These fungi primarily attack wood in moist or extreme environments where white or brown rot fungi are less active. They form cavities inside the cell walls and lead to a softened wood structure. *Chaetomium globosum* and *Kretzschmaria deusta* are common soft rot fungi in tropical environments.

Assessment of timber logs

The research was carried out in prominent forest timber depots of Madhya Pradesh, specifically at Jabalpur, Chhindwara, Seoni, Balaghat, Mandla, Hoshangabad, Betul, and Mandideep (Bhopal) throughout 2023. Timber logs in storage were visually examined for indications of fungal deterioration. Principal symptoms assessed comprised surface discolouration, occurrence of mycelial mats or fruiting bodies, structural degradation (softening, cracking), and moisture accumulation. The percentage of infestation in each depot was determined by calculating the ratio of rotting timber volume to the total observed timber stock. Estimations were derived from ocular assessments corroborated by photographic evidence.

The investigation revealed notable fungal infestation in wood samples from multiple depots in Madhya Pradesh, with Jabalpur and Seoni exhibiting the highest rates of infestation at 27% (Table 1, Figure 3). Species such as *Trametes versicolour, Ganoderma lucidum*, *Polyporus spp.*, and *Fomes fomentarius* were frequently noted (Figure 4), resulting in surface discolouration, mycelial growth, and structural deterioration, including softening, and crumbling of wood. The fungi significantly impacted bamboo species (*Dendrocalamus strictus*), underscoring their susceptibility. Surface discolouration and structural degradation (Figure 1) were commonly observed in many depots, especially in Jabalpur, Seoni, and Hoshangabad. This suggests the presence of early fungal activity, frequently attributed to white rot fungi such as Trametes versicolour. The existence of mycelial mats and fruiting bodies facilitates active growth in wood, while continued growth, spread, and reproduction contribute to fungal contamination and structural degradation. Moisture accumulation was frequently observed across depots, intensifying fungal growth. The fungal frequency observed in Jabalpur, Seoni, and Mandla was notably higher, likely attributable to the conducive environmental conditions present in these areas. Which is essential for the threat of fungal infestation to timber and bamboo necessitates improved storage management and effective fungal control strategies to avert wood degradation.

Table 1: Common Wood-Degrading Fungi Observed in Forest Depots of Madhya Pradesh

S. No.	Forest Depot	Tree/Bamboo Species Affected	Observed Fungal	% Infestation Observed	Key Symptoms	Frequency Across Depots
1	Jabalpur	*Tectona grandis, Shorea robusta, Dendrocalamus strictus*	*Trametes versicolor, Polyporus arcularius*	22%	Surface discoloration, white rot, mycelial mat, moisture patches	High
2.	Chhindwara	*Dalbergia sissoo, sissoo, Terminalia tomentosa, Dendrocalamus strictus*	*Ganoderma lucidum, Schizophyllum commune*	19%	Fruiting bodies, spongy texture, moisture accumulation	Medium
3.	Seoni	*Acacia catechu, Madhuca indica, Dendrocalamus strictus*	*Fomes fomentarius, Phellinus spp*	27%	Brown cubical rot, cracking, brittle wood	High
4.	Balaghat	*Tectona grandis, Cassia fistula, Dendrocalamus*	*Trametes hirsuta, Xylaria polymorpha*	21%	Discoloration, laminar fruiting, moist decay strictus	Medium
5.	Hoshangabad	*Shorea robusta, Dalbergia latifolia, Dendrocalamus strictus*	*Trametes versicolor, Fomitopsis pinicola*	25%	Crumbling surface, white rot, concentric fungal rings	High
6.	Hoshangabad	*Shorea robusta, Dalbergia latifolia, Fomitopsis strictus*	*Trametes versicolor, Fungal rings pinicola*	25%	Crumbling surface, white rot, concentric Dendrocalamus	High
7.	Betul	*Terminalia arjuna, Syzygium cumini, Dendrocalamus strictus*	*Schizophyllum commune, Polyporus spp.*	20%	Mycelial masses, structural degradation, spore deposits	
8.	Mandideep (Bhopal)	*Acacia nilotica, Tectona grandis, Dendrocalamus strictus*	*Xylaria spp., Fomes fomentarius, Ganoderma lucidum*	24%	Surface fruiting, cubical brown rot, mycelial covering	High

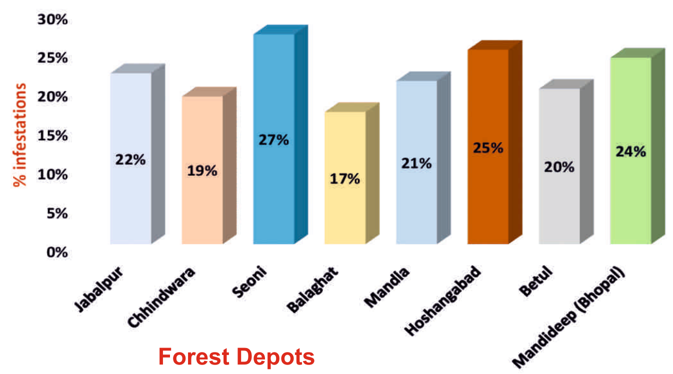

Figure 3. Graph showing the percentage of fungal infestation in stored timber across different forest depots

Figure 4. Wood degrading fungal genera like Trametes, Xylaria, *Ganoderma* and *Schizophyllum* species

Management Strategies

The subsequent interventions may assist in reducing fungal infestation and maintaining timber quality (International Timber, 2023):

- **Proper Storage Practices:** Elevate timber using concrete or metal supports, maintaining a gap between logs to enhance air circulation. It is essential to ensure that the timber is separated from damp masonry using an air space or a damp-proof membrane, facilitating unobstructed air circulation.
- **Management of Moisture:** It is advisable to store wood in covered sheds or shelters to avoid direct exposure to rain and elevated humidity levels. The optimal moisture content for all timber should be maintained below 16-18 percent.
- **Inspection and Monitoring:** Conduct routine examinations of timber to identify initial indicators of fungal decay, including discolouration, soft patches, or atypical odours.
- **Application of Fungicides:** The utilisation of boron compounds, copper-based preservatives, or environmentally friendly botanical fungicides serves as a protective measure against fungal growth.
- **Prompt Removal:** Infected wood must be isolated and disposed of without delay to inhibit the spread of fungi.
- **Capacity Enhancement:** Educate depot personnel and forest supervisors on the identification of fungi, safe handling techniques, and optimal storage methods.

Interpretation

The findings emphasises the considerable influence of wood-degrading fungi on timber and bamboo in the forest depots of Madhya Pradesh, with predominant fungal species including *Trametes versicolour, Ganoderma lucidum*, and *Polyporus spp*. The accumulation of moisture in stored wood and bamboo fosters an environment that promotes fungal growth, which in turn accelerates the degradation of the wood. Future investigations ought to concentrate on the advancement of environmentally sustainable bio-control agents, the improvement of storage methodologies, and the examination of genetic resistance in timber and bamboo species. Furthermore, conducting broader surveys in various regions and implementing seasonal monitoring will enhance our comprehension of the environmental factors that affect fungal infestations. Applying these strategies will effectively reduce the economic impacts linked to the degradation of wood and bamboo, while also safeguarding forest resources for sustainable utilisation.

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Ganoderma Root Rot in Arid Zone Timber Species: Pathogenesis, Symptoms, and Management Strategies

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Introduction

The arid and semi-arid regions of India are home to several important indigenous and exotic timber-yielding tree species that play a vital role in ecological balance, desertification control, and rural livelihoods. However, the sustainability of these forest and agroforestry systems is increasingly threatened by soil-borne pathogens, among which *Ganoderma* spp. have emerged as one of the most devastating fungal agents causing root rot diseases. Belonging to the family Ganodermataceae, these fungi are known to infect over 200 tree species worldwide and are capable of surviving for years in the soil through resistant fungal structures such as chlamydospores and rhizomorphs. In the arid zone, where trees are already stressed due to poor soil quality, water scarcity, and extreme temperatures, the additional burden of *Ganoderma*-induced root rot severely compromises tree health and survival.The major timber species affected in the arid region include Dalbergia sissoo (Shisham), Acacia nilotica (Babul), *Prosopis cineraria* (Khejri), and *Tecomella undulata* (Rohida), among others (Table 1). These species not only provide valuable wood and non-timber products but also contribute to biodiversity conservation and soil fertility improvement. In recent years, Ganoderma lucidum, *G. applanatum*, and G. australe have been frequently isolated from diseased roots and lower stems of these species. Infections typically begin in the roots and gradually spread upward, degrading lignin and cellulose, resulting in white rot. The visible symptoms include yellowing and wilting of foliage, reduced leaf size, premature defoliation, dieback of branches, and eventual death of the tree.

Field surveys conducted across Rajasthan and other arid parts of western India have revealed the prevalence of *Ganoderma* (Figure 1 and 2), in some of the arid tree species. Studies indicate that the incidence of *Ganoderma* root rot can range from 15% to 40% in natural stands and plantations, with mortality rates reaching as high as 70% in older and poorly managed plantations of *Dalbergia* sissoo and *Tecomella undulata*. In nurseries and young plantations, the infection rate may appear lower initially but often escalates rapidly due to favorable microclimatic conditions and repeated use of contaminated planting materials or soil.The pathogen spreads mainly through root-to-root contact and movement of infected soil or organic debris. Waterlogging, soil compaction, and physical injuries to roots serve as predisposing factors that facilitate fungal entry and colonization. Once infected, trees rarely recover, as the internal decay progresses silently and by the time external symptoms appear, the structural integrity of the tree is often severely compromised. Moreover, conventional management practices such as pruning or soil drenching are largely ineffective due to the deep-seated nature of the infection.

The lack of early detection tools and limited awareness among forest managers and farmers further complicates the management of *Ganoderma* root rot. Therefore, integrated strategies involving regular monitoring, use of disease-free planting material, soil health improvement, biological control agents, and removal of infected stumps are urgently required to mitigate losses. Understanding the epidemiology and host specificity of *Ganoderma* in arid ecosystems is essential for designing effective and sustainable forest health management plans.

The lack of early detection tools and limited awareness among forest managers and farmers further complicates the management of *Ganoderma* root rot.

Taxonomic position

Kingdom	:	Fungi
Phylum	:	Basidiomycota
Class	:	Agaricomycetes
Order	:	Agaricales
Family	:	Ganodermataceae
Genus	:	*Ganoderma*

Species: Multiple species, including *Ganoderma lucidum, Ganoderma applanatum, Ganoderma sinense,* etc.

Figure 1. *Ganoderma* infection in a Khejri tree (*Prosopis cineraria*), showing symptoms of root rot, and the appearance of hard, woody, shelf-like fruiting bodies at the base of the tree.

Table 1. Host range and symptoms of *Ganoderma* infection in arid region tree species

Host species	**Symptoms of infection**
Prosopis cineraria	Yellowing of leaves, premature leaf drop, stunted growth, and root rot leading to tree mortality.
Acacia tortilis	Yellowing and wilting of leaves, reduced shoot growth, and dieback from the top or base of the tree.
Acacia senegal	Slow growth, yellowing of leaves, wilting, and basal swelling with fungal fruiting bodies.
Tamarix spp.	Reduced vigor, yellowing of leaves, stunted growth, and root rot near the base of the tree.
Ziziphus mauritiana	Wilting, early leaf drop, reduced growth, and blackened roots.
Leucaena leucocephala	Yellowing of leaves, stunted growth, and dieback, particularly in young trees.
Dalbergia sissoo	Yellowing of leaves, root rot, dieback from the base, and fungal fruiting bodies at the root zone.

Fig. 2. Ganoderma infection in the buttresses of some of the common arid-region tree species

Pathogenesis

Ganoderma species are destructive soil borne fungi responsible for causing root rot in a wide range of timber tree species, particularly in arid and semi-arid regions. The pathogenesis begins when fungal propagules mainly basidiospores, mycelial fragments, or rhizomorphs come into contact with susceptible tree roots. These fungal units can remain viable in soil, infected roots, or decaying stumps for extended periods. Infection is typically initiated through wounds or natural openings in the root tissues, often caused by mechanical injury, pest attack, or adverse environmental conditions. Once inside, the fungus begins to colonize the root tissues by producing a suite of ligninolytic and cellulolytic enzymes such as laccases, cellulases, and lignin peroxidases. These enzymes degrade the structural components of the wood particularly lignin and cellulose resulting in a characteristic white rot. As the infection progresses, the fungus advances from the roots into the basal stem, compromising the vascular tissues and disrupting water and nutrient transport.

The early stages of infection are often asymptomatic, making detection difficult. However, as colonization advances, visible symptoms appear including leaf yellowing, reduced leaf size, branch dieback, and overall wilting of the tree. Internally, the wood becomes soft, spongy, and discoloured, severely weakening the tree's structural integrity. Infected trees may also exhibit basal stem swelling, cracking, and the formation of bracket like fruiting bodies (basidiocarps) near the root collar or on exposed roots. These basidiocarps produce millions of basidiospores which are released into the environment and serve as the primary source of new infections. The pathogen spreads rapidly through root to root contact or via movement of infected soil especially in densely planted or monoculture systems. Environmental stressors such as poor drainage, compacted soil, and prolonged drought further predispose trees to infection by weakening their defence mechanisms.

Host response to *Ganoderma* infection is generally inadequate as the fungus invades both the sapwood and heartwood causing extensive internal decay. Tyloses formation or accumulation of phenolic compounds may slow down the spread temporarily but these defences are usually overcome. In unmanaged or older plantations especially those of *Dalbergia sissoo*, T*ecomella undulata*, and Acacia nilotica the mortality rate can be extremely high often exceeding 40 percent if timely intervention is not made. The disease is particularly challenging to manage because of its slow progression, deep seated colonization, and the absence of effective curative treatments. Therefore, understanding the detailed mechanism of *Ganoderma* pathogenesis is critical for early diagnosis, breeding resistant varieties, and developing integrated management strategies that include cultural, biological, and sanitary practices.

Symptoms

The symptoms of *Ganoderma* root rot in timber tree species are often subtle in the initial stages, making early detection difficult. The disease usually begins underground, with the decay of fine feeder roots, and progresses slowly toward the main root system and basal stem. One of the earliest signs is a gradual decline in tree vigor, which may manifest as reduced leaf size, chlorosis (yellowing) of foliage, and premature leaf drop. As the infection advances, affected trees may show sparse foliage, dieback of twigs and branches, and poor canopy development. Wilting during dry seasons is a common symptom due to the disrupted uptake of water and nutrients. In many cases, the tree becomes more susceptible to secondary pests and pathogens, which further accelerates decline.

Externally, one of the characteristic symptoms is the appearance of basal swelling or cracking at the collar region near the soil line. Over time, bracket-shaped fruiting bodies (basidiocarps) of *Ganoderma* emerge at the base of the trunk or on exposed roots. These fruiting bodies are typically hard, woody, and shelf-like, with a shiny reddish brown upper surface and white margin when fresh. Their presence is an indication of advanced internal decay. Beneath the bark, the wood appears white, stringy, and spongy, a typical feature of white rot caused by enzymatic degradation of lignin and cellulose. Affected roots and basal stem tissues often exhibit a distinctive sour or musty odour.

In severely infected trees, the structural weakening of the root system and basal stem may lead to sudden collapse or toppling, especially during storms or strong winds. This is because the decayed wood can no longer support the mechanical load of the tree. The disease progression is typically slow and chronic, but once external symptoms appear, the internal damage is usually extensive and irreversible. In plantation settings, symptoms often occur in patches, as the fungus spreads through root contact, affecting clusters of trees in proximity. The mortality rate can vary depending on the tree species, environmental conditions, and age of the plantation, but in unmanaged or stressed stands, it can exceed 40 to 50 percent.

Integrated disease management

Ganoderma root rot requires a comprehensive approach that integrates several control methods to prevent and manage the disease in timber plantations. Since *Ganoderma* is a persistent soil-borne pathogen that can survive in infected root debris and stumps for many years, eradication becomes very challenging once the infection is established. The focus, therefore, shifts to prevention, early detection, and integrated management.Site selection and sanitation are essential in preventing the spread of *Ganoderma*. Disease-free sites should be selected for plantation establishment, especially in areas that have a history of *Ganoderma* infection. Infected stumps and root debris must be removed and destroyed before planting new trees. Deep ploughing and solarization, which involves covering the soil with transparent plastic sheets during peak summer months to heat the soil, help reduce the inoculum load in the soil.

Cultural practices also play a significant role in disease management. Avoiding over-irrigation and improving drainage will prevent waterlogging, which promotes fungal growth. Preventing mechanical damage to roots during plantation maintenance and intercultural operations is also essential. Ensuring proper spacing between trees reduces root-to-root contact and limits the spread of the pathogen. Organic amendments like compost and farmyard manure should be used to improve soil structure, fertility, and tree vigor. Planting resistant or less susceptible species, such as *Azadirachta indica* or Prosopis cineraria, in high-risk zones can help mitigate the disease's impact. Establishing mixed plantations with non-host species can break the pathogen's cycle.

Biological control agents are an effective and eco-friendly way to suppress *Ganoderma.* Several beneficial microbes have shown antagonistic activity against *Ganoderma*. *Trichoderma harzianum* produces enzymes that degrade the cell wall of *Ganoderma* and competes for nutrients. It can be applied as a soil drench at a dose of 10–20 grams per liter of water, drenching around the base of the tree and root zone during nursery stages and transplanting. *Pseudomonas fluorescens* produces secondary metabolites that inhibit *Ganoderma* growth and can be applied as a root dip or soil drench at a dose of 20–30 grams per liter of water. *Bacillus subtilis* produces antifungal compounds and improves plant health by enhancing root growth and nutrient uptake. It can be applied at 25–30 grams per liter of water as a soil drench or root treatment. Arbuscular Mycorrhizal Fungi (AMF) improve root health, nutrient uptake, and induce resistance against pathogenic fungi. AMF spores should be applied at a recommended dose of 5–10 grams per plant at transplanting or during the nursery phase.

Chemical control, though limited in effectiveness due to the deep-seated nature of *Ganoderma* infections, can be used preventively or to manage early infections in combination with other methods. Systemic fungicides such as *hexaconazole, propiconazole*, and carbendazim are effective. *Hexaconazole* can be applied as a soil drench at a dose of 10–15 milliliters of fungicide diluted in 1 liter of water, applied around the root zone during early stages of infection. *Propiconazole* can be used at 5 milliliters per liter of water as a soil drench around the root zone. *Carbendazim* can be applied at 5 grams per liter of water for soil drenching around the root zone. Chemical fungicides should be used sparingly and in conjunction with biological agents to minimize environmental impact.

Regular monitoring and early detection of symptoms such as basal swelling, fruiting bodies, dieback, and reduced tree vigor are crucial for managing the disease. Visual inspections of tree roots and stems for signs of disease, especially during the growing season, can help identify the problem early. Trees showing early signs of infection should be isolated or removed promptly to prevent the pathogen from spreading to healthy trees. Ongoing education of farmers, plantation managers, and field staff about disease symptoms, risk factors, and control methods is essential for effective IDM. Organizing workshops and awareness campaigns can equip local communities with the knowledge needed for effective disease management.

ICFRE-AFRI intervention in biological control of *Ganoderma*

The Indian Council of Forestry Research and Education - Arid Forest Research Institute (ICFRE-AFRI), Jodhpur, has made significant strides in mitigating the root rot caused by *Ganoderma* through the use of *Trichoderma harzianum* (*T. harzianum*), a biological control agent. Root rot caused by *Ganoderma* is a major concern for timber species, particularly in arid and semi-arid regions, where it threatens the sustainability of plantations. The persistence of the pathogen in the soil, coupled with its ability to infect healthy plants and lead to tree mortality, requires an innovative and sustainable approach to disease management.ICFRE-AFRI has focused on exploring eco-friendly and cost-effective alternatives to chemical control, with *T. harzianum* emerging as a promising biological control agent. *T. harzianum*, a beneficial soil fungus (Figure 2), has demonstrated remarkable antagonistic activity against *Ganoderma* by producing enzymes that break down the pathogen's cell walls, inhibiting its growth and proliferation. It competes with *Ganoderma* for nutrients and space in the soil, effectively suppressing the pathogen's establishment and spread. Through this process, *T. harzianum* helps to maintain the health of soil ecosystems and improves the overall vitality of plant roots.

Figure 2. *Trichoderma harzianum* cultured on an agar plate, showing its characteristic fast growth with greenish mycelium,

ICFRE-AFRI's intervention involves the application of *T. harzianum* in various forms, including as a soil drench, root dip, or as part of seedling treatment during the nursery stage and transplanting. The recommended dosage for the application of *T. harzianum* varies based on the severity of the disease and plantation size. Typically, a concentration of 10-20 grams of *T. harzianum* spores per liter of water is applied for soil drenching. For root dipping, a similar concentration is prepared, and young saplings or seedlings are dipped before planting. This application not only helps in controlling *Ganoderma* root rot but also promotes the growth of plant roots, enhances soil health, and induces resistance to other fungal pathogens.A critical aspect of *T. harzianum* application is the mass multiplication of the biological agent to ensure sufficient inoculum for widespread use. ICFRE-AFRI has adopted a highly efficient protocol for mass multiplication of *T. harzianum* using sorghum grain as a substrate. Sorghum grain is preferred for its availability, cost-effectiveness, and nutrient-rich composition, which facilitates optimal growth and sporulation of *T. harzianum.*

The process begins with sterilizing the sorghum grains to eliminate any existing microbial contamination. The sterilized grains are then inoculated with pure cultures of *T. harzianum*, which are grown on agar plates in laboratory conditions. Once inoculated, the grains are incubated at temperatures between 25°C to 30°C for about 10 to 14 days, during which the fungal spores proliferate and colonize the grains. The grains are then dried and ground to a fine powder or can be used directly as a granular inoculum for field applications.The mass-produced *T. harzianum* is packaged in suitable containers and is ready for use in large-scale plantations. This method of mass production ensures that *T. harzianum* is available in large quantities for various field applications, reducing the need for expensive and harmful chemical fungicides. The application of *T. harzianum* has been shown to reduce the incidence of *Ganoderma* root rot in timber plantations, resulting in healthier, more resilient trees.

In addition to its biological control properties, *T. harzianum* is known to enhance plant growth by improving nutrient uptake and promoting root development. This holistic approach to disease management aligns with ICFRE-AFRI's broader objectives of sustainable forest management, where the use of chemical fungicides is minimized, and natural, eco-friendly solutions are promoted.ICFRE-AFRI has also been actively involved in training and capacity building for local communities, forestry officials, and plantation managers in the proper application of *T. harzianum.* This knowledge transfer is crucial to ensure that biological control methods are widely adopted and effectively implemented across regions affected by *Ganoderma*. Field trials and demonstration plots are regularly conducted to assess the effectiveness of *T. harzianum* in diverse environmental conditions. The positive outcomes from these trials have encouraged the adoption of *T. harzianum* as a key component of Integrated Disease Management (IDM) strategies in combating *Ganoderma* root rot. Through these interventions, ICFRE-AFRI is contributing significantly to sustainable forestry practices and is working towards minimizing the ecological impact of forest diseases, while enhancing the productivity and resilience of arid region plantations.

References:

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Sustaining Forest Health: Historical Challenges and Modern Solutions for Tree Disease

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Abstract

Forest trees are indispensable for environmental stability and economic prosperity. Beyond serving as a renewable source of bio-energy, they play a pivotal role in preserving global biodiversity, mitigating pollution, and alleviating the impacts of climate change. The demand for timber and forest-derived products is projected to rise steadily in the foreseeable future. However, this sustainability is threatened by diseases, insect pests, and adverse climatic conditions. Pathogen-induced threats often manifest abruptly or evade detection until irreversible damage occurs, complicating timely disease mitigation. Consequently, resources are typically allocated to diseases posing the gravest ecological and economic risks. Effective forest disease control is imperative, as disturbances from invasive and emerging pathogens significantly impair forest growth and productivity. Optimal management necessitates integrating diverse strategies, including disease-resistant genotype selection, biological and chemical controls, and Integrated Pest Management (IPM). Immediate deployment of rapid disease detection tools, biotechnological interventions (e.g., genetic modification), and beneficial microbiome engineering is critical. Accelerating tree genomics to identify resistance or susceptibility genes will further enable the development of resilient tree species. A holistic approach, combining traditional methods with advanced technologies is essential for sustaining forest health.

Keywords: Forest, Diseases, Management, IPM, Microbiome

The Evolution and Contemporary Challenges of Forest Pathology

Forest pathology investigates fundamental and applied aspects of diseases afflicting forest trees, predominantly caused by oomycete and fungal pathogens. The discipline's evolution has been shaped by innovations in microbiology, health sciences, and forestry practices. Historically, catastrophic outbreaks such as chestnut blight and white pine blister rust in North America and Europe have defined the field, mirroring the impact of potato late blight on plant pathology (Desprez-Loustau et al., 2016). Invasive pathogens and tree diseases trigger severe socioeconomic repercussions, including diminished timber value, reduced recreational utility, and loss of forest biodiversity (Sturrock et al., 2011).

Applying Steffen et al.'s (2015) planetary boundaries framework, Trumbore et al. (2015) identified diseases, invasive species, climate change, deforestation, and escalating resource demand as primary stressors on global forests. Industrialization and intensified forest management have exacerbated these issues, increasing vulnerability to biological invasions and climatic disruptions (Steffen et al., 2015; Trumbore et al., 2015; Ramsfield et al., 2016).

Global timber demand has surged dramatically in recent decades, necessitating high-yield plantations. These expanded from 168 million hectares in 1990 to 278 million hectares in 2015, an annual growth of 4.4 million hectares, and are projected to increase by 25–67 million hectares by 2030 (Solís et al., 2025). While plantations meet timber needs, they intensify disease prevalence. The host-pathogen "arms race" drives continuous evolution of resistance and virulence, accelerated by shorter generation cycles. Soularue et al. (2017) demonstrated that reduced plantation rotation periods, driven by human activity, further hasten pathogen virulence evolution (Garbelotto & Gonthier, 2017).

Multifaceted Impacts of Diseases on Tree Health

Forest trees face health challenges across all life stages: seed, seedling, plantation, mature forest, and post-harvest. Disease-induced seed degradation and abortion directly impair germination and seedling survival. Foliar diseases reduce plant vigor, growth, and aesthetic value, while root infections cause mortality or chronic stunting from germination to maturity (Harsh, 2025).

Regional declines in tree species highlight the long-term consequences of deteriorating soil and climatic conditions interacting with genetic susceptibility (Desprez-Loustau et al., 2016). Diseases exert ecological and economic impacts by altering habitat dynamics and timber quality. Ecologically, they disrupt ecosystems exponentially, affecting species behavior, population dynamics, habitat structure, and nutrient cycling. Weakened trees increase branch fall and mortality, posing public safety risks (Dahlsjö, 2023). Forests with diverse species and age structures exhibit greater resilience, as infection and mortality rates correlate with tree spacing and genetic variability (Roberts et al., 2020). Species selection prioritizing local adaptation and disease resistance is crucial. Diversification mitigates ecological disruption and economic losses by allowing complementary species to occupy disease-generated gaps and maintain ecosystem functions like nutrient cycling (Hill, 2017).

Integrated Strategies for Tree Health Management

Managing invasive pathogens remains fraught with challenges: undetected introduction pathways, low-abundance pathogen identification in natural ecosystems, failed eradication efforts, and native plant susceptibility (LeBoldus et al., 2024). Future research must prioritize three critical areas: developing rapid early-stage disease detection; selecting and propagating resistant trees for sustainable yield; and leveraging microbiome-based strategies for disease suppression and growth enhancement.

Accurate diagnosis is the cornerstone of forest health management. Advances in detection technologies from serological kits to molecular diagnostics, sensor-based assays, spectroscopy, and remote sensing have revolutionized this field. Spectroscopic tools, categorized by platform (laboratory, handheld, or aircraft-mounted), offer non-destructive, high-throughput screening. These complement DNA-based and serological methods, enabling real-time asymptomatic detection via volatile and biophotonic sensors. Remote sensing spatializes diagnostic data, minimizing pesticide overuse and promoting sustainable practices (Fang et al., 2023; Martinelli et al., 2015).

Biotechnological interventions extend beyond genetic engineering (GE). Options include conventional and genomic-informed breeding, GE, genome editing, RNA interference (RNAi), tissue culture, biological control, and grafting. Host-Induced Gene Silencing (HIGS) exploits conserved eukaryotic RNAi pathways to engineer plant defenses. Similarly, Spray-Induced Gene Silencing (SIGS) applies dsRNAs topically for pathogen-specific control. CRISPR-Cas9 genome editing introduces sequence-specific DNA breaks for precision trait modification (LeBoldus et al., 2024). These methods must be deployed responsibly, prioritizing environmentally safe traits.

Plant immune mechanisms, Pathogen-Associated Molecular Pattern (PAMP)-Triggered Immunity (PTI), Effector-Triggered Immunity (ETI), and exosome-mediated Cross-Kingdom RNA Interference (CKRI), offer additional defense layers (Solís et al., 2025). "Omics" technologies (genomics, proteomics, transcriptomics, metabolomics) are vital for elucidating molecular traits in tree breeding. Key approaches include:

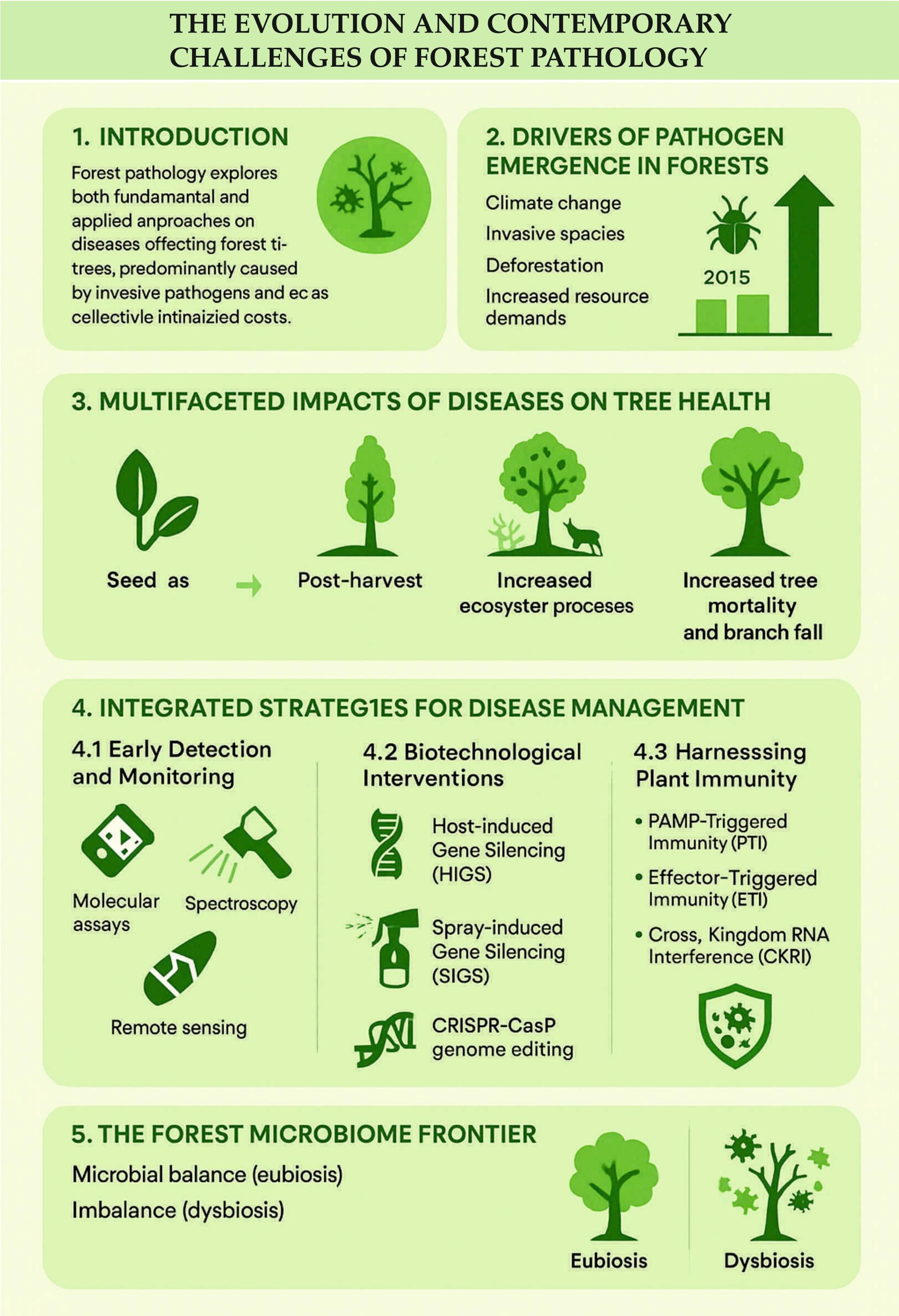
- Analyzing the NBS-LRR gene family for resistance genetics.
- Conducting cross-species transcriptome analyses of hosts and pathogens.
- Utilizing Genome-Wide Association Studies (GWAS) to link phenotypes to genotypes via linear mixed modeling.
- Characterizing Resistance Gene Analogs (RGAs) through physicochemical profiling, subcellular localization, protein fingerprinting, in silico annotation, and structural modeling (LeBoldus et al., 2024; Latif et al., 2025).

The microbiome's role is critical in human health and agriculture, demands equal attention in forestry. Eubiosis (microbial balance) promotes host health, while dysbiosis triggers disease. Advances in sequencing and bioinformatics accelerate microbiome research. Aligning with the One Health framework, managing soil and plant microbiomes can sustainably boost productivity while preserving ecosystems (Schweitzer et al., 2025). Studies on forest microbiomes (e.g., fungi, bacteria, mycorrhizae) remain nascent, highlighting a research imperative (Enea et al., 2025; Wainwright et al., 2023).

Conclusion

Integrating these approaches ensures forest resilience against threats while sustaining ecosystem services, carbon sequestration, biodiversity conservation, and water regulation. Inclusive decision-making, engaging local communities, Indigenous groups, and stakeholders, is paramount for durable forest health strategies. Immediate public outreach via media campaigns, seminars, and educational programs is essential to disseminate best practices. Ultimately, forest health management must bolster ecological integrity and resilience.

References: Contact author at charishma@icfre.org



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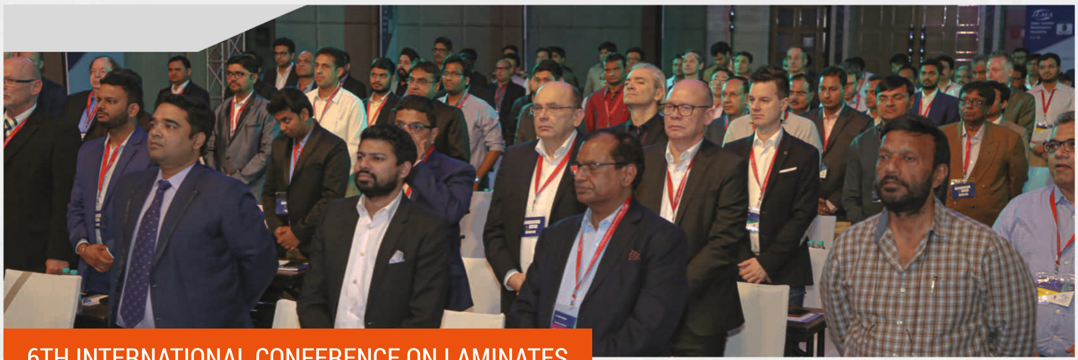

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1. Organized six International Conference on Laminates between 2010 to 2018
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3. Restrict import of low quality laminate
4. Study on Cleaner Production
5. Launch of Technical book on laminate
6. Catalogue shows at National and International Level
7. Launch of awareness video on Laminate application
8. Networking with members for raw materials, production, market and government policy related issues
9. Export incentive benefits to laminate exporters
10. Support to PM Cares fund during pandemic

Upcoming Events

1. 7^{th} International Conference on Laminates during Delhi wood March 2021
2. Catalogue show at Interzum, Germany 2021
3. Online technical workshop on production and environment aspects during October 2020.
4. Environment clinic with Pollution control board (December 2020)

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Ministry of Environment, Forest & Climate Change

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(formed vide Notification No.F.No.36-5/2022-ICFRE dated 23rd Dec, 2022)

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(पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय, भारत सरकार का एक स्वायत्त निकाय)
(An Autonomous body of Ministry of Environment, Forest & Climate Change, Govt. of India)
डाकघर मल्लेश्वरम/P.O. Malleswaram, बेंगलुरु/Bengaluru – 560003

सं/No:16-214/2023-24/IWST/EXTN/Incubation Centre/436(a) दिनांक/Dated: 17.01.2024

GUIDELINES FOR REGISTRATION AT INCUBATION CENTRE OF ICFRE-IWST

About ICFRE-Institute of Wood Science and Technology (IWST), Bengaluru

ICFRE-IWST is a premier research Institute under Indian Council of Forestry Research and Education (ICFRE) with specialized mandate to work on the research aspects of wood science and technology. In order to promote innovation and entrepreneurship among students, faculty and stakeholders, ICFRE-IWST has established Incubation Centre for wood products under the guidance of expert scientists of ICFRE-IWST.

Vision

To nurture the culture of invention and entrepreneurship in the wood products among students, faculty, stakeholders and community inventors.

Mission

i. To focus on invention by identifying problems and providing solutions that would be commercialized into venture development.
ii. Product development would be prime focus by normalizing resources.

Objectives

i. Identifying areas, proof of concepts to prototype modules and translating them into product development.
ii. Conducting hackathons and wood camps to engage and develop interest among students, faculty, stakeholders and community inventors.
iii. To inculcate generation of Intellectual Property Rights (IPRs) among students, faculty, stakeholders and community inventors.

Incubation Space

ICFRE-IWST has full-fledged Incubation Centre with 250 sq.mt. work space with modern wood working machineries to assist the inventors and entrepreneurs. Institute also host IT Cell and library to access the knowledge in the field of wood science and technology. ICFRE-IWST host Wood Properties and Processing (WPP) Division and Plywood and Panel Product Technology Division with experienced wood scientists and technical officers to guide and assist students, faculty, stakeholders and community inventors on their invention ideas into business model.

Fields of incubation

i. Wood and bamboo based products
ii. Engineered wood
iii. Wood polymer composites
iv. Wood modification
v. Wood and lignocellulose panel products
vi. Forest Protection
vii. Tissue Culture
viii. Forest management and certification

Process of Registration and Operationalization

Interested students, faculty, stakeholders, community inventors and entrepreneurs who like to work in the Incubation Centre of ICFRE-IWST on wood products shall register by submitting duly filled necessary data in Registration Form enclosed. The applicants shall pay ₹10,000/- (Rupees Ten Thousand only) as a deposit amount to ICFRE-IWST.

The incubation after registration has to sign a Memorandum of Association with IWST and bear cost of material required for developing prototypes, charges for machine usage and meet any other financial obligations as agreed in the Memorandum of Association.

REGISTRATION FORM TO WORK IN ICFRE-IWST INCUBATION CENTRE

PHOTOGRAPH

PERSONAL INFORMATION		
1.	**Name:**	
2.	**Contact Number:**	
3.	**E-mail Id:** ✉	
4.	**Postal address:**	

BUSINESS INFORMATION		
1.	**Name of the business:**	
2.	**Which topic is most aligned with your idea?**	
3.	**How long you have been working in your business idea?**	
4.	**Any progress so far made?**	
5.	**Any prototype model developed (if applicable)?**	
6.	**How would your business idea contribute to improve life using business as a force for good things?**	

Signature of the applicant

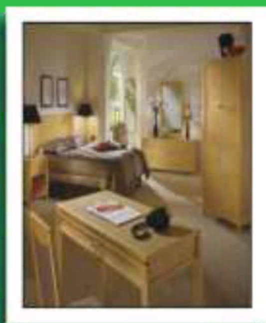
FEDERATION OF INDIAN PLYWOOD & PANEL INDUSTRY (FIPPI)

REGISTERED UNDER THE SOCIETIES REGISTRATION ACT XXI OF 1860, REGN. NO. S/2985/1968-69 DT. 4.1.1969

Part of FIPPI Achievements

With great efforts of Federation of Indian Plywood & Panel Industry (FIPPI), an Apex representative body of Plywood / Panel / Other Allied products including Furniture and Wood / Bamboo Working Machinery Manufacturers in India alongwith close cooperation with various Ministries and Premier Institutes through Agro and Farm Forestry and other Captive Plantation programme, the dying woodbased industry is again reviving in the country to produce various standard products like Veneer, Plywood, Panelboard, Particleboard, MDF, Laminates etc. which are internationally accepted. Further with great pursuance of the President and Senior Executive members of FIPPI we are highlighting and representing the crucial issues confronting the Plywood & Panel Industry. FIPPI also publishes quarterly Journal Indian Wood & Allied Products highlighting the development taking place in India and abroad, market profile, world timber market report, statistics, international exhibition and conferences, articles, write-ups etc.

FIPPI is cordially inviting all plywood / panel / bamboo / Laminates and other allied products manufacturers to become active member for the strengthening the platform of FIPPI and working for the development of the industry which is Internationally recognized by ITTO, FAO, European Union, IWPA, BIS, MoEFCC, Ministry of Commerce & Industry, BIS, FICCI, CII and other renowned Organizations.



FEDERATION OF INDIAN PLYWOOD & PANEL INDUSTRY (FIPPI)

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Website : www.fippi.org

THE INDIAN ACADEMY OF WOOD SCIENCE

Working Office: Institute of Wood Science & Technology Campus,
P.O. Malleswaram, Bengaluru-560 003 (India)
E-Mail: iaws.india@yahoo.com Website: http://www.iaws.org.in

The Indian Academy of Wood Science was founded in 1968 to advance the knowledge of wood science & technology and covers in its activities all the aspects related to wood, cellulose and their products such as logging, saw milling, wood working, plywood, fibre boards, particle boards, improved and composite woods, cellulose and cellulose based sciences and industries and allied fields. The Academy runs a Journal called "Journal of the Indian Academy of Wood Science". In addition to this, it also organises seminars and workshops. During some annual meetings, lectures from eminent scientists are also arranged. The Academy has joined hands with Springer, an internationally reputed publishing house, for bringing out the journal fully online for wider international readership. Authors may submit the manuscript of their research papers online following the Springer publication link http://www.editorialmanager.com/jiaw

APPLICATION FOR MEMBERSHIP

To,

The General Secretary
Indian Academy of Wood Science
Institute of Wood Science & Technology Campus
P.O. Malleswaram, Bangalore-560 003 (India)

Sir,

I wish to become a member of the Indian Academy of Wood Science and give below the necessary particulars for enrolling as "Corporate Member/Institutional Member/Individual Member" (as the case may be). Necessary remittance of Rs.* .... is made by a Demand Draft/Cash, which may please be acknowledged. I agree to abide by the constitution of the academy and agree to the code of ethics contained therein.

Place: …………………….. (Signature of the Applicant)

Date: ……………………..

1. Name of applicant in full (in block capitals)	
2. (a) Date of Birth, (b) Age (in case of individuals only)	
3. Academic and professional qualifications (in case of individuals only)	
4. Present employment/how engaged and brief history of previous career in case of individuals (separate sheet may be attached, if necessary)	
5. Brief description of general activities in case of Corporate, Institutional Members	
6. Address to which communications should be sent including phone, fax & e-mail	

* *Demand Draft should be drawn in favour of 'Indian Academy of Wood Science' and payable at Bangalore.*

Membership Type	**Annual Fee**	**Life Time Fee**
Indian :		
Corporate	N. A.	Rs. 100,000
Institutional	Rs. 2,000	N.A.
Individual	Rs. 500	Rs. 5,000
Foreign :		
Corporate	N. A.	US $ 2,500
Institutional	US $ 50	N.A.
Individual	US $ 20	US $ 200

(To be Photocopied for Use)

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