

Malabar neem (*Melia dubia*):

A promising agroforestry tree in India

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*Agroforestry, the integration of woody perennial plants with agricultural systems, offers ecological and economic benefits while supporting sustainable land management. In India, the demand for raw materials in the pulp and paper industry exceeds supply, creating a 45% shortfall. Malabar neem (*Melia dubia*) is emerging as a promising alternative due to its fast growth, excellent pulp recovery, and robust wood quality. This tree species thrives in a variety of soils, with minimal maintenance, making it ideal for agroforestry systems. Malabar neem (*Melia dubia*) growth characteristics, including its straight stem, minimal branching, and low shade impact, promote its integration with intercrops, enhancing economic returns. With proper management, Malabar neem plantations provide reliable income and contribute to carbon sequestration.*

Keywords: Agroforestry, *Melia dubia*, Pulpwood

Agroforestry is a land use strategy that deliberately integrates woody perennial plants with agricultural crops and/or livestock in a specific spatial configuration or temporal sequence. Agroforestry systems encompass ecological and economic interactions among several components. This system integrates the production of several outputs while safeguarding the resource base. It focuses on utilizing multiple native trees, especially in low-input and delicate situations, and involves the interaction of socio-cultural values more than many other land-use systems.

India's present production of raw materials for paper and pulp is 2.76 million tonnes, whereas the demand is 5.04 million tonnes, leading to a 45% deficit. Wood-based companies had to become self-sufficient in sourcing their own raw materials due to insufficient resources and strict forest regulations. Paper businesses have created farm and agroforestry plantations using contract farming. *Eucalyptus* spp. and *Casuarina* spp.

are the primary tree species that gets utilized as raw material for pulp and paper production. Poor production and an increase in pests and diseases are the constraints in these two tree species. Malabar neem (*Melia dubia*) is now being considered as a substitute raw material for the pulp and paper sectors, because of its enhanced pulp recovery and outstanding paper strength.

Malabar neem, scientifically known as *Melia dubia*, is a rapidly growing tree species valued for its high-quality timber and fuelwood characteristics. Wood is mostly utilized in plywood industries, matchbox production, packaging materials, musical instrument crafting, and furniture manufacturing. Malabar neem has been evaluated as a potential tree species for pulpwood production. It is well-suited for agroforestry with a rotation period ranging from 8–12 years. The Malabar neem is becoming increasingly popular in both local and global markets due to its economic significance and unique tree characteristics, such as faster

growth, straight stem with minimal branching, and low shade impact. The species requires minimal upkeep, providing a reliable income while also aiding in carbon sequestration and mitigating the effects of climate change. Intercrops can be successfully grown in block plantations of Malabar neem for the first several years depending on the canopy coverage and closure. Identifying appropriate intercrops for block plants is crucial for promoting the Malabar neem-based agroforestry system.

Botanical characters

The Malabar neem tree is deciduous to semi-evergreen, attaining heights of up to 25 m, characterized by broad, spreading branches and appealing foliage. The bark is dark brown, fibrous, and exfoliates in substantial rectangular fragments. It flourishes in deciduous forests and rural regions, encompassing wastelands. The leaves are complex, rich in essential oils, and exhibit bipinnate to tripinnate structures.

The arrangement on the stem is alternating, including a terete rachis that can reach lengths of up to 30 cm. The petiole ranges from 0.3–1.2 cm, featuring 3–8 pairs of pinnae and 2–11 leaflets per pinnae. The leaflets are opposite, ovate or elliptic, featuring an acuminate apex and a cuneate or attenuate base. They exhibit asymmetry, possess a crenate edge, have a coriaceous appearance, and become glabrous at maturation. The midrib is elevated, featuring 10 pairs of progressively curved secondary veins and extensively reticulate tertiary veins. The inflorescence is an axillary panicle, reaching 12–20 cm in length. The flowers are tiny, greenish-white, and have a honeyed fragrance. They emerge in clusters adjacent to fresh foliage from January to March. The fruit is a drupe with an ovoid or ellipsoid shape and distinct longitudinal ridges. As it ripens, it turns yellowish, softens, and emits a pleasant fragrance. Each fruit typically contains 3–4 seeds and has a tough endocarp, making germination quite challenging.

Distribution

Melia dubia is native to the Western Ghats of southern India at elevations ranging from 1,500–1,800 m and is commonly found in the moist deciduous forests of Kerala. It also grows in the Khasi hills, hilly parts of Orissa, north Bengal, Sikkim Himalaya, upper Assam, Deccan Plateau. Known for its rapid growth, it is widely used in forestry initiatives.

Silvicultural characters

In its native habitat, the temperature in the shade of *Melia dubia* thrives in tropical and subtropical climates with temperatures ranging from 0°C to 37.5°C. It requires an annual rainfall of around 1000 mm and is best suited for humid regions. It grows at an altitude of 600–1800 m above sea level. *Melia dubia* requires sunlight, its seedlings struggle in shaded conditions. Although young seedlings can withstand mild cold, they are unable to survive severe frost. The species is vulnerable to

fire damage, and browsing affects juvenile trees. It adapts to various soil types, but while fertile sandy loam soil supports optimal growth, shallow gravelly soils limit its development.

Phenology

The tree remains leafless from December to February, with new foliage emerging in March alongside its blossoms. Its fruits mature during the winter months, from October to February.

Propagation technology

Through seeds: Fully matured fruits are collected in January and February, after which the seeds are extracted by rubbing, followed by washing, drying, and storing them in airtight containers. These seeds exhibit a germination rate <25%. In nurseries, they are sown on raised beds, with the suggested pre-treatment involving a one-day soak in a cow dung mixture. However, studies conducted by Institute of Forest Genetics and Tree Breeding in Coimbatore, Tamil Nadu, India, indicate that germination rates can reach up to 60% even without pre-treatment. Seeds are planted in March-April in rows spaced 5 cm apart, using a farmyard manure mixture in a 2:1 ratio. A standard

nursery bed requires around 6–7 kg of dried drupes, which contain approximately 1,500 seeds. The seeds should be watered twice a day. In regions with moderate daytime temperatures or shaded nursery environments, covering the beds with a tarpaulin helps regulate soil temperature. Germination takes place up to 90 days, and seedlings need six months to complete their nursery stage.

Vegetative propagation: Young stem cuttings and fresh growth from felled trees respond positively to 1,000–2,000 ppm of IBA in liquid form. Coppiced shoots from older trees also show improved root development. Propagation is most effective when using cuttings with the thickness of a pencil, as delicate sprouts are susceptible to root rot. For optimal growth, place the shoots in a sand substrate and irrigate them twice daily. Proper drainage is crucial to prevent waterlogging, which can harm the shoots. Seasonal conditions greatly impact rooting success, with dry seasons being more favourable for root development. A rooting success rate of around 75% can be achieved. During transplantation, careful handling is necessary to avoid damage, whether removing seedlings from beds or transferring rooted shoots into bags.



Block plantation of 3-year-old *Melia dubia* with different spacing at Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh

Mini clonal technology: Forest College and Research Institute in Mettupalayam, Tamil Nadu, India, has introduced a miniaturized clonal propagation method for *Melia dubia*. This advanced method entails the cultivation of enhanced clonal plants within a compact clonal garden with contemporary technology, guaranteeing uniform irrigation and fertilization to promote shoot development. This method entails positioning mother plants 10 cm apart, facilitating the harvesting of cuttings from plants aged 30–45 days. The recently produced shoots are meticulously segregated, subjected to a 1,500 ppm IBA liquid formulation, and positioned in 90 cc root trainers filled with decomposed coir pith. Rooting commences within 15 days, and by the 25th day, the rooted plants are ready for acclimatization. This method enhances rooting efficacy and uniformity, facilitating consistent establishment, growth, and development. The small-scale clonal garden continues to yield approximately 0.1 million plants annually for a duration of up to five years.

Cultural operations: Seedlings in plantations thrive with rough tillage, while cultivated areas experience fewer weed issues with thorough tillage. The spacing between crops depends on factors such as field size, intercropping practices, water availability, and farmer preferences. During plantation establishment, six-month-old seedlings are planted in 45 cm³ pits. An optimal spacing of 5 m × 5 m is recommended, while a preferred spacing of 8 m × 8 m allows for better growth. Farmers commonly adopt spacing of 3 m × 3 m or 3 m × 4 m for cultivation. To encourage straight and cylindrical trunks, annual pruning is performed. Early growth benefits from daily irrigation and fertilizer application every three months for the first three years. During dry seasons, watering every 10–15 days ensures healthy development. Additionally, applying 25–50 g of nitrogen, phosphorus, and potassium per tree twice a year promotes growth, with



(a) Intercropping of chickpea under 2-year-old *Melia dubia* (b) Intercropping of lenticil varieties under 3-year-old *Melia dubia* plantation at Rani Lakshmi Bai Central Agricultural University, Jhansi, Uttar Pradesh

fertilizer adjustments made based on the tree's progress.

Tending operations: In *Melia dubia* plantations, maintenance activities such as ploughing, cleaning, and weeding are routinely carried out. However, when intercropping is practiced, these efforts primarily focus on the associated agricultural or horticultural crops. In monoculture and bund-planted areas, thinning, pruning, and selective felling are conducted, especially when shade affects agricultural crops or there is a need for fodder and fuelwood. Biannual pruning is recommended to effectively manage branch growth and maintain tree health.

Suitable agroforestry systems: *Melia dubia* is a valuable agroforestry species that thrives when cultivated alongside crops such as groundnut, chili, turmeric, ginger, black gram, green gram, lentil, melon, foxtail millet, and sugarcane.

Yield: Malabar neem trees reach a volume of 15 cubic feet by 15 years, generating revenue of ₹350/ft³ from the 5th year onward. Under intensive management, they grow at a rate of 20–25 cm/yr, whereas in unmanaged plantations, the growth rate is limited to 6–8 cm annually. Within five years, the tree is expected to yield 12–15 ft³ (0.4–0.5 m³) of timber. Currently, *Melia dubia* billets with a girth of 50–120 cm are priced at ₹7,300/t, while trees with a girth exceeding 120 cm are valued at ₹370/ft³.

Utilization: The sapwood of *Melia dubia* is grayish-white, while the

heartwood ranges from light pink to pinkish hues, darkening to pale russet brown as it ages. The material has a glossy finish with a dry tactile quality, is exceptionally lightweight (specific gravity, 0.33; weight, 21 kg/ft³), features a linear grain, coarse texture, and a somewhat irregular surface. The lumber lacks endurance when subjected to the weather but has significant resilience when sheltered. It is inferior in durability and longevity when compared to neem. The wood is employed for diverse applications including musical instruments, ceiling boards, packing cases, construction materials, matchboxes, agricultural implements, splints, pencils, and tea boxes.

SUMMARY

Malabar neem (*Melia dubia*) is referred to as a money spinning tree of short rotation due to its diverse uses in the plywood, pulp wood, and timber sector, as well as its fast growth and tolerance to various agro-climatic conditions in the country. This native tree is being widely cultivated commercially in various agroforestry systems because there have been no reports of allelopathy in this species. Farmers need to be educated on the cultivation methods and potential of this versatile tree, as well as provided with high-quality planting materials.

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