

connections. The pits then should be backfilled with a mixture of native soil and compost.

FERTILIZATION AND IRRIGATION

Organic fertilizers (15-20 kg per plant), such as compost or farmyard manure, may be applied regularly. A balanced amount of inorganic fertilizers like NPK fertilizers may be judiciously applied if soil tests indicate nutrient deficiencies, starting with 50 g/plant after 6 months of planting and going up to 250 g/plant after 2.5 years after planting.

During initial 2-3 years, irrigation should be provided regularly, particularly in the dry season. Seedlings may require 5-6 litres per day for up to 1 month. Drip irrigation may be used around seedlings to ensure proper watering and conserve water. In drier regions without sufficient rain, supplemental irrigation may be continued.

MAINTENANCE AND MONITORING

Effective termite and pest management involves regular monitoring, pre-planting soil treatment with termiticides, and the use of natural or chemical pest control methods, alongside good plantation hygiene. Pruning host trees helps control shading, improve air circulation, and maintain optimal growth conditions for sandalwood. Weed and grass control through manual removal and mulching supports moisture retention and minimizes competition. Consistent monitoring, timely seedling replacement, and worker training ensure healthy growth and proper maintenance of the plantation.

PROTECTION

Protecting sandalwood trees from theft becomes challenging after 4–5 years and intensifies as trees mature. Effective measures include fencing, armed guards, solar electric fences, and patrol dogs.

HARVEST AND ESTIMATED RETURNS

Sandalwood trees typically take 15–20 years to yield economically viable heartwood, which begins forming around 7–8 years, influenced by climatic conditions. While full harvest takes time, farmers can still earn annual profits by integrating sandalwood with other crops. Early assessment of heartwood and oil content can help determine optimal harvest time.

As per an estimation by ICFRE-IWST (December 2023), a farmer can earn a net income of ₹ 2.3 crore from 320 sandalwood trees per hectare after 15 years, assuming 7 kg heartwood per tree at ₹ 6000/kg, with total returns of ₹ 3.54 crore and expenses of ₹ 1.24 crore. However, heartwood price may range from ₹ 3000–6000/kg, so profits may vary based on quality.

FIELD TRIAL OF ICFRE-AFRI UNDER AICRP-03

A field trial of sandalwood was established in August 2023 on ~1.0 hectare of land provided by a progressive farmer in Kanasar, Phalodi, Rajasthan, where mousambi served as the permanent host crop. This trial was laid to assess the potential of sandalwood cultivation in the region as well as to assess the performance of different seed sources.

A total of 315 one-year-old sandalwood seedlings from seven seed sources across India (1 each from Kerala, Karnataka, and Madhya Pradesh, and 2 each from Tamil Nadu and Rajasthan) were planted in a randomized block design with 4m × 4m spacing. As per the data from March 2025, a survival rate of 49% was observed. Karnataka and Kerala sources show a superior height at 18 months of site establishment, with mean height of ~111 cm and ~110 cm, respectively, while Madhya Pradesh seed source exhibits the greatest collar diameters (20.59 cm).

In July 2025, the survival % was recorded as 47%. The second year growth data (24 months after planting) will be recorded in near future. The trial has so far shown promising results. In the future, trial will be continuously monitored and data will be collected to reach meaningful conclusions.



Sandalwood trial at Kanasar (Photograph taken in July, 2025)

CONCLUSION

Integrating sandalwood into Rajasthan's agroforestry can boost land productivity, biodiversity, and farmer income, offering a sustainable alternative to traditional farming. Collaborative support through training, making available QPM, and financial and technical assistance is key to realizing its economic potential. Systematic implementation of these measures can undoubtedly play a transformative role in the rural economy of Rajasthan.

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Cultivation of Sandalwood in Arid Zone of Rajasthan in Agroforestry System



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INTRODUCTION

In the arid and semi-arid geographical landscape of Rajasthan, characterized by extreme temperatures, scanty and erratic rainfall, there is a growing and persistent need for sustainable and economically viable agroforestry models. In this context, Indian sandalwood (*Santalum album*) is emerging as a highly valuable tree species that holds potential as a source of long-term economic gain.

IMPORTANCE OF SANDALWOOD



The economic significance of Indian sandalwood is such that it is often referred to as “Green Gold.” It is highly priced for its heartwood which yields a very fragrant essential oil that is in high demand and is extensively used in perfumery, medicinal products, Ayurvedic therapies, cosmetics, and religious rituals. In international markets, the wood can fetch prices ranging from ₹ 20- ₹ 50 lakh per ton or even more, depending on quality.

POTENTIAL OF SANDALWOOD IN ARID REGIONS

Due to excessive exploitation and illegal logging in South India, the natural availability of sandalwood has drastically declined. Escalating prices and India’s diminishing monopoly in the sandalwood trade, led the government to relax policies governing sandalwood cultivation and felling, allowing farmers and private land owners to take up sandalwood cultivation. This also resulted in expanding the scope for its legal and commercial cultivation in new regions, including Rajasthan.

Previous investigations have reported a variation in oil content ranging from 0.9%-3% across various girth classes of sandalwood in natural forests and agricultural lands in Rajasthan. This indicates the potential of fetching good revenue in this region.

Sandalwood-based farming can yield returns of approximately ₹ 50 lakh to ₹1 crore per hectare (ha) within a span of 12–15 years, making it an ideal long-term investment for farmers.

ECOLOGICAL ADAPTATIONS OF SANDALWOOD ADVANTAGEOUS UNDER ARID CONDITIONS

- ◆ Deep root system: access to groundwater in low-rainfall regions
- ◆ Parasitic nature: ability to derive nutrition from host plants
- ◆ Thick tough leaves: reduced transpiration and water conservation
- ◆ Drought tolerance: ability to endure long periods of dry spell



CLIMATIC AND EDAPHIC REQUIREMENTS

Sandalwood demonstrates exceptional adaptability, capable of growing in a variety of soil types, including gravelly loam and sandy clay soils. Although the species can tolerate soil pH levels up to 9.0, it does not prosper in waterlogged conditions. It exhibits resilience to a wide temperature range, from 4°C to 46°C, and thrives in areas receiving annual rainfall between 500 mm and 5000 mm.

REQUISITES FOR SANDALWOOD-BASED AGROFORESTRY

IMPORTANT CONSIDERATIONS FOR SANDALWOOD FARMING

- ◆ Land selection and sunlight
- ◆ Quality Planting Material (QPM): raising or procurement of healthy, certified seedlings
- ◆ Host Species Selection: planting of compatible host species
- ◆ Fertilization: addition of organic manure and balanced fertilizers
- ◆ Irrigation: provision for supplemental irrigation systems
- ◆ Protection, management practices, and growth monitoring: pruning, weeding, regular checks, replacements, and protection
- ◆ Legal and administrative awareness: farmers must be fully informed about legal provisions related to sandalwood plantation, harvesting, and marketing.

LAND SELECTION

The foremost requirement for establishing a sandalwood-based agroforestry plantation is the selection of suitable land. Well-drained, deep soils, such as sandy loam or red ferruginous loam, with pH between 6.0 and 8.0 are suitable for sandalwood cultivation. The site should receive full or partial sunlight, and preferably an annual rainfall above 500 mm. However, supplemental irrigation, particularly in summer months, is required till plants become fully established. In arid areas with inadequate rain, the provision of supplemental irrigation systems is critical to ensure survival.

WHAT TO AVOID?

- ◆ Waterlogged or poorly drained soils
- ◆ Heavy clay soils or saline soils
- ◆ Extremely arid areas with no supplemental irrigation systems
- ◆ Cold and frost-prone regions
- ◆ Areas with hardpans and very shallow soils (<30 cm)

SEED COLLECTION AND NURSERY

Quality planting material is vital for successful sandalwood



plantations and can be sourced from reliable nurseries or raised from certified seeds or seeds from authentic sources.

Mature, ripened, deep purple fruits may be collected during fruiting periods of March-April and September-October from trees 3 years or above in age. However, the fruit maturation period may vary with region. The seeds may be stored up to 3-6 months after depulping, washing and thorough drying under shade.



Sandalwood seeds are best germinated in sand or a sand-red earth mix on raised or sunken beds, with regular application of fungicide (Dithane Z-78) and nematicide (Ekalux) to prevent disease. Seed sowing may be done in May–June, with watering twice daily in beds. Seedlings can be transplanted at the 4–6 leaf stage into polybags with host plants in a 2:1:1 mixture of sand, red earth, and fertilizer. Healthy, well-branched seedlings of 30 cm height are ready for field planting in 6–8 months.

HOSTS FOR SANDALWOOD

Selection of compatible host is of utmost importance as sandalwood is a hemi-parasite and depends on host for its nutritional requirements. Initially, a primary or intermediate host may be planted, however, a long-term secondary host is also required. Hosts should be prepared along with sandalwood seedlings.

WHAT COULD BE SUITABLE HOSTS IN ARID SYSTEMS?

In Rajasthan’s arid conditions, millets (bajra), pulse crops (green gram, black gram, and cluster beans), oilseed crops (sesame, castor, mustard), horticultural species (ber, pomegranate, guava, date palm, amla, ker and khejri) are usually grown in traditional farming systems. Some of these may serve as either intercrops or hosts in sandalwood-based farming.

Species like red gram and sesbania can be used as intermediate hosts, while horticultural species like ber, pomegranate, citrus, guava, amla, ker, etc., and forestry species like babul, neem, moringa, khejri, Pongamia, Casuarina, etc., as secondary hosts.

PLANTING TECHNIQUES

Sandalwood seedlings should be planted in pits sized approximately 45 cm × 45 cm × 45 cm. Insecticides and pesticides may also be applied as needed. Maintenance of an appropriate spatial arrangement allows parasitic root connections without excessive competition (e.g., 4 m × 4 m or 5 m × 5 m spacing between sandalwood and hosts). Healthy, disease-free sandalwood seedlings, preferably 6-12 months old, should be used for planting. Proper root handling should be ensured while placing in pits to avoid root damage. Hosts should be planted simultaneously or shortly before planting of sandalwood. Sandalwood seedlings should be placed adjacent to host roots to facilitate root