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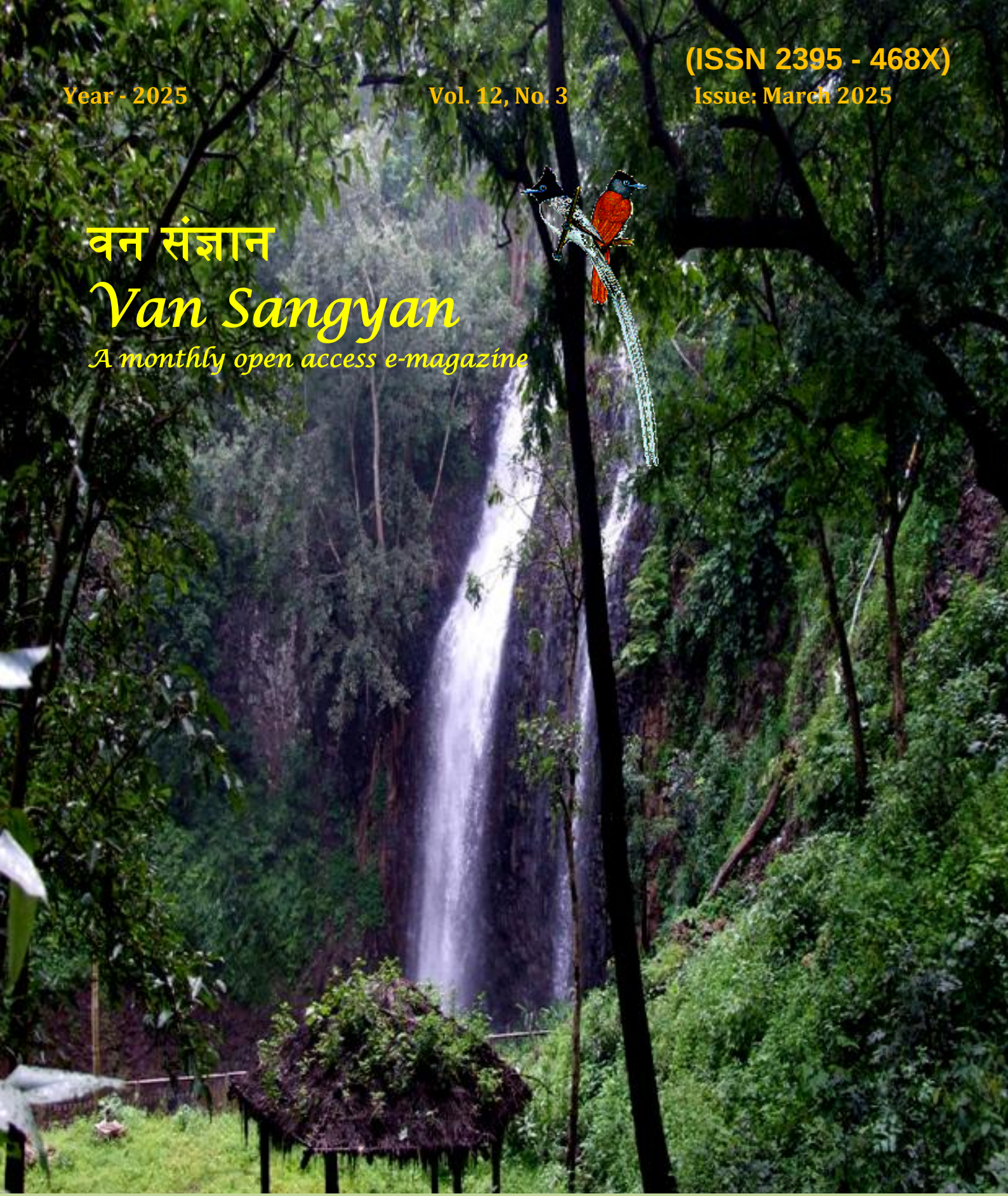

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Van Sangyan

Note to Authors:

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

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

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

Sandalwood, scientifically known as Santalum album, is a highly revered and economically significant tree species, often referred to as "the royal tree." Native to India and parts of Southeast Asia, it is renowned for its distinctive, long-lasting fragrance, which is derived from the precious essential oil extracted from its heartwood. This aromatic wood has been cherished for centuries in various cultures, playing a pivotal role in religious ceremonies, traditional medicine systems like Ayurveda, and the perfumery and cosmetic industries. Due to its slow growth and historical over-exploitation, Santalum album has faced threats, making conservation and sustainable cultivation practices crucial for its continued existence and the preservation of its invaluable contributions.

In line with the above, this issue of Van brings you a rich collection of articles, from the enigmatic Himalayan poppy (Meconopsis aculeata Royle), to broader ecological discussions. We explore critical topics such as Greenhouse gas emissions from wetlands, highlighting their role in climate change, and the impact of extension interventions on agro-forestry practices. You'll also find insights into emerging challenges like Fusarium leaf spot in bael nurseries and the exciting potential of nanotechnology in forestry. This issue further enriches our understanding of conservation with an article on empowering wildlife through 'Trans-boundary' conservation. For our Hindi readers, we have insightful piece on the natural gum. Finally, we examine practical aspects of forest product management with a focus on post-harvest management and packaging of Prosopis cineraria. We hope this collection sparks your curiosity and provides valuable knowledge on the ever-evolving landscape of our natural world.

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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The royal tree: Sandalwood (*Santalum album*)

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Abstract

In Indian culture, sandalwood (*Santalum album L.)* is a valuable tree. It is the second most expensive plant in the world. The sandalwood tree is often referred to as the "royal tree" due to its high value and significance in various cultures. Its heartwood produces sandalwood oil, which is prized for its fragrance and therapeutic properties. Historically, sandalwood has been associated with royalty and luxury, used in religious rituals, perfumes, and traditional medicine. Additionally, its slow growth and limited supply contribute to its esteemed status, making it a symbol of wealth and prestige. Although the species is semiparasitic and has the ability to photosynthesize, it is dependent on the host plant for organic matter, water, and mineral sustenance. Indian tradition dictates the use of sandalwood from the newborn till the cremation. Sandalols are the aromatic components of sandalwood oils. The Indian market places a high commercial value on sandalwood trees and oil. There are many varieties of sandalwood, and they are all commonly accessible.

Keywords: *Heartwood, Semiparasitic, Sandalols, Therapeutic.*

Introduction

Santalum album, a small to medium-sized evergreen tree, is native to India and found in various regions, including Karnataka, Tamil Nadu, and other states. It has a smooth, reddish-brown bark, thin leaves, and straw-colored flowers. The tree is a root parasite, associating with various host plants, and requires specific climate, topography, and soil conditions to thrive. Sandalwood is highly valued for its fragrant heartwood, used for carving, oil extraction, and medicinal purposes. The tree's natural regeneration occurs through seeds and root suckers, with seedlings

requiring lateral shade and being sensitive to drought and waterlogging. Artificial regeneration methods include seed sowing, transplanting, and vegetative propagation, but can be challenging due to the tree's parasitic nature and sensitivity to root disturbance. Sandalwood is susceptible to spike disease, caused by a virus transmitted by Lantana, which can impact its growth. The tree's wood is highly prized for its fragrance, durability, and medicinal properties, with the heartwood being used for carving, oil extraction, and traditional medicine**.**

Morphology of sandalwood

These are small to medium size, evergreen, glabrous tree with slender drooping branchlets. Generally, attains a height of 13.5-16.5 m and 1-1.5 m girth. Bark reddish-brown or dark brown, smooth in young trees and rough with deep vertical cracks in old trees. Leaves are thin, opposite, ovate or ovate-lanceolate, blade entire, 3.8 to 6.4 cm. Flowers are straw-colored, brownish-purple or violet, unscented in axillary or terminal panicled cymes. The ovary is unilocular and semi-inferior. The tree begins to bloom at a young age of two to three years.Usually, March to May and September to December, trees bloom twice a year.No leaf shedding, as it is a true evergreen tree, though the foliage gets thinner during protracted monsoons and dry season. Flowering - May.

Seed formation - October.

Fruit ripening - October-November.

Scientific classification

Phylum: Spermatophyta

Sub Phylum: Angiospermae

Class: Magnoliopsida

Order: Santalales

Family: Santalaceae

Genus: Santalum

Species: album

Botanical name: *Santalum album Linn***.**

Species and varieties: Geographical occurrence

- S. album L Australia, Indonesia, India
- S. austrocaledonicumViell New Caledonia, Vanuatu
- S. boninense (Nakai) Tuyama Bonin Islands
- S. lanceolatum R.Br.Australia
- S. macgregorii F. Muell Papua New Guinea
- S. obtusifolium R.Br. Fiji, Tonga
- S. insulare Bertero Australia
- S. acuminatum (R.Br. A.D.C.) Australia
- S. murrayanum (T. Mitch) C. A. Gardner Australia
- S.freycinetianumGaudich
- S.haleakale. Hillebr
- S. paniculatumHook&AM.
- S. fernaandezianumF.Phil.
- S. spicatum (R.Br.) A.D.C.

Distribution

Karnataka

Makarvalli in Hangal range, small blocks of Sandur, Huliyurdurga of Kollegal, Yedehalli of Bhadravathi, Coorg, Shimoga, Hassan, Kolar, Bangalore, Dharwar, Belgaum, North and South Kannada, Chickamaglur and Tumkur.

Tamil Nadu

Mainly in North Arcot (Javadis and Yelagiri hills), Salem, Periyar, Coimbatore, Vellore and sparsely in Nilgiris, Madurai and Trichy districts. Dense population is found in Chitteries, Jevadis, parts of Shevaroys and Tenmalai

hills.Andhra Pradesh, Kerala, Maharashtra, Madhya Pradesh, Orissa, Rajasthan, Uttar Pradesh, Bihar and Manipur. A. P. - Chittoor, Cuddahpah, Hyderabad, Kurnool and Ananthapur. M.P- Sehora, Sagar and Seoni forest divisions, Bhopal, Indore, Rewa, Ujjain and Neemuch. Kerala - Wynaad, Marayoor and Thenmalai. Orissa-Jeypore, Kalahandi and Parlekmandi forest divisions. H.P- Few trees are located in Kangra Valley near Jwaladevi.

Santalum album associates

Pterocarpus santalinus, Anogeissus latifolia, Hardwickia binata, Cassia fistula etc.SSSSS

Site Factors

Climate - mean annual temp. 17.8°C-33.8°C. Rainfall - upto 1900 mm.

Topography

It is a tree of upland plateau, growing chiefly on undulating ground but often on hill sides and in open places along the bank of rivers. Flourishes between altitudes at sea level to 1250 m, but best growth is obtained at 375-1100 m elevation.

Geology and Soil

Most commonly grows on red ferruginous loam, the underlying rock often being metamorphic, and chiefly Gneis sand igneous origin in Dharwar district. On typical black clayey soils in Madhya Pradesh, where the underlying rock is Deccan Trap.

Silvicultural Characters

Mainly occur in open scrub forests, hedgerows among Lantana bushes, bamboo clumps and round the edges of cultivated lands. Young trees coppice fairly well, older trees have little or no coppicing power except on moist ground along the banks of water courses. Seedlings are subject to attack of insects; hypocotyl and young leaves and taproots are readily attacked. Extremely fire-sensitive. Dense branches are capable of intercepting high velocities. Seedlings require lateral shade, but intolerant of low overhead cover. In its middle and later life, it is intolerant to heavy overhead shade. Seedlings are sensitive to drought as well as waterlogging.

Root-parasitism

It is a root-parasite i.e., numerous lateral roots establish their contact with the neighbouring roots of other host trees through the formation of haustoria. Out of large no. of associates, good host plants are *Cajanus cajan, Azadirachta indica, Pongamia pinnata, Cassia spp, Acacia spp, Melia dubia, Casuarina equisetifolia, Ficus benghalensis, Murraya koengii, Syzygium cumini, Terminalia spp, Lagerstroemia spp, Dendrocalamus strictus, Bambusa arundinacea, Albizia spp, Dalbergia spp* etc.

Silvicultural regeneration

Natural regeneration: Regenerate profusely through seeds and root suckers. Good seed year occur every year and germination take place during rainy season. The fruit-stone cracks, radicle emerges and seed is carried either above ground or left in the ground. Hypocotyl elongates, cotyledons break off remaining within the seed, above which young foliage develop quickly. Leaves are simple, opposite, exstipulate and earlier ones are smaller than the later ones. Important cultural operations for natural regeneration include maintainance of natural host plants, eradication of obnoxious undesirable weeds, protection

of seedlings from drought and facility for free and natural expansion of crown. Seedlings grow better under partial shade. Seed collection and storage- Seeds are collected from fresh fruits and then dried under shade and the dry seeds are stored in polythene bags. No. of seeds in one kg is about 6000.

Seed Germination

Fresh seeds usually have dormancy period of 2 months and viable up to 9 months. Seed takes 4 to 12 weeks to germinate after the dormancy period. Soaking seeds in 0.05% Gibberellic acid overnight and then sowing ensures uniform germination. Soaking the seeds for 24-48 hr sis reported to give 75 percent germination.

Artificial Regeneration

It can be propagated by dibbling seeds under the bushes or on the mounds, by transplanting nursery raised plants and by vegetative propagation through air layering or through root suckers. Artificial regeneration of this species fails at times due to many reasons such as-

- Improper appreciation of obligate roots.
- Parasitic nature of the species.
- Selection of unsuitable tree species. Removal of host plants from the site.
- Sensitiveness of root system during transplanting.
- Inadequate measures against lopping, grazing, fire etc.
- Lack of cultural operations.

Spike disease of Sandal first reported by McCarthy from Kushalnagar in 1891

In this disease, plant puts out stiff and erect bristles looking like a ‘spike’ with four lines or erect leaves growing down like a ‘chimney brush’. According to Venkata Rao (1935), the incidence of disease was highest in the scrub jungles where there is thick vegetation, while it was low in pole forest or open areas where undergrowth is less or scanty. Later Nayar and Srimathi (1968) confirmed that Lantana is a symptomless carrier of the disease. It was also felt that sandal in association with certain hosts was more susceptible to disease than others. Highest incidence of this disease is from May to July, with a peak in June.

Utilization Wood

Sapwood is white and scentless, heartwood yellowish-brown and strongly scented. Heartwood is hard, close-grained, oily used for carving and other fancy work, distilled for fragrant oil called sandal oil. Sapwood, also called ’White wood’, is used for the manufacture of agarbattis. Depending upon its colour and grains, sandal wood is graded into four types - Red and White Sandalwood (based on colour) and the Snake and Peacock Sandalwood (based on grains). Fragrance of sandal is due to Santalol, a polyphenol. Sandal wood oil Powder of heartwood upon steam distillation yields the East Indian Sandalwood oil, which is esteemed high for its sweet, fragrant, persistent, spicy, warm, woody note, non-varying composition and fixative property. It is used in agarbatti, cosmetic, perfumery and soap industries. In medicine, it finds use as an antipyretic, antiseptic, antiscabietic, diuretic, expectorant, stimulant and for treatment of bronchitis, dysuria, gonorrhoea and urinary infections.

Economic importance of sandalwood

Sandalwood (*Santalum album*) is a highly valued tree species renowned for its aromatic heartwood, which has been

traded for centuries. The economic importance of sandalwood in forestry is substantial.

Timber

Sandalwood is prized for its durable, fragrant timber, used in furniture, carving, and construction.

Essential Oil

Sandalwood oil, extracted from the heartwood, is used in perfumery, cosmetics, and pharmaceuticals.

Medicinal Properties

Sandalwood has antibacterial, anti-inflammatory, and antiseptic properties, making it valuable for traditional medicine. **Incense and Aromatics**: Sandalwood is used in incense sticks, powder, and chips for religious and cultural purposes.

Market Demand

Global Market Value

The global sandalwood market is projected to reach USD 1.5 billion by 2025.

Demand from Asia

India, China, and Japan are significant consumers of sandalwood products.

Luxury Goods

High-end perfumes, cosmetics, and furniture drive demand for sandalwood.

How farmers are benefits of sandalwood by intercropping: Sandalwood (*Santalum album*) is often cultivated as an intercrop with other plants to maximize land use and increase farmer benefits:

Advantages of Sandalwood Intercropping

Increased land productivity, Diversified income streams, improved soil health, Enhanced biodiversity, reduced pest and disease incidence, better water utilization.

Benefits to Farmers

Additional income from intercrops (Rs. 50,000-100,000 per acre per year), Improved sandalwood growth and productivity due to shade and nutrient sharing, Reduced sandalwood mortality rates (10-20% reduction), Enhanced soil fertility and structure**,** Increased employment opportunities for rural labor, better risk management through diversified income streams.

Successful Sandalwood Intercropping Models

1. Sandalwood + Rice + Pulses (Andhra Pradesh, India)
2. Sandalwood + Groundnut + Sunflower (Karnataka, India)
3. Sandalwood + Turmeric + Ginger (Tamil Nadu, India)
4. Sandalwood + Napier Grass + Leguminous shrubs (Australian model)

Conclusion

Indian sandalwood is one of the most auspicious and economically important tree species regarded as the “Royal Tree”in the Indian subcontinent. It is recommended that farmers only buy Quality Planting Material (QPM) stock from known seed sources.Sandalwood plants should only be purchased from nurseries that are accredited and certified. It's getting harder for farmers to keep their growing sandalwood trees safe.*Santalum album* required careful conservation and sustainable management. To ensure its continued availability for future generations, it is crucial to address its specific needs and challenges. Effective conservation strategies, research, and sustainable practices are vital for preserving this iconic Indian tree,

maintaining its ecological, economic, and cultural significance.

References

Anand, S., & Sivaramakrishnan, V. R. (2015). Spike disease of sandalwood (*Santalum album* L.): A review. *Journal of Mycology and Plant Pathology*, 45(2), 151-158.

International Union for Conservation of Nature (IUCN) Red List of Threatened Species: *Santalum album.*

National Centre for Biotechnology Information (NCBI) Taxonomy Browser: *Santalum*.

Sandalwood (*Santalum album*)- *A Monograph" by the Ministry of Environment, Forest and Climate Change, Government of Indi*a. 2018.

Sandalwood: *A Review" by the Kerala Forest Research Institute (KFRI*), 2018.

Santalum album - A Review of its Ecology and Conservation" by the Karnataka Forest Department, 2017

Santalum album L." by the *Botanical Survey of India (BSI)*, 2015.

Santalum album" by the Indian Council of Forestry Research and Education (ICFRE), 2019.

Shankar, N., & Kumar, P. (2017). *Santalum album* L.: A review on its botany, ecology, and conservation. *Journal of Applied and Natural Science*, 9(2), 742-748.

Sivaramakrishnan, V. R., & Venkatesan, S. (2017). Sandalwood (*Santalum album* L.): A review on its cultivation, management, and utilization. *Journal of Forestry Research*, 28(3), 537-545.

World Agroforestry (ICRAF) Tree Seed Suppliers Directory: *Santalum album*.

Greenhouse gas emissions from wetlands: Understanding their role in climate change

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Abstract

Wetlands are critical ecosystems that significantly impact global greenhouse gas (GHG) emissions, including carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). This article explores the dual role of wetlands as both carbon sinks and sources of GHGs. It delves into the biogeochemical processes driving emissions and the factors that influence them, including human activities. The paper highlights the importance of wetlands in climate change mitigation and offers strategies for reducing GHG emissions.

Keywords: Wetlands, greenhouse gases, methane, climate change, GHG mitigation

Introduction

Wetlands, defined by the Ramsar Convention as areas of marsh, fen, peatland or water that may be natural or artificial are essential ecosystems with a profound role in the global carbon cycle. They occupy about 6 per cent of the Earth's surface and are known for their ability to act as both carbon sinks and emitters of greenhouse gases (GHGs). The anaerobic conditions in wetlands lead to the formation of methane (CH_4) and other gases which have a significant impact on climate change due to their high global warming potential. Methanogenesis driven by microbial activity in water-saturated soils is a major contributor to methane production. Furthermore, human activities such as agriculture and drainage often disrupt the natural processes, leading to increased GHG emissions from these ecosystems.

The balance between GHG sequestration and emissions in wetlands is influenced by various factors, including water temperature, soil composition, organic matter availability and human interventions. Understanding these processes is crucial to developing strategies for mitigating the effects of climate change and preserving the ecological benefits that wetlands provide

Wetland Classification and Distribution

Wetlands can be classified into coastal and inland types with each further divided into natural and manmade wetlands. Coastal wetlands include estuaries, mangroves and coral reefs, while inland wetlands encompass lakes, rivers and marshes. India, for instance is home to an estimated 152,600 square kilometres of wetlands accounting for 4.63 per cent of its total geographical area. The country's wetlands are unevenly distributed with a notable increase in manmade inland wetlands over the past decade (National Wetland Atlas, 2011)

Greenhouse Gas Emissions from Wetlands

Wetlands emit three major greenhouse gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). While CO_2 is the most common GHG, methane has a much higher global warming potential and nitrous oxide is a potent ozone-depleting gas. The anaerobic, waterlogged conditions in wetlands foster the production of methane through methanogenesis, a process in which microbes break down organic matter in the absence of oxygen. However, the release of GHGs from wetlands is not uniform; it is influenced by

environmental conditions such as water level, temperature, and organic matter availability

Human-induced changes, such as wetland drainage for agriculture or urbanization, further exacerbate GHG emissions. Research has shown that agricultural runoff and industrial pollutants increase nutrient levels in wetlands, leading to eutrophication and enhanced methane production. These conditions promote the growth of methanogens, microbes responsible for methane production(Mitsch, 1996).

Strategies to Reduce GHG Emissions

Efforts to reduce GHG emissions from wetlands focus on restoring natural hydrology and reducing human disturbances. Restoring the natural water flow in wetlands can enhance their carbon sequestration capabilities while reducing methane emissions. For instance, tidal marsh restoration has been shown to significantly increase carbon storage while minimizing GHG emissions. Additionally, managing nutrient inputs by controlling agricultural runoff and limiting industrial pollutants can help maintain the ecological balance and reduce emissions of both methane and nitrous oxide(Malerba *et al.*, 2022).

Plant management is another key strategy. Promoting vegetation that enhances oxygenation can reduce methane emissions, while controlling excessive plant density can limit the release of methanogenic substrates into sediments. Wetland conservation efforts that focus on preventing soil disturbance and maintaining water levels are essential for sustaining the natural processes that mitigate climate change

Conclusion

Wetlands play a dual role in climate change: they act as both carbon sinks and sources of potent greenhouse gases. The emission dynamics of these ecosystems are influenced by natural factors such as soil composition and water levels, as well as human interventions like agriculture and industrial activities. Protecting and restoring wetlands is vital for reducing GHG emissions and enhancing their role as carbon sinks. Future research should focus on improving the accuracy of emission measurements and understanding the long-term impacts of climate change on wetland ecosystems.

References

Mitsch WJ (1996) Managing the world's wetlands — Preserving and enhancing their ecological functions. *SIL Proceedings*,*26*(1), 139–147.

Malerba ME, Friess DA, Peacock M, Grinham A, Taillardat P, Rosentreter JA, Webb J, Iram N, Al-Haj AN and Macreadie PI (2022) Methane and nitrous oxide emissions complicate the climate benefits of teal and blue carbon wetlands. *One Earth*,*5*(12): 1336-1341.

Space Applications Centre (ISRO), (2011) ***National Wetland Atlas***. Ministry of Environment and Forests, Government of India, Ahmedabad.

Himalayan poppy (*Meconopsis aculeata* Royle): Nature's mysterious blue wonder

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Introduction

The Himalayan Poppy, scientifically named *Meconopsis aculeata* Royle (Family: Papaveraceae), is a striking flowering plant that captivates botanists, gardeners, and herbal enthusiasts alike. It is referred to locally as the Blue Poppy and is an important visual wonder and part of the region's culture and traditional medicine. This species has been known for its striking blooms as the "Queen of Himalayan Flowers". The local names are Vanita and Kanta in Hindi and Gul-e Nilam in Urdu. It was first described by Viguier in 1814 (Ahmad et al. 2016), and the species was later characterized by Royle in 1833, based on specimens he had collected. It is an endangered medicinal plant which is indigenous to the Himalayas and has its cycle of growth in plants with flowers and seeds borne within the third year after its germination (Shukla et al., 2022). The population of Himalayan Poppy is gradually declining because of habitat degradation, overexploitation, unsustainable harvesting practices, and overgrazing (Rana and Samant, 2011). The species has been classified as Endangered in Himachal Pradesh, Uttarakhand, and the Jammu & Kashmir Union Territory. It is considered Critically Endangered in Pakistan and Kashmir by IUCN criteria (Majid et al., 2015).

Botanical Description and Habitat:

A herbaceous perennial with tapering rootstocks leaves being deeply and irregularly lobed; sparsely bristle-haired, with flowers sky-blue to purplish-blue with very many yellow-colored stamens. The rosette of broad hairy leaves may reach 30 cm in length. Those leaves provide nourishment as well as protection to the plant. The most remarkable feature of Himalayan Poppy is the enormous bowl-shaped flowers. From the color of flowers, there are two morpho-variations identified within the species: one is pale purple-flowered while the other has blue-colored flowers. Seed capsules form after flowering, on becoming elongated with hundreds of small seeds, and their wind dispersal leads to natural propagation. It is very variable in habit, size, and dissection of leaves, nature of inflorescence, and size and color of petals (Sharma et al. 1993). It is mainly found in the cool, moist conditions of the eastern Himalayas, especially in places like Nepal, Bhutan, and parts of northern India. The species occurs between the altitudes of 3,300 to 4,600m in the Western Himalayas (Hooker 1872). Himalayan Blue Poppy thrives best in fertile well-drained soils, and often

flowers in the summer months when cool weather and adequate moisture conditions for growth are available. It flowers and fruits in July- August.

Morphology of plant (Light purple and blue flowers)

Chromosomal Analysis

During the different cell division stages, the number of chromosomes has been enumerated through chromosomal study: 2n = 56. This count is consonant with earlier reports not only from the Kashmir Himalayas and Lahaul Spiti in Himachal Pradesh but also from around the world. Interestingly, the reports have been there historically with the count of the chromosome being different as 2n=28. Therefore, it shows that intraspecific polyploidy that occurs within the same species where one set of the chromosome appears more than once. Even scientists still argue with the basic chromosome number of the genus *Meconopsis*. For example, one may present the x=7 or x=8 (Basic chromosome numbers) while another can show that it is commonly represented by the number x=7 or x=11. More researchers have also noted that x=14 is a fundamental number because of the chromosome behaviour during meiosis. Another interesting aspect is on polyploidy role in the speciation of Blue Poppy, with new studies focusing on this feature of its speciation.

Medicinal Uses

The Himalayan Poppy, other than being such a beautiful plant, is also documented in history by traditional medicinal uses. Various parts of the plant have been used in folk medicine locally for several treatment purposes. This species is regarded to be the most vital drug of medicinal importance in folk medicines in the treatment and control of rheumatic pain. The species is a general adjuvant febrifuge, an analgesic, an analgetic, and cure of bone diseases mostly confined in and around the region of the ribs (Tsarong 1994). The flowers of this species have been used to treat asthma, pain, fever, and cough; often used by the local communities in Chamba and Lahaul-Spiti of Himachal Pradesh (Singhal and Kumar 2008) as well as in Bageshwar, Uttarakhand (Rawat et al. 2013). Moreover, the tradition has it that

Himalayan Poppy has a sedative effect and people believe that herbal preparations help to induce sleep and aid in sleep and are considered to be a natural remedy for stress and anxiety.

Phytochemistry and Research

The medicinal properties of the Himalayan Poppy are attributed to its varied phytochemical composition. It is used in the treatment of a range of diseases because of its high concentration of bioactive compounds. The herb is a rich source of polyphenolic compounds and natural antioxidants, which make it suitable for use as a dietary supplement. Research into the phytochemistry of the Himalayan Poppy is still current, and further studies will likely identify more therapeutic areas of applications in modern medicine. The Himalayan Poppy has ethnomedicinal uses that include the management of chronic pain, narcotic-related conditions, kidney colic, backaches, stomachaches, and other abdominal discomforts. It is also valued for its tonic properties and as a remedy for poisoning (Chauhan et al. 2020). It can be used as a topical form to treat body pain that is prepared by mixing with milk from the flowers of the plant. The leaves are applied as a paste on the legs to overcome swelling due to walking excessively. The plant is said to be helpful in healing fever and chickenpox. For enhanced immunity towards pregnancy and child delivery, the women are given an overall powder made from *M. aculeata*.

Conservation concerns:

Although it is beautiful and also medicinal, the Himalayan Poppy is still suffering from substantial threats that danger its survival. Its natural population is greatly threatened by agriculture, urbanization, and climate change. Declines in wild populations are partly due to overharvesting for medicinal and ornamental use. This species requires conservation efforts. The main strategies include the sustainable harvesting strategy; therefore, guidelines on the collection of the plant should be advocated for in a manner that will continue to leave the plant in its original habitat. Institutes of the Medicinal Plant Conservation Societies should be initiated to help conserve and manage medicinal herbs that are strictly confined within certain high altitude areas; the emphasis shall be conservation of medicinal plants for sustenance and conservation for successive generations. This practice of ecological niche modelling will be very useful for rehabilitating and reintroducing species that are under threat as it will help predict a habitat. Further, conservation of habitats is also inevitable in which the native ecosystems are conserved so that the plant cannot be trespassed and degraded. As this seed germination forms an essential tool for such reintroduction and management schemes in the plan of the conservation strategies, studies must be done regarding this area also. Another approach to reducing the pressure on wild populations would be through propagation programs in botanical gardens and home gardens, which will help raise the awareness of this importance of this fantastic plant.

Conclusion

The Himalayan Poppy is not merely a pretty flower, but the rich biodiversity of the Himalayas has found reflection in it and holds health benefits that need to be researched. It’s beautiful form and

medicinal values point towards its preservation. Because this particular plant is still widely explored through research to find more extent of its therapeutic use, conservation and sustainable ways can be promoted to help retain the Himalayan Poppy for many succeeding generations. In an international context where biodiversity is rapidly emerging, the Himalayan Poppy serves as a symbol of the natural treasures that the world holds. This rare gem will thus gain an appreciation, ensuring its beauty and medicinal potential shall be a part of our natural heritage for years to come.

References

Ahmad, M., Kaloo, Z.A., Ganai, B.A., Ganaie, H.A. and Singh. S. 2016. Phytochemical screening of *Meconopsis aculeate* Royle an important medicinal plant of Kashmir Himalaya: A Perspective. Research Journal of Phytochemistry.10 (1):1-9.

Chauhan, P.P., Nigam, A. and Santvan, V.K. 2020. Ethnobotanical uses of medicinal plants among the rural people of Pabbar Valley in District Shimla, Himachal Pradesh, India Plant Archives. 20:3707-3719.

Hooker, J.D. 1872. The Flora of British India I. L. Reeve & Co. Ltd., NR Ashford, Kent, England.

Majid, A.H.A., Ahmad, H., Saqib, Z., Ali, H. and Alam, J. 2015. Conservation status assessment of *Meconopsis aculeata* Royle; A threatened endemic of Pakistan and Kashmir. Pakistan Journal of Botany. 47: 1-5.

Rana, M.S. and Samant, S.S. 2011. Diversity, indigenous uses and conservation status of medicinal plants in Manali Wildlife Sanctuary, North Western Himalaya. Indian Journal of Traditional Knowledge. 10: 439-459.

Rawat, B., Sekar, K.C. and Gairola, S. 2013. Ethnomedicinal plants of Sunderdhunga valley, western Himalaya, India-traditional use, current status and future scenario. Indian Forester. 139:61–68.

Sharma, B.D., Balakrishnan, N.P., Rao. R.R. and Hajra, P.K. (eds.). 1993. *Flora of India*. Vol.1. Bot. Surv. India, Calcutta.

Shukla,V,. Singh, A,. Nautiyal, A.R. and Rani. P. 2022. Phenological growth stages of *Meconopsis aculeata* Royle, an endangered medicinal plant of western Himalaya, using BBCH scale. Journal of Applied Horticulture. 24:16-21.

Singhal, V.K. and Kumar, P. 2008. Impact of cytomixis on meiosis, pollen viability and pollen size in wild populations of Himalayan poppy (*Meconopsis aculeata* Royle). Journal of Biosciences. 33:371–380

Tsarong, T.J. 1994. *Tibetan medicinal plants* (India: Tibetan Medical Publications). ISBN No. 81-900489-0-2

Impact of extension interventions on agro-forestry practices: A systematic review

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Abstract

Agro-forestry, the integration of trees and agricultural crops and or livestock, offers numerous ecological and socioeconomic benefits. Farmers' adoption to agroforestry models is influenced by a variety of factors, such as their socioeconomic status, land ownership, the suitability of agroforestry models, cultural and social values, benefits and risk involved and institutional concerns.Therefore to effectively promote and implement agro-forestry practices, extension interventions play a vital role. This systematic review aims to evaluate the impact of extension interventions on agro-forestry practices by examining relevant studies. A comprehensive search was conducted, and a total of 30 studies met the inclusion criteria. The findings provide valuable insights into the effectiveness of extension interventions and their contribution to agro-forestry development.

Introduction

Agro-forestry, the integration of trees and agricultural crops or livestock on farm land, is gaining recognition worldwide as a sustainable land-use system that offers numerous ecological, economic, and social benefits. By combining agricultural production with tree cultivation, agro-forestry practices provide opportunities for biodiversity conservation, climate change mitigation, soil improvement, water management, and enhanced livelihoods for rural communities (Nair, 1993, Nair et al., 2022; Garrity et al., 2017).Three criteria are typically used to evaluate an agro-forestry model's success: production, sustainability, and adoptability. The potential of agro-forestry is widely acknowledged, effective implementation and widespread adoption of these practices require appropriate knowledge dissemination, technical assistance, and support for farmers. This is where extension interventions play a crucial role. Extension services serve as a bridge between scientific research, best practices, and local farming communities, facilitating the transfer of information, skills, and resources necessary for successful agro-forestry implementation (Falconer, 2021).

The effectiveness of extension interventions in promoting agro-forestry practices and their impact on farmers' adoption, sustainable practices, and livelihood improvement have been the subject of increasing research interest. This systematic review aims to evaluate the existing body of literature to provide valuable insights into the impact of extension interventions on agro-forestry practices.By synthesizing and analyzing relevant studies, this review aims to answer key questions: How do extension

interventions influence farmers' awareness and knowledge of agro-forestry practices? What is the role of extension interventions in facilitating the adoption of agro-forestry systems? How do these interventions contribute to the implementation of sustainable practices within agro-forestry contexts? Last but not the least, how do extension interventions impact farmers' livelihoods and socioeconomic outcomes?Understanding the impact of extension interventions on agro-forestry practices is crucial for policymakers, practitioners, and researchers to develop evidence-based strategies and programs that effectively support agro-forestry development. The five most effective models of agro-forestry extension approachesaremedia based extension, commodity based extension, farming systems research and extension,training and visit model and community based extension (Scherr, 1992).By identifying successful approaches, challenges, and gaps in current extension interventions, this review aims to provide guidance for the design and implementation of future extension programs in the context of agro-forestry.Overall, this systematic review contributes to the growing body of knowledge on the role of extension interventions in promoting and enhancing agro-forestry practices, ultimately contributing to the sustainable development of agricultural landscapes and the well-being of farming communities.

Methodology

A systematic literature search was conducted in major academic databases, resulting in the identification of 30 relevant studies. Inclusion criteria were set to select studies that focused on extension interventions and their impact on agro-forestry practices. Data extraction and synthesis were performed to evaluate the key findings.

Research findings

1. Extension Interventions and Awareness: The reviewed studies consistently reported that extension interventions significantly increased awareness about the benefits of agro-forestry practices among farmers. This increased awareness contributed to enhanced knowledge and understanding of the ecological and socioeconomic advantages associated with agro-forestry systems (Kiptot et al., 2018; Nair et al., 2020).
2. Extension Interventions and Adoption: The findings indicated that extension interventions played a crucial role in promoting the adoption of agro-forestry practices. Farmers who participated in extension programs were more likely to adopt and implement agro-forestry systems on their land. These interventions provided technical support, training, and resources necessary for successful implementation (Franzel et al., 2014; Sinclair et al., 2019).
3. Extension Interventions and Sustainable Practices: Extension interventions were found to contribute to the adoption of sustainable practices within agro-forestry systems. Farmers who received extension services were more likely to implement environmentally friendly

techniques, such as conservation tillage, organic fertilizers, and integrated pest management. These practices helped improve soil quality, enhance biodiversity, and reduce the use of chemical inputs (Jha et al., 2017; Russo et al., 2021).

4. Extension Interventions and Livelihood Improvement: Extension interventions had a positive impact on farmers' livelihoods. Agro-forestry practices facilitated diversification of income sources, improved food security, and increased resilience to climate change impacts. Farmers reported higher yields, enhanced market opportunities, and improved household income due to the adoption of agro-forestry practices facilitated by extension services (Garrity et al., 2016; Sileshi et al., 2020).

Discussion

The systematic review reveals several important findings regarding the impact of extension interventions on agro-forestry practices.

- Extension Interventions and Knowledge Transfer: Extension interventions have been successful in increasing farmers' knowledge and understanding of agro-forestry practices. Studies by Sileshi et al. (2019) and Alavalapati et al. (2020) found that extension programs provided farmers with information on suitable tree species selection, tree-crop interactions, and management techniques, leading to improved knowledge among participants. This knowledge transfer is essential for empowering farmers to make informed decisions and effectively implement agro-forestry systems.
- Extension Interventions and Technology Adoption: Extension interventions play a critical role in promoting the adoption of appropriate technologies in agro-forestry. Through training sessions and demonstrations, farmers are introduced to innovative techniques such as alley cropping, silvopasture, and contour planting. Studies by Sinclair et al. (2018) and Kiptot et al. (2021) have shown that extension programs significantly increase the adoption of these technologies, leading to enhanced productivity, soil fertility, and overall system resilience.
- Extension Interventions and Market Linkages: Access to markets and value chains is crucial for the economic viability of agro-forestry systems. Extension interventions often incorporate market-oriented training and networking opportunities for farmers. Research by Garrity et al. (2017) and Nair et al. (2022) highlights that extension programs facilitate market linkages, enabling farmers to connect with buyers, negotiate better prices, and diversify their income streams. This aspect contributes to improved livelihoods and encourages the long-term sustainability of agro-forestry practices.
- Extension Interventions and Policy Support: Extension interventions also play a significant role in influencing policy support for agro-forestry. By showcasing the environmental and

socioeconomic benefits of agro-forestry, extension programs can advocate for favorable policies and incentives. Studies by Falconer (2021) and Russo et al. (2022) indicate that extension interventions have been instrumental in raising awareness among policymakers, resulting in the formulation and implementation of supportive policies that promote agro-forestry adoption and sustainable land management practices.

Conclusion

The systematic review demonstrates the wide-ranging impact of extension interventions on agro-forestry practices. Through knowledge transfer, technology adoption, market linkages, and policy support, extension programs have significantly contributed to the success and expansion of agro-forestry systems. However, the resources available, the knowledge of extension workers, and the sustained involvement of farming communities are all necessary for these interventions to be successful.The findings underscore the importance of continued investment in extension services, capacity building, and institutional support to further enhance the adoption and impact of agro-forestry practices.

Future Directions

Further research is warranted to explore innovative approaches to extension interventions, including the integration of digital technologies and participatory approaches. Additionally, more emphasis should be placed on evaluating the cost-effectiveness and long-term sustainability of extension programs in agro-forestry contexts. Furthermore, studies focusing on the socio-cultural aspects, gender dynamics, and local knowledge systems in extension interventions can provide valuable insights into tailoring programs to specific contexts and maximizing their impact.

References

Alavalapati, J. R., et al. (2020). Agroforestry adoption and its determinants: Evidence from farmers in Georgia, USA. Agroforestry Systems, 94(2), 521-534.

Falconer, J. (2021). Agroforestry for sustainable land-use systems: A review. Agroforestry Systems, 95(1), 1-21.

Garrity, D., et al. (2017). Agroforestry and the Sustainable Development Goals. In: Handbook of International Food and Agricultural Policies. Springer, Cham, 1-22.

Kiptot, E., et al. (2021). Adoption of agroforestry innovations in eastern Africa: A review. Agroforestry Systems, 95(1), 23-40.

Nair, P. K. R., et al. (2022). Agroforestry for biodiversity conservation and improved livelihoods in Southeast Asia. Biodiversity and Conservation, 31(1), 11-32.

Russo, L., et al. (2022). Agroforestry as a climate change mitigation option in the tropics: An integrated modeling framework for policy support. Environmental Modelling& Software, 140, 105057.

Scherr J S. (1992). The role of extension in agroforestry development: evidence from western Kenya. Agroforestry Systems, 18(1):47-68

Sinclair, F., et al. (2018). The roles and potential of agroforestry in

delivering ecosystem services for sustainable intensification in Sub-Saharan Africa. International Journal of Agricultural Sustainability, 16(1), 4-18.

Sileshi, G., et al. (2019). Agroforestry for ecosystem services and environmental benefits: An overview. Agroforestry Systems, 93(5), 1381-1388.

Falconer, J. (2019). Agroforestry extension: A way forward for widespread adoption. Agroforestry Systems, 93(5), 1541-1554.

Franzel, S., et al. (2014). Scaling up the impacts of agroforestry: Lessons from three sites in Africa and Asia. Agroforestry Systems, 88(4), 641-651.

Garrity, D., et al. (2016). Agroforestry and landscape restoration: Reforestation and land-use change in a densely populated country. In: Agroforestry - The Future of Global Land Use. Springer, Cham, 277-294.

Jha, P., et al. (2017). Extension education in agroforestry: A review. Indian Journal of Extension Education, 53(3-4), 62-71.

Kiptot, E., et al. (2018). Role of extension agents in adoption of agroforestry technologies: Evidence from western Kenya. Journal of Agricultural Extension and Rural Development, 10(1), 1-10.

Nair, P. K. R (1993). An Introduction to Agroforestry. Kluwer Academic Publisher, London.499p.

Nair, P. K. R., et al. (2020). Agroforestry as a sustainable land use option in the tropics: The Latin American experience. Agroforestry Systems, 94 (6), 2231-2251.

Russo, L., et al. (2021). Agroforestry as a climate change mitigation option in the tropics: An integrated modeling framework for policy support. Environmental Modelling& Software, 140, 105057.

Sinclair, F., et al. (2019). Agroforestry education and training: Present and future. Agroforestry Systems, 93(5), 1555-1571.

Sileshi, G., et al. (2020). Agroforestry as a strategy for climate change adaptation and mitigation in Africa. Forests, Trees and Livelihoods, 29(1), 1-23.

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 pressurelowering 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 alternata*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 Ayodhyaregion 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).

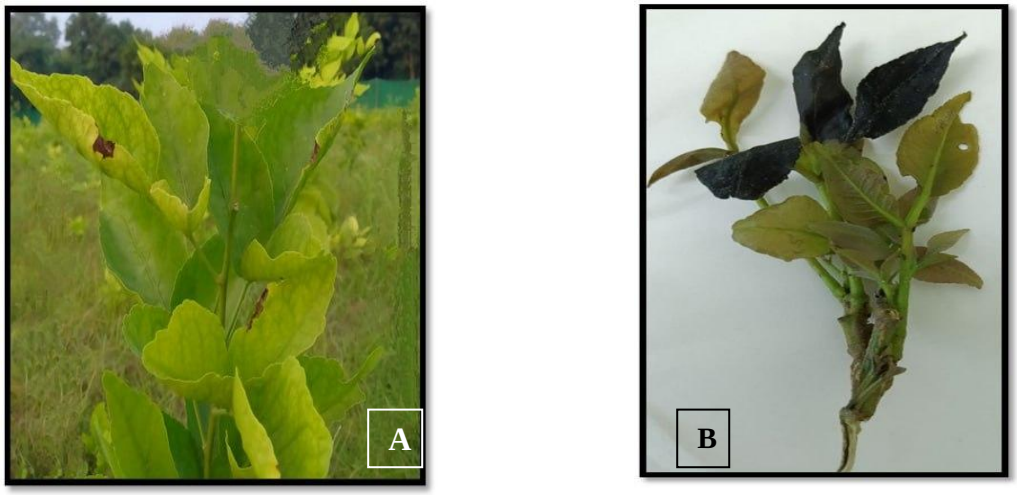

Fig. (A) Showing fusarium leaf spot Symptoms and Fig. (B) Showing dieback symptoms.

Management

For the effective management of Fusarium leaf spot, the efficacy of differentchemical fungicide, botanical extracts and bioagents are tested againstthe *Fusarium pallidoroseum*in the laboratory,

Department of Plant pathology, Acharya Narendara Deva University of Agriculture and Technology by using poisoned food techniques and dual culture methods respectively. On the basis of results, we are obtained in the lab following recommendation are suggested.

- 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 eastern 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.

Small wonders: The impact of nanotechnology on the future of forestry

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Introduction

Forests are invaluable to our planet, crucial in maintaining biodiversity, regulating climate, and supporting countless ecosystems. However, forests worldwide face escalating challenges, from disease and pest infestations to the impacts of climate change and human activity. As traditional forestry methods strive to keep pace with these growing threats, a new technology frontier offers promising solutions: nanotechnology.

Nanotechnology, the science of manipulating materials on an atomic or molecular scale, has already proven transformative in fields like medicine and engineering. Now, its potential is expanding into forestry, where it can help address complex issues more precisely and effectively. From disease management and soil enhancement to advanced wildlife monitoring and reforestation support, nanotechnology offers innovative ways to safeguard forests while promoting sustainable growth.

This article will explore how nanotechnology reshapes forestry practices and its benefits to tree health, soil quality, wood protection, and conservation. While there are challenges to consider, the future of forestry with nanotechnology holds tremendous potential for a more resilient and sustainable world.

Understanding Nanotechnology

Nanotechnology is the science of manipulating materials at the nanoscale, typically between 1 and 100 nanometers (Nasrollahzadeh et al., 2019), where unique physical, chemical, and biological properties emerge. This technology enables the creation of materials with enhanced reactivity, strength, or electrical properties that differ significantly from larger-scale versions. Initially applied in electronics and medicine, nanotechnology has expanded into forestry and agriculture. By harnessing these nanoscale properties, scientists aim to develop solutions that improve efficiency and sustainability in forestry, opening up possibilities for advanced pest management, soil health enhancement, and wood preservation.

The role of nanotechnology in forestry

Nanotechnology offers groundbreaking solutions to enhance forestry practices and address pressing challenges. Below are some key areas where nanotechnology is making a notable impact.

Tree Disease management

Tree diseases can devastate forests, reducing biodiversity and affecting ecosystem health. Nanotechnology offers precision solutions for disease management through nano-pesticides and nano-based delivery systems for antimicrobial agents. Nano-pesticides allow targeted treatment of pathogens with minimal environmental impact. Atthe same time, nanoparticles like silver or copper exhibit antimicrobial properties (Yadava et al., 2024), effectively controlling disease-causing agents without harming beneficial organisms. This targeted approach enhances tree health and

reduces chemical runoff, supporting a healthier ecosystem.

Improving Soil Health

Soil health is crucial for tree growth and forest resilience. Nanotechnology improves soil by developing nano-fertilizers and nano-based soil amendments (Younis et al., 2021). Nano-fertilizers encapsulate nutrients, releasing them slowly and steadily, ensuring plants' efficient nutrient uptake and minimizing leaching. Nanoclays and other soil amendments can also improve soil structure and water retention, making soil more fertile and less prone to erosion. By enhancing nutrient efficiency and soil stability, nanotechnology helps create healthier forests with improved resistance to climate change and environmental stressors.

Wood technology

Nanotechnology is transforming wood technology by enhancing wood's durability, strength, and resistance to decay (Bi et al., 2021). Nano-coatings, made from nanoparticles like zinc oxide and titanium dioxide, protect wood from moisture, UV radiation, and pests, extending its lifespan without harmful chemicals. Additionally, nano-engineered wood composites, where cellulose nanofibers are embedded within the wood matrix, increase wood's strength, making it suitable for construction and industrial applications. These advances improve wood quality and contribute to more sustainable forestry by reducing the need for chemical treatments.

Nano Seed Treatment

Seed germination and early seedling growth are critical stages in forest development. Nano-seed treatments enhance these processes by coating seeds with nanoparticles that directly deliver essential nutrients and growth stimulants to the seed (Zhao et al., 2023). This approach can improve germination rates, increase resistance to stress, and promote healthier initial growth. For instance, seeds treated with nano-copper or nano-silicon show improved root and shoot growth, giving young trees a more vigorous start and greater resilience to environmental challenges like drought and soil salinity.

Forest Biotechnology & Tissue Culture

Nanotechnology also complements forest biotechnology and tissue culture by facilitating gene transfer and tissue growth. Nanoparticles are used as carriers in genetic engineering, enabling precise delivery of genes that enhance disease resistance, growth rates, and stress tolerance (Cunningham et al.,2018). In tissue culture, nano-based media can improve nutrient availability and uptake, accelerating plant growth and propagation rates (Haydar et al., 2024). Integrating nanotechnology into biotechnology enhances the efficiency of forest regeneration programs, ensuring a steady supply of healthy, resilient trees for reforestation and conservation.

Nano Fire Detection

Forest fires significantly threaten ecosystems, property, and human life. Traditional fire detection systems can be limited in remote forest areas where rapid detection is essential to prevent extensive damage. Nanotechnology offers a revolutionary solution with nano fire detection systems, which use susceptible nanosensors to temperature, gas emissions, and smoke particles associated with early fire stages (Rabajczyk et al., 2021).These nanosensors can be embedded in forest environments or trees, continuously monitoring for subtle chemical changes that indicate combustion. For instance, carbon-based nanosensors or metal oxide nanoparticles can detect trace amounts of gases like carbon monoxide or volatile

organic compounds (VOCs) that are often released during the initial stages of a fire. When these compounds are detected, the nanosensors can trigger an alert system, allowing for a rapid response before the fire spreads.

The benefits of nano fire detection include:

High Sensitivity

Nanosensors can detect minuscule environmental changes, enabling earlier detection than conventional systems.

Remote and Real-Time Monitoring

Many nanosensors can transmit data wirelessly, making monitoring vast forest areas in real time feasible.

Cost-Effective and Energy-Efficient

Nanosensors are typically low-power, meaning they can function in remote locations for extended periods with minimal maintenance.

With nano fire detection technology, forestry managers can act swiftly to contain fires before they become unmanageable, protecting forest ecosystems and reducing wildfire's environmental and economic costs.

Nano Fire Detection

In New Zealand, nanosensors revolutionize wildlife monitoring by enabling precise, non-invasive tracking and environmental data collection (Poddar et al., 2011). These tiny sensors can be attached to animals, allowing researchers to track movements and monitor health indicators like stress or disease in species such as kiwi birds and Hector's dolphins. Nanosensors also detect environmental changes and pollutants, helping to assess habitat quality. Nanosensors identify specific biological markers for invasive species, allowing early intervention.

By transmitting data wirelessly from remote locations, nanosensors support continuous, real-time monitoring. This technology enhances New Zealand's conservation efforts, ensuring better protection for its unique biodiversity.

Challenges and Considerations

While nanotechnology is shaping the future of forestry and conservation, it also brings essential challenges. As we use nanotech to fight tree diseases, improve soil, enhance wood durability, treat seeds, and support biotech advances in tissue culture, we must considerits impact carefully.

Environmental Impact

Adding nanoparticles to forests for disease control or soil improvement sounds great but raises questions. These particles might accumulate over time, affecting plants, animals, and the food chain. We need more research to ensure that what we put into our forests is safe for the ecosystem.

Safety First

From nano-coatings on wood to nano-fertilizers in soil, balancing effectiveness with environmental safety is essential. Eco-friendly, biodegradable materials are ideal, so they donot linger in the soil or water, harming unintended parts of the ecosystem.

Animal and Ethical Considerations

Tracking wildlife with nanosensors provides new insights, but we must be mindful of the animal's well-being. These devices should be as non-intrusive as possible, especially when studying endangered species, ensuring they donot interfere with natural behaviour.

Real-World Challenges

Using nanotechnology in remote forests isonly sometimes practical. For example, nanosensors need reliable power sources and maintenance, which can be challenging in isolated areas. These technologies must be designed to withstand rugged forest environments to be effective.

Making Nanotech Accessible

The cost of advanced nanotech solutions is still high, which limits broader use. Affordable nano-fertilizers, pest control, and monitoring tools could help forests worldwide, but they must be cost-effective for widespread adoption.

Nanotechnology's potential in forestry is enormous, but it is a balancing act. With careful consideration of these challenges, nanotechnology can help us create healthier, more resilient forests, benefiting both nature and future generations.

The Future of Nanotechnology in Forestry

The future of nanotechnology in forestry holds tremendous potential for sustainable forest management, biodiversity conservation, and climate resilience. As research advances, we expect nanotechnology to play a more prominent role in overcoming many of forestry's toughest challenges, from disease control and soil health to wildlife protection.

In the coming years, smarter nanosensors could transform forest monitoring, enabling real-time data on tree health, soil conditions, and even early wildfire detection. These sensors will likely become smaller, more energy-efficient, and more durable, making remote monitoring of vast forest areas more feasible and affordable. This can help forest managers quickly respond to threats like pests, diseases, or environmental changes, ensuring healthier, more resilient forests.

Eco-friendly nano-formulations are another exciting area of development. Nano-based pesticides and fertilizers designed to release nutrients gradually and target specific problems with minimal environmental impact could support forest growth while reducing chemical runoff and soil degradation. Additionally, biodegradable nano-coatings for wood protection and enhancement could provide longer-lasting, natural solutions for construction materials and other wood products.

In biotechnology and seed enhancement, nanotechnology could lead to the creation of resilient, climate-adaptive forest species. By integrating nanoscale delivery systems with biotechnology, researchers can develop seeds more resistant to drought, pests, and diseases. This could make reforestation efforts more successful, particularly in areas affected by climate change.

Finally, as the technology becomes more cost-effective and widely available, nanotechnology may become a staple in global forestry practices. Integrating these innovations promises to create more sustainable, adaptive forest ecosystems, safeguard natural resources and support economic and environmental goals. In the hands of forward-thinking forestry professionals, nanotechnology could be critical in shaping a greener, more resilient future for forests worldwide.

Conclusion

As we look toward the future, integrating nanotechnology in forestry presents an exciting frontier for enhancing sustainability and resilience in our forests. The potential applications are vast and transformative, from improving tree health and soil quality to revolutionizing wildlife monitoring and boosting the efficacy of reforestation efforts.However, realizing this potential requires a thoughtful approach to address the associated challenges, including environmental safety, ethical considerations, and the need for cost-effective solutions. By balancing innovation with responsibility, we can harness the power of nanotechnology to protect our forests, promote biodiversity, and combat the impacts of climate change.The path forward is not just about embracing cutting-edge technology; it is

about fostering a deeper understanding of our ecosystems and working collaboratively to ensure that nature and technology thrive together. As researchers, practitioners, and policymakers continue exploringnanotechnology possibilities, we move closer to a future where forests are healthier, more resilient, and equipped to face the challenges of tomorrow.

References

Nasrollahzadeh, M., Sajadi, S.M., Sajjadi, M. and Issaabadi, Z., 2019. An introduction to nanotechnology. In *Interface science and technology* (Vol. 28, pp. 1-27). Elsevier. https://doi.org/10.1016/B978-0-12-813586-0.00001-8

Yadava, Y.P., Raju, V., Chathoth, A.M., Vasu, A.E., Vijayaraghavan, R. and Surendran, A.K., 2024. Characterization and Antifungal Potential of Green-Synthesized Copper Nanoparticles Using Waste Leaf Biomass. https://doi.org/10.21203/rs.3.rs-4795027/v1

Younis, S.A., Kim, K.H., Shaheen, S.M., Antoniadis, V., Tsang, Y.F., Rinklebe, J., Deep, A. and Brown, R.J., 2021. Advancements of nanotechnologies in crop promotion and soil fertility: Benefits, life cycle assessment, and legislation policies. *Renewable and Sustainable Energy Reviews*, *152*, p.111686.

Bi, W., Li, H., Hui, D., Gaff, M., Lorenzo, R., Corbi, I., Corbi, O. and Ashraf, M., 2021. Effects of chemical modification and nanotechnology on wood properties. *Nanotechnology Reviews*, *10*(1), pp.978-1008.

Zhao, L., Zhou, X., Kang, Z., Peralta-Videa, J.R. and Zhu, Y.G., 2023. Nano-enabled seed treatment: A new and sustainable approach to engineering climate-resilient crops. *Science of The Total Environment*, p.168640.

Cunningham, F.J., Goh, N.S., Demirer, G.S., Matos, J.L. and Landry, M.P., 2018. Nanoparticle-mediated delivery towards advancing plant genetic engineering. *Trends in biotechnology*, *36*(9), pp.882-897.

Haydar, M.S., Saha, P., Mandal, P. and Roy, S., 2024. Evaluating the impact of phytosynthesized micronutrient nanoparticles on the growth and propagation of mulberry cuttings: dose determination and toxicity concerns. *Environmental Science: Nano*, *11*(3), pp.1179-1203.

Rabajczyk, A., Zielecka, M., Popielarczyk, T. and Sowa, T., 2021. Nanotechnology in fire protection—application and requirements. *Materials*, *14*(24), p.7849.

Poddar, A.K., 2011. Nanotechnology and Biodiversity: A Case Study on Nanosensors for Wildlife Monitoring.

Empowering wildlife through'Trans-boundary' conservation

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For the protection and conservation of Environment including wildlife, several legislations exists in India namely Environment Protection Act, 1986; Water (Prevention and Control of Pollution) Act, 1974; Water Cess Act, 1977; Air (Prevention and Control of Pollution) Act, 1981, Indian Forest Act, 1927; Forest (Conservation) Act, 1980; Wild Life (Protection) Act, 1972 and Biodiversity Act, 2002. Further Article 48-A of the Constitution of India states that "*The State shall endeavour to protect and improve the environment and to safeguard the forests and wildlife of the country*". India has a great conservation history and enactment of National Environment Policy in the year 2006 indicates the priorities and strong planning of the Government of India towards conservation actions.

Most of the wild animals migrate to fulfil their basic requirements including feeding and breeding. Literature reveals that these migrations are the periodic movement of animals from one geographical area to another. In fact, these migrations assist the animals to play an important functional role in maintaining the dynamism of the ecosystems. It allows a species to periodically exploit resources in areas that would not be otherwise suitable for continuous use. It is an important, but threatened ecological process, and, therefore, requires the maintenance of functional connectivity across large areas. Long-distance migrations performed by the wildlife are dependent upon the connectivity of landscapes and environmental conditions. It is important for maintaining the dynamics of the forest ecosystems and biodiversity. Trans- boundary conservation is a process of cooperation to achieve conservation goals across one or more international boundaries. This process facilitates range countries in ensuring the cooperative conservation efforts across international boundaries.

Under the aegis of United Nations, a Convention on the Conservation of Migratory Species of Wild Animals (CMS) has been in force which provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range.Migratory species threatened with extinction are listed on Appendix I of the Convention. CMS Parties strive towards strictly protecting these animals, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might

endanger them. Besides establishing obligations for each State joining the Convention, CMS promotes concerted action among the Range States of many of these species.Migratory species that need or would significantly benefit from international co-operation are listed in Appendix II of the Convention. For this reason, the Convention encourages the Range States to conclude global or regional agreements.In this respect, CMS acts as a framework Convention. The agreements may range from legally binding treaties (called Agreements) to less formal instruments, such as Memoranda of Understanding, and can be adapted to the requirements of particular regions. The development of models tailored according to the conservation needs throughout the migratory range is a unique capacity to CMS.

India has signed a non-legally binding Memorandum of Understanding (MoU) with CMS on conservation and management of Siberian Cranes (1998), Marine Turtles (2007), Dugongs (2008), and Raptors (2016).The Indian sub-continent is also part of the major bird flyway network, i.e, the Central Asian Flyway (CAF) that covers areas between the Arctic and Indian Oceans, and covers at least 279 populations of 182 migratory water bird species, including 29 globally threatened species.India hosted the 13th Meeting of the Conference of the Parties to the Convention on Migratory Species (CoP-13 to CMS) from 17-22 February 2020. Of the ten species included in the Appendices I & II of the CMS (seven in Appendix I and three in Appendix II), three were proposed by India; (i) Asian Elephant, (ii) Great Indian Bustard, and (iii) Bengal Florican. This conservation success, one side will provide these species with a wider landscape to migrate frequently across their traditional home ranges and on the other side will assist the range countries to manage and strengthen the international boundaries/corridors from where elephants use to move. This will also support gene flow (genetic exchange) among the species and in minimizing the man-elephant conflict.

Asian Elephant

The Government of India has declared Indian elephant as National Heritage Animal. Indian elephant is also provided highest degree of legal protection by listing it in Schedule I of the Wildlife (Protection) Act, 1972.The Asian elephant (*Elephas maximus*) is distributed in 13 range countries spanning across South and South-East Asia. Literature reveals that the population of Asian elephants is estimated about 43,445 individuals (with a minimum of about 39,463 and maximum of about 47,427), of which India holds over 27,000 elephants, which is about 55% of the species' global population.Elephant is one of the flagship species in the Indian forests, requiring large landscapes for their migration, feeding and breeding activities, which have cascading effects in altering the vegetation regeneration and habitat formation. However, in the recent past, their population has been

fragmented and restricted to the foothill dominant areas due to conversion of natural habitats in agricultural fields, industrial areas and human settlements resulting in man-elephant conflicts. Since elephants in India are known to migrate to neighbouring countries like Nepal, Bangladesh and Bhutan and probably to Myanmar as well, this conservation action will support India to persuade neighbouring countries where the elephants migrate to protect them. Elephants travel long distances across different landscapes and countries and notably such exhibition of the interstate movements by the elephants exposes the species to threats, including poaching and illegal trade. Therefore, it is also important to initiate the trans-boundary conservation of the species for global protection.

Asian Elephants (Photo credit: Ritesh Joshi)

Great Indian Bustard

The Great Indian Bustard, an iconic, critically endangered and conservation dependent species, exhibits transboundary movements, and its migration exposes it to threats such as hunting in boundary area of Pakistan-India and power-line collisions in India. Inclusion of the species in Appendix I of CMS will aide in transboundary conservation efforts facilitated by International conservation bodies and existing international laws and agreement.As per the data available, the Great Indian Bustard has a small population of about 100–150 individuals that is largely restricted to Thar desert in Rajasthan, India.The

species has disappeared from 90% of this range; their population has reduced by 90% within 50 years (six generations); and their threats are expected to increase in future.

Bengal Florican

The Bengal Florican an iconic, critically endangered species of topmost conservation priority, exhibits transboundary movements, and its migration exposes it to threats such as land use changes, collision with power transmission line at boundary area of India-Nepal and probable power-line collisions. Inclusion of the species in Appendix I of CMS will aid in transboundary conservation efforts facilitated by International conservation bodies and existing international laws and agreement.Populations have declined as a result of habitat loss, hunting and the species no longer breeds outside Protected Areas in the Indian subcontinent, except in a few areas of Assam.

Migration across the larger landscapes is an important ecological process. These giant migrations are dependent upon the connectivity of landscapes and environmental conditions.However, rapidly increasing demand for land for habitation, agriculture and industries and unsustainable land-use practices is overarching negative impacts on the large migratory corridors.Considering the strengtheningof trans-boundary management and conservation of species, monitoring the seasonal movements across the international borders, documenting ecological data across the landscapes and conducting research activities would be of paramount importance. Besides, using biotechnological conservation techniques (DNA-based wildlife forensics) and satellite tracking could be some of the conservation tools to monitor the population of elephants and illegal wildlife trade. Joint comprehensive assessment and review of trans-boundary wildlife corridors may also help in understanding the status, their movement and the threats they are facing.

References

Convention on the Conservation of Migratory Species of Wild Animals, https://www.cms.int/.

Glowka L (2000). Complementarities between the Convention on Migratory Species and the Convention on Biological Diversity. *J Int Wildl Law Policy* 3:205–252 .

Ministry of Environment, Forest and Climate Change (2017). Guidelines for management of human elephant conflicts. Ministry of Environment, Forest and Climate Change, New Delhi, India.

Purdon A, Mole MA, Chase MJ, Aarde RJvan, (2018). Partial migration in Savanna elephant populations distributed across Southern Africa. *Sci Rep* 8:11331.

Vasilijevic M, Zunckel K, McKinney M, Erg B, Schoon M, Rosen Michel T, Groves C (2015). Transboundary conservation: a systematic and integrated approach. Best

Practice Protected Area Guidelines Series No. 23, Gland, Switzerland: IUCN.

प्राकृतिक गोंद: प्रकृति का अनमोल उपहार

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परिचय

गोंद एक प्राकृतिक प्रक्रिया के रूप में पौधों के उन भागों में उत्पन्न होते हैं जिनमें आंतरिक ऊतक क्षतिग्रस्त हो जाते हैं। गोंद निकालने की प्रक्रिया कृत्रिम (मानव निर्मित) रूप से पौधे को घायल कर गोंद उत्पादन करने की होती है। गमीकरण की प्रक्रिया के माध्यम से, इससे गोंद गुहाएं या नलिकाएं बनती हैं, जो कार्बोहाइड्रेट के एक बहुलक को बाहर निकालती हैं, जिसे गोंद कहते हैं।

कई शोधकर्ताओं ने यह आकलन करने का प्रयास किया है कि क्या गोंद उत्पन्न करने वाले पौधों द्वारा उत्पन्न गोंद की मात्रा पर उत्तेजक पदार्थों का कोई प्रभाव पड़ता है। एथीफोन, जो एक रासायनिक रूप से संश्लेषित यौगिक है और एथिलीन के उत्पादन के लिए जिम्मेदार है, जो पौधों से गोंद उत्पादन का एक अच्छा उत्तेजक माना जाता है। पौधों में गोंद उत्पादन के संदर्भ में सूरज की रोशनी के साथ टैपिंग दिशा एक बहुत महत्वपूर्ण कारक है। एडम एट अल. (2009) ने बबूल पर एक अध्ययन किया था ताकि यह देखा जा सके कि गोंद उत्पादन पर घाव की दिशा का क्या प्रभाव पड़ता है। उन्होंने बबूल में सूरज की रोशनी के संदर्भ में चार दिशाओं (पूर्व, पश्चिम, दक्षिण और उत्तर) में घाव किया और उत्पन्न गोंद की मात्रा को मापा। अध्ययन में पाया गया कि जब टैपिंग पूर्वी और पश्चिमी दिशा में सीधी धूप की ओर की गई, तो गोंद उत्पादन 60% बढ़ गया, क्योंकि ये दो दिशाएं अधिकतम मात्रा में धूप प्राप्त होती हैं, जो उच्च तापमान के साथ तेजी से सूखने में मदद करती हैं और उच्च गोंद उत्पादन को बढ़ावा देती हैं।

गोंद पौधों के सदस्यों द्वारा उत्पन्न किए जाते हैं, लेकिन व्यापारिक उपयोग की विशेषता कुछ पेड़ों की है जैसे Leguminosae, Sterculiaceae और Combretaceae परिवारों की। महत्वपूर्ण गोंद उत्पादन करने वाले पेड़ों में Acacia nilotica (बबूल), A catechu (खैर), Sterculia urens (कुल्लू), Anogeissus latifolia (धवरा), Butea monosperma (पलाश), Bauhinia retusa (सेमल), Lannea coromandelica (लेंडिया) और Azadirachta indica (नीम) शामिल हैं।

गोंद कुछ पौधों के बीजों से भी प्राप्त की जाती है, जैसे कि ग्वार, इमली, *Cassia tora* आदि । ग्वार गोंद बीज से निकलने वाला प्रमुख प्राकृतिक गोंद है।

गोंद की प्रमुख विशेषताएँ हैं:

- वे पॉलीसैक्शराइड्स या उनके अवयवों से बने होते हैं।
- वे पानी में घुलनशील होते हैं या कम से कम पानी के साथ मिश्रित होने पर नरम और सूजने लगते हैं। हालांकि वे शराब और अन्य कार्बनिक विलयन में अनवरत होते हैं।
- उन्हें गर्म करने पर पूरी तरह से विघटित हो जाते हैं और पिघलते नहीं हैं, बल्कि जलते हैं।
- अधिकांश गोंद पौधों से तरल रूप में उत्पन्न होते हैं। वे हवा के संपर्क में आकाशीय, अनूद्विक, आंसू के आकार के शरीर या फ्लेक्स में सूख जाते हैं।

प्राकृतिक गोंद का रासायनिक संघटन

प्राकृतिक गोंद की रासायनिक संरचना विभिन्न प्रकार के पॉलीसेकेराइड या उनके घटकों से बनी होती है। इनमें आम तौर पर कार्बोहाइड्रेट, ग्लूकोज, मैनोज, अरेबिनोज, गैलेक्टोज, रैफिनोज और गैलेक्टुरोनिक एसिड होते हैं। ये गोंद पानी में घुलनशील होते हैं और फूल जाते हैं, लेकिन अल्कोहल और अन्य कार्बनिक घोल में स्थिर रहते हैं।

प्राकृतिक गोंद का औषधीय महत्व

गोंद के महत्वपूर्ण औषधीय गुण होते हैं। विभिन्न प्रकार के गोंद आयुर्वेद और यूनानी चिकित्सा

प्रणालियों में बुखार, खांसी, सर्दी, यौन दुर्बलता, पेचिश आदि जैसे विभिन्न रोगों के इलाज के लिए उपयोग किए जाते हैं आजकल गोंद एक ऐसा आदर्श उत्पाद है जिसे बहुकार्यकारी कार्यों के लिए उपयोग किया जाता है, जैसे भौतिक-रासायनिक गुणस्थितियों को नियंत्रित करना, कम घुलनशील दवाओं की घुलनशीलता बढ़ाना, नियंत्रित दवा वितरण प्रणाली को प्राप्त करना। आजकल गोंद कागज, वस्त्र, और सौंदर्य प्रसाधन उद्योगों में भी उपयोग किए जाते हैं क्योंकि इनमें इमल्शन क्षमता, नमी बनाए रखने और एक चिकनी बनावट प्रदान करने की गुणवत्ता होती है।

S.NO.	सामान्य नाम	वैज्ञानिक नाम	रासायनिक संरचना	औषधीय अनुप्रयोग
1	धौड़ा	एनोजीसिस लैटिफोलिया	1-3-लिंक्ड डी गैलेक्टोज़ इकाइयाँ कुछ ß1-6- के साथ जुड़ा हुआ डी-गैलेक्टोज इकाइयां	बाइंडिंग गुण ,इमल्सीफायर और सस्पेंडिंग
2	अल्बिज़िया गोंद	अल्बिज़िया ज़िगिया	गैलेक्टोज,मन्नोज़ अरबीनोज़,ग्लुकुरोनिक एसिड,4-0- -मिथाइल अनुरूप	टेबलेट बाइंडर,पायसीकारकों कोटिंग सामग्री में,संपीड़न-लेपित गोलियाँ
3	नीम का गोंद	अज़दिरचता इंडिका	ग्लूकोज़,ज़ायलोज़,फ्यूकोज़,	बाइंडिंग गुण ,सुस्तैनेड

			गैलेक्टोज़,अरबिनोज़, ग्लूकोसामिन, मैनोज़	रिलीज़ "मैट्रिक्स टेबलेट
4	ओलिबैनम गम	बोसवेलिया सेराटा रॉक्सब	5–9% तेल, 13–17% रेसिन एसिड्स ,20–30% पोल्यसच्चारिद 40–60%बोस्वेलिक एसिड	निरंतर जारी बंधनकारी पदार्थ
5	मोरिंगा ओलिफेरा	मोरिंगा ओलिफेरा	अरबिनोस ,गलैक्टोस ग्लुक्रोनिक एसिड	जेलिंग गुण, बाइंडिंग गुण, रिलीज़ रिटार्डेंट गुण, विघटन गुण, इमल्सिफाइंग गुण
6	बबूल गोद	एकेसिया,निलोटिका	1,3-संयुक्त β-D-गैलेक्टोपाइरानोसिल	बाइंडर, निलंबन एजेंट, इमल्सिफाइंग एजेंट, शीतलकारी, त्वचा कोमल बनाने वाला पदार्थ
7	पलास	बूटी मोनोस्पर्मा	अल्कालोईएडस फ्लावोनॉयड्स फेनोलिक यौगिक अमीनो एसिड ग्लाइकोसाइड्स स्टेरॉयड	त्वचा के रोग,केराटाइटिस बवासीर,मूत्र निर्गमन मस्तिष्क की बीमारियाँ

प्राकृतिक गोंद बाजार विश्लेषण : बढ़ती स्वास्थ्य जागरूकता बाजार की वृद्धि को उल्लेखनीय रूप से प्रेरित कर रही है। जैसे-जैसे उपभोक्ता अपने आहार और स्वास्थ्य के बीच संबंध को समझने लगे हैं, खाद्य और पेय पदार्थों में प्राकृतिक और जैविक स्रोतों से प्राप्त सामग्री की मांग बढ़ रही है। ये प्राकृतिक गोंद विभिन्न स्रोतों जैसे कि अकासिया, ग्वार, लोकेस्ट बीन और गोंद अरबी से प्राप्त होते हैं। प्राकृतिक गोंद के स्वास्थ्य लाभों में बेहतर दंत स्वास्थ्य, पाचन में सुधार और वजन प्रबंधन शामिल हैं। इसके अलावा, इनका 'क्लीन-लेबल' स्वभाव, यानी इनमें कोई सिंथेटिक योजक या रसायन नहीं होते, उन्हें उपभोक्ताओं की स्वास्थ्य प्राथमिकताओं के अनुरूप और भी लोकप्रिय बना रहा है। प्राकृतिक गोंद बाजार का आकार 2023 से 2028 के बीच 7.67% की वार्षिक वृद्धि दर (CAGR) के साथ USD 2.14 बिलियन तक बढ़ने का अनुमान है चूंकि प्राकृतिक गोंद पौधों पर आधारित होते हैं, इन्हें सिंथेटिक योजकों की तुलना में अधिक पर्यावरण अनुकूल माना जाता है। यह पर्यावरण के प्रति जागरूक उपभोक्ताओं के साथ जुड़ता है, जो ऐसे उत्पादों की तलाश में हैं जिनका पर्यावरण पर न्यूनतम प्रभाव हो। ये सभी उपर्युक्त कारक पूर्वानुमान अवधि के दौरान बाजार की वृद्धि को बढ़ावा देंगे।

प्राकृतिक गोंद बाजार की चुनौती

गुणवत्ता नियंत्रण और मानकीकरण से संबंधित मुद्दे बाजार की वृद्धि में बाधा डालने वाली एक प्रमुख चुनौती हैं। मानकीकरण और गुणवत्ता नियंत्रण बड़ी चुनौतियाँ हैं जो बाजार की वृद्धि, रुझानों और प्रतिस्पर्धात्मकता को प्रभावित करती हैं। गोंद अरबी, ग्वार प्राकृतिक गोंद, ज़ैंथन प्राकृतिक गोंद और अन्य प्राकृतिक गोंद खाद्य और पेय उद्योग से लेकर फार्मास्यूटिकल्स और सौंदर्य प्रसाधनों तक विभिन्न उद्योगों में उपयोग किए

जाते हैं। विभिन्न भौगोलिक क्षेत्रों और आपूर्ति श्रृंखलाओं में एक समान गुणवत्ता मानकों को बनाए रखना कई चुनौतियाँ उत्पन्न करता है। इसके अलावा, विभिन्न देशों में एकल नियामक ढांचे की कमी के कारण मानकीकरण प्रभावित होता है।

निष्कर्ष

उपरोक्त अनुच्छेद का निष्कर्ष यह है कि बढ़ती स्वास्थ्य जागरूकता के कारण प्राकृतिक गोंद बाजार का तेजी से विस्तार हो रहा है। उपभोक्ता अपने आहार और स्वास्थ्य के बीच के संबंध को अधिक समझ रहे हैं, जिससे खाद्य और पेय उत्पादों में प्राकृतिक और जैविक स्रोतों से प्राप्त सामग्री की मांग बढ़ रही है। प्राकृतिक गोंद, जो सिंथेटिक योजकों या रसायनों से मुक्त होते हैं, उपभोक्ताओं के स्वास्थ्य संबंधी प्राथमिकताओं के अनुरूप होते हैं, और इससे दांतों के स्वास्थ्य, बेहतर पाचन और वजन प्रबंधन जैसे लाभ इसे और अधिक लोकप्रिय बना रहा हैं। प्राकृतिक और जैविक उत्पादों की बढ़ती मांग और उपभोक्ताओं की पर्यावरण-अनुकूलता और स्वास्थ्य के प्रति जागरूकता प्राकृतिक गोंद बाजार की वृद्धि को तेज़ी से बढ़ा रही है। हालांकि, गुणवत्ता नियंत्रण और मानकीकरण की चुनौतियाँ इस बाजार की वृद्धि और प्रतिस्पर्धा के लिए एक बड़ी बाधा हैं। इन चुनौतियों का समाधान करते हुए स्थिरता और नैतिक स्रोतों पर ध्यान केंद्रित करने से बाजार के विकास को और अधिक प्रोत्साहन मिलेगा।

Post harvest management & packaging of *Prosopis cineraria*

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Abstract

Khejri (***Prosopis cineraria***) is indeed a remarkable tree, particularly well-suited for the harsh conditions of the Thar Desert. Its adaptability and multiple benefits make it a vital part of the ecosystem in arid and semi-arid regions of north-western India. The Khejri tree's ability to thrive under extreme conditions is quite remarkable. Its deep, extensive root system allows it to access water from deeper soil layers, helping it survive prolonged droughts. Tree's impressive features is its ability to flower and produce pods even during the peak of the summer due to the capacity to continue its reproductive cycle under such conditions highlights its resilience and adaptability. The continuous growth and pod production contribute to the local ecosystem by providing a reliable source of food for wildlife and livestock. Additionally, the presence of green vegetation helps in mitigating soil erosion and maintaining soil health.

Introduction

Prosopis cineraria

Commonly known as the Khejri tree, is indeed a crucial species in the Thar Desert's ecosystem. This hardy flora plays a vital role in the arid regions of India, providing sustenance and ecological benefits in a harsh climate. Here's a detailed overview based on your description:

Ecological and Economic Importance

Ecological Resilience

Prosopis cineraria is well-adapted to extreme temperatures and arid conditions, thriving in environments that are inhospitable to many other species.

- The tree contributes to soil stabilization, preventing erosion, and enhances soil fertility through its nitrogen-fixing ability.

Economic Benefits

Sangri (the immature pods) is highly valued both as a fresh and dehydrated product, with prices ranging from ₹200/kg to ₹800/kg respectively.

It is a significant component in traditional dishes, notably in Panchkutta vegetables, which is a staple in local cuisine.

Nutritional Value

- Sangri is rich in essential minerals such as potassium, magnesium, calcium, zinc, and iron.
- It provides a good source of protein and dietary fiber.
- Contains high levels of antioxidants, phenols, flavonoids, and saponins that contribute to health benefits like boosting immunity and lowering bad cholesterol levels.

Traditional and modern uses

Food and culinary uses

- Sangri is used extensively in local cuisine, both fresh and dried, for its unique flavor and nutritional value.

- It is a key ingredient in traditional dishes, enhancing the diversity and nutritional profile of local diets.

Fodder and Fuel

- The tree is also used for fodder, supporting local livestock.
- Its wood is used for fuel and construction, making it a versatile resource.

Overall, *Prosopis cineraria* is a lifeline for the desert communities, providing not only crucial resources but also supporting biodiversity and ecosystem health in one of the world's most challenging environments.

Green tender pods of khejri (*Prosopis cineraria*)

Standardization of horticultural maturity indices

The study on **sangri** (a vegetable) suggests that the ideal maturity stage for harvesting pods to produce high-quality dehydrated products lies between **10 to 18 days after pod setting**. Here's a summary of the findings:

Rehydration Quality

Rehydration percentage, which is directly related to the quality of the dried product, was highest in pods harvested at 10, 13, and 16 days, with rehydration percentages of 296, 289, and 287, respectively. Pods harvested at 19 and 22 days had lower rehydration percentages of 256 and 216, indicating reduced quality.

Color of Dried Sangri

Color is an important marketing factor, as black color fetches the highest price. Pods harvested between 10 to 16 days after setting turned black after drying, which is the desired color. In contrast, pods harvested later (19 to 22 days) turned **brown**, both after drying and rehydration, which is less desirable for consumers.

Harvesting Recommendations

For optimal vegetable and dehydration purposes, it is recommended to harvest green pods of Thar Shobha when they are between 10 to 18 **days** after setting, with a thickness of 1.0-2.5 mm and a deep green to green color. Pods harvested at 19 to 25 days may not be ideal for vegetable consumption but can still be used effectively for pickles and cooked vegetable dishes. This research helps standardize the ideal harvesting period for sangri, ensuring high-quality dried products that are both visually appealing and acceptable to consumers.

Solar Drying System

Harvesting

Manual picking is recommended to ensure the harvest of high-quality tender pods, and to achieve the maximum yield of good-quality produce, 3-4 pickings are essential for each tree. These pickings should occur at 3-4 day intervals, starting from the second fortnight of April through to the first fortnight of May. Prior to processing, it is important to separate under-sized and over-matured pods from the tender ones to ensure a uniform quality in the dried product.

Blanching

Blanching plays a crucial role in the processing of sangri to produce a superior quality dried product with desirable color and texture. Among various blanching treatments, a 5-minute blanching period in boiling water is found to be ideal. After blanching, the pods should be quickly dipped into cold water for 5 minutes to prevent overcooking. Following this, the pods should be removed from the cold water and spread out in a single layer on clean cotton cloth or an aluminum/steel tray for drying.

Drying

The traditional method of drying sangri in open sunlight, commonly used by farmers and rural women, is not ideal, as it exposes the produce to dust, insects, rodents, and birds, leading to unhygienic and inferior-quality products, particularly in terms of color. To faced this problem design the simple, low-cost, tunnel-type drying structure to provide hygienic drying conditions. The structure measures 260 cm in length, 120 cm in width, and has a tunnel height of 45 cm, with a 70 cm height from the ground. It is equipped with a 48-volt DC exhaust fan powered by a solar panel, and can accommodate 25 kg of fresh produce for drying in a single batch. Using this solar dryer, sangri can be dried within 8 hours, retaining better color and improved sensory qualities, whereas open sun drying typically takes 24 hours. The drying recovery of sangri, which depends on the harvesting stage, ranges from 25.86% to 28.05% of the fresh

produce. The ICAR-CIAH solar dryer is highly suitable for on-farm drying of sangri and other native fruits and vegetables, as it is portable, easy to handle, can be locally fabricated, and is cost-effective.

Packaging and labelling

Dried sangri is sold in the retail market at premium prices, ranging from 800 to 1000 INR per kg by traders. However, it is procured from farmers by middlemen at much lower prices, typically between 400 to 500 INR per kg, with a significant portion of the retail price being taken by middlemen and retailers. To help maximize farmers' profits, a standardized packaging and labeling system has been developed for direct marketing of sangri to consumers. The dried sangri is packed in food-grade standee pouches and plastic boxes, with storage capacities of 100, 200, 250, 500, and 1000 grams, and each package is clearly labeled. The labels provide essential information, including details about the product's quality, nutritional value, consumption methods, storage instructions, and contact details. Among the packaging options, the 250-gram capacity package is found to be the most suitable for retail marketing directly to consumers as a family pack. This approach to packaging and marketing is being demonstrated to rural women and farmers to help eliminate middlemen from the sangri marketing chain, allowing them to benefit more from direct sales to consumers.

Conclusions

Khejri is a vital tree in desert ecosystems, supporting livelihoods, livestock, and providing environmental services. In the context of liberalization and commercial agriculture, cultivating khejri varieties in arid regions, coupled with value addition, packaging, labeling, and marketing, can offer farmers a sustainable income through high-value dried sangri and nutrient-rich fodder. Additionally, khejri plantations provide low-cost fuel from pruned twigs and help mitigate the effects of extreme climates. Scientific management of khejri plantations for high yields would enhance the profitability of dehydrated sangri, ensure stable income for farmers, and create entrepreneurial opportunities for rural women and farmers.

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