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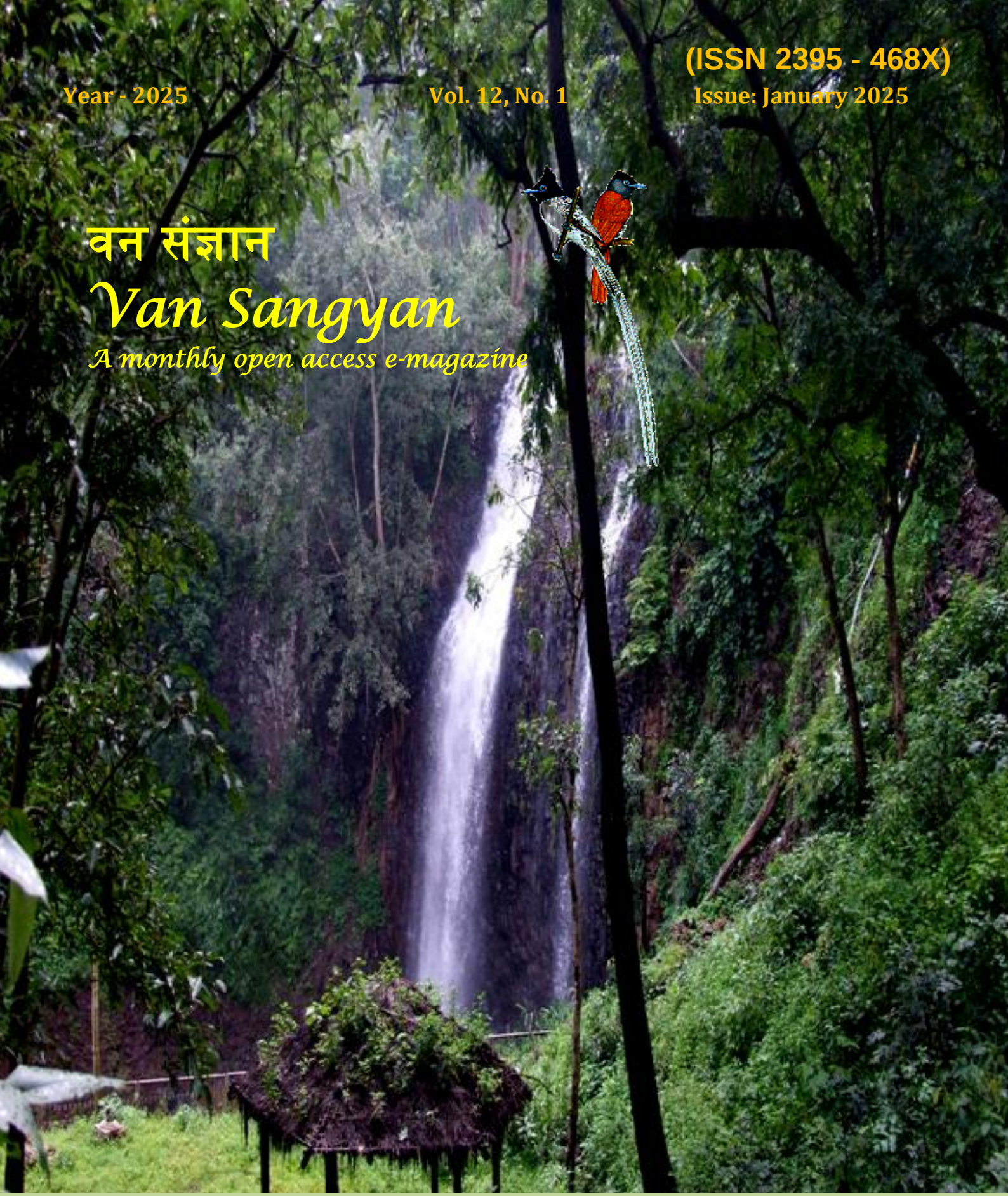

वन संज्ञान
Van Sangyan
A monthly open access e-magazine

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Van Sangyan

Note to Authors:

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

by e-mail to vansangyan_tfri@icfre.org

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

The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number. TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

The collection of tendu leaves (Diospyros melanoxylon) has been a crucial livelihood source for many indigenous communities in India, particularly in tribal regions. These leaves are harvested primarily for the production of bidis (traditional cigarettes) and serve as a significant economic resource. The process of gathering tendu leaves not only supports local economies but also provides seasonal employment to millions of people. The Forest Rights Act empowers indigenous communities to collect and manage forest resources, ensuring their right to sustain their livelihoods through such activities. Tendu leaves, often referred to as "green gold," are essential to the economic stability of these communities, providing income and promoting social well-being. Data from the Tribal Cooperative Marketing Development Federation of India reveals that the collection of tendu leaves provides employment to 7.5 million people nationwide for about three months each year. The article 'तेंदू पत्ता संग्रह - एक आजीविका का साधन ' highlights the importance of tendu leaf collection in supporting rural livelihoods and its broader socio-economic impact in India.

In line with the above, this issue of Van Sangyan contains an useful articles viz.. Doubling the farmer's income through Melia dubia under Agroforesry, Blue carbon as a climate change mitigation strategy, अगरबत्ती उद्योग के लिए जिगट का वैकल्पिक स्त्रोत , Fusarium leaf spot: An emerging foliar leaf disease of nursery in Bael (Aegle marmelos Correa.), Gmelina arborea: An indigenous multipurpose tree species, Nanopore sequencing technology, Bambusa tulda Rox: A promising bamboo forindian farmers, RNAi: A revolutionary approach to combat insect infestation in forest trees and A comprehension on Azadirachta indica through the perspective of agroforestry.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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तेंदू पत्ता संग्रह एक आजीविका का साधन

सोमनाथ सरवदे, राकेश बाजपाई एवं एस बी अग्रवाल

वानिकी विभाग, कृषि महाविद्यालय, जबलपुर

जवाहरलाल नेहरू कृषि विश्वविद्यालय, जबलपुर (म.प्र.)

तेंदू या केंदू पेड़ (*डायोस्पाइरॉस मेलेनोक्सिलॉन* रॉक्सब.) जो ईबेनेसी परिवार का है, ये भारतीय उप महाद्वीप में एंडेमिक है। स्थानीय रूप से इसे टेम्बुरनी कहा जाता है। यह सूखे और बर्फबारी में मजबूत है, लेकिन जल भराव के प्रति संवेदनशील है। यह एक महत्वपूर्ण कम जाना जाने वाला फल है जो मध्य प्रदेश, छत्तीसगढ़, झारखंड और ओडिशा राज्य के स्थानीय बाजारों में गर्मियों में उपलब्ध होता है और एक खास वस्तु के रूप में उपयोग किया जाता है। यह फल बहुत पोषक तत्वों और फाइबर का एक उत्कृष्ट स्रोत है। इन क्षेत्रों के आदिवासी इस फल का उपयोग गर्मियों में लू या गरम हवाओं से अपनी सुरक्षा के लिए कर रहे हैं। जीनेरिक नाम यूनानी शब्द 'डियोस' (दिव्य) और 'पायरोस' (फल) से लिया गया है, जो जीनस के उत्कृष्ट फल का संदर्भ करता है। विशेष नाम ग्रीक है और इसका का अर्थ 'डार्क वुड' है।

ये फल अत्यधिक पोषक है और यह फेनोल्स और फाइबर का एक समृद्ध स्रोत हैं। इसके फल का गूदा पीला, चिपचिपा, नरम, मीठा और थोड़ा सा कसैला होता है। ये फल शर्करा, प्रोटीन, फाइबर और विटामिन सी में समृद्ध होते हैं। इसके अलावा, फल में β-कैरोटीन, टर्पेनॉइड्स, फ्लैवोनॉइड्स, सैपोनिन और टैनिन जैसे कई लाभकारी फायदेमंद फायटोकेमिकल्स होते है। पके हुए फल कुछ गैर-एंटीऑक्सिडेंट्स, अपरिचित ऑलिगोसैक्साइड, फ्यूमैरिक एसिड और गैलिक एसिड का महत्वपूर्ण स्रोत होते हैं।

पेड़

पत्ता

छाल

पत्ते एवं फल

फल

(Source: https://indiabiodiversity.org/species/show/265568)

तेंदू के गूदे का रासायनिक संरचना का विवरण

मापदंड	गूदा (ग्राम / 100 ग्राम)	रस (ग्राम / 100 मिलीलीटर)
वजन	72.0±2.7	-
नमी	68±2.3	-
कुल शर्करा	28.6±3.0	22.1±1.7
एस्कोर्बिक एसिड (विटामिन-सी)	2.8±0.56	1.78±0.6
फेनोल	1.72±0.64	1.36±0.55
β-कैरोटीन	22.0±1.0	18.0±0.27
राख	0.25±0.04	0.23±0.05

तेंदू फल के घटक

कार्बोहाइड्रेट्स: तेंदू फल में मुख्य रूप से कार्बोहाइड्रेट्स पाए जाते हैं, जो ऊर्जा का प्रमुख स्रोत होते हैं।

प्रोटीन: इसमें कुछ मात्रा में प्रोटीन भी पाया जाता है, जो शरीर के विकास और मरम्मत के लिए आवश्यक होता है।

विटामिन्स: तेंदू फल में विटामिन सी, विटामिन ए और कुछ बी विटामिन्स जैसे थियामिन, राइबोफ्लेविन और नियासिन पाए जाते हैं।

मिनरल्स: इसमें आयरन, कैल्शियम, फॉस्फोरस और मैग्नीशियम जैसे खनिज तत्व होते हैं, जो हड्डियों और दांतों के लिए महत्वपूर्ण होते हैं।

फाइबर: तेंदू फल में आहार रेशे (फाइबर) भी होता है, जो पाचन क्रिया को सुधारने में मदद करता है।

एंटीऑक्सीडेंट्स: इसमें एंटीऑक्सीडेंट्स भी होते हैं, जो शरीर को मुक्त कणों से बचाते हैं और प्रतिरक्षा प्रणाली को मजबूत बनाते हैं।

तेंदू फल का सेवन स्वास्थ्य के लिए लाभकारी माना जाता है, क्योंकि इसमें पोषक तत्वों की विविधता होती है।

पके खाने योग्य गूदे के घटक	मात्रा (%)
नमी	79.1-82.4
प्रोटीन	0.43-0.58
कच्चे रेशे	0.37-0.49
टी.एस.एस.	16.2-19.5
ग्लूकोज़	1.05-11.9
फ्रक्टोज़	4.65-6.79
घुलनशीलपेक्टिन	4.40-7.29
घुलनशीलटैनिन	0.50-0.68

इसकी विविधता और महत्व को निम्नलिखित बिंदुओं में समझा जा सकता है:

प्राकृतिक वितरण: तेंदू वृक्ष मुख्यतः मध्य प्रदेश, छत्तीसगढ़, महाराष्ट्र, ओडिशा, झारखंड, आंध्र प्रदेश और तेलंगाना जैसे राज्यों में व्यापक रूप से

पाया जाता है। यह शुष्क और अर्ध-शुष्क क्षेत्रों के वनों में उगता है।

पर्यावरणीय सहिष्णुता: तेंदू वृक्ष विभिन्न प्रकार की मिट्टी और जलवायु परिस्थितियों में उग सकता है। यह वृक्ष सूखे की स्थिति में भी अच्छी तरह से जीवित रह सकता है, जिससे यह वृक्ष वन्य जीवन के लिए भी महत्वपूर्ण है।

जैविक विविधता: तेंदू के वनों में कई प्रकार के पौधे और जानवर पाए जाते हैं। ये वन स्थानीय जैव विविधता को बनाए रखने में महत्वपूर्ण भूमिका निभाते हैं।

औषधीय गुण: तेंदू के फल, पत्ते, छाल और लकड़ी में औषधीय गुण होते हैं। आयुर्वेद में इसके विभिन्न भागों का उपयोग विभिन्न रोगों के इलाज में किया जाता है।

आर्थिक महत्व: तेंदू पत्तों का उपयोग बीड़ी बनाने में किया जाता है, जो भारत में एक प्रमुख कुटीर उद्योग है। तेंदू पत्तों का संग्रहण ग्रामीण और आदिवासी समुदायों के लिए एक प्रमुख आजीविका का साधन है।

सांस्कृतिक महत्व: तेंदू वृक्ष और इसके उत्पाद विभिन्न सांस्कृतिक और धार्मिक अनुष्ठानों में उपयोग किए जाते हैं। कई आदिवासी समुदाय तेंदू को अपने पारंपरिक जीवन का हिस्सा मानते हैं।

प्रजातियों की विविधता: तेंदू वृक्ष की कई उप-प्रजातियाँ और किस्में पाई जाती हैं, जो विभिन्न क्षेत्रों में उनकी अनुकूलन क्षमता को दर्शाती हैं।

वन्यजीवों के लिए महत्व: तेंदू वृक्ष वन्यजीवों के लिए आश्रय और भोजन का स्रोत है। इसके फल कई जानवरों द्वारा खाए जाते हैं, और इसकी शाखाएँ पक्षियों के घोंसले बनाने के लिए उपयुक्त होती हैं।

तेंदू की यह विविधता इसे न केवल पर्यावरणीय और जैविक दृष्टिकोण से महत्वपूर्ण बनाती है, बल्कि सामाजिक और आर्थिक रूप से भी इसे एक महत्वपूर्ण संसाधन बनाती है।

तेंदू पत्ता संग्रह एक आजीविका का साधन है, जो विशेष रूप से ग्रामीण और आदिवासी क्षेत्रों में रहने वाले लोगों के लिए महत्वपूर्ण है। तेंदू पत्ता बीड़ी बनाने के लिए उपयोग किया जाता है, जो एक प्रकार का स्थानीय सिगार है। तेंदू पत्तों का संग्रहण और विक्रय एक मौसमी गतिविधि है, जिससे कई लोगों को रोजगार मिलता है।

तेंदू पत्ता संग्रहण की प्रक्रिया में महिलाएं और बच्चे भी भाग लेते हैं। इस कार्य में कुशलता और मेहनत की आवश्यकता होती है, क्योंकि तेंदू पत्तों को सही समय पर तोड़ना और सुखाना जरूरी होता है।

सरकार और कई गैर-सरकारी संगठनों द्वारा तेंदू पत्ता संग्रहण करने वालों को न्यूनतम समर्थन मूल्य (MSP) प्रदान किया जाता है, जिससे उनकी आजीविका को स्थिरता मिलती है। यह ग्रामीण अर्थव्यवस्था को सशक्त बनाने में महत्वपूर्ण भूमिका निभाता है और लोगों को आत्मनिर्भर बनने में मदद करता है।

सही समय का चयन: तेंदू पत्तों का संग्रहण गर्मियों के मौसम में किया जाता है, विशेषकर मई और जून के महीनों में। इस समय पत्ते पूरी तरह से विकसित और काटने के लिए तैयार होते हैं।

पत्तों का चयन: तेंदू पेड़ पर से सही पत्तों का चयन किया जाता है। केवल स्वस्थ, हरे और पूरी तरह से खुले पत्तों को ही तोड़ा जाता है।

पत्तों की तोड़ाई: पत्तों को सावधानीपूर्वक पेड़ से तोड़ा जाता है ताकि उन्हें नुकसान न पहुंचे। यह कार्य हाथ से किया जाता है और इसके लिए स्थानीय लोग विशेष रूप से प्रशिक्षित होते हैं।

पत्तों का बंडल बनाना: तोड़े गए पत्तों को एकत्र कर छोटे-छोटे बंडलों में बांध दिया जाता है। हर बंडल में लगभग 50 से 100 पत्ते होते हैं।

पत्तों को सुखाना: बंडलों को खुली जगह पर धूप में सुखाया जाता है। यह सुनिश्चित किया जाता है कि पत्ते पूरी तरह सूख जाएं ताकि उनमें नमी न रहे।

पत्तों का भंडारण: सूखे पत्तों को विशेष भंडारण केंद्रों में रखा जाता है, जहां उन्हें नमी और कीड़ों से बचाने के लिए उचित देखभाल की जाती है।

पत्तों की बिक्री: संग्रहित और भंडारित पत्तों को सरकार या बीड़ी निर्माताओं को बेचा जाता है। इसके लिए न्यूनतम समर्थन मूल्य (MSP) तय होता है, जिससे संग्रहकर्ताओं को उचित मूल्य प्राप्त हो सके।

सरकारी निगरानी और समर्थन: सरकार तेंदू पत्ता संग्रहण की प्रक्रिया पर निगरानी रखती है और संग्रहकर्ताओं को आवश्यक समर्थन और सुविधाएं प्रदान करती है, जैसे कि टूल्स, प्रशिक्षण, और वित्तीय सहायता।

- इस पूरी प्रक्रिया में कई लोग शामिल होते हैं, जो इस कार्य को मिल-जुलकर अंजाम देते हैं और इस प्रकार यह कार्य उनकी आजीविका का महत्वपूर्ण साधन बनता है।
- तेंदू पत्तों का बाजार मूल्य विभिन्न कारकों पर निर्भर करता है, जैसे पत्तों की गुणवत्ता, क्षेत्रीय मांग, सरकारी नीतियाँ और न्यूनतम समर्थन मूल्य (MSP)। आमतौर पर तेंदू पत्तों का बाजार मूल्य प्रति मानक बोरी के हिसाब से तय किया जाता है। एक बोरी में लगभग 1,000 से 2,000 पत्ते होते हैं।
- विभिन्न राज्यों में तेंदू पत्तों के बाजार मूल्य में अंतर होता है। उदाहरण के लिए, मध्य प्रदेश, छत्तीसगढ़, महाराष्ट्र, ओडिशा आदि राज्यों में तेंदू पत्तों की कीमतें अलग-अलग हो सकती हैं।
- सरकार हर साल तेंदू पत्तों के लिए न्यूनतम समर्थन मूल्य (MSP) निर्धारित करती है ताकि संग्रहकर्ताओं को उचित मूल्य मिल सके। समर्थन मूल्य निर्धारित करने के बाद, राज्य सरकारें और वन विभाग स्थानीय मंडियों में तेंदू पत्तों की खरीद करते हैं।
- सामान्यतः तेंदू पत्तों का बाजार मूल्य प्रति बोरी 2,500 रुपये से 4,000 रुपये तक हो सकता है, लेकिन यह दर हर साल बदल सकती है। 2023 में, उदाहरण के लिए, मध्य प्रदेश सरकार ने तेंदू पत्तों का समर्थन मूल्य4,000 रुपये प्रति मानक बोरी तय किया था।
- यह ध्यान रखना महत्वपूर्ण है कि तेंदू पत्तों के बाजार मूल्य में मौसमी बदलाव, उत्पादन की मात्रा, और बीड़ी उद्योग की मांग के अनुसार उतार-चढ़ाव आ सकता है।

मध्य प्रदेश में तेंदू पत्ता संग्रहण विधि

मध्य प्रदेश में तेंदू पत्ता संग्रहण एक महत्वपूर्ण ग्रामीण आर्थिक गतिविधि है, जो विशेष रूप से आदिवासी और वनवासी समुदायों के लिए आय का प्रमुख स्रोत है। तेंदू पत्ते का उपयोग बीड़ी बनाने में किया जाता है। यहाँ तेंदू पत्ता संग्रहण की प्रक्रिया को विस्तार से बताया गया है:

संग्रहण की तैयारी

लाइसेंस और अनुमति:तेंदू पत्ता संग्रहण के लिए राज्य वन विभाग से लाइसेंस और अनुमति लेना आवश्यक होता है। इसके तहत एक निर्धारित क्षेत्र आवंटित किया जाता है।

ट्रेनिंग:संग्रहणकर्ताओं को तेंदू पत्तों की पहचान, कटाई के सही तरीके, और पत्तों के संरक्षण के उपायों के बारे में प्रशिक्षण दिया जाता है।

संग्रहण प्रक्रिया

समय:तेंदू पत्तों का संग्रहण आमतौर पर अप्रैल और मई के महीनों में किया जाता है, जब पत्ते पूरी तरह से विकसित और हरे होते हैं।

पत्तों की पहचान:सही और स्वस्थ पत्तों का चयन किया जाता है। रोगग्रस्त, फटे हुए, या पीले पत्तों को छोड़ दिया जाता है।

पत्तों की कटाई:पत्तों को सावधानीपूर्वक तोड़ा जाता है ताकि पेड़ को नुकसान न हो। आमतौर पर, पत्तों को हाथ से तोड़ा जाता है और एकत्र किया जाता है।

संग्रहण और बंडलिंग:एकत्रित पत्तों को गड्डियों में बांधा जाता है। प्रत्येक गड्डी में 50 पत्ते होते हैं। गड्डियों को रस्सी या धागे से बांधा जाता है।

प्रसंस्करण और भंडारण

सूखाना:पत्तों को अच्छी तरह से धूप में सुखाया जाता है ताकि नमी निकल जाए और पत्ते मजबूत हो जाएं। यह प्रक्रिया आमतौर पर दो से तीन दिनों तक चलती है।

गुणवत्ता जाँच:सुखाए गए पत्तों की गुणवत्ता की जाँच की जाती है। गुणवत्ता पूर्ण पत्तों को ही आगे की प्रक्रिया के लिए चुना जाता है।

भंडारण:गुणवत्ता पूर्ण पत्तों को गोदामों में संग्रहित किया जाता है। गोदामों को सूखा और हवादार रखा जाता है ताकि पत्ते सुरक्षित रहें और उनमें फफूंद न लगे।

विपणन और बिक्री

सरकारी नीलामी:संग्रहित पत्तों को सरकारी नीलामी के माध्यम से बेचा जाता है। यह नीलामी राज्य सरकार द्वारा आयोजित की जाती है।

बीड़ी निर्माता:बीड़ी निर्माता नीलामी में हिस्सा लेते हैं और तेंदू पत्तों को खरीदते हैं। इसके बाद इन पत्तों का उपयोग बीड़ी बनाने के लिए किया जाता है।

समस्याएँ और समाधान

वातावरणीय चुनौतियाँ:अत्यधिक गर्मी या बरसात संग्रहण प्रक्रिया को प्रभावित कर सकती है। इसके समाधान के लिए उचित योजना और संग्रहण तकनीकों का उपयोग किया जाता है।

स्वास्थ्य और सुरक्षा: संग्रहणकर्ताओं को स्वास्थ्य और सुरक्षा के लिए आवश्यक उपकरण और ट्रेनिंग प्रदान की जाती है।

- मध्य प्रदेश में तेंदू पत्ता संग्रहण एक संरचित और संगठित प्रक्रिया है, जो स्थानीय समुदायों के जीवनयापन का एक महत्वपूर्ण साधन है। इस प्रक्रिया में शामिल हर चरण, संग्रहण से लेकर भंडारण और विपणन तक, राज्य सरकार के नियमानुसार किया जाता है ताकि पत्तों की गुणवत्ता और संग्रहणकर्ताओं की सुरक्षा सुनिश्चित हो सके।

Doubling the farmer's income through *Meliadubia* under Agroforesry

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Introduction

Melia dubia is a promising tree and highly suitable in agroforestry for generating higher income in the tropical and subtropical regions. Agroforestry is a sustainable land management system

which increases the overall yield of the lands; combines the trees and shrubs with agricultural crops and or livestock on the same unit of land, either simultaneously or sequentially. One of the main problems that farmers face today is decreasing income from an acre per year against sudden increase in the value of agricultural lands. Planting certain tree such as *Melia dubia* which fetch a handsome price in the market, assured buyback, and require low maintenance expenditure may help in this regard. In addition, the trees also aid the planet by preventing temperature rise and checking gas emission into the atmosphere. *Melia dubia* is the fastest growing tree and the wood from this tree is used in plywood industry. This moneyspinning business of *M. dubia* caught the attention of farmers and industries to reap maximum monetary benefits among farmers of Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Punjab, Haryana, Gujarat and to some extent in Uttar Pradesh and Madhya Pradesh. *M. dubia* grows up to 20–25 m in height with a clear bole up to 10–12 m and 120–150 cm girth in 15–18 years (Chavan *et al.*, 2022). The major shares of the land to be brought under agroforestry will come from fallows, cultivable fallows, pastures, groves and through rehabilitation of problem soils. This will be possible through appropriate research interventions, adequate investment and suitable extension strategies along with a forward looking agroforestry policy (Dhyani*et al.*, 2013). *Melia dubia* come under the family Meliaceae commonly known as Malabar neem, is an indigenous, fast-growing, multipurpose, short rotation, and valuable timber species that emerged as one of the most suitable tree species for different agroforestry systems (Sushil Kumar *et al.*, 2022). This money-spinning business of *Melia dubia* caught the attention of farmers and industries to reap maximum monetary benefits among farmers of Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Punjab, Haryana and Gujarat and to some extent in Uttar Pradesh and Madhya Pradesh. *M. dubia* is the most promising tree for industrial agroforestry

with rotation varying between 2 to 8 years (Sathya *et al.*, 2017).

Tree Ideotype for agroforestry system

- It should not interfere with soil moisture.
- It should have very little water requirement.
- It should not compete with crops for resources/nutrients.
- It should not be nutrients exhaustive.
- It should help in building soil fertility.
- It should have a tap root system and root growth characteristics.
- It should have a light branching pattern
- It should withstand pruning operations.
- It should have a high survival rate.
- It should have fast-growing habit and easy management.
- It should have a short rotation.
- It should have wider adaptability.
- It should have high palatability as fodder.
- It should have capability to withstand management practices.
- It should have nutrient cycling and nitrogen fixation attributes.

***Meliadubia*-based Agroforestry**

- It is a good agroforestry tree species which can support a variety of crops throughout its phase of cultivation. In the first three years, intercropping can be done with various annual crops and then spices like pepper can be grown. Intercrops like groundnut, chilli, turmeric, blackgram, papaya, banana, melon, sugarcane etc. are being successfully cultivated. Along the field bunds, if *Meliadubia* is planted in a single row, about 60 trees can be planted at six feet (1.8 m) spacing which will fetch an income of about 2 lakhs in the sixth year.
- Banana can be included as a crop, if *Meliadubia* is planted for timber purpose with wider spacing of 5 to 6 m between rows of the planted trees. Intercropping the tree with other tree species is not advisable as it could slow down the growth or the erectness of the Malabar Neem, and lead to bending.

Uses

Wood obtained from *Meliadubia* has various uses like packing cases, matchbox sticks, pencils, minifurniture like stools, benches, wooden racks and packing industries, wooden tables, interior decoration, cigar boxes, tea powder boxes, musical instruments, splints and building purposes. It has also a medicinal value and also used for fodder.

Profit/ Acre

A famer can earn profit of about Rs. 90 000 by growing 1 acre of land (0.4 ha) area with about 1 000 seedlings planted. This corresponds to a yield of 30 tons of wood per acre (75 per hectare respectively). Intercrops, like groundnut, green gram or black gram can be raised within the interspace in the first year of planting.

Yield

This tree gives good economic returns due to its property of fast growth. It can be used in match or plywood industries.

Under high density plantation 1,000 to 1,600 trees can be planted in an acre and the yield would be 30-40 tonnes/acre which is possible at the age of 4 years old plantation. The tree attains a volume of 15 cu. ft. at the end of 15 years of plantation and earns revenue of ` 350 per cubic foot from the 5th year onwards. Growth rate ranges from 20 to 25 cm per year in intensively managed plantation than unmanaged plantations where the growth rate ranges only from 6 to 8 cm per year.

Demand and supply

India produces about 47 million cu m of round wood & associated products a year, while their annual demand is 57-58 million cu m.The study forecasts a jump of nearly 70% in demand for round wood in India in the next decade, from 57-65 million m3 in 2025-2030 to above 98 million cu m in 2035-2040 driven largely by the construction sector. Here will be a substantial increase in wood consumption in India by 2030, exacerbating an existing shortfall between wood production and demand and increasing the country's reliance on wood imports, according to an ITTO report.

Summary

Meliadubia is a promising tree highly suitable for farm forestry and agroforestry. This is a fast-growing tree whose wood is readily used in plywood industries. This timbre species has gained a lot of interest among farmers in India as it is known to fetch a good income with minimal investment and maintenance due to its positives such as straight stem without much branching, less shade effect, not being susceptible to insect attack and its ability to grow in all types of soil and even in areas of low rainfall.Each tree of appropriate girth can fetch up to ` 4,000 to 5,000 per tree over a 6 to 7 year period, if sold as veneer. It plays a vital role in multi-farming of sheep, goat and dairy farming. In this way due to its various uses, it can become a most important income generating tool among farmers.

References

Chavan, S.B., Uthappa, A.R., Sridhar, K.B. and VijaysinhaKakade, (2022). Scientific techniques for *Meliadubia*-based agroforestry systems: an emerging indigenous tree species for wood-based industries in India. *Current Science*, **122** (12, 25) : 1451-1454.

Dhyani S.K., Handa A.K., Uma (2013). Area under agroforestry in India: An assessment for present status and future perspective. *Indian Journal of Agroforestry*, **15 (1):**1-11

Sathya, M., G. Thiribhuvanamala, B. Palanikumaran and Revathi, R. (2017). Studies on Various Bio Chemical Components Present in the *Meliadubia* Bark. *International Journal of Current Microbiology and Applied Sciences*, **6(6)**:2895-2901.

Sushil Kumar, Ashok Yadav and Ayyanadar Arunachalam (2022). *Melia dubia*: An ideal tree for commercial agroforestry. *Indian Farming*, **72 (03)**: 33-34.

Blue carbon as a climate change mitigation strategy

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Introduction

Blue carbon refers to the carbon stored in coastal and marine ecosystems such as mangroves, tidal marshes, and seagrass meadows. These ecosystems are highly effective at sequestering and storing carbon, often surpassing terrestrial forests in their carbon storage capacity per unit area. Beyond their role in carbon sequestration, these coastal ecosystems offer critical benefits for climate change adaptation, including protecting coastlines and supporting food security for many coastal communities (Bandh *et al.*, 2023).

However, when these ecosystems are degraded or damaged, their ability to act as carbon sinks is significantly diminished, and the carbon they have stored can be released back into the atmosphere, exacerbating climate change (Raihan, 2023). Therefore, dedicated conservation and restoration efforts are essential to maintain and enhance the capacity of these ecosystems to function as long-term carbon sinks. Mangroves, in particular, play a crucial role in this blue carbon cycle, contributing significantly to the sequestration and storage of organic carbon in coastal and marine environments.

Geographic distribution of blue carbon ecosystems

Blue Carbon ecosystems are found in every continent except Antarctica.Blue carbon ecosystems are heavily concentrated in a few countries and regions, with Southeast Asia as the unambiguous geographic centre. Almost one half of all global mangroves and one quarter of all global seagrass areas are in this region. Indonesia is home to about one fifth of all global mangroves. The other top-five mangrove countries are Brazil, Australia, Mexico, and Nigeria. Countries with greatest seagrass areas include Australia, Saudi Arabia, the United States, Indonesia, and Guinea-Bissau (Macreadie *et al.*, 2019).

Mangroves are found in tropical areas and concentrated on both sides of the equator. Seagrass areas are more broadly distributed and include tropical, temperate and high latitudes. Salt marshes are found everywhere outside the tropics; in the tropics, areas similar to salt marshes become occupied by mangroves.

Types of blue carbon ecosystems

1. Seagrass meadows - 1,25,000 km^2
2. Tidal marsh - 45,000 km^2
3. Mangroves - 1,50,000 km^2

Seagrass meadows

Seagrasses are submerged flowering plants with deep roots found in meadows along the coasts of all continents except Antarctica. Carbon accumulates in sea

grasses over time and is almost entirely stored in soils measured up to four meters deep. Despite accounting for less than 0.2 percent of the world's oceans, sea grasses sequester approximately 10% of the carbon buried in ocean sediment each year (27.4Tg of carbon per year). Seagrasses can store up to twice as much carbon per hectare as terrestrial forests. The global organic carbon pool in the seagrass ecosystem could be as large as 19.9 billion metric tonnes. Seagrass meadows filter sediment and other nutrients from the water and are constantly building and securing sediment, which protects coastlines from erosion, storms, and flooding.

They are also important habitats for fisheries and flagship marine species such as sea turtles and manatees. Seagrasses are one of the world's most threatened ecosystems, with an annual global loss of around 1.5 percent that has been increasing in recent decades. Globally, approximately 29 percent of the Earth's seagrass ecosystems have been lost. Deforestation and dredging are two major threats to seagrasses.

Tidal marshes

Tidal marshes are coastal wetlands with deep soils formed by the accumulation of mineral sediment and organic material and flooded by salty water brought in by the tides. The soil, which can be several meters deep, contains almost all of the carbon in tidal marsh ecosystems. The average annual carbon sequestration rate for tidal marshes is estimated to be between 6 and 8 Mg CO2e/ha (Mg of CO2 equivalent per hectare).

These rates are roughly two to four times higher than in mature tropical forests. Tidal marshes filter pollutants from land runoff and thus aid in the preservation of coastal water quality. They provide critical habitat for many important marine species at various stages of their life cycles, which is critical for healthy fisheries and coastal marine ecosystems.

Tidal marshes also act as a buffer for coastal communities, absorbing some of the energy from storms and floods and preventing erosion. Tidal and freshwater marshes are disappearing at a 1-2 percent annual rate. Draining for coastal development, conversion to agriculture, and rising sea levels are all major threats to tidal marsh ecosystems.

Mangroves

Mangroves are extremely important to the coastal ecosystems they inhabit. Physically, they serve as a buffer between marine and terrestrial communities and protect shorelines from damaging winds, waves and floods. Mangrove thickets improve water quality by filtering pollutants and trapping sediments from the land, and they reduce coastal erosion ecologically, they provide habitat for a diverse array of terrestrial organisms, and many species of coastal and offshore fish and shellfish rely exclusively on mangroves as their breeding, spawning, and hatching grounds. Because of their high salt tolerance, mangroves are often among the first species to colonize mud and sandbanks flooded by seawater, but an increase in coastal development and altered land use led to a decline in global populations. Several species are listed as vulnerable or endangered on the Nature. Major causes for this destruction have been urban development, aquaculture, mining,

and overexploitation of timber, fish, crustaceans and shellfish. The average monetary value of mangroves has been estimated as second only to the value of estuaries and seagrass meadows, and greater than the economic value of coral reefs, continental shelves and the open sea. They play important role in sequestration and storage of carbon dioxide for decades so preservation of these ecosystems is very important.

Healthy blue carbon ecosystems and degraded blue carbon ecosystems

Mangroves, tidal marshes, and seagrasses sequester and store large amounts of carbon through natural capture during photosynthesis or by trapping sediments and natural debris in their complex root systems. Within these ecosystems, CO_2 from the atmosphere is taken up via photosynthesis, most of which is returned almost immediately to the atmosphere through plant and microbe respiration or stored temporarily in plant foliage. The remainder is sequestered for a longer period of time in woody biomass and soil. Between 50 and 90% of all coastal wetland carbon, depending on vegetation type, is found in the soil.

In addition, tidal inundation keeps the soils wet or submerged, thereby inhibiting microbial action and slowing decomposition such that carbon accumulates in time. Global estimates of carbon stocks in these systems range from 10.4–25.1 billion mega grams of carbon but this is likely an underestimate, because although organic-rich soil profiles may extend several meters deep, most studies account for carbon only in the topmost meter of soil. The vast stocks of stable carbon, as well as the high rates of sequestration, demonstrate why coastal wetlands are well suited for climate mitigation policy efforts (Howard *et al.*, 2017).

Coastal wetlands are relevant to climate mitigation in another respect; human activities can convert these large natural carbon sinks into major carbon sources (of GHG emissions). For example, when mangrove forests are drained for development, microbial action in the soil, previously inhibited by tidal inundation, oxidizes the carbon and emits it to the atmosphere as CO_2

In intact coastal wetlands (from left to right: mangroves, tidal marshes, and seagrasses carbon is taken up via photosynthesis (purple arrows) where it gets sequestered long term into woody biomass and soil (red dashed arrows) or respired (black arrows). When soil is drained from degraded coastal wetlands, the carbon stored in the soils is consumed by microorganisms, which respire and release CO_2 as a metabolic waste product.

This happens at an increased rate when the soils are drained (when oxygen is more available), which leads to greater CO_2 emissions. The degradation, drainage, and conversion of coastal blue carbon ecosystems from human activity (i.e., deforestation and drainage, impounded wetlands for agriculture, dredging) results in a reduction in CO_2 uptake due to the loss of vegetation (purple arrows) and the release of globally important GHG emissions (orange arrows). This is a unique trait of coastal blue carbon ecosystems compared to the other ecosystems discussed.

For mangroves and tidal marshes, this loss is largely due to human conversion and

degradation related to coastal development, agriculture, and aquaculture. Loss of seagrass habitat is caused by several factors, but is mainly due to reduced water quality as a result of sediment and nutrient runoff from anthropogenic sources, and from direct impacts such as dredging and trawling Managing coastal wetlands is not always straightforward, in part because it is typically subject to issues involving land tenure and jurisdictional boundaries; however, these ecosystems have secured a prominent position in terms of climate mitigation strategies, given their inherent capacity to sequester large volumes of carbon, given the large amounts of carbon already stored therein, and given that proper initiatives can help to ensure that their stored carbon is retained rather than released to the atmosphere.

Causes for loss of blue carbon ecosystems

Coastal blue carbon ecosystems are among the most endangered on the planet. They are degraded or destroyed at four times the rate of tropical forests, and climate change threatens to exacerbate this loss. Since the nineteenth century, nearly half of the pre-industrial, natural extent of global coastal wetlands has been lost. This decline is still ongoing, with annual losses ranging from 0.5 to 3 percent depending on the ecosystem type. Blue carbon ecosystems, due to their high carbon content, can become significant sources of greenhouse gas emissions when degraded or lost. Ongoing carbon losses from blue carbon ecosystems are estimated to account for up to 19% of global deforestation emissions. The primary causes of blue carbon ecosystem conversion and degradation vary by region, but are largely driven by human activities. Aquaculture, agriculture, mangrove forest exploitation, terrestrial and marine pollution sources, and industrial and urban coastal development are all common drivers. Climate change is expected to exacerbate and prolong these effects.

Measures taken to prevent loss of blue carbon ecosystem

Many policies, coastal management strategies, and tools have been developed and implemented around the world to conserve and restore coastal ecosystems. Policies and financing mechanisms being developed to combat climate change may provide an additional avenue for effective coastal management. By combining best practices in coastal management with climate change mitigation goals and needs, blue carbon now provides the opportunity to mobilize additional funds and revenue. UNEP is helping to reverse this trend by promoting international cooperation on the issue, promoting science-based and ecosystem-based management approaches, assisting with regional and global assessments, developing best practice manuals, and assisting with conservation and restoration projects on the ground. It is also collaborating with a wide range of stakeholders and partners to protect coastal ecosystems.

There is a significant opportunity to include and expand blue carbon ecosystems clearly into the mitigation section of future, revised NDCs of all coastal countries. India has demarcated vulnerable areas on the coasts and declared them as Coastal Regulation Zone (CRZ.Integrated Coastal Zone Management (ICZM). Mapping and

demarcation of coastal hazard lines for development of emergency response plans is being carried out in all the coastal states and union territories. 'Mangroves for the Future (MFF)' coordinated by International Union for Conservation of Nature (IUCN) in India.Similar to Small Island Developing States, the 1,238 Indian islands are vulnerable to loss of coastal wetlands including mangroves and salt water intrusion in fresh water aquifers.The Government notified the Island Protection Zone (IPZ) in 2011 with the objective of ensuring livelihood security to the local communities, conserving and protecting coastal stretches, and promoting development in a sustainable manner.

Blue carbon is tool to mitigate climate change

It reduces CO_2 emissions and global warming Sequesters carbon stored for centuries to millennia (Duarte *et al.*, 2005). It captures carbon of 329Tg C/year. Blue Carbon ecosystems saturated soil deposited vertically at high rates continuous build-up of carbon over time. Terrestrial ecosystems due to high O_2 availability aerobic microbial carbon oxidation takes and release C back into atmosphere. Preventing degradation and destruction of coastal ecosystems and encouraging restoration are important tools for mitigating climate change. Mangroves, tidal marshes, and seagrass beds are among the most rapidly disappearing natural systems on the planet. When they are lost, they not only stop sequestering carbon, but they also release their carbon stores, becoming new sources of climate change-causing carbon emissions that can last for centuries.

If half of the annual coastal wetlands loss was halted, emissions would be reduced by a 0.23Gt CO_2yr^{-1}. This is equivalent to offsetting the 2013 emissions of Spain. If coastal wetlands were restored to their 1990 extent, it would have the potential to increase annual carbon sequestration 160Mt CO_2yr^{-1} which is the equivalent to offsetting the burning of 77.4 million tonnes of coal.

Avoiding coastal wetland conversion is a cost-effective climate solution. Many interventions such as establishing protected areas, improving land tenure, and enforcing land-use laws can be put into place immediately and yield significant climate benefits. If we stopped loss of coastal wetlands today, we could prevent the release of over 0.45 Gt CO_2 per year. Realistically, if we halted half of annual loss using interventions mentioned above, we would reduce emissions by a 0.23 Gt CO_2 per year.

This is equivalent to offsetting the 2013 emissions of Spain.Another significant opportunity for coastal wetlands is restoration. If coastal wetlands were restored to their 1990 extent, it would have the potential to increase annual carbon sequestration by 160Mt CO_2 yr^{-1} or roughly equivalent to offsetting the burning of 77.4 million tonnes of coal.Additionally, it is estimated that it only takes 100 meters of mangroves to reduce wave height by 66%, providing a significant adaptation benefit.The loss of coastal habitats is often driven by development, which engenders sustainable development and environmental integrity challenges. The re-establishment of natural areas often means removing or abandoning existing development and related activities (such as aquaculture). Such initiatives require community support as well as providing

economic alternatives for those communities affected. One example is that restoring coastal wetlands will increase fish populations and other extractive resources and could provide jobs as viable alternatives.

Conclusion

The coastal ecosystems of mangroves, tidal marshes, and seagrass meadows provide numerous benefits and services that are essential for climate change adaptation along coasts globally, including protection from storms and sea level rise, prevention of shoreline erosion, regulation of coastal water quality, provision of habitat for commercially important fisheries and endangered marine species, and food security for many coastal communities. Additionally, these ecosystems sequester and store significant amounts of coastal blue carbon from the atmosphere and ocean and hence are now recognized for their role in mitigating climate change.

Despite these benefits and services, coastal blue carbon ecosystems are some of the most threatened ecosystems on Earth, with an estimated 340,000 to 980,000 hectares being destroyed each year. It is estimated that up to 67% and at least 35% and 29% of the global coverage of mangroves tidal marshes and seagrass meadows respectively have been lost. If these trends continue at current rates, a further 30–40% of tidal marshes and sea grasses and nearly all unprotected mangroves could be lost in the next 100 years. When degraded or lost, these ecosystems can become significant sources of the greenhouse gas carbon dioxide. Coastal ecosystems are some of the most productive on Earth. They provide us with essential ecosystem services, such as coastal protection from storms and nursery grounds for fish. We also know that they provide another integral service - sequestering and storing "blue" carbon

References

Macreadie, P.I., Anton, A., Raven, J.A., Beaumont, N., Connolly, R.M., Friess, D.A., Kelleway, J.J., Kennedy, H., Kuwae, T., Lavery, P.S. and Lovelock, C.E., 2019. The future of Blue Carbon science. *Nature communications*, *10*(1), pp.1-13.

Bandh, S.A., Malla, F.A., Qayoom, I., Mohi-Ud-Din, H., Butt, A.K., Altaf, A., Wani, S.A., Betts, R., Truong, T.H., Pham, N.D.K. and Cao, D.N., 2023. Importance of blue carbon in mitigating climate change and plastic/microplastic pollution and promoting circular economy. *Sustainability*, *15*(3), p.2682.

Raihan, A., 2023. A review of tropical blue carbon ecosystems for climate change mitigation. *Journal of Environmental Science and Economics*, *2*(4), pp.14-36.

Howard, J., Sutton-Grier, A., Herr, D., Kleypas, J., Landis, E., Mcleod, E., Pidgeon, E. and Simpson, S., 2017. Clarifying the role of coastal and marine systems in climate mitigation. *Frontiers in Ecology and the Environment*, *15*(1), pp.42-50.

Duarte, C.M., Middelburg, J.J. and Caraco, N., 2005. Major role of marine vegetation on the oceanic carbon cycle. *Biogeosciences*, *2*(1), pp.1-8.

अगरबत्ती उद्योग के लिए जिगट का वैकल्पिक स्त्रोत

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एशिया वैश्विक स्तर पर अगरबत्ती का प्रमुख उत्पादक और उपभोक्ता है। अगरबत्ती उत्पादन सर्वोत्तम रोजगार उपलब्ध कराने वाला कुटीर उद्योग है। अगरबत्ती का उपयोग धार्मिक उपयोग के अलावा अब कीड़ों, मच्छरों को दूर भगाने, आध्यात्मिक, ध्यान, आनंद एवं आरोग्यथैरेपी के लिए भी किया जा रहा है।

भारत, विश्व में अगरबत्ती के उत्पादकों में शीर्ष स्थान रखता है, भारतीय राज्यों में कर्नाटक अगरबत्ती के उत्पादन में शीर्ष स्थान पर है, वहीं दक्षिण भारतीय राज्यों द्वारा अगरबत्ती उत्पादन में घरेलू बाजार का 35% हिस्सा शामिल है, जबकि पष्चिम-भारत 30%, उत्तर भारत 18% और पूर्वी भारत क्रमषः 17% उत्पादन करता है। घरेलू उपयोग के अलावा, भारत दुनिया की आधे से अधिक अगरबत्ती आवष्यकताओं की आपूर्तिकर्ता है। भारत में निर्मित अगरबत्ती ज्यादातर संयुक्त राज्य अमेरिका, ब्रिटेन, लैटिन अमेरिका, मिस्र, संयुक्त अरब अमीरात और नाइजीरिया को निर्यात की जाती है। बताया जाता है कि भारत लगभग 150 देषों को अगरबत्ती निर्यात कर रहा है, जिसकी कीमत लगभग 900 करोड़ रूपये प्रति वर्ष है।

अगरबत्ती उद्योग एवं निर्माण के लिए बुनियादी/आवष्यक कच्चा माल

1) बांस की पतली लकड़ी (अगरबत्ती के केन्द्रीय भाग के लिए)
2) चारकोल पाउडर
3) इत्र/खुषबू
4) पैकेजिंग सामग्री
5) बाइंडर, जिगट

उपरोक्त में से जिगट सबसे महत्वपूर्ण सामग्रियों में से एक है, जो विभिन्न सामग्रियों के लिए बंधनकारी पदार्थ (बाइंडर एजेंट) है, जो अंतिम उपयोग के लिए अगरबत्ती तैयार करने के लिए बांस की पतली लकड़ियों/डंडियों पर रोल करता है। मूल रूप से जिगट (चिपकने वाला पदार्थ) भारत के मध्य भाग में *पर्सिया मेंक्रान्था* की चिपिचिपी छाल से निकाला जाता है। बाद में, *लिट्सिया ग्लूटिनोसा* (सित. *लिट्सिया चिनेसिस*) और *कैनेरियम स्ट्रिक्टम* की छाल जिगट के प्रमुख विकल्प के रूप में उपयोग की जाती है। इनके अलावा *एलियेन्थस ट्राइफिसा ट्राइफिसा, अकेसिया फरनेसियाना, माइरोजाइलॉन टोलुइफेरा, बोसवेलिया सेराटा,* गोंद और *अकेसिया निलोटिका* आदि की राल को भी स्रोत के रूप में उपयोग किया जाता है।

अगरबत्ती उद्योगों के लिए बाइंडिंग सामग्री की उपलब्ध साहित्य से पता चलता है कि, अगरबत्ती उद्योगों द्वारा उपयोग किये जाने वाले 50% से अधिक जिगट को घरेलू स्त्रोतों से पूरा किया जाता है और अगरबत्ती उपयोग के लिए बाकी भाग मलेषिया, वियतनाम, थाईलैंड से आयात किया जाता है। लेकिन पष्चिमी घाट और पूर्वोत्तर भारत के सदाबहार और अर्द्ध सदाबहार वन के जिगट उत्पादक पेड़ों की अव्यवस्थित, असतत् कटाई के कारण, भारत में अगरबत्ती उपयोग किया जाने वाला, जिगट पाउडर की कमी से प्रभावित हो रहा है। इस परिस्थिति में कृत्रिम रसायन से निर्मित बाइंडिग एजेंटों का उपयोग हो रहा है जो

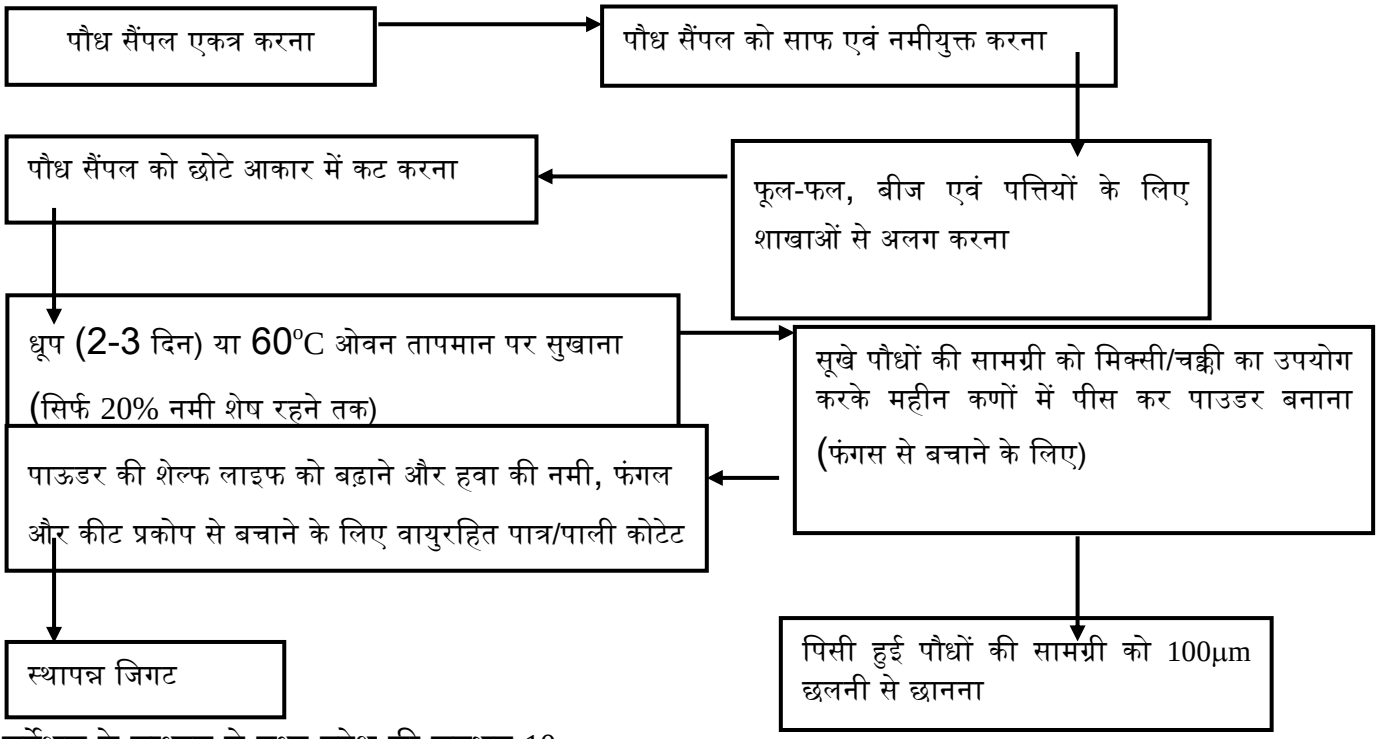
कि स्वास्थ्य के लिए हानिकारक है। उष्णकटिबंधीय वन अनुसंधान संस्थान में एक परियोजना के अंतर्गत ऐसे बाइंडिंग एजेंटों की मांग को पूरा करने के लिए पर्याप्त ज्वलनषील गुणों के साथ जिगट के वैकल्पिक स्त्रोतों की पहचान की गयी, परीक्षण किया गया और उपयोग के लिए तैयार उत्पादों को तैयार किया गया। वैकल्पिक स्त्रोतों से जिगट के उत्पादन में चिपचिपी प्रकृति वाले पौधों के विभिन्न भागों की पहचान करना शामिल है यानी गोंद, श्लेष्मा या चिपचिपे पदार्थों की उपस्थिति ऐसे कच्चे माल यानी पौधों के हिस्सों का संग्रह या कटाई और प्रसंस्करण, सुखाना, पीसना, छानना और भण्डारण करना।

गोंद (जिगट) स्त्रोतों/पौध प्रजातियों की पहचान

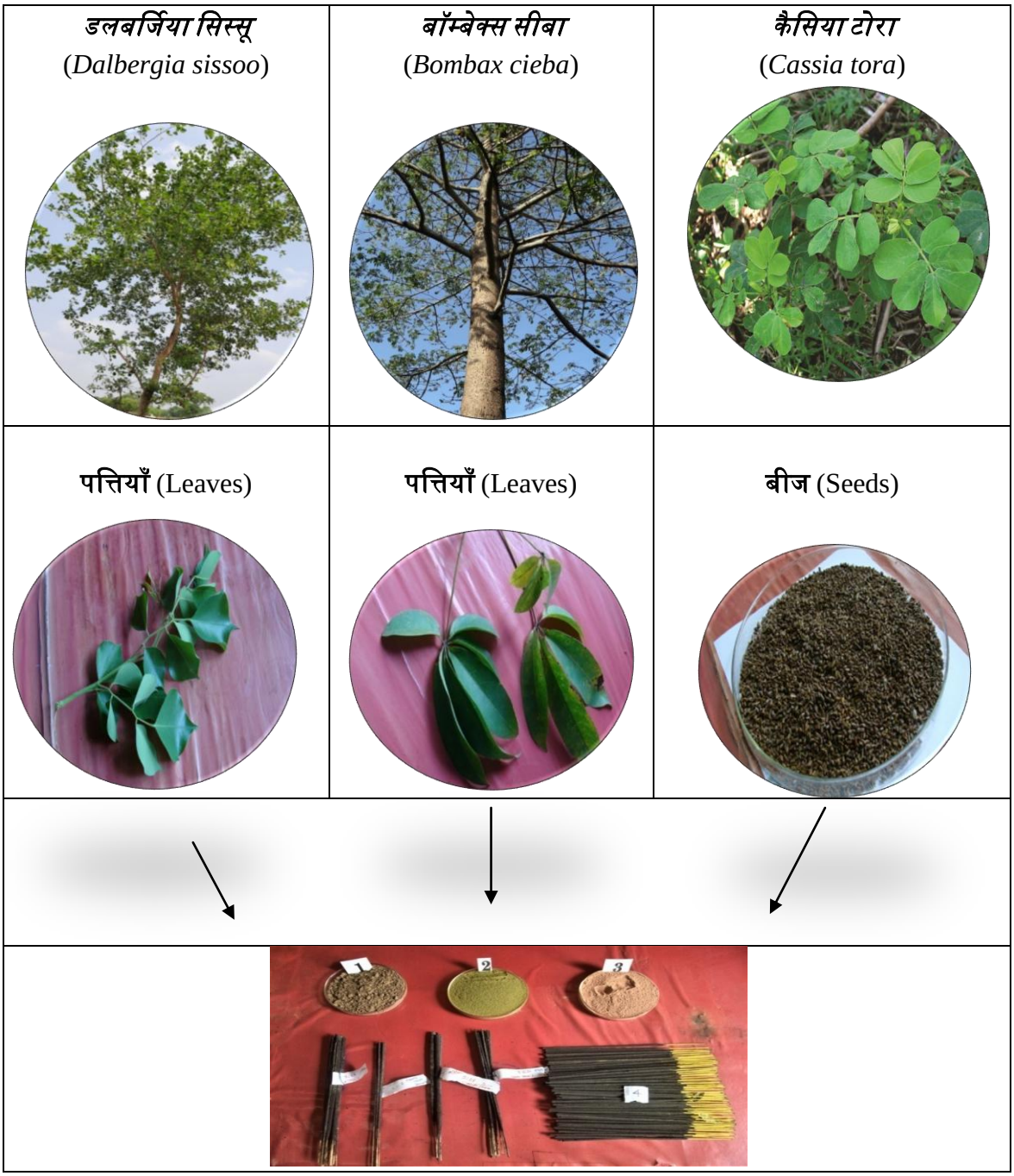
मध्यप्रदेष के विभिन्न हिस्सों में जिगट के सम्भावित स्त्रोतों की पहचान की गयी। सर्वेक्षण के दौरान पौधों के नमूने जैसे- छाल, पत्तियां, बीज, फूल, सम्पूर्ण पौध (या काटे) और कोमल तना प्रत्येक पौधे की प्रजाति के लिए अलग-अलग कर एकत्र (या काटे) किए गए। पौधों की सूची निम्नानुसार है -

स्थानीय नाम	वानस्पतिक नाम	कुल
कुर्मा	*पर्सिया मेंक्रान्था* (*Peraca macrantha*)	लुरेसी (Lauraceae)
मैदा लकड़ी	*लिट्सिया ग्लूटिनोसा* (*Litsea glutinosa*) (सित. *लिट्सिया चिनेसिस*)	लुरेसी (Lauraceae)
रॉल, काला डामर	*कैनेरियम स्ट्रिक्टम* (*Canarium strictum*)	बर्सेरासी (Burseraceae)
अरालू	*एलियेन्थस ट्राइफिसा* (*Ailanthus triphysa*)	सिमरौबेसी (Simaroubaceae)
सफेद खैर	*अकेसिया फरनेसियाना* (*Acacia farnesiana*)	फैबेसी (Fabaceae)
पेरू बाल्सम	*माइरोजाइलॉन टोलुइफेरा* (*Myroxylon toluifera*)	फैबेसी (Fabaceae)
सलई	*बोसवेलिया सेराटा* (*Boswellia serrata*)	बर्सेरासी (Burseraceae)
बबूल	*अकेसिया निलोटिका* (*Acacia nilotica*)	फैबेसी (Fabaceae)
शीशम	*डलबर्जिया सिस्सू* (*Dalbergia sissoo*)	फैबेसी (Fabaceae)
सेमल	*बॉम्बेक्स सीबा* (*Bombax cieba*)	मालवेसी (Malvaceae)
सेना	*कैसिया टोरा* (*Cassia tora*)	फैबेसी (Fabaceae)

प्राथमिक प्रसंस्करण



सर्वेक्षण के माध्यम से मध्य प्रदेश की लगभग 10 पौधों की प्रजातियों की पहचान संभावित प्रजातियों के रूप में की गई है, जिनका उपयोग अगरबत्ती के व्यवसायिक उत्पादन के लिए जिगट बनाने के लिए किया जा सकता है। जिगट की तीन नवीन रचनाएँ तैयार की गई और अगरबत्ती के व्यावसायिक उत्पादन के लिए इन जिगटों की उपयोगिता का मूल्यांकन किया गया और इन्हें सकारात्मक पाया गया। स्थानीय अगरबत्ती उद्योगों ने इन नई जिगट रचनाओं को स्वीकार किया और अगरबत्ती के व्यावसायिक उत्पादन के लिए उपयुक्तता रिपोर्ट प्रस्तुत की। *डलबर्जिया लेटिफोलिया* की पत्तियाँ, *बॉम्बेक्स सीबा* की छाल और कैसिया टोरा के बीज को जिगट की तैयारी के लिए वैकल्पिक स्त्रोत के रूप में अच्छा पाया गया।



स्थानापन्न जिगट (एस.जे.) की प्रभावकारिता का मूल्यांकन

इस एस.जे. की प्रभावकारिता की तुलना चिपचिपाहट, बेली हुई अगरबत्ती की चिकनाई (चिकनापन), जलने का समय, जलने के दौरान उत्पन्न होने वाली सुगंध और संग्रहण के दौरान परिवर्तन की तुलना पारंपरिक जिगट से की गयी।

संभावित पौधों की प्रजातियों से प्राप्त स्थानापन्न जिगट (एस.जे.) का इष्टतम अनुपात नेत्र निरीक्षण जैसे एस.जे. बांधने की क्षमता, अगरबत्ती की बनावट, सूखने, फेकने और भण्डारण के दौरान टूटने और टूटने से निर्धारित किया गया था। तैयार अगरबत्ती की जलने की क्षमता और निरंतर जलने की क्षमता, जलने में लगा समय, जलने के परीक्षण के दौरान निरंतल अवलोकन द्वारा निर्धारित

किया गया था। जलने के समय और जलने में निरंतरता के मूल्यांकन की तुलना विभिन्न विकल्प और पारंपरिक जिगट से बनी अगरबत्तियों से की गयी। प्रयोगों के लिए अगरबत्तियों की लम्बाई और भार को ध्यान में रखा गया। अगरबत्ती द्वारा अवषोषित सुगंध या सुगंधित तरल के साथ अर्थव्यवस्था की भागीदारी को ध्यान में रखते हुए, समय की एक इकाई में अवषोषित सुगंध के रूप में पचौली (*पोगोस्टेमान कॅबलिन, Pogostemon cablin*) तेल की मात्रा को रिकार्ड करने के लिए एक प्रयोग भी किया गया था, और इसकी तुलना नियंत्रण से की गयी। प्रत्येक एस.जे.पी से उत्पादित अगरबत्ती के लिए स्कोर प्राप्त करने के लिए सुगंध मूल्यांकन किया गया था । एस.जे.पी. के कारण अगरबत्ती की गंध की गुणवत्ता निर्धारित करने के लिए 5 व्यक्तियों का औसत स्कोर 1-10 पाइंट रेंज टेबल पर दर्ज किया था। एस. जे. ने *बॉम्बेक्स सीबा* (पत्तियां), *कैसिया टोरा* (बीज) और *डलबर्जिया सिस्सू* (पत्तियां) का उपयोग करके तैयार किया था, जो जिगट का सबसे अच्छा बाइंडर और विकल्प पाया गया।

उपरोक्त अध्ययन को भारतीय मानक ब्यूरो (बी.आई.एस.) के दिषानिर्देषों के अनुसार प्रयोगों की एक श्रृंखला के साथ भी किया गया था, जिसमें *बॉम्बेक्स सीबा* (पत्तियों) से तैयार भौतिक विषेषताओं जैसे- चिपचिपाहट, गंध, भण्डारण के दौरान दृष्य निरीक्षण, जलने की क्षमता और समय आदि के सभी मानकों को शामिल करते हुए स्थानापन्न जिगट (एस.जे.) का उपयोग किया गया था। *केसिया टोरा* (बीज) और *डलबर्जिया सिस्सू* (पत्तियां) में अच्छी बांधने की क्षमता पाई गई और जिगट को व्यावसायिक स्तर पर विकल्प के रूप में उपयोग करने की क्षमता है।

Fusarium leaf spot: An emerging foliar leaf disease of nursery in Bael (*Aegle marmelos* Correa.)

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Abstract

Fusarium leaf spot is an emerging disease affecting bael (*Aegle marmelos*), a culturally and medicinally important tree in India. The disease, caused by *Fusarium pallidoroseum*, has recently gained attention due to its increasing incidence in nurseries in Ayodhya region of Uttar Pradesh, leading to significant foliar damage and reduced plant vigor. Symptoms of the disease include small, brown to black necrotic spots on the leaves, which can coalesce, causing large areas of tissue death and defoliation in severe cases. The disease thrives in warm, humid nursery environments, where crowded planting and poor sanitation practices exacerbate its spread. *Fusarium pallidoroseum* involved in this infection produce mycotoxins that further impair plant growth. The pathogenicity of Fusarium in bael nurseries raises concerns for long-term impacts on tree health and productivity. Current management strategies for Fusarium leaf spot in bael primarily focus on cultural practices, including proper spacing, regular pruning of infected leaves, and maintaining clean nursery conditions. Biological control agents, such as *Trichoderma* spp., have shown promise in reducing pathogen load, while chemical fungicides and foliar application of essential oils, though effective, are used sparingly to minimize environmental impact. Further research is needed to develop integrated disease management strategies that combine cultural, biological, and chemical control methods to effectively manage Fusarium leaf spot in bael nurseries.This disease presents a significant challenge to bael cultivation, and timely intervention is crucial to prevent its spread to mature orchards. Enhanced understanding of the pathogen's biology and the epidemiology of the disease will aid in the development of resistant bael varieties and sustainable disease management protocols

Keywords: *Aegle marmelos*, Foliar infection, Fusarium leaf spot, Nursery disease, Pathogen management.

Introduction

Bael, also known as Bengal-quince,bel, belwa, maredoo, bili, bilva, belo, sriphal,golden apple, or stone apple, stands out among the multitude of plant species on Earth for its medicinal value. This tree belongs to the Rutaceae family and possesses chromosomes with 2n=18.The bael tree is commonly found in India and neighboring countries such as Sri Lanka, Pakistan, Myanmar, Bangladesh, Thailand, and Nepal.In India, it is grown in various states including eastern Uttar Pradesh primarily in Mirzapur, Varanasi, Gorakhpur, Gonda and Ayodhya districts and Siwan district of Bihar It holds a special place in India, where it's revered as

a sacred tree, often found near Lord Shiva temples and honored by worshippers. Throughout ancient history, Bael has been treasured for its medicinal properties, playing a significant role in ayurvedic medicine.Bael trees also play a beneficial role in their environment by purifying gases and releasing a higher percentage of oxygen compared to other trees.Various products such as candy, squash, toffee, pulp powder, and nectar can be made from bael fruits (Jauhari *et al.* 1969). Almost all parts of the tree, including the stem, bark, root, leaf, flower, seed oil, and fruits (at any stage of ripeness), are utilized in Ayurvedic medicines for their phytochemical, hypoglycemic, hypolipidemic, and blood pressure lowering effects. Like all other plants bael is also affected by various diseases including root rot, collar rot, and wilt. They also suffer from various leaf spot diseases such as Alternarialeaf spot and Myrothecium leaf spot caused by *Alternaria alternate* and *Myrothecium roridum* respectively. Among these diseases, fungal leaf spot, especially caused by *Fusarium pallidoroseum*, leads to significant losses in foliage and is a major concern for bael plants.

The first report of *Fusarium pallidoroseum* (Cooke) Sacc. on bael (*Aegle marmelos* Correa.) causing leaf spot and die back disease in nursery was observed by Singh *et al.*(2021) from Ayodhyar egion of (U.P). Much vegetative loss has been recorded in the nursery with this disease. The disease appeared during post rainy season (September-Oct).

Symptoms

In this disease initial symptoms appear on leaves as irregular spots, which is brown in colour and later become dark brown with greyish center, which increase very fast and cover the most of the leaf area. After severe infection, affected leaf become dry and fall off after the sometime (Fig. A). The disease progresses downward causing dieback symptombut are remain healthy and they produce new shoot after destroying the vegetative parts (Fig.B).

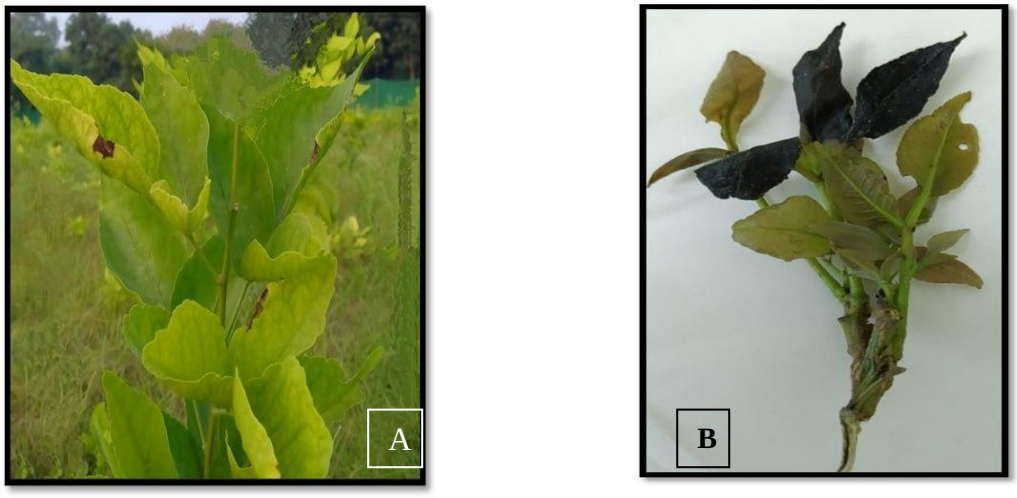

Fig. (A) Showing fusarium leaf spot Symptoms and Fig. (B) Showing dieback symptoms.

Management

- Application of chemical fungicidePropiconazole 25% EC or Tebuconazole 25.9% w/w @ 0.01%

- Application of Tebuconazole 25% + Trifloxystrobin 50% WG or Hexaconazole 4% + Zineb 68% WP @ 0.05%
- Application of Botanical extract of Datura & Garlic @ 5%
- Application of Essential oils Clove oil or Pepper mint oil or Eucalyptus oil or Lemon grass oil or Citronella oil @ 2%.
- Application of *Trichoderma harzanium* and *Trichoderma viridae*
- Regular pruning of infected leaf
- Clean cultivation of Nursery
- Field Sanitation

Conclusion

Fusarium leaf spot, caused by *Fusarium pallidoroseum*, is an emerging disease affecting bael (*Aegle marmelos*) in nurseries, particularly in Uttar Pradesh. It causes necrotic spots on leaves, leading to defoliation and reduced plant health. The disease thrives in warm, humid conditions, exacerbated by overcrowded planting and poor sanitation. Management includes chemical fungicides, botanical extracts, essential oils, and biological controls like *Trichoderma* spp. Cultural practices, such as regular pruning and maintaining clean nurseries, are also recommended. Further research is needed to develop integrated management strategies in field condition and prevent the disease's spread to mature orchards.

References

Bose, T., Ghosh, S. and Ghosh, S. N. 2010. First report of *Fusarium pallidoroseum* (Cooke) Sace. causing wilt disease of *Chlorophytum nepalense* (Lindley) Baker. *J Mycopathol. Res.*, 48(1):111-114.

Herath, H. and Abeywickrama, K. 2008. *In vitro* application of selected essential oils and their major components in controlling fungal pathogens of crown rot in embul banana (*Musa acuminata*- Aab*). Int. J. Food Sci. Tech*., 43(3): 440-447.

Jauhari, O. S., Singh, R. D. and Awasthi, R. K. 1969. Survey of some important varieties of bael (*Aegle mormelos* Correa.). *Punjab J. Hortic*., 9:48-53

Kumar, S., Singh. H. K. and Kumar, S. 2021. First report of *Fusarium pallidoroseum* (Cooke) Sacc. on bael (*Aegle marmelos Correa*) causing leaf spot and dieback disease in nursery, *J. AgricSearch*, 8 (2): 108-111.

Kumawat, R., Jat, R. G., Jain, S. C. and Kumawat, K. 2013. Efficacy of biocides against *Fusarium Pallidoroseum* causing fruit rot of kachari (*Cucumis callosus*). *J. Pl. Sel. Res*., 29 (1):15-17.

Madaan, R. L. and Gupta, P. C. 1985. A leaf spot disease of bael (*Aegle marmelos* (L.) Correa) caused by *Alternaria alternata* (Fr.) Keissler. *Indian J. Plant Pathol.*, 3(2): 239.

Mailem, Y. S., Bhat, B. N., Rao, V. K., Maheshwari, T. U., Rajeswari, B. and Reddy, D. R. R. 2015. Management of chickpea wilt, *Fusarium oxysporum* f. sp. *ciceri* using fungicides, botanicals and bioagents. *Indian j. Pant Prot.*, 43(1):85-89.

Patra, S., Biswas, M. K. and Mahato, A. 2017. Sustainable management of chickpea wilt caused by *Fusarium oxysporum*f.sp. *Ciceri. Int. J. Pure App. Biosci*., 5 (1): 526-529.

Ram, D. 2013. Investigation on fusarium fruit rot (*Fusarium pallidoroseum* (Cooke) Sacc. of tomato (*Lycopersicon esculentum* Mill.) and its management. M.Sc. thesis. B. A. College of Agriculture, Anand Agricultural University, Gujrat.

Wani, F. A. 2007. Integrated management of chilli wilt *Fusarium pallidoroseum* (Cooke) Sacc. in Kashmir. Thesis M.Sc. University of Agriculture Science and Technology of Kashmir 32 p.

Gmelina arborea: An indigenous multipurpose tree species

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Introduction

Gmelina arborea commonly known as white teak, gabar, or siwan belongs to Liminaceae family. It is indigenous, fast-growing deciduous tree species found across the world majorly in tropical countries like Brazil, Philippines, Gambia, Nigeria, India, China, Bangladesh, Sri Lanka, Myanmar, Cambodia, Laos, Thailand and Indonesia. The tree species owns equal importance for both medicinal and timber values. It is also a promising multipurpose tree for fuel, feed, and other household necessities. In recent days it is used in reclamation of wastelands, marginal lands, and social forestry programs.

In India, the species is distributed between latitude 8° to 27° N and longitude 72° to 96° E. It accounted for 0.47% of nation's agroforestry (ISFR 2013). Their population is significant in states like Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Jharkhand, West Bengal, Assam, Nagaland, Mizoram and Tripura with plantations raised majorly outside the forests. Under regular conditions *G. arborea* can grow up to 35 m tall and 3m in diameter. With multi-potent uses, the population of *Gmelina* is decreasing. The IUCN has identified it as a "Least Concern" species (de Kok., 2019).

Fig 1: a) *Gmelina arborea*; b) Worldwide distribution of *G. arborea*
(Source: https://www.cabi.org/isc/datasheet/25465#toDistributionMaps)

Ecology

Gmelina arborea is a popular tree species found in evergreen and dry deciduous forests associated with mean annual temperature of 21-28°C and annual rainfall of 750-5000 mm for optimum growth. Deep, loamy, clay loams, calcareous, and moist soils are best suited for its growth with pH range of 5.0 and 8.0 and clay or least drained soils are avoided for its

cultivation. The species is extensively planted as an integral part of agroforestry systems in humid tropical regions. Due to its high adaptability for different ecological conditions and coppice ability for propagation it's been cultivated in many countries as commercial plantations.

Wood related aspects

G. arborea possesses native trees of high-quality wood.With favourable conditions, the the species can reach 20 m height in five years with remarkable growth. Form of the tree is fair to good, with 6-9m of clear bole. Some trees can reach 3m height within a year after planting. The tree attains more than 30m height with about 60cm dbh at maturity with 4.5-5 years. At the age of 12 years of planting, the yield of gamhar is recorded on average aslow (84 m'lha)in poor sandy soils whereas it is quite higher (210 m'lha) in clay or lateritic soils, and highest (252 m'lha) in alluvial soils. Compared to other hardwood pulps, *G. arborea* produces average yield but of superior quality. Its wood can be utilized for carpentry, feed, plywood, shipbuilding, molding, furniture and interior woodworking (Wang 2004). Rotations for pulpwood and sawn wood are usually done for six and ten years respectively. Rotations of 5-l0 years are common for fuel wood. The *Gmelina* wood is similar to soft woods and possesses coarse texture with white-pale yellow colored heartwood and white sapwood. The heartwood of *Gmelina* is moderately durable and offers good dimensional stability. Fiber dimension and derived indices values of *Gmelina arborea* wood are mentioned in table 1.

Table 1: Fiber dimension and derived indices values of *Gmelina arborea* wood

Wood parameters (µm)	Measured value
Fiber length	783.70
Fiber Width	24.10
Cell Wall thickness	03.60
Lumen width	16.90
Runkel ratio	00.40
Flexibility coefficient	70.12
Slenderness ratio	38.80
Rigidity coefficient	00.30

(**Source:** Chaudhari et al., 2015; Azzez et al., 2016)

Plantation techniques

The plants can be regenerated both naturally (seed, coppice, root sucker) and artificially by methods namely, direct sowing, stump planting, entire transplanting and vegetative propagation.

Direct sowing

It is the easiest method to raise commercial plantation. Sowing is done in patches. Patches of 0.3×0.3×o.3 are hoed on 1.8m×1.8m field and are allowed to weather for a month and then filled with well-drained soil up to 7.5cm above the ground. During monsoon breaks, seeds are sown 1.0cm to 2.5cm deep at the rate of four seeds per patch in line sowing with 0.9m apart.

Stump planting

The seedlings rose in the month of May become ready for stump planting in June. The stumps prepared from one year old seedlings are used for planting.

Entire transplanting

It is widely used in which seedlings are planted along with earthy material without trimming the roots. The entire transplanting is generally done at onset of rains when the young plants are of one month age or of 2.4 to 2.7m height as it gives 95% survival.

Vegetative propagation

Tropical Forest Research Institute, Jabalpur has developed be effective methods for mass propagation of the species through micropropagation or cuttings. The micropropagation method is standardized with MS basal medium + l µM BA+ 4mg/l AgNO3, for shoot multiplication and WPM basal medium + 10 µM IBA for rhizogenesis. Among different types of cuttings and treatments employed, sprout cuttings treated with 5mM IBA is considered as an efficient procedure for cloning of the *G. arborea*.

Medicinal Uses

Therapeutic value of *G. arborea* is equally significant with its timber value. Root extracts of the species are important ingredient of "Dashmula" an Ayurvedic formulation to improve digestion, treat haemorrhoids, piles and heart diseases. Fruits and leaves are used to treat ulcer, anaemia, leprosy and other gasto-intestinal issues. It is also used as a nerve tonic in insanity and epilepsy. The leaves are also applied to snakebite and scorpion stings. The crushed juice of roasted fruit is applied dermally to treat itching and other skin allergies.

Pests and pathogens

The *G. arborea* species is susceptible to a variety of pests and pathogens from nursery to plantation stage. Some of the significant diseases include, Foot rot (*Fusarium oxysporum*), Poria root rot (*Poria rhizomorpha*), Stem rot (*Phoma nebulosa*), Root rot and collar rot (*Sclerotium rolfsii*), Leaf spots (*Pseudocercospora ranjita, Deptohaeria gmelinae, Phoma tropica, Alternaria laternata, Macrophomina phaseolina*), Powdery mildew (*Phyllactinia suffulta* var. *Gmelina), wilting (Ceratocystis fimbriata***)** *and Stem canker (Thyronectria pseudotricha* and *Hendersonula toruloidea***)** has caused most significant failures of *G. arborea* plantations .

Among the insect pests, defoliators like*Calopepla leayana* and *Owla minor* considered to be significant pests along with a phanerogamic parasite *Loranthus scurrula* is found to severely affect *G. arborea* due to its thin bark. Apart from them, *Spilosoma (Diacrisia) maculosa, Lixus camerunus, Empacamenta calabrica, Zonoceros variegates* and *Achaea lienardi* are also recorded to cause huge damage to the *G.arborea* plantations.

Genetic resources for tree improvement

In order to develop improved germplasm with desired traits of interest genetic exploration is required. Assessment of morphological and genetic diversity in *G. arborea*is performed by using various tools of population genetics like ISSR, SSR, and RAPD nuclear ribosomal DNA molecular marker based on ITS region for better end results. However, there are many challenges to identify economically productive germplasm with resistance against pests and pathogens. Some cultivars of the *G. arborea* tree include,

i) *Gmelina arborea* var. canescens: This cultivar has subcoriaceous and grey-pubescent lamina features.

ii) *Gmelina arborea* var. glaucescens: This cultivar has glaucous and glabrous lamina features.

Conclusion

Gmelina arborea is as multipurpose tree. Due to its fast growing potential and adaptation features, it is emerging as “agroforestry” species.It is cultivated

along with other crops and is widely recommended for reclamation of degraded lands. As the species has high demand for various end uses, more efforts are required for its genetic improvement. Commercial plantations of *G. arborea*need to be encouraged by persuading farmers with applicability of silvicultural practices to harness splendid economic returns.

References

Akeem Azeez, M., Andrew, J. E., & Sithole, B. B. (2016). A preliminary investigation of Nigerian Gmelina arborea and Bambusa vulgaris for pulp and paper production. Maderas. Ciencia y tecnología, 18(1), 65-78.

Chaudhari P.A., Sohagiya N.J., Sinha S.K., Thakur N.S. and Jha S.K. (2015). Wood anatomical screening of short rotation trees for pulp and paper making properties: A review. In Book: Plantation and agroforestry pulpwood value chain approach. (Ed. Parthiban, K.T. and Seenivasan, R.). Scientific Publishers, p517.

de Kok, R., 2019. Gmelina arborea. The IUCN Red List of Threatened Species 2019: e.T32354A67741197.https://dx.doi.org/10.2305/IUCN.UK.20192.RLTS.T32354A67741197.en.

ISFR. 2013. India State of Forest Report, Forest Survey of India, Dehradun, Government of India.

Wang Z (2004) Cultivation and utilization of Gmelina arborea in South Yunnan, China. New Forests 28:201–205.

Nanopore sequencing technology

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Introduction

The sequencing process uses biochemical techniques to determine the sequence of nucleotide bases in a DNA macromolecule with the help of sequencing machines. This technology has facilitated the accomplishment of significant projects, including the Human Genome Project and the 1000 Genomes Project. Since its inception with Sanger sequencing in 1977, sequencing technology has revolutionized molecular biology by decoding genetic information. Among the forefront of these advancements is nanopore sequencing, a third-generation sequencing technology noted for its long reads, portability, and cost-effectiveness. This technology has found applications in various fields, including epidemic prevention, disease diagnosis, and breeding of animals and plants.

The concept of nanopore sequencing, which involves single-stranded nucleic acids traversing a nanopore within a membrane under an electric field, was introduced by David Deamer in the 1980s Deamer *et. a/.*, *(*2016). The commercialization of this technology was significantly advanced by Oxford Nanopore Technologies (ONT), a company established in 2005 by Oxford professor Hagan Bayley and his team Chen *et al.*, *(*2023). In 2014, ONT released the MinION sequencer, making nanopore sequencing widely accessible. Today, ONT offers a comprehensive sequencing system, integrating advanced library preparation techniques, amplicon technologies, and various bioinformatics tools for data analysis and interpretation Wang *et al.*, *(*2021)

Molecular mechanisms of nanopore sequencing

Principle and specific process of nanopore sequencing

Nanopore sequencing utilizes nanopores as biosensors. These nanopores are embedded in a resistive film, creating the sole channel between the two sides of the film. An ion solution on the cis side of the film connects with the ion solution on the trans side via the nanopore. Electrodes positioned at both ends of the sequencer generate a stable electric field.

Nucleic acids, such as DNA and RNA, are drawn towards the nanopores by this electric field. Motor proteins facilitate the movement of nucleic acids through the nanopore, controlling the speed at which they pass. As nucleic acid molecules traverse the nanopore, changes in the nanopore's charge occur, leading to alterations in the electron flow across the resistive membrane. This flow varies based on the different bases or modifications in the molecular structure, each producing a distinct electronic signal. These signals are captured and recorded by the nanopore sequencer, which then uses

an algorithm to identify the base types and produce the sequencing results.

Key Components of Nanopore Sequencing

The core component of nanopore sequencing is the nanopore itself. Initial experiments utilized nanopores derived from Staphylococcus aureus α-hemolysin, a heptamer consisting of 14 antiparallel β-strands with a diameter of approximately 2.6 nmAshkenasy*et al.,* (2005). Other biological nanopores with similar functions can also be used. For example, Aerolysin, a pore-forming toxin from Aeromonas hydrophila, has a diameter of 1.0–1.7 nm and enables sensitive single base-pair discrimination. Another potential candidate is the outer membrane protein G from Escherichia coli, although its open and closed conformational states currently limit its suitability for single-molecule sensing.

Oxford Nanopore Technologies (ONT) predominantly uses MspA for their sequencing devices. MspA is an octamer with a minimum inner diameter of 1 nm, which is narrower and more stable than α-hemolysin, resulting in higher single-nucleotide resolution. The ionic current differences of the four DNA bases through the MspA nanopore are more distinct than those through α-hemolysin, enhancing base distinction. MspA also performs better under extreme conditions, making it adaptable to harsh environments.

Motor proteins play a crucial role in controlling the rate of nucleic acid translocation. If the translocation rate is too fast, it complicates base identification. Early experiments showed single-stranded DNA moving through the nanopore at a rate of 1–10 bases per millisecond, making signal detection challenging. The unstable translocation rate also complicates data analysis. To address this, the phi29 DNA polymerase from bacteriophage was used as a molecular ratcheting system. Pairing MspA with phi29 DNAP slows DNA translocation, allowing for single-base discrimination MacKenzie and Argyropoulos (2023).

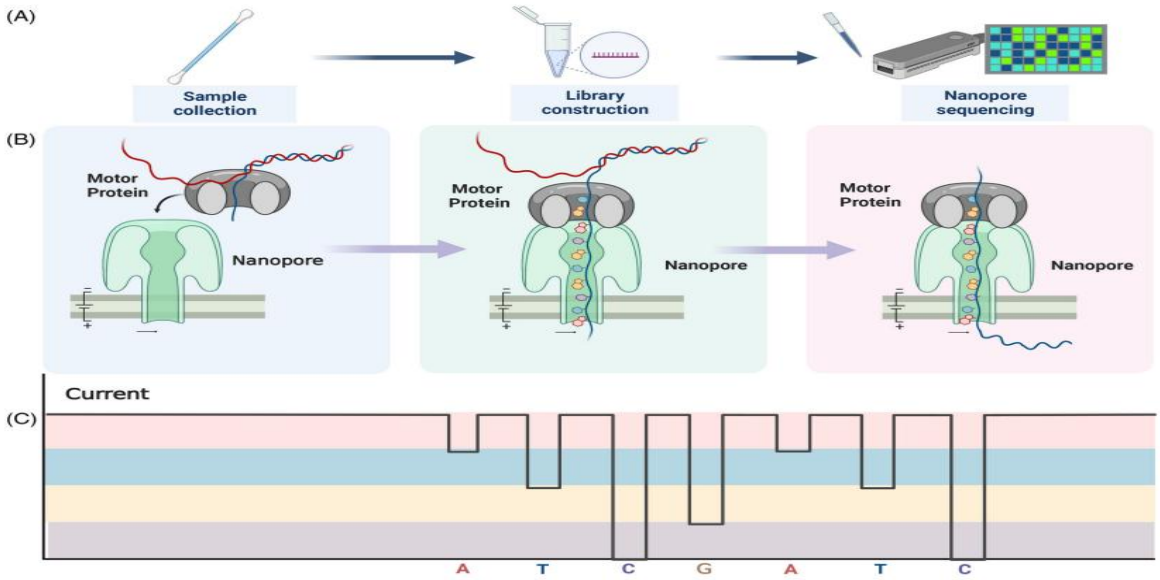

Figure 1: Schematic diagram of the basic principle and process of nanopore sequencing detection.

After the nucleic acid samples are collected, they can be added to the nanopore sequencer after simple library preparation, and the sequencing results can be obtained in real-time (A). Motor proteins pull the nucleic acid through the nanopore, and the nucleic acid is detected and transmitted to the computer through the generated tiny current signal (B). The computer recognizes the base type by analyzing the current characteristic signal and converts the current signal into the base sequence (C).

Advantages and Disadvantages of Nanopore Sequencing

Advantages

Single-Molecule Direct Sequencing

Nanopore sequencing can read ultra-long DNA and RNA molecules directly, providing insights that first and second-generation sequencing methods cannot achieve.

Timely Sequencing

It allows for the rapid sequencing of DNA and RNA, which is beneficial for applications requiring quick results.

Disadvantages

Higher Error Rate

Compared to first and second-generation sequencing methods, nanopore sequencing has a higher error rate.

Higher Sample Quality Requirements

The sequencing mechanism requires higher quality samples to function optimally.

Conclusion

Nanopore sequencing has emerged as a groundbreaking technology in the field of molecular biology, offering unique advantages over traditional sequencing methods. By enabling direct sequencing of ultra-long DNA and RNA molecules in real-time, it provides critical insights into genetic information that were previously inaccessible. The technology's portability and cost-effectiveness make it particularly valuable for applications that demand rapid and on-site sequencing, such as epidemic prevention and disease diagnosis. However, like any technological advancement, nanopore sequencing is not without its challenges. The higher error rate and stringent sample quality requirements can limit its effectiveness in certain applications. Despite these drawbacks, continuous improvements in nanopore technology, driven by advancements from companies like Oxford Nanopore Technologies, suggest a promising future. As the technology matures, it is likely to become an even more integral tool in genomics, expanding its impact across diverse fields such as personalized medicine, environmental monitoring, and the breeding of plants and animals.

References

Ashkenasy, N., Sánchez-Quesada, J., Ghadiri, M. R., & Bayley, H. (2005). Recognizing a single base in an individual DNA strand: a step toward nanopore DNA sequencing. *AngewandteChemie (International ed. in English)*, *44*(9), 1401.

Chen, P., Sun, Z., Wang, J., Liu, X., Bai, Y., Chen, J., ... & Li, J. (2023). Portable nanopore-sequencing technology: Trends in development and applications. *Frontiers in Microbiology*, *14*, 1043967.

Deamer, D., Akeson, M., & Branton, D. (2016). Three decades of nanopore

sequencing. *Nature biotechnology*, *34*(5), 518-524.

MacKenzie, M., & Argyropoulos, C. (2023). An introduction to nanopore sequencing: past, present, and future considerations. *Micromachines*, *14* (2), 459.

Wang, Y., Zhao, Y., Bollas, A., Wang, Y., & Au, K. F. (2021). Nanopore sequencing technology, bioinformatics and applications. *Nature biotechnology*, *39*(11), 1348-1365.

Bambusa tulda Rox: A promising bamboo forindian farmers

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Introduction

Bambusa tulda, commonly known as Indian timber bamboo, is native to the Indian subcontinent and Southeast Asia. This species is appreciated by farmers and the forest industry for its robust and durable culms, which are ideal for building, furniture manufacturing, and handicrafts. It is known by various names in different regions: Wamunna (Assam), Tulda (Bengal), Mirtinga (Tripura), Jati (Assam, Arunachal Pradesh, Nagaland, West Bengal), Wati, Owati (Meghalaya), Rawthing (Mizoram), Paoshiding, Koraincho bans (Sikkim), Deobans (Bihar), and Longmeii (Nagaland). Besides its economic importance, it plays a crucial role in local ecosystems and is used in traditional medicine. Additionally, its tender shoots are harvested for their delicious culinary uses.

Morphology of *Bambusa tulda*

Bambusa tulda is characterized by its tall, erect culms (Fig. 1), which reach heights of 17.7–21.3 m. The culms range in color from bright to dark green, occasionally with vertical yellow striations, and have a diameter of 500–880 mm. Culm nodes are typically swollen, displaying sheath scars and whitish rings (Bhattacharya et al., 2006). The culms are green when young and turn yellowish with age. Nodes are prominent and slightly swollen, while the internodes are typically long and smooth. Culm sheaths (Fig. 2), which are modified leaves protecting young culms, exhibit notably different sizes at various culm heights. The adaxial surface of culm sheaths is glabrous, while the abaxial surface is covered with abundant black hairs (Bhattacharya et al., 2006).

Leaves are lanceolate and provide substantial canopy cover. They are cauline, with smooth, glabrous leaf sheaths and pale oral hairs. The leaf sheath auricles are falcate, and the ligule is an unciliated membrane. A hairy, 0.2-cm-long petiole connects the leaf blade base to the sheath, and the collar features an external ligule. Leaf blades are oblong or linear, 17–37 mm in width and 15–25 cm in length. The leaf blade midrib is evident, along with secondary veins. The leaf blade surface is hairy and puberulous; the apex is acuminate, and the margins are scabrous (Chandra & Iftikher, 2014).

The inflorescence resembles a leafless panicle, with a branching structure similar to a vegetative culm. Its smooth rachis has three to five spikelets at each node, arranged in a capitate-like pattern. Spikelets range in length from 20 to 50 mm and are distichously grouped, encircled by glossy, chaffy bracts. Each spikelet has two to four lowermost florets reduced to empty glumes, followed by four to six viable florets (Bhattacharya et al., 2006).

Fig1. Bambusa tulda clump on the field

Fig. 2 Culm sheath

Cultivation Techniques

Propagation through seeds

Seeds can be used for propagation because *B. tulda* undergoes gregarious flowering. Mature bamboos are ideal for seed collection, and after that, the debris will be removed from the seed lot, and later, the seeds will be soaked in water for 24 hours to improve germination rates. Seeds are sown on a seed tray or ground with a mixture of sand, compost, and garden soil in equal parts. Usually, seeds are covered lightly with a thin layer of soil or sand and watered gently to keep the soil moist but not waterlogged. A steady supply of moisture is essential for germination. Usually, bamboo seeds germinate in two to four weeks. Transplant the seedlings into nursery beds or polybags after they have a few true leaves on them and are strong enough to handle. The seedlings can be moved to the field when they have reached a height of 30 to 60 cm and are well-established, which usually takes 6 to 12 months.

The seeds show 3 months of viability; germination will take 9–30 days; and they are 92% viable under proper storage conditions. The availability of seed may only be after long time intervals, seed viability may be poor and brief, storage facilities suitable for seed may be lacking, highly heterogeneous seedling populations may occur, and often overall poor seed set and consumption of seed by wild animals are the major problems with seed-based propagation. Seed-based propagation methods, therefore, cannot be relied on for mass multiplication on a sustainable basis, so there is a strong need to explore the possibility of vegetative propagation for mass multiplication of bamboo (Ray & Ali, 2017).

Macro-propagation

One method of widely propagating the species is by seeds. Despite being monocarpic, this species produces clusters of blooms. The seeds have three-month vitality when stored properly; germination occurs in 9–30 days, and the viability rate is 92%. The conventional method of propagation is used with great success. For

this propagation method, a healthy culm that is one to two years old is selected. This culm is carefully cut at the neck to separate it from its mother clump, along with the rhizome and root system. To prevent it from drying out, the top of the clump is cut above the first internode and covered with a mixture of cow dung and mud. This cover must be kept tightly sealed and frequently misted with water. This offset is ready to be planted. Enough water is added to an excavated 60 x 60 x 60 cm^3 pit. Once the offset is prepared in this way, it is placed into the pit and covered with dirt until all the air is gone. Planting during or immediately before the rainy season is ideal (Singh et al., 2010).

Micro propagation

Healthy single nodal segments (1.5 to 2.0 cm in length) with an internodal portion are excised from the young lateral branches of the main culm of 10- to 20-year-old *Bambusa tulda* from a natural bamboo stand in October. The leaf sheath of the nodal segment is removed, sized, and surface sterilized using a cotton swab dipped in 70 percent ethanol. The explants are then rinsed with sterile distilled water. Pretreatment of the explants is carried out with an aqueous solution of 0.5 percent Bavistin, a systemic carbendazim fungicide, and gentamycin for 15 minutes. Nodal segments are aseptically cultured in culture tubes containing 15 ml of semi-solid Murashige and Skoog's medium. After 4 weeks, axillary bud break occurs, and shoots proliferate. The proliferated shoots are excised from the mother plant and cultured on MS medium supplemented with cytokinin, where the concentrations of bud break and multiplication rate are higher.

The in vitro-rooted shoots from 4-week-old cultures are hardened and acclimatized before field transfer. Plantlets with well-developed roots are washed gently under running tap water to remove all traces of medium attached to the roots and transferred to a root trainer containing cocopeat and vermicompost in a 3:1 ratio. They are irrigated with water and acclimatized by keeping them in a closed condition and maintaining the humidity in the greenhouse for 20 to 30 days. The plantlets are kept in a mist chamber with 85 to 90 percent relative humidity and a temperature of 28±2°C. After that, the plantlets are transferred to the propagation bed for a period of one to two months in the shade net house, where they produce mini clumps of shoots in abundance (Bhadrawale et al., 2018).

Macro proliferation

Bamboo, because of its inherent proliferating capacity, is generated through its rhizomes. The new propagules start sprouting from the potted seedlings within 7-9 days, and by the end of 2 months, separable propagules are produced. During the separation of propagules from potted seedlings, care is taken to ensure that the segregated propagule comes out with a portion of rhizome, bud, and roots.

The segregated propagules are planted in polybags of size 24 cm x 18 cm filled with a mixture of sieved soil, sand, and vermicompost in a 1:1:1 ratio. These propagules in the polybag are kept under shade and watered regularly. The emergence of new shoots, their rooting, and the rhizome enlargement of the propagules are observed regularly (Fig. 3). The propagules begin to sprout new propagules in 7-9 days, and by the end of

two months, 2-3 separable propagules are produced (Dubey et al., 2008).

Fig. 3 Macro proliferation technique in *Bambusa tulda*

Plantation

After selection, the plantation site is cleared of vegetation and stones. Since the *Bambusa tulda* produces smaller-diameter clumps, the propagules are planted at a distance of 5 m × 5 m from each other to provide enough space for clump establishment (Fig 4). Planting pits of size 50 cm × 50 cm × 50 cm are dug as per the pattern

Harvesting

When clumping bamboo is not appropriately managed, it tends to become congested, leading to a decline in both the quality and quantity of the bamboo. Usually within a clump, new culms grow outward, towards the edges, while older stems remain towards the center. Consequently, bamboo harvesting should primarily focus on the center of the clumps rather than the sides, using methods such as the horseshoe or tunnel technique. The horseshoe method of harvesting clumps is managed by creating a horseshoe-shaped pattern or an inverted V, opening the densest area. This process involves removing all aged, dried, and decayed culms, retaining only the vigorously growing ones that are one year old. In the tunnel method, the clump is divided into four sections by creating two tunnels through its center. These tunnels serve as access points to the interior of the clump, facilitating easy management. Culms of sufficient maturity are then carefully chosen and harvested from each section (Vanlalfakawma et al., 2017).

Growth & Economics

Starting in the fifth year, a minimum annual yield of 400 bamboo culms per hectare is feasible with *Bambusa tulda*. Each culm can be sold for at least INR 40, leading to earnings beginning in the fifth year. Over the course of 10 years, starting in the fifth year, the farmer is expected to generate an average annual income of INR 35,000 (INBAR report).

Pest and disease

Bamboo species are vulnerable to insect pest attacks, especially from coccids, sap suckers, and defoliators. *Pyrausta coclesalis*, also known as the defoliating leaf roller, is recognized as a significant pest that causes serious harm to nursery seedlings and young plants of *the Bambusa tulda* (Rishi et al., 2014). Web blight disease, caused by Rhizoctonia solani fungi, is one of the common diseases of bamboo under nursery conditions. In mature *Bambusa tulda* plantations, diseases such as culm rot and

bamboo blight, caused by the fungus *Fusarium udum*, can lead to substantial economic losses. The disease manifests as symptoms such as internodes not fully expanding and remaining covered by apical culm sheaths. Leaf diseases such as leaf spot, tar-like spot, and various foliage and minor branch infections are common fungal diseases that affect *Bambusa tulda* (Gurpreet, 2021).

The primary management strategies for major nursery and plantation diseases involve employing regular cultural practices, applying biocontrol agents, and using chemical treatments. Web blight disease, caused by *Rhizoctonia solani*, is a significant issue in nurseries and can be controlled with a 0.1% foliar spray of Validamycin. Culm rot and bamboo blight are other major diseases affecting bamboo stands and can be managed by soil drenching with carbendazim at 0.1% twice, once before and once after the emergence of new shoots (Gurpreet, 2021).

Utilization

Source of food

In the northeastern regions of India, *Bambusa tulda* is recognized as a commercially valuable edible bamboo species. Besides being gathered from forests, these edible varieties are also grown in home gardens. The harvest period for edible bamboo shoots spans from the first week of June to the third week of September each year for commercial sales (Singh et al., 2010).

Religious ceremonies

This bamboo plays a vital role in religious ceremonies as it is used to construct mandaps for various events such as weddings and funerals. Additionally, it is utilized for building jatras, which serve as pillars or posts (Singh et al., 2010).

Medicine

The juice from crushed *Bambusa tulda* shoots is used to heal nail injuries caused by iron swords or arrows. A boiled concoction of fermented bamboo shoots is advised for treating ringworms, tumors, and meningitis. The fruit is thought to increase fertility (Singh et al., 2010). *Bambusa tulda* leaf extract, in methyl hydroalcoholic form, has shown anti-diabetic properties, confirming its potential use for treating hyperglycemic (diabetic) patients. The crude aqueous methanolic extract of *Bambusa tulda* leaf is a possible source of natural antioxidants. Additionally, the antibacterial activity of *Bambusa tulda* leaf extract against certain bacterial strains has been observed (Navina et al., 2022).

Bamboo articles

Bambusa tulda is utilized for crafting baskets and containers, as well as decorative items such as artificial flowers, wall hangings, flower vases, pen holders, trays, and the production of fishing gear. Once dried, the whole bamboo, particularly the leaves, culm sheaths, and dried culms, serves as firewood. The middle portion of a three-year-old *Bambusa tulda* Culm is the most preferred raw material for the industrial production of agarbatti sticks (Singh et al., 2010).

Agroforestry

Bambusa tulda can be grown along with agricultural crops like paddy, groundnut, lady's finger, pigeon pea, cowpea, etc. It also grows on marginal and degraded land and elevated ground, along with field bunds and riverbanks (Kumar et al., 2022).

Conclusion

Bambusa tulda culms are strong and durable, making them an excellent alternative to traditional timber in construction. As sustainable building practices gain traction, this bamboo species may see increased demand in green architecture and eco-friendly construction projects. The rapid growth and ability to thrive in a variety of soil conditions make it ideal for agroforestry and land rehabilitation projects. It can improve soil quality, prevent erosion, and restore degraded land.

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Reference

Sharma, M. L., & Nirmala, C. (2015, September). Bamboo diversity of India: an update. In *10th World Bamboo Congress, Korea* (pp. 17-22).

Dr. Chandra Barooah & Iftikher Ahmed (2014) Assam Science Technology and Environment Council. https://indiabiodiversity.org/species/show/243285

SINGH, K. P., Devi, S. P., Devi, K. K., Ningombam, D. S., & ATHOKPAM, P. (2010). Bambusa tulda Roxb. in Manipur State, India: exploring the local values and commercial implications. *Notulae Scientia Biologicae*, *2*(2), 35-40.

Vanlalfakawma, D. C., Lalnunmawia, F., Tripathi, S. K., & Sen, S. K. (2017). Sporadic flowering of Bambusa tulda in Mizoram: A preliminary report. *Science Vision*, *17*(3), 160-162.

Konyak, P. M. (2022). Introduction of Bambusa tulda Roxb. along with shifting cultivation as a sustainable bioresource in Northeast India. Current Science (00113891), 123(1).

Dubey, R. M., Das, P. K., & Choudhury, R. (2008). An investigation into macro-proliferation of some selected bamboo species of Assam. *Indian Forester*, *134*(3), 367.5

Dev, I., Ram, A., Ahlawat, S. P., Palsaniya, D. R., Singh, R., Dhyani, S. K., ... & Prasad, J. (2020). Bamboo-based agroforestry system (Dendrocalamus strictus+ sesame–chickpea) for enhancing productivity in semi-arid tropics of central India. *Agroforestry Systems*, *94*, 1725-1739.

Nirala, D. P., Kumar, J., Ahmad, M. S., & Kumari, P. (2018). Bamboo based agroforestry system for livelihood and ecological security in North Chhotanagpur division of Jharkhand. *Journal of Pharmacognosy and Phytochemistry*, *7*(1S), 1996-1999.

Kumar, R., Sharma, A., & Yadav, S. (2022). Bamboo based agroforestry models for livelihood security of Madhya Pradesh.

SINGH, K. P., Devi, S. P., Devi, K. K., Ningombam, D. S., & ATHOKPAM, P. (2010). Bambusa tulda Roxb. in Manipur State, India: exploring the local values and commercial

implications. *Notulae Scientia Biologicae*, *2*(2), 35-40.

Bhadrawale, D., Mishra, J. P., & Mishra, Y. (2018). An improvised in vitro vegetative propagation technique for Bambusa tulda: influence of season, sterilization and hormones. *Journal of Forestry Research*, *29*, 1069-1074.

Bamboo Plantation (Bambusa tulda) Rhizome Cutting Method- INBAR report.

Navina G*, D. Visagaperumal, Vineeth Chandy. (2022). Pharmalogical review on bambusa tulda Roxb. International Journal of Research Publication and Reviews, Vol 3, Issue 7, pp 466-476.

Oli, B. N. (2005). Biomass estimation of Bambusa tulda grown at Eastern Terai, Nepal. *Journal of Bamboo and Rattan*, *4*(1), 33-39.

Ray, S. S., & Ali, M. N. (2017). Factors affecting macropropagation of bamboo with special reference to culm cuttings: a review update. New Zealand Journal of Forestry Science, 47(1), 1-8.

Rishi, R. R., Barthakur, N. D., Borah, R. K., Kumar, R., & Pandey, S. (2014). Pest problems of some commercially important bamboo species in Assam, India. International Journal for Life Sciences and Educational Research, 2(4), 113-120.

Gurpreet Kaur Bhamra and Rajib Kumar Borah. 2021. Incidence and Management of Bamboo Diseases in Northeast India.*Int.J.Curr.Microbiol.App.Sci.* 10(11): 266-276.

Bhattacharya, S., Das, M., Bar, R., & Pal, A. (2006). Morphological and molecular characterization of Bambusa tulda with a note on flowering. *Annals of Botany*, *98*(3), 529-535.

RNAi: A revolutionary approach to combat insect infestation in forest trees

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Forests are a diverse ecosystem, and trees have a wide genetic base, which makes them susceptible to various pathogens and pests. Due to increasing food demand and variations in climatic patterns like altered precipitation, rising temperatures impacted the distribution and behavior of pathogens and insect pests. Insect infestations are a grave threat to forest ecosystems because they severely harm trees and disrupt the equilibrium of the environment. Pest and insect infestations posed a danger to 142 million hectares of forest area world wide between 2003 and 2012 according to the State of the World's Forests report (2020). About 40 million hectares of land suffered the attack of insect pests in 2015 alone posing a threat to the productivity and sustainability of the forests.

Traditional pest management techniques, such as the use of chemical insecticides frequently, have negative environmental effects and low efficacy. Forest trees need to be more climate-resilient to resist any biotic and abiotic stress to ensure ecosystem sustainability and long-term health. Genetic engineering approaches like double-strandedRNA mediated interference (RNAi) have proved to be a significant tool in managing insect pests of forest trees. RNAi has been increasingly popular due to its accuracy, non-target effects, and environmental safety as it degrades after some time on its own. Additionally, it targets multiple genes simultaneously, making it difficult to develop resistance to the pest

Principles of RNAi

RNAi is a natural cellular mechanism that regulates gene expression by knocking down the specific target mRNA. It was first discovered by Andrew Fire and Craig Mello in 1998 in *Caenorhabditis elegans* (Fire et al. 1998).It worksby degrading the target-specific mRNA or suppressing the transcription, thereby inhibiting the protein formation. There are two fundamental pathways associated with RNAi one is MicroRNA (miRNA) and small interfering RNA (siRNA). They both have similar elements but different biogenesis and mechanism of action.

The mechanism of RNAi is simple and involves the following steps-

1. Formation of dsRNA either by introduction into the cell exogenously or formation of the transcript into the cell itself through evolutionary processes.
2. This dsRNA is then processed into short double-stranded siRNA by the action of ribonuclease III called Dicer.
3. Loading of these siRNAs into the RNA-induced silencing complex (RISC) with the help of argonaute protein, it has endo nucleolytic properties and unwound the

dsRNA into sense and antisense strands.

4. Recognition of target mRNA- here, the antisense strand, also called guide RNA (gRNA), guides the RISC and forms the complementary base pairing with the target mRNA, which leads to its translational repression.

Comprehending the complexities of these pathways provides valuable insight into the diverse and intricate methods by which RNAi controls gene expression in cells.RNAi has advantages over traditional pest control techniques like they are target-specific and ensuringenvironmental safety. Chemical pesticides affect a broad range of organisms including non-target organisms and beneficial insects, causing biodiversity losses and these persist in the environment for a longer duration, contaminating the environment and also harming the life of wild organisms. The role of RNAi in combating abiotic stress like drought, osmotic regulation, etc., and biotic stress like pests and pathogens has been explored in different forest trees.

RNAi against insect pests-

Many studies have been done using the RNAi technology for viral bacterial and fungal infections in *Arabidopsis thaliana* (Gao et al. 2018) and other horticultural species like plum pox virus, banana bunchy top virus disease but in the field of forestry the use of RNAi in disease management is very scanty.Here it is explored in the insect-pest control, and researchers explored this in several forestry species (Table 1). *Bursaphelenchus xylophilus* is an essential insect of the Pine tree, and one gene, BxAK1, an arginine kinase, is known for pathogenicity and is cloned and targeted using RNAi. It was found that it significantly increased the mortality of the pest and also reduced its fertility (Wang et al. 2012). This nematode is adapted very well to lower temperatures, and the effect of its associated bacteria linked to low-temperature adaptability was studied by silencing the daf-11 gene using RNAi. Insect mortality was observed at 10°C, and survival rates were also affected (Yuan et al., 2023). *Dendroctonus frontalis*, southern pine beetle (SPB), was fed orally dsRNA, and it silenced target genes, achieving 100% insect mortality (Kyre et al. 2019).In another pine insect, *D. ponderosae*, mountain pine beetle (MPB), RNAi was used to silence three genes (hsp, iap, and shi), crucial for insect survival, when ingested orally and absorbed dermally. It caused insect mortality within seven days (Kyre et al., 2020).Later on, Kyre and Rieske (2022) found that dsRNA designed for SPB can induce silencing in the MPB, thereby suggesting that the RNAi may be developed as a *Dendroctonus*-specific control measure to combat the rapidly increasing populations of bark beetles.

Out of all the other orders that come under the class Insecta, Coleoptera is most sensitive towards RNAi, according to Yoon et al. (2018), as Staufen, a dsRNA binding protein that is responsible for the processing of siRNA is found exclusively in the coleopteran insects.Emerald ash borer (EAB), *Agrilus planipennis*, is an invasive pest of the Ash tree, and out of thirteen genes screened, two were found to be the best for RNA-mediated gene silencing. When orally ingested, these genes recorded up to 90% mortality in the

insect (Rodrigues et al. 2018).Researches are conducted on the delivery methods also, and Mehlhorn et al. (2021) suggested that the Mustard leaf beetle could be a potential model organism for foliar RNAi applications in coleopteran insects. Transcriptional analysis of *Batocerahors field*, longhorn beetle, which affects about 100 tree species, was performed to find out the target genes for RNAi and these three genes (BhorOBP3, BhorCSP2, and BhorOBPC1/C3/C4) were screened out which were responsible for the host identification (Yang et al. 2018). Asian longhorn beetle (ALB), *Anoplophora glabripennis*, which affects numerous species, was screened for RNAi, and the study found it has essential RNAi genes like Dicer and AGO2 protein soRNAi methods can be explored to control this pest (Rodrigues et al., 2017). Similar work was done by Zhao et al. (2015) in EAB. Dhandapani et al. (2020a) orally fed dsRNA to larvae of *A. glabripennis* containing target genes and recorded 80% mortality with 2.5µg concentration. In another research, Dhandapani et al. (2020b) observed 100% mortality in adult and larval stages when dsRNA containing target genes were transferred to them via microinjection, but for field application, they suggested the use of heat-killed bacteria for dsRNA delivery. Since oral ingestion and microinjection techniques are unsuitable for forest trees as they have tall height and expanded canopy cover, researchers are trying to find other best possible methods for dsRNA delivery to the economically important tree species. Bragg and Rieske (2022) drenched the roots of *Quercus alba* L. hydroponically into the dsRNA solution and then, after 1, 3, 5 and 7 days, sampled the plants and analyzed the dsRNA uptake ability of *Q. alba*. They recorded successful uptake and translocation of dsRNA to other parts of the plant. Another method of dsRNA delivery was shown by Pampolini and Rieske (2023); seedlings of *Fraxinus* sp. wereexposed to the dsRNA through foliar application.Experiments using rtPCR and Sanger sequencing confirmed the translocation of dsRNA to other parts of the plant, and the persistence of dsRNA was confirmed even after 21 days after the infection.

Table 1 Represents RNAi experiments in insects affecting forest trees

Test organism	**Affected plant species**	**Target gene**	**dsRNA delivery methods**	**References**
Dendroctonus frontalis	Pine	GAPDH Actin	Orally ingested	Kyre et al. 2019
Dendroctonus frontalis	Pine	Shi	Root drenched	Bragg and Rieske, 2022
Dendroctonus ponderosae	Pine	Hsp Iap Shi	Oral ingestion and topical absorption	Kyre et al. 2020
Bursaphelenchus xylophilus	Pine	BxAK1	Soaking bioassay	Wang et al. 2012
Bursaphelenchus	Pine	Daf-11	Injection	Yuan et al. 2023

xylophilus				
Agrilus planipennis (EAB)	Fraxinus	Hsp Shi	Orally ingested	Rodrigues et al. 2018
Agrilus planipennis (EAB)	Fraxinus	Shi	Root absorption and Topical application	Pampolini et al. 2020
Agrilus planipennis (EAB)	Fraxinus	Shi Hsp	Oral ingestion of dsRNA-expressing bacteria	Leelesh and Rieske 2020
Anoplophora glabripennis (ALB)	A wide range of species	GAPDH pl32	Injection	Rodrigues et al.,2017
Anoplophora glabripennis		IAP SNF7 SSK	Oral feeding	Dhandapani et al. 2020a
Anoplophora glabripennis		IAP SNF7	Heat killed bacteria	Dhandapani et al. 2020b
Dendroctonus armandi	Conifers	DarmCSP2	Microinjection	Li et al. 2018
Dendroctonus armandi	Conifers	DaAqp12L	Microinjection	Fu et al. 2019
Leptocybeinvasa	Eucalyptus	Chitin metabolism	Oral bioassays	Nambiar-Veetil et al., (2011)
Hyblaea puera	Teak	HpChi-h, HpEcR, HpCHS1	Oral bioassays	Kottaipalayam et al., (2022)

Conclusion

RNAi is a remarkable technology for integrated pest management in crops and forest trees. Researchers are trying to improve dsRNA delivery methods and reduce the production cost for vast-scale applications. A significant nuisance is the wood borer in the trees, where the foliar application of dsRNA is impractical; then other delivery methods can be adopted, like trunk injection, use of symbiotic microorganisms, and mixing these RNA-based pesticides in the soil.Significant challenges are the off-target and non-target genes, and to avoid unintended impacts on non-target genes, it is imperative to ensure the specificity of the RNAi response to the target gene. While RNAi is an innovative technology with the potential to revolutionize forest pest management when combined with traditional silvicultural pest management techniques, it can provide a multifaceted management strategy that preserves beneficial species while maintaining endemic populations of tree-killing forest pests.

References

Bragg, Z., & Rieske, L. K. (2022). Feasibility of systemically applied dsRNAs for pest-specific RNAi-induced gene silencing in white oak. *Frontiers in Plant Science*, *13*, 638.

Dhandapani, R. K., Duan, J. J., & Palli, S. R. (2020a). Orally delivered dsRNA induces knockdown of target genes and mortality in the Asian long-horned beetle, Anoplophoraglabripennis. *Archives of insect biochemistry and physiology*, *104*(4), e21679.

Dhandapani, R. K., Gurusamy, D., Duan, J. J., & Palli, S. R. (2020b). RNAi for management of Asian long-horned beetle, Anoplophoraglabripennis: identification of target genes. *Journal of Pest Science*, *93*, 823-832.

FAO and UNEP. 2020. *The State of the World's Forests 2020. Forests, biodiversity and people*. Rome

Fire, A., Xu, S., Montgomery, M. K., Kostas, S. A., Driver, S. E., & Mello, C. C. (1998). Potent and specific genetic interference by double-stranded RNA in Caenorhabditis elegans. *nature*, *391*(6669), 806-811.

Fu, D., Dai, L., Gao, H., Sun, Y., Liu, B., & Chen, H. (2019). Identification, expression patterns, and RNA interference of aquaporins in Dendroctonusarmandi (Coleoptera: Scolytinae) larvae during overwintering. *Frontiers in Physiology*, *10*, 967.

Gao, H., Yang, M., Yang, H., Qin, Y., Zhu, B., Xu, G., ... & Xie, D. (2018). Arabidopsis ENOR3 regulates RNAi-mediated antiviral defense. *Journal of Genetics and Genomics*, *45*(1), 33-40.

Kottaipalayam-Somasundaram, S. R., Jacob, J. P., Aiyar, B., Merzendorfer, H., & Nambiar-Veetil, M. (2022). Chitin metabolism as a potential target for RNAi-based control of the forestry pest Hyblaeapuera Cramer (Lepidoptera: Hyblaeidae). *Pest Management Science*, *78*(1), 296-303.

Kyre, B. R., & Rieske, L. K. (2022). Using RNAi to silence heat shock protein has congeneric effects in North America's Dendroctonus bark beetles. *Forest Ecology and Management*, *520*, 120367.

Kyre, B. R., Bentz, B. J., & Rieske, L. K. (2020). Susceptibility of mountain pine beetle (Dendroctonusponderosae Hopkins) to gene silencing through RNAi provides potential as a novel management tool. *Forest Ecology and Management*, *473*, 118322.

Kyre, B. R., Rodrigues, T. B., & Rieske, L. K. (2019). RNA interference and validation of reference genes for gene expression analyses using qPCR in southern pine beetle, Dendroctonus frontalis. *Scientific Reports*, *9*(1), 5640.

Leelesh, R. S., & Rieske, L. K. (2020). Oral ingestion of bacterially expressed dsRNA can silence genes and cause mortality in a highly invasive, tree-killing pest,

the emerald ash borer. *Insects*, *11*(7), 440.

Li, Z., Dai, L., Chu, H., Fu, D., Sun, Y., & Chen, H. (2018). Identification, expression patterns, and functional characterization of chemosensory proteins in Dendroctonusarmandi (Coleoptera: Curculionidae: Scolytinae). *Frontiers in Physiology*, *9*, 291.

Mehlhorn, S., Ulrich, J., Baden, C. U., Buer, B., Maiwald, F., Lueke, B., ... &Nauen, R. (2021). The mustard leaf beetle, Phaedon cochleariae, as a screening model for exogenous RNAi-based control of coleopteran pests. *Pesticide Biochemistry and Physiology*, *176*, 104870.

Nambiar-Veetil, M., Sangeetha, M., Sowmiya Rani, K. S., Aravinthakumar, V., Selvakesavan, R. K., Balasubramanian, A., ... & Krishna Kumar, N. (2011, December). Identification of insect-specific target genes for development of RNAi based control of the Eucalyptus gall pest Leptocybeinvasa Fisher & La Salle (Hymenoptera: Eulophidae). In *BMC Proceedings* (Vol. 5, pp. 1-3). BioMed Central.

Pampolini, F., & Rieske, L. K. (2023). Foliar Application of dsRNA to Induce Gene Silencing in Emerald Ash Borer: Systemic Distribution, Persistence, and Bioactivity. *Forests*, *14*(9), 1853.

Pampolini, F., Rodrigues, T. B., Leelesh, R. S., Kawashima, T., & Rieske, L. K. (2020). Confocal microscopy provides visual evidence and confirms the feasibility of dsRNA delivery to emerald ash borer through plant tissues. *Journal of Pest Science*, *93*, 1143-1153.

Rodrigues, T. B., Dhandapani, R. K., Duan, J. J., & Palli, S. R. (2017). RNA interference in the Asian longhorned beetle: identification of key RNAi genes and reference genes for RT-qPCR. *Scientific Reports*, *7*(1), 8913.

Rodrigues, T. B., Duan, J. J., Palli, S. R., & Rieske, L. K. (2018). Identification of highly effective target genes for RNAi-mediated control of emerald ash borer, Agrilus planipennis. *Scientific Reports*, *8*(1), 5020.

Wang, X. R., Cheng, X., Li, Y. D., Zhang, J. A., Zhang, Z. F., & Wu, H. R. (2012). Cloning arginine kinase gene and its RNAi in Bursaphelenchusxylophilus causing pine wilt disease. *European journal of plant pathology*, *134*, 521-532.

Yang, H., Cai, Y., Zhuo, Z., Yang, W., Yang, C., Zhang, J., ... & Guan, F. (2018). Transcriptome analysis in different developmental stages of Batocerahorsfieldi (Coleoptera: Cerambycidae) and comparison of candidate olfactory genes. *PloS one*, *13*(2), e0192730.

Yoon, J. S., Mogilicherla, K., Gurusamy, D., Chen, X., Chereddy, S. C., & Palli, S. R. (2018). Double-stranded RNA binding protein, Staufen, is required for the initiation of RNAi in coleopteran insects. *Proceedings of the National Academy of Sciences*, *115*(33), 8334-8339.

Yuan, Y., Pan, M., Shen, L., Liu, Y., Zhu, Q., Hong, J., ... & Tan, J. (2023). Effect of Associated Bacteria GD1 on the Low-Temperature Adaptability of Bursaphelenchusxylophilus Based on RNA-Seq and RNAi. *Microorganisms*, *11*(2), 430.

Zhao, C., Gonzales, M. A. A., Poland, T. M., &Mittapalli, O. (2015). Core RNAi machinery and gene knockdown in the emerald ash borer (Agrilus planipennis). *Journal of insect physiology*, *72*, 70-78.

A comprehension on *Azadirachta indica* through the perspective of agroforestry

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Introduction

Azadirachta indica, or neem, is a tropical and semi-tropical tree species belong to the Meliacece family, which is native to South and South east Asia (Daniel and Hegde 2007) and usually found all over the world. It was originally discovered in the Indian subcontinent, which is currently considered an invasive species in Australia and Africa. Throughout Maharashtra, Madhya Pradesh, and other parts of India, neem has naturalized aside from very high and cold areas (Sindhu 1995).

It is a medium to large tree of 20m height (Daniel and Hegde 2007), which thrive in a variety of climates and soil types. Compared to other species, this tree is known to grow on nearly all types of soil and is highly suited to stressful environments, but prefers deep clay soils.The acidic soils and pH 10 are suitable for its survival.The versatile neem tree can be used for general soil amendment, amelioration of saline soils, and restoration of damaged lands.It grows best in regions with 750–1000 mm of yearly rainfall.Its native temperature ranges from 15 to 45 degrees Celsius.It grows up to an elevation of 1200 meters in tropical arid regions of India. This tree all parts, including the bark, fruits, seeds, and leaves, possess antifungal and antibacterial characteristics, being utilized in medicine.Its seed must be sown within a month of harvesting due to its extremely short viability period. Planting stumps is the most effective way to establish neem. It can withstand drought because it can thrive in a variety of environmental circumstances, such as high temperatures and little rainfall.Its wood is of a rather good grade, making it suitable for construction and the manufacture of agricultural tools (Daniel and Hegde 2007).

Source: EZ GRO Garden

Source: natureneem.com

Neem in Agroforestry systems

Agroforestry refers to land use systems in which woody perennials are deliberately planted alongside agricultural crops and/or animals on the same plot of land, either in the form of a unique temporal sequence arrangement or otherwise (Dwivedi 2013).Compared to pure agriculture or forestry, agroforestry provides farmers with a higher income per unit of land. Numerous studies conducted across the globe indicate that, for a given piece of land, agroforestry is more profitable for farmers than either agriculture or forestry (Tewari et al. 2014). Agroforestry enhances soil quality in a number of ways, including increased nutrient cycling efficiency (Nair et al. 2009), decreased runoff and soil erosion, increased fertility through nitrogen fixation, and—above all—a notable increase in soil organic matter due to the ongoing addition of litter, which in turn promotes soil biota/microflora and water infiltration rate (Fontes et al. 2010). Planting MPTs like neem, which restores soil fertility and richness and encourages the growth of more herbs and shrubs, can increase the productivity of waste land (Drechsel et al. 1991).

One of the most widely grown trees is neem (*A.indica*), which is grown in most of India (14 million persons, with the exception of high and cold locations) (Sidhu 1995). Neem is one of the most valuable multipurpose trees found in arid and semi-arid regions. It is especially valued for its ability to meet the basic needs of rural households, including pesticides, nematicides, insect repellent, fertilizers, fodder, soaps, lubricants, tooth brushes, and medicines (antiallergic, antifungal, anti-inflammatory, cardiac, and diuretic, among others. Itcan adapt to a variety of environments and climates, neem (*Azadirachta indica* L.) is regarded as a source of compounds with many applications. Its use in shelterbelts also makes it a valuable species for agroforestry (Shankarnarayanan et al. 1987). The value of *A. indica* L. has multiplied recently due to a greater focus on agroforestry research (Gill and Deb 1993).

Neem and other tree species enhanced the production of the silivicultural system by up to 8.5 tons per hectare in dry and semi-arid environments.In an agroforestry system, the tree component is preferred because it could yield a variety of goods that are readily marketable and have a high economic value, depending on local requirements (Bohra et al. 2016). Agroforestry tree species along with neem and systems has been laid down in the bullet points:

- The agri-silvi-horticultural system of neem is found in the tropical plains together with crops including vegetables, peanuts, mung beans, cowpeas, pearl millet, cotton, sorghum, and horsegram (Kumar 1999).
- Sunflower with Neem and Meliadubia was also studied/reported by (Panneer Selvem, 2003).
- In agroforestry systems, neemcan also work effectively with a variety of annual crops and tiny trees like jatropha (Daniel and Hegde 2007).
- In Maharastra, neem is grown with babool in lines with agricultural crops (Chakravarty et al. 2010).

- In Karnataka, Andhra Pradesh and Tamil Naidu it is grown in farm lands (Chakravarty et al. 2010).
- In Hyderabad sorghum along with neem (Chakravarty et al. 2010).
- Neem is a multipurpose tree that is seen to be cultivated alongside crops such as sorghum, black gram, wheat, chickpea, etc. in central India (Bijalwan et al. 2017).
- Neem (*Azadirachta indica*) and teak (*Tectona grandis*) agroforestry system to study microbial density and soil chemical propertieswas done under rainfed and irrigated ecosystems in Karnataka (Chittapurand Gurumurthy, 2018).

Commerical uses of neem

- Neem extracts have been used in the manufacturing of nanoparticles, where biomolecules such as terpenoids function as both reducing and capping agents.
- Neem wood is utilized for its timber because it is resistant to termites and woodworms and is durable even in exposed environments (Prakash et al. 2022).
- Neem extract's insecticidal qualities have long been recognized in India, where it has been used in agriculture to control pests and provide nutrients to plants (Prakash et al. 2022).
- Neem leaves are utilized in the production of green leaf manure and high-nutrient litter compost, which includes calcium, sulphur, potassium, and nitrogen (S. Lokanadhan et al. 2012).
- Neem extracts are widely used in marketed skin, hair, and dental care products due to their effective treatment of dandruff and epidermal dysfunctions such acne, psoriasis, and eczema (T. Lakshmi et al. 2015).

Conclusion

Neem trees diversify the farm; produce goods that are domestic and marketable. It is a crucial and perfect part of a developing agroforestry system that farmers can use in almost every part of India. These trees can provide farmers with a multitude of benefits, and they blend well with a wide variety of crops to yield the highest financial returns.

References

Bijalwan, A., Dobriyal, M. J., Thakur, T. K., Verma, P., & Singh, S. (2017). Scaling-up of neem (Azadirachtaindica A. Juss) cultivation in agroforestry for entrepreneurship and economic strengthening of rural community of India. *International Journal of Current Research in Biosciences and Plant Biology*, *4*(1), 113-118.

Chakravarty, S. U. M. I. T., Dey, A. N., & Shukla, G. O. P. A. L. (2010). Tree borne oilseed species in agroforestry. *Environment and Ecology*, *28*(3), 1507-1511.

Chittapur, B.M., &Gurumurthy, H. (2018). Microbial density in Azadirachtaindica A. Juss. and Tectona grandis Lf based agroforestry systems in north-eastern tropical Karnataka, India. *Indian Journal of Agroforestry*, *20*(2), 80-84.

Daniel, J.N., &Hegde, N.G. (2007). Tree-borne oilseeds in agroforestry. *Proc. Conservation and Management of Agroresources in Accelerating the Food*

Production for 21st century, ICAU, Raipur, 263-276.

Drechsel, P., Glaser, B., Zech, W., 1991. Effect of four multipurpose tree species onsoil amelioration during tree fallow in Central Togo. Agrofor. Syst. 16(3), 193-202.

Dwivedi, R. P. (2013). Trees under Agroforestry: An Analysis of Farmers' Preferences for Tree Species. *Indian Journal of Extension Education*, *49*(1&2), 83-87.

Gill, A.S., Deb Roy, R., 1993. Agroforestry uses. In: Randahwa, N.S., Parmer, B.S. (Eds.), Neem Research and Development Society of Pesticide Science, IARI, New Delhi, pp. 49–58.

Kumar, B.N., 1999. Agroforestry in the Indian tropics. Ind. J. Agrofor. 1, 47-62

Nair, P.K.R., Kumar, B.M. and Nair, V.D. 2009. Agroforestry as a strategy for carbon sequestration. Journal of Plant Nutrition and Soil Science, 172: 10-23.

PanneerSelvem, 2003. M.Sc.(Agri.) Thesis, Acharya NG Ranga Agricultural University, Hyderabad.

Prakash, V., Akhtar, S., Kumar, J., Mishra, S. K., & Pandey, R. R. (2022). Neem: The multifaceted and versatile tree. *Current trends in medicinal chemistry*.

S. Lokanadhan, P. Muthukrishnan, S. Jeyaraman, Journal of Biopesticides 2012, 5, 72.

Sidhu, D.S. 1995. Neem in agroforestry as a source of plant derived chemicals for pest management. The Indian Forester 121: 1012-1021.

Shankarnarayanan, K.A., Harsh, L.N., Kathju, S., 1987. Agroforestry in the arid zone of India. Agrofor. Syst. 5, 69–88.

Tewari JC, Moola-Ram RMM, Dagar JC (2014) Livelihood improvements and climate change adaptations through agroforestry in hot arid environments. In: Dagar JC, Singh AK, Arunachalam A (eds) Agroforestry systems in India: livelihood security & ecosystem services, Advances in agroforestry, vol 10, pp 155–184

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