



FAQs ON AGROFORESTRY



INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION
(An Autonomous Council of Ministry of Environment, Forest and Climate Change,
Govt. of India)





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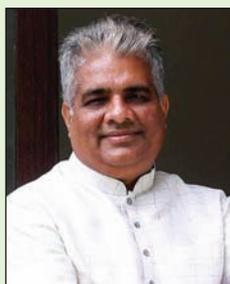
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मंत्री
पर्यावरण, वन एवं जलवायु परिवर्तन,
और
श्रम एवं रोजगार
भारत सरकार



भूपेन्द्र यादव
BHUPENDER YADAV

MINISTER
ENVIRONMENT, FOREST AND CLIMATE CHANGE
AND
LABOUR AND EMPLOYMENT
GOVERNMENT OF INDIA



Foreword

Agroforestry has been practiced in India since time immemorial, the diverse benefits of which have been well documented and appreciated. Taking cues from traditional models and home gardens, the researchers and policymakers focused on its multifunctional potential to address the issues of employment and livelihood of the rural population, fulfill industrial and domestic wood requirements, and increase green cover. With the advances in technology and the availability of quality planting material for region-specific tree species, various agroforestry models have been developed for increased productivity and sustainable land use. With a futuristic approach, India is the first country in the world to introduce a separate policy on agroforestry that provides opportunities towards the goal of doubling farmers' income and helping the nation achieve its target of enhancing forest cover.

There are several publications on the various agroforestry models; however, addressing the need to satisfy the queries of farmers and tree growers on a variety of queries related to agroforestry is not available. ICFRE has taken an initiative and compiled a book on "FAQs on Agroforestry", which would serve as a guide in a question-answer approach to address many of the likely queries raised by field practitioners. The book details cultivating 36 selective species-specific concepts, including bamboo suitable for agroforestry systems and home gardens. Information is also on prospective state-specific agroforestry tree species, ICFRE-developed agro climate-specific models, supplemented with state-specific felling and transit regulations.

I believe this book will be a useful resource for farmers and tree growers and inspire them to pursue agroforestry, which will enable enhancing incomes and green cover.

Date: 14.03.2023


(Bhupender Yadav)



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Introduction to Agroforestry

Q1. What is agroforestry?

Ans. Agroforestry is a combination of practicing agriculture and forestry together on the same unit of land. It is a traditional practice recognizing and promoting trees and/or livestock on farms in a special arrangement pattern. It focuses on the interaction and interdependence of various elements in nature rather than on individual elements.

Q2. What are the components of agroforestry?

Ans. There are three main components of agroforestry - crops, trees and livestock.

Q3. What are the major agroforestry systems based on the type of component?

Ans. Agroforestry systems are classified into three categories based on the type of component: Agrisilviculture (crops + trees), silvopastoral (pasture/livestock + trees); and Agrosilvopastoral (crops + pasture + trees).

Q4. What are the major attributes that agroforestry systems should possess?

Ans. There are three attributes of agroforestry systems:
Productivity - production of preferred goods and increasing productivity of the land resources
Sustainability - conserving the production potential of the resource base
Adoptability - acceptance of the prescribed practice by the users or in line with existing regional practices

Q5. Can we adopt a common agroforestry model for the country?

Ans. A 'one-model-fits-all' approach does not work for agroforestry because of the diverse biophysical and socioeconomic conditions of the country. Different agro-ecological regions require different combinations of trees and crops depending on factors such as climate, soil type, slope, and water availability.

Q6. What are the benefits of adopting agroforestry practices?

Ans. Agroforestry practices have both financial and environmental advantages:

- It enhances farm profitability.
- The combined output of trees, crops, and livestock per unit area is greater than the combined output of any one of the components acting alone.
- By generating mulch/leaf litter as manure and bio-pesticides from tree components, agroforestry reduces input costs for agriculture production
- Crops and livestock are protected from wind damage as trees reduce the wind intensity and provide shelter to the livestock.
- New products from agroforestry increase the farming enterprise's financial flexibility and diversification.



- Agroforestry aids in the preservation and protection of natural resources by reducing pollution, managing soil erosion, and establishing wildlife habitat. With the help of agroforestry, agriculture's economic and resource sustainability improves significantly.
- It also aids in carbon sequestration.

Q7. What are the Government of India's initiatives to promote agroforestry?

Ans. Since the 1970s, India has promoted research in the field of agroforestry. India is the first country to develop and adopt an agroforestry policy - the National Agroforestry Policy (NAP). A Sub-Mission on Agroforestry (SMAF) under National Mission for Sustainable Agriculture (NMSA) was initiated by the Department of Agriculture, Cooperation & Farmers Welfare in 2016. The aim of the submission was to expand the tree coverage on farmland complementary with agricultural crops. To achieve this, the Sub-Mission had the five broad components - Nursery Development for quality planting material (NDQPM), Peripheral and Boundary Plantation (PBP), Low Density Plantation on Farm Lands (LDPFL), High Density Block Plantation (HDBP), Demonstration of Agroforestry Models and Capacity Building & Trainings. The "**Har Medh Par Ped**" scheme was launched in 2016-17 to encourage tree plantation on farmland along with crops/cropping systems to help the farmers get additional income and make their farming system more climate resilient and adaptive.

Q8. What are the goals of National Agroforestry Policy, 2014?

Ans. The major policy goals of National Agroforestry Policy are:

- Setting up a National Agroforestry Mission or an Agroforestry Board to implement the National Policy by bringing coordination, convergence and synergy among various elements of agroforestry scattered in various existing, missions, programmes, schemes and agencies pertaining to agriculture, environment, forestry, and rural development sectors of the Government.
- Improving the productivity, employment, income and livelihood opportunities of rural households, especially of the smallholder farmers through agroforestry.
- Meeting the ever increasing demand of timber, food, fuel, fodder, fertilizer, fibre, and other agroforestry products; conserving the natural resources and forest; protecting the environment and providing environmental security; and increasing the forest / tree cover, there is a need to increase the availability of these from outside the natural forests.

Q9. What are the measures to scale up agroforestry in India?

Ans. The National Agroforestry Policy has been a major step towards scaling up agroforestry in India. Other initiatives include exempting many tree species from the Felling and Transit rules, and removing bamboos from the category of forest produce to enable large scale cultivation. The MoEFCC has encouraged preparation of agroforestry maps for five-year cycles to provide species-wise maps using spectral signature data of common agroforestry species available in digital libraries.

The following measures can further be taken to scale up agroforestry in India.

- Development of new agroforestry models for different agro-climatic zones.
- Ensuring the availability of certified planting material to the farmers and other users.
- Participatory research on larger agroforestry models viable across different agroecological regions.
- Developing ideotypes (specific tree varieties) suitable to various agroforestry systems.
- Development of industries and/or secondary processing units near the agro forestry zones.
- Introducing innovative technologies for an efficient and well managed agroforestry system.
- Improving market access to farmers and incentivising value added agroforestry.
- Research on ecological and social impacts on adoption of agroforestry.
- Decision Support Systems for the selection and management of species in agroforestry systems.
- Improve the delivery of technology know-hows to the farmers through extension programmes involving research institutions and industries.

Q10. What are the constraints faced by the farmers while adopting agroforestry?

Ans. Agroforestry adoption is hampered by factors such as trees interfering with agricultural crop yield, long tree gestation period resulting in delayed investment returns, increased crop damage from birds that trees attract and the pests that use trees as alternate hosts, the release of some allelochemicals from some tree leaves that have an allelopathic effect on crop productivity, a lack of market mechanisms for tree produce, and a dearth of remuneration for undertaking tree cultivation under agroforestry systems.

Q11. Can soil fertility be maintained in an agroforestry system?

Ans. Agroforestry systems help in improving soil fertility. The introduction of leguminous trees helps accumulate a significant quantity of nitrogen in the soil which is made available to crops. The leaf litter serves as a mulch in many cases, retaining nutrients and moisture of the soil. Some of the tree species used to improve soil fertility also have fodder value and can improve livestock manure quantity and quality.

Q12. What are the trees suitable for rainfed areas?

Ans. *Azadirachta indica, Pongamia pinnata, Ailanthus excelsa, Albizia lebbeck, Hardwickia binata, Pterocarpus marsupium, Pterocarpus santalinus, Santalum album, Syzygium cumini, Acacia nilotica, Acacia leucophloea, Ziziphus jujuba.*

Q13. What are the tree crops suited for saline / sodic lands?

Ans. *Eucalyptus, Casuarina, Pongamia pinnata, Azadirachta indica, Pithecellobium dulce, Salvadora oleoides, Salvadora persica, Capparis decidua, Terminalia arjuna, Cordia rothii, Albizia lebbeck, Pongamia pinnata, Sesbania sesban, Butea monosperma and Acacia leucophloea.*

Q14. What are the trees suitable for water logged areas?

Ans. *Syzygium cuminii*, *Pongamia pinnata*, *Michelia champaca*, *Terminalia arjuna*, *Holoptelea integrifolia*, *Thespesia populnea*, *Acacia nilotica*, *Calophyllum inophyllum*, *Lannea coromandelica*, *Casuarina* and *Eucalypts*.

Q15. What are the trees suitable for farm bunds?

Ans. *Tectona grandis*, *Gmelina arborea*, *Thespesia populnea*, *Albizia lebbbeck*, *Bamboo*, *Ailanthus excelsa*, *Azadirachta indica*, *Melia dubia*, *Casuarina*, *Bombax ceiba*, *Lannea coromandelica*, *Delonix elata*, etc. are suitable for bunds. Apart from the above, horticultural species such as mango, sapota, jamun, guava are also suitable.

Q16. Can cultivating medicinal plants be considered as agro forestry / farm forestry?

Ans. Yes, medicinal plants are cultivated predominantly in farm forestry models. There are many case studies where species like ginger, turmeric, rosemary etc. are grown in agroforestry/farm forestry. However it is important to be aware of the existing market channel before planning for medicinal plantations. It is advisable to cultivate medicinal plants only when there is a buyer with a buy back agreement for the produce.

Q17. What are the tree crops suitable with turmeric?

Ans. Tree species like *Casuarina*, *Acacia mangium*, *Neolamarckia cadamba*, *Melia dubia*, *Gmelina arborea*, *Tectona grandis*, *Bombax ceiba*, and palms like (coconut, arecanut, etc.) are suitable with turmeric.

Q18. Which species are suitable around a pisciculture farm?

Ans. *Syzygium cuminii*, *Pongamia pinnata*, *Michelia champaca*, *Terminalia arjuna*, *Holoptelea integrifolia*, *Thespesia populnea*, *Acacia nilotica*, *Calophyllum inophyllum*, *Lannea coromandelica*.

Q19. What are the trees suitable for dry land farming?

Ans. *Ailanthus excelsa*, *Azadirachta indica*, *Tamarindus indica*, *Albizia lebbbeck*, *Acacia nilotica*, *Pongamia pinnata*, *Madhuca latifolia*, *Aegle marmelos*, cashew, amla, custard apple, wood apple, etc. are suitable for dry land.

Q20. What are the tree crops suitable for fodder?

Ans. *Albizia lebbbeck*, *Hardwickia binata*, *Albizia procera*, *Hardwickia binata*, *Gmelina arborea*, *Bauhinia purpurea*, *Bauhinia variegata*, *Sesbania sesban*, *Ziziphus mauritiana*, *Moringa oleifera*, *Sesbania grandiflora*, *Grewia sp.*, *Gliricidia sepium*, *Erythrina indica*, *Morus alba*.

Q21. Which tree crops can be grown as green manure?

Ans. *Gliricidia sepium*, *Pongamia pinnata*, *Azadirachta indica*, *Thespesia populnea*

Q22. What are the trees suitable for controlling soil erosion?

Ans. *Pongamia pinnata*, *Leucaena leucocephala*, *Gliricidia sepium*, *Albizia lebbbeck*.

Q23. What are the trees suitable for growing in quarry and mining areas?

Ans. *Casuarina equisetifolia*, *Acacia auriculiformis*, *Eucalyptus camaldulensis* are the suitable tree species for growing in mine dumps and quarries.

Q24. What is a windbreak agroforestry system?

Ans. A windbreak is a narrow row of trees, planted bordering a farm plot. Its main aim is reduction of wind speed. Other important advantages include reducing soil erosion, evapo-transpiration losses and in turn increases "Water Use Efficiency (WUE)", leading to "**More Crop Per Drop**", moderates air and soil temperatures in the field, keeps higher relative humidity, minimizing early shedding of immature fruits.

Q25. Can agroforestry practices minimize usage of fertilizers?

Ans. Yes. One of the objectives of agroforestry practices is to minimize the dependency on inputs as the output of one component could be an input for another. Livestock rearing in agroforestry helps in generating Farm Yard Manure and compost which is an input for agricultural crops, minimizing use of fertilisers.

Q26. Which are the ideal months for planting tree crops?

Ans. Onset of the monsoon (July to September) is the best period for planting trees which will help in easy establishment.

Q27. Are there any restrictions imposed for felling of trees grown in farm lands?

Ans. Yes, for felling of scheduled trees cutting and transport permission from the State Forest Department is required. However State Forest Departments have exempted some trees from felling and transit regulations. Details of the tree species free from Felling and Transit Regulations growing on non forest area /private land is given in Chapter 6.

Q28. Does the adoption of agroforestry accrue intangible benefits/ environmental and ecological benefits?

Ans. Agroforestry systems play a significant role in improving soil and water conservation. These systems reduce soil erosion, preventing sediment runoff. The presence of the tree component slows water runoff, enhances water retention, stabilizes soil and reduces erosion.



State-wise List of Potential tree species for Agroforestry

S.No	State	Tree species
1.	Andhra Pradesh	<i>Azadirachta indica</i>
		<i>Casuarina equisetifolia</i>
		<i>C. junghuhniana</i>
		<i>Eucalypts</i>
		<i>Gmelina arborea</i>
		<i>Leucaena leucocephala</i>
		<i>Melia dubia</i>
		<i>Moringa oleifera</i>
		<i>Santalum album</i>
		<i>Swietenia macrophylla</i>
		<i>Tectona grandis</i>
		Bamboos
		<i>Bambusa balcooa</i>
		<i>B. nutans</i>
<i>Dendrocalamus strictus</i>		
<i>D. stocksii</i>		
2.	Arunachal Pradesh	<i>Anthocephalus chinensis</i>
		<i>Artocarpus heterophyllus</i>
		Bamboos
		<i>Bambusa balcooa</i>
		<i>B. pallida</i>
<i>B. tulda</i>		
<i>Dendrocalamus giganteus</i>		
3.	Assam	<i>Bombax ceiba</i>
		<i>Dillenia indica</i>
		<i>Phyllanthus emblica</i>
		<i>Gmelina arborea</i>
		<i>Litsea monopetala</i>
		<i>L. serrata</i>
		<i>Mesua ferrea</i>
		<i>Michelia champaca</i>
		<i>Phoebe goalparensis</i>
		<i>Ricinus communis</i>
		<i>Tectona grandis</i>
		Bamboo
		<i>B. balcooa</i>
		<i>B. bambos</i>
<i>B. nutans</i>		
<i>B. tulda</i>		

S.No	State	Tree species
4.	Bihar	<i>Casuarina equisetifolia</i>
		<i>C. junghuhniana</i>
		<i>Dalbergia sissoo</i>
		<i>Bombax ceiba</i>
		<i>Eucalyptus tereticornis</i>
		<i>Gmelina arborea</i>
		<i>Khaya anthotheca</i>
		<i>Melia azedarach</i>
		<i>Melia dubia</i>
		<i>Moringa oleifera</i>
		<i>Neolamarckia cadamba</i>
		<i>Populus deltoides</i>
		<i>Salix alba</i>
		<i>Swietenia mahagoni</i>
		Bamboo
		<i>Bambusa balcooa</i>
		<i>B. nutans</i>
<i>B. tulda</i>		
<i>Dendrocalamus strictus</i>		
5.	Chhattisgarh	<i>Acacia mangium</i>
		<i>Gmelina arborea</i>
		<i>Leucaena leucocephala</i>
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)
		Bamboo
<i>Bambusa nutans</i>		
<i>B. tulda</i>		
<i>Dendrocalamus stocksii</i>		
<i>D. strictus</i>		
6.	Gujarat	<i>Ailanthus excelsa</i>
		<i>Azadirachta indica</i>
		<i>Prosopis cineraria</i>
		<i>Senegalia catechu</i> (<i>Acacia catechu</i>)
		<i>Tectona grandis</i>
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)
		Bamboo
		<i>Bambusa arundinacea</i>
<i>Dendrocalamus strictus</i>		

S.No	State	Tree species
7.	Haryana	<i>Azadirachta indica</i>
		<i>Dalbergia sissoo</i>
		<i>Eucalyptus hybrid</i>
		<i>Melia dubia</i>
		<i>Populus deltoides</i>
		<i>Prosopis cineraria</i>
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)
8.	Himachal Pradesh	<i>Bauhinia variegata</i>
		<i>Eucalyptus tereticornis</i>
		<i>Grewia optiva</i>
		<i>Morus alba</i>
		<i>Phyllanthus emblica</i>
		<i>Populus deltoides</i>
		<i>Salix alba</i>
		<i>Senegalia catechu</i> (<i>Acacia catechu</i>)
9.	Jammu, Kashmir and Ladakh Union Territories	<i>Eucalyptus spp.</i>
		<i>Grewia optiva</i>
		<i>Morus alba</i>
		<i>Phyllanthus emblica</i>
		<i>Populus deltoides</i>
		<i>P. nigra</i>
		<i>Salix alba</i>
		<i>Senegalia catechu</i> (<i>Acacia catechu</i>)
10.	Jharkhand	<i>Artocarpus heterophyllus</i>
		<i>Bauhinia variegata</i>
		<i>Gmelina arborea</i>
		<i>Melia azedarach</i>
		<i>M. dubia</i>
		<i>Moringa oleifera</i>
		Bamboo <i>Bambusa bambos</i> <i>B. nutans</i> <i>B. tulda</i> <i>Dendrocalamus strictus</i>
		<i>Ailanthus excelsa</i>
11.	Karnataka	<i>Azadirachta indica</i>
		<i>Casuarina junghuhniana</i>
		<i>Phyllanthus emblica</i>
		<i>Ailanthus excelsa</i>

S.No	State	Tree species
12.	Kerala	<i>Gmelina arborea</i>
		<i>Grevillea robusta</i>
		<i>Moringa oleifera</i>
		<i>Melia dubia</i>
		<i>Pongamia pinnata</i>
		<i>Santalum album</i>
		<i>Swietenia macrophylla</i>
		<i>Tectona grandis</i>
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)
		Bamboo <i>Bambusa balcooa</i> <i>B. nutans</i> <i>B. tulda</i> <i>Dendrocalamus asper</i> <i>D. stocksii</i> <i>Thyrsostachys oliveri</i>
		<i>Ailanthus triphysa</i>
		<i>Artocarpus hirsutus</i>
13.	Madhya Pradesh	<i>A. heterophyllus</i>
		<i>Gmelina arborea</i>
		<i>Melia dubia</i>
		<i>Swietenia mahagoni</i>
		<i>Tectona grandis</i>
		Bamboo <i>Dendrocalamus brandisii</i> <i>D. giganteus</i> <i>D. strictus</i> <i>Ochlandra travancorica</i>
		<i>Dalbergia sissoo</i>
		<i>Eucalyptus spp.</i>
		<i>Gmelina arborea</i>
		<i>Leucaena leucocephala</i>
		<i>Neolamarckia cadamba</i>
		<i>Phyllanthus emblica</i>
<i>Tectona grandis</i>		
13.	Madhya Pradesh	Bamboo <i>Bambusa bambos</i> <i>B. nutans</i> <i>B. tulda</i> <i>B. vulgaris</i> <i>Dendrocalamus strictus</i>

S.No	State	Tree species
14.	Maharashtra	<i>Ailanthus excelsa</i>
		<i>Buchanania lanzan</i>
		<i>Casuarina equisetifolia</i>
		<i>Dalbergia sissoo</i>
		<i>Gmelina arborea</i>
		<i>Leucaena leucocephala</i>
		<i>Melia dubia</i>
		<i>Santalum album</i>
		<i>Tectona grandis</i>
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)
		Bamboo <i>Bambusa balcooa</i> <i>B. bambos</i> <i>B. nutans</i> <i>Dendrocalamus stocksii</i> <i>D. strictus</i>
15.	Manipur	<i>Albizia spp.</i>
		<i>Alnus nepalensis</i>
		<i>Artocarpus heterophyllus</i>
		<i>Ficus spp.</i>
		<i>Litsea polyantha</i>
		<i>Parkia timoriana</i>
		Bamboo <i>Dendrocalamus brandisii</i> <i>D. longispathus</i>
16.	Meghalaya	<i>Alnus nepalensis</i>
		<i>Aquilaria malaccensis</i>
		<i>Pinus kesiya</i>
		<i>Schima wallichii</i>
		Bamboo <i>Bambusa tulda</i> <i>Dendrocalamus asper</i> <i>D. hamiltonii</i>
17.	Mizoram	<i>Albizia procera</i>
		<i>Anthocephalus chinensis</i>
		<i>Melocanna baccifera</i>
		<i>Tectona grandis</i>
		Bamboo <i>Bambusa mizorameana</i> <i>B. multiplex</i>

S.No	State	Tree species		
18.	Nagaland	<i>Alnus nepalensis</i>		
		<i>Aquilaria malaccensis</i>		
		<i>Pinus kesiya</i>		
		<i>Prunus domestica</i>		
		<i>Pyrus communis</i>		
		<i>Schima wallichii</i>		
		19.	Odisha	<i>Acacia nilotica</i>
				<i>Casuarina equisetifolia</i>
				<i>Eucalyptus spp.</i>
				<i>Tectona grandis</i>
<i>Melia dubia</i>				
<i>Gmelina arborea</i>				
Bamboo <i>Dendrocalamus giganteus</i> <i>Bambusa balcooa</i> <i>B. tulda</i> <i>B. nutans</i> <i>B. vulgaris</i>				
20.	Punjab	<i>Eucalyptus hybrid</i>		
		<i>Melia dubia</i>		
		<i>Populus deltoides</i>		
21.	Rajasthan	<i>Ailanthus excelsa</i>		
		<i>Azadirachta indica</i>		
		<i>Dalbergia sissoo</i>		
		<i>Prosopis cineraria</i>		
		<i>Prosopis juliflora</i>		
		<i>Salvadora oleoides</i>		
		<i>Senegalia catechu</i> (<i>Acacia catechu</i>)		
		<i>Senegalia senegal</i> (<i>A. senegal</i>)		
		<i>Tectona grandis</i>		
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)		
<i>V. tortilis</i> (<i>A. tortilis</i>)				
<i>Ziziphus mauritiana</i>				
22.	Sikkim	<i>Alnus nepalensis</i>		
		<i>Ficus spp</i>		
		<i>Schima wallichii</i>		
		Bamboo <i>Dendrocalamus hamiltonii</i> <i>D. sikkimensis</i>		

S.No	State	Tree species
23.	Tamil Nadu and Puducherry	<i>Ailanthus excelsa</i>
		<i>Azadirachta indica</i>
		<i>Casuarina equisetifolia</i>
		<i>Eucalyptus spp.</i>
		<i>Gmelina arborea</i>
		<i>Melia dubia</i>
		<i>Swietenia mahagoni</i>
		<i>Tectona grandis</i>
		<i>Thespesia populnea</i>
		<i>Vachellia leucophloea</i> (<i>Acacia leucophloea</i>)
		Bamboo <i>Dendrocalamus strictus</i>
24.	Telangana	<i>Casuarina junghuhniana</i>
		<i>Dalbergia latifolia</i>
		<i>D. sissoo</i>
		<i>Gmelina arborea</i>
		<i>Melia dubia</i>
		<i>Santalum album</i>
25.	Tripura	<i>Tectona grandis</i>
		<i>Aquilaria malaccensis</i>
		<i>Artocarpus heterophyllus</i>
		Bamboos <i>Bambusa cacharensis</i> <i>Thyrsostachys oliveri</i>
26.	Uttar Pradesh	<i>Aegle marmelos</i>
		<i>Ailanthus excelsa</i>
		<i>Azadirachta indica</i>
		<i>Bauhinia variegata</i>
		<i>Bombax ceiba</i>
		<i>Ceiba pentandra</i>
		<i>Dalbergia sissoo</i>
		<i>Phyllanthus emblica</i>

S.No	State	Tree species
27.	Uttarakhand	<i>Eucalyptus hybrid</i>
		<i>Gmelina arborea</i>
		<i>Hardwickia binata</i>
		<i>Melia azedarach</i>
		<i>Melia dubia</i>
		<i>Moringa oleifera</i>
		<i>Neolamarckia cadamba</i>
		<i>Populus deltoides</i>
		<i>Spondias pinnata</i>
		<i>Swietenia mahagoni</i>
		<i>Syzygium cumini</i>
		<i>Tectona grandis</i>
		<i>Vachellia nilotica</i> (<i>Acacia nilotica</i>)
		Bamboo <i>Bambusa bambos</i> <i>Dendrocalamus strictus</i> <i>Schizostachyum dullooa</i>
		<i>Bauhinia spp.</i>
		<i>Grewia optiva</i>
		<i>Melia dubia</i>
<i>Populus deltoides</i>		
28.	West Bengal	<i>Cinnamomum tamala</i>
		<i>Gmelina arborea</i>
		<i>Neolamarckia cadamba</i>
		<i>Pongamia pinnata</i>
		<i>Swietenia mahagoni</i>
		Bamboos <i>B. balcooa</i> <i>B. jaintiana</i> <i>B. multiplex</i> <i>B. nutan</i> <i>B. tulda</i> <i>B. vulgaris</i> <i>D. strictus</i> <i>Thyrsostachys oliveri</i>







**SPECIES
SPECIFIC
FAQs**



Casuarina equisetifolia

Q1. What are the botanical and local names of Casuarina?

Ans. Two species are cultivated in India. Their botanical names are *Casuarina equisetifolia* and *Casuarina junghuhniana*. It is called Savukku in Tamil and Katradi in Malayalam.

Q2. What is the geographical distribution along with the agroclimatic zone?

Ans. Casuarina is naturally distributed in Australia, southern Thailand, Malaysia, Philippines, Indonesia, Melanesia and Polynesia. It was introduced into India during the late nineteenth century. Suitable for growing in agroclimatic zones 10, 11, 12 and 13.

Q3. What are the suitable areas for cultivation?

Ans. Casuarina trees are part of the landscape of an altitude below 1000 m throughout the country. However the commercial cultivation in large areas is in Andhra Pradesh, Karnataka, Odisha, Tamil Nadu, Telangana and the Union Territory of Puducherry. Recent field tests have shown Casuarina as a promising short term tree crop in Bihar, Gujarat and Punjab.

Q4. What are the major uses and services of Casuarina trees?

Ans. The principal uses of Casuarina wood are as a pulp for papermaking, poles for rural construction and scaffolding and fuelwood. It is a nitrogen fixing species and is preferred for various environmental services like shelterbelts, windbreak, reclamation of mined areas and salt-affected areas.

Q5. What is the rotation period?

Ans. Casuarina plantations are harvested in short rotations of 3-5 years under irrigated conditions and 5-7 year rotation in rainfed areas.

Q6. What are the methods of propagation of Casuarinas?

Ans. Casuarina is generally propagated through seeds. Clones are propagated through sprig cuttings.

Q7. What are the nursery practices for propagation through seeds?

Ans. Seeds of Casuarina are small and a kilogram contains about 6 lakh seeds. Germination ranges between 40-60% and a kg of seed can produce up to 100,000 seedlings. Seeds are sown in 10 x 1 m size raised mother sand beds. 250 g seeds are mixed with fine sand and are covered with a thin coating of straw. Germination initiates from fifth day and on seventh day the straw is removed from the mother bed and the seedlings are raised in the mother beds for three to four weeks.

After 4 weeks when the seedlings attain 8 – 10 cm height they are transferred to polythene bags or root trainers. Potting mixture of sand, soil and farm manure in a ratio of 2:1:1 are suitable for raising casuarina seedlings in Polybags of size 15 x 7 cm. Root trainers (60 – 100 cc) are filled with composted coir pith as a potting medium. Within 2 months seedlings may reach plantable size but if planting is delayed it can be maintained for another 4 to 6 months.



Q8. How is clonal propagation carried out in Casuarina?

Ans. Outstanding casuarina trees can be propagated clonally by rooting of young shoots ('sprigs'). Such plants produce uniform superior growth in plantations. Sprigs collected from selected trees are trimmed to 8-10 cm long and washed in a 5% solution of fungicide like Carbendazim. The lower portion of the shoot is treated with a rooting hormone, Indole butyric acid. The treated cuttings are placed in root trainers containing vermiculite or treated coir pith and kept in mist chamber or propagation chambers made of polythene sheets. Rooting occurs in 15 to 20 days. Followed by transferring the plants into polybags or root trainers and grown in the same manner as seedlings.

Q9. What is the best planting time and method?

Ans. It is ideal to plant Casuarina plantations availing pre-monsoon showers. However, where irrigation is available, Casuarina can be planted throughout the year. The land should be disc ploughed twice and planting done in pits of 30 x 30 x 30 cm. In particular the clones have to be planted in pits for proper root development and to prevent lodging of saplings.

Q10. What are the suitable spacing options for raising Casuarina plantations?

Ans. Clonal plantations should be planted with wider spacing compared to seedling plantations. The optimal stocking of clonal plantations is 2100 to 2400 trees per acre for a rotation period of three to four years. Spacing to be adopted for different types of planting material and rotation period and the estimated yield are given below.

Planting material	Spacing (ft)	No. of trees per acre	Pulpwood yield (tonnes per acre)
Unimproved seed	3 x 3	4000	30 – 40
Seed orchards seed	4 x 4	2700	40 – 50
Clone (up to 3 years)	6 x 3	2400	50 – 70
Clone (more than 3 years)	6 x 3.5	2100	70 – 80

Q11. How do we manage weeds and grow crops with Casuarina trees?

Ans. Saplings of the high-yielding varieties grow rapidly once they are established and it is essential to keep the plantation free from weeds to obtain maximum early growth. Two to three weedings during the first six months after planting are needed. The canopies of trees close between six months to one year after which no weeding is necessary. Intercropping with legumes like groundnut, moong dal and black gram is the best way to manage the weed and to get an additional income.

Q12. What is the irrigation requirement of Casuarina?

Ans. Casuarina trees respond well to irrigation which reduces the rotation period. However keeping the field always wet may cause disease infection and lodging of trees especially in clay soils. Adopting a drying-wetting-drying approach of irrigation is ideal. In unirrigated lands drought-tolerant clones like IFGTB-CJ9 or seedlings of *Casuarina junghuhniana* would be suitable.

Q13. How do we achieve higher wood production in Casuarina trees?

Ans. Removing side branches helps in maximum diameter growth and also increases the pole quality of the trees. Pruning may be taken up at 12 months and between 18-24 months during the dry season to prevent disease infection.

Q14. What is the fertilizer requirement for Casuarina?

Ans. The composition and amount of fertilizer to be applied to casuarina plantations should be decided for a given site after conducting soil tests. A basal dose of 10 g of superphosphate per pit is recommended for early establishment and root nodule development. A general recommendation for post-planting fertilizer application is provided below.

Fertilizer	Quantity to be applied (kg per acre)					Total
	3 months	6 months	12 months	18 months	24 months	
Urea	7	10	12	12	0	43
Superphosphate	12	12	12	12	12	60
Muriate of potash	7	10	14	14	14	59
Total	26	32	38	40	26	162

Q15. Are Casuarina trees susceptible to pests and diseases?

Ans. Casuarina is attacked by the bark-eating caterpillar which digs up deep tunnels in the main stem making them weak and prone to breaking during heavy wind. It can be controlled by spraying Monocrotophos (1.25 ml/litre) at 0.5% over the feeding area or by injecting 0.5% (1 ml/litre) Dichlorvos into the bore holes and sealing with mud. Biological control by application of *Beauveria bassiana* is an eco-friendly option and commercial formulations are available in the market.

In clayey soils, trees may die due to root / collar rot caused by fungal pathogens. The affected trees show yellowing of leaves followed by drying up of the entire tree. Application of biocontrol agents like *Trichoderma viride* and *Pseudomonas fluorescens* in the pits while planting prevents infection. Irrigation should be provided only when necessary by following wetting and drying methods. The disease incidence can be controlled by soil drenching using fungicidal solutions (SAFF-2 @2 % or Folicure @ 1 %).

Q16. What are the clones available for Casuarina?

Ans. The following clones are the widely planted clones in south India.

Rainfed areas: IFGTB-CJ9

Irrigated plantations: IFGTB-CH1, IFGTB-CH2 and IFGTB-CH5

Windbreaks: IFGTB-WB-CJ1, IFGTB-WB-CJ2, IFGTB-WB-CJ3, IFGTB-WB-CJ4, IFGTB-WB-CJ5

Sodic soils: IFGTB-CE5, IFGTB-CE6, IFGTB-CE7



Q17. From where can farmers get clones of Casuarina?

Ans. The ICFRE-Institute of Forest Genetics and Tree Breeding, Coimbatore, paper industries (Andhra Paper Limited, Seshasayee Paper and Boards Limited, Tamil Nadu Newsprint and Papers Limited) and licensed nurseries (Santhi Clonal Nursery and Sangeetha Hitech Nursery) produce large numbers of quality planting material of the new varieties and supply to farmers.

Q18. What is the most suitable pattern for planting Casuarina?

Ans. It is recommended to have wider spacing between rows (minimum 2m) to facilitate inter-ploughing and other management operations. The tree rows may preferably run from east to west directions to facilitate more sunshine in the wider space and also to have free air flow. In bund plantations, trees may be planted in 'Quincunx' pattern.

Q19. What are all the special traits of tree varieties / clones released for windbreaks by ICFRE?

- Ans.**
- i) High level of branch persistence with 40 to 50 thick and horizontal branches within 3 m height from the base of the tree.
 - ii) Greater branch thickness (having thickening of branches at the rate of 8 to 11 mm per year).
 - iii) Wider branch angle (66 to 82 degrees - near right angle).
 - iv) Greater height growth rate (2.5 to 3 m per year).
 - v) Faster diametrical growth rate of main stem (1.5 to 2 cm per year).
 - vi) Higher wood yield (20 MT per ha - about 40% more yield when compared to other clones in the market).
 - vii) Branch persistence is very high with no self-pruning of branches once formed.
 - viii) Coppices well, and hence once planted, 2 to 3 rounds of harvest of wood is possible.

Q20. Is there any specific pattern to plant Casuarina trees as windbreaks around agricultural and horticultural crops?

Ans. After land preparation by ploughing and formation of three channels at distance of 0.5 or 1 m all along the boundary, within each channel, superior clones of Casuarina are planted at 2 m intervals within the rows in 'Quincunx' or 'Zig-zag' pattern. Thus the tree density will be around 250 trees per acre. Planting of two rows of windbreak trees is also suggested, when land is a constraint to establish three rows of windbreaks. In this model, the distance between the rows is 0.5 m and the distance between trees within the row is 2 m. The planting configuration is 'Zig-zag'.

Q21. What is the yield, cost of cultivation and B-C Ratio?

Ans. Harvesting should be carried out when the rotation period is completed since growth increment reduces thereafter. The average yield of pulpwood in a four year old irrigated plantation is 175 tonnes per ha. The mill gate price of pulpwood in Tamil Nadu is

Rs. 6,300/- per tonne (as on February 2023). The cost of cultivation is Rs.60,000/- per acre and the cost of harvest and transport is Rs.1,300/- per tonne. The total expenditure is Rs. 3.78 lakhs per ha. The net income is Rs. 7.25 lakhs per ha and B-C ratio is 1:2.92.

Q22. What is the current and future market demand?

Ans. There has been a stable market for Casuarina wood during the past two decades. Since the major paper mills in south India alone require 15 lakh tonnes of wood per year, it is expected that Casuarina cultivation will remain profitable to the growers in the near future.



A young Casuarina plantation intercropped with black gram



A plantation of high-yielding clone IFGTB-CH5 in farmer's land



Clonal windbreak in lemon orchard



4-year-old clonal windbreak for protecting banana crop

Melia dubia

Q1. What are the common/vernacular names of *Melia dubia*?

Ans. Malabar neem, Gora neem (Hindi), Malayvembu (Tamil), Malaveppu (Malayalam), Kadbevu or Hebbevu (Kannada) and Munnatikaraka (Telugu).

Q2. Where is *M. dubia* geographically distributed?

Ans. The species occurs naturally in the Western Ghats of Kerala, Karnataka, and Tamil Nadu, Eastern Ghats, Deccan Plateau, Northern Himalayas, North Bengal, Upper Assam.

Q3. What are the characteristics of *M. dubia* tree?

Ans. It is a fast growing large deciduous tree which requires abundant overhead light for its growth and development. It is an excellent coppicer, coppicing profusely from large stumps, however, younger stems or stumps of one to two year old trees yield only a few coppice shoots. It produces root suckers freely. The trunk of the tree is smooth and cylindrical without knots.

Q4. What are the growth requirements of *M. dubia*?

Ans. *M. dubia* grows well in temperature ranges of 30 – 45°C, mean annual rainfall range of 750 – 2500 mm and at an altitude of 650 – 1800 m. It grows in well drained red, red loam and black loam soils with pH ranging from 5.5 to 7.0 and depth 50 – 150 cm, requires moderate soil fertility and can come up in soils with salinity of <4 dS/m.

Q5. Is *M. dubia* a suitable agroforestry species?

Ans. Yes. It is a fast growing tree species preferred under agroforestry. Sheds leaves and twigs during winter resulting in increased soil texture and organic matter. Clear bole of 8-15 m is achieved easily.

Q6. Which are the areas where the species has adapted?

Ans. Commercial plantations have come up in Peninsular and Northern States and the current extent of plantations has been estimated to be around 50,000 ha.

- In North and Central India, it is cultivated in major states like Haryana, Punjab, Uttar Pradesh, Uttarakhand, Himachal Pradesh, Bihar, Jharkhand, Madhya Pradesh and Chattisgarh
- In Southern part of India it occurs naturally, and is also cultivated in Karnataka, Andhra Pradesh, Kerala and Tamil Nadu.

Q7. What are the uses of *M. dubia*?

Ans. The principal use of *M. dubia* wood is for plywood manufacturing. Quality face veneer is produced from girth > 90 cm and lesser than that is used for core veneer. In recent years paper mills have started using young trees for pulpwood. Its utility in the match industry is also being explored. The older trees >10 years produce medium class timber.

Q8. What is the rotation period of *M. dubia*?

Ans. The rotation period varies depending on the management conditions. Under irrigated conditions, it can be harvested in 3 years for pulpwood and energy, in 6 years for core veneer of plywood, in 8-10 years for high quality face veneer, and >10 years for medium class timber. Under rainfed conditions, the growth is slow, hence attains desirable volume in 10-15 years.

Q9. What is the planting season for *M. dubia*?

Ans. Planting is to be carried out in February – March or June – July in North India and June to December in South and Central India.

Q10. What are the basic requirements for planting?

Ans. Six month old seedlings are suitable for raising plantations. Pits of 45 x 45 x 45 cm or 60 x 60 x 60 cm based on soil type with 250g of vermi-compost or farmyard manure per pit. Water logging is not preferred. One disc ploughing and one cultivator ploughing is required.

Q11. Does *M. dubia* require irrigation? What is the irrigation schedule for the species?

Ans. The species responds well under good maintenance and controlled irrigation. Irrigation once in fortnight during the first three years, followed by once in a month from fourth year onwards improves growth. Irrigation schedule can be planned as per requirement.

Q12. Is the species susceptible to browsing?

Ans. The leaves are palatable and protection has to be ensured as young plants are easily browsed during the first year of planting.

Q13. What are the silvicultural practices for the species?

Ans. The species requires light pruning upto three years by singling of multiple shoots, by retaining 1 or 2 on each plant. Application of 500 grams of FYM per plant improves productivity.

Q14. Which are the intercrops that can be grown with *M. dubia*?

Ans. Intercropping with banana or sugarcane during the first two years followed by turmeric, groundnut or papaya once the canopy closes for the next two years. It is also planted as an intercrop among coconut trees. Groundnut, blackgram and greengram grow well as an intercrop under *M. dubia*. It also performs well as a bund for Casuarina, banana, drumstick and sugarcane plantations and mango orchards. The species can form a three tier agroforestry system with tomato/ turmeric. It is also grown as a shade tree in coffee and tea plantations. In North India, a rabi crops like wheat, barley, vegetables etc. are grown upto final harvest.

Q15. What is the suitable spacing for *M. dubia* as per end use?

Ans. For face veneer/timber a spacing of 10 x 10 m, for plywood 8 x 8 m or 4 x 4m with a thinning at the end of two years, for energy and plywood 2 x 2m, for energy and plywood with periodic mechanical thinning once in two years 1.5 x 1.5m, and for bund planting 4 m is recommended.



Q16. Does seed source affect seed germination ?

Ans. The seeds from the Southern India are larger in size with harder endocarp and therefore the physical dormancy hinders easy germination. However seeds from North India have 100% germination.

Q17. Which is the best time for fruit collection?

Ans. Fully mature yellow-brown fruits are collected in November – December, depulped and stones are sun dried.

Q18. What are the requirements for seed germination in nursery?

Ans. About 6-7 kg of dried drupes (1500 numbers) are required for one standard nursery bed. It is best to sow seeds during Feb.-March. Cleaned and dried stones should be sown in the open raised nursery beds, in drilled lines, 5 cm apart. Seeds do not germinate in sand and are sown in sand: soil: farm yard manure medium in the ratio 1:1:2. The beds are watered twice a day. At places where daytime temperature is not very high, or where nursery beds are in shade, the bed should be covered with a tarpaulin sheet to retain temperature in the medium. Germination occurs within 90 days for seeds from South India, while seeds from north India germinate in 25 to 40 days.

Q19. Is *M. dubia* amenable for vegetative propagation?

Ans. Juvenile stem cuttings and coppice shoots respond well to 1000 – 2000 ppm IBA (liquid formulation). Coppice from older trees responds better to rooting. Pencil thick cuttings are taken for clonal propagation. Thin shoots are easily susceptible to root rot. The shoots can be placed on sand medium and watered twice a day. A provision for drainage is a must as water logging destroys the shoots. Season also plays a major role in the rooting of cuttings. Drier seasons are more conducive for rooting and about 75 per cent rooting can be obtained.

Q20. What are available varieties of *M. dubia* and what is their growth and productivity?

Ans. ICFRE-FRI, Dehradun has released ten varieties for Northern region viz., Sharad, Shashi, Bahumukhi, Varsha, Kartik, Kshitiz, Amar, Megha, Dev and Ritu. Productivity of a plantation from unimproved sources is 10 to 12 m³ha⁻¹yr⁻¹. For released varieties, average productivity is 34.57 m³ha⁻¹yr⁻¹ under irrigated conditions at 7 years of age.

Q21. Which are the clones available for *M. dubia* and what is the productivity?

Ans. Presently available clones are GK series (Tamil Nadu Newsprint and Paper Ltd., Seshasayee Paper Boards Ltd), MTP 1 and MTP 2 (Forest College and Research Institute, Mettupalayam, Tamil Nadu). GK 10 shows superior growth at the end of five years with a girth of 90 cm and yield of 275.75 MT per ha. MTP clones recorded 50-60 cm girth and a yield ranging from 180-254 MT per ha.

Q22. Are there any growth differences between the seedling origin and clonal plants?

Ans. Clones show uniform growth. At the end of seven years, clonal plantations with a spacing of 8 x 8 m recorded an average girth of 100 cm while a seedling plantation of the same spacing showed about 80 cm. The clean bole height was greater for clonal plantations than seedling-raised plantations, especially in closer spacing. However, it is also observed that with proper management, seedlings also perform on par with clonal

material, reaching the same girth as clones. In North India girth upto 140 cm has been recorded at seven years of age under irrigated conditions.

Q23. What are the possible planting options for *M. dubia*?

Ans. It can be planted as boundary, block, bund and wide-row alley cropping. Trees planted along bunds have been recorded to put on girth faster than the block plantation because of lower competition.

Q24. What are the conditions to be considered for achieving optimum growth?

Ans. The optimum performance can be expected only under good maintenance and controlled irrigation up to at least six years. Unattended plantations with weed growth, poor soil conditions, water logging, etc., do not produce logs of the desired size.

Q25. What is the expected yield of *M. dubia*?

- Ans.**
- In Tamil Nadu, for a block plantation with no intercropping. For pulpwood it is 50 – 60 tonnes/ha at the end of three years, and for plywood 100 – 125 tonnes/ha at the end of seven years [based on field observations (2020-21)].
 - In North India, with intercrop after seven years, productivity per plant is 10-15 cubic feet and total production per acre is 2000 cubic feet.

Q26. What is the cost of cultivation per acre?

Ans. In North and Central India, cost of cultivation per acre has been reported to be about Rs 48,000 per hectare .

Q27. What is the economics of raising Melia plantations?

Ans.

S.No.	Financial analysis	Pulpwood model	Plywood model	Pulp and Ply model
1	BC ratio at 15%	2.18	3.94	2.92
2	NPV at 15%	446183	484083	611940
3	IRR	90%	79.50%	84%

Source: (Handa et al., 2019)

Q28. From where can QPM of Melia be obtained?

Ans. Quality planting stock can be obtained from

- ICFRE-Forest Research Institute, Dehradun, Uttarakhand
- ITC WIMCO, Rudrapur, Uttarakhand
- Bbezini Seedlings, Saharanpur, Uttar Pradesh
- ICFRE-IFGTB, Coimbatore, Tamil Nadu
- Tamil Nadu Newsprint and Paper Ltd., Karur, Tamil Nadu
- Seshasayee Paper Boards Ltd, Erode, Tamil Nadu
- Forest College and Research Institute, Mettupalayam, Tamil Nadu
- ICFRE-IFP, Ranchi, Jharkhand



Q29. What is the potential market demand for Melia?

Ans. *M. dubia* is the most preferred species for the plywood industry. Because industries are constantly in need of raw materials, this species will always be in high demand. India's plywood market size reached INR 195.8 billion in 2021 and is expected to reach INR 297.2 billion by 2027.



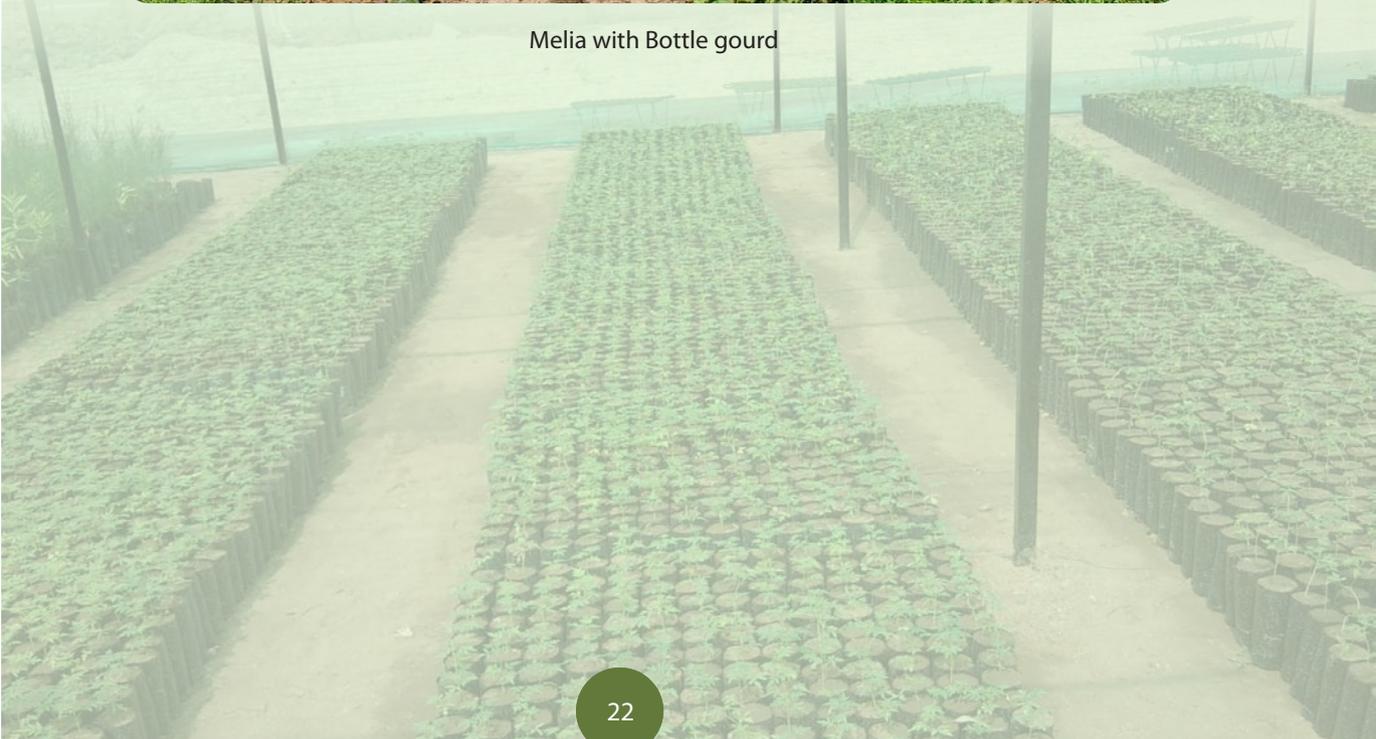
Melia with Wheat



Melia with Turmeric



Melia with Bottle gourd



Populus deltoides

Q1. What are the common names of *Populus deltoides*?

Ans. *P. deltoides* is commonly known as poplar in India, other species of the genus *Populus* are also referred as poplar. In the USA, it is called Eastern cottonwood.

Q2. What type of tree is poplar?

Ans. Poplar is a fast growing, tall, light demanding deciduous tree with a straight trunk. It is sensitive to drought and water logging.

Q3. What is the geographical distribution of this species?

Ans. It is native to North America and was introduced in India in the late 1950s. It has been successfully cultivated for over four decades as an agroforestry crop above 28° N from the Punjab plains in the west to *tarai* region of Uttar Pradesh in Gangetic plains.

Q4. In which agroclimatic zones is poplar grown?

Ans. Agroclimatic zones 2, 3 and 4.

Q5. In which states the species is being cultivated?

Ans. *P. deltoides* is a widely accepted species under agroforestry in north-west India in western Uttar Pradesh, Punjab and Haryana and to some extent in the outer plains/valleys of Uttarakhand, Himachal Pradesh, and Jammu. ICFRE introduced its cultivation to parts of northern Bihar a decade ago.

Q6. How popular is poplar cultivation?

Ans. *P. deltoides* is the most widely planted species of poplar in India. About 60,000 hectares equivalent plantations of poplar exist in India.

Q7. What are the uses of poplar?

Ans. The wood of *P. deltoides* is light and medium hard, easy to saw and work. The wood has good nail holding ability, and other physical properties are about half those of teak. The wood is suitable for making plywood, fillings for ply-boards, matchsticks, paper, packing cases, spoons, toothpicks, ice cream sticks, etc.

Q8. How is poplar propagated in the nursery?

Ans. Poplar is propagated using cuttings from stems of one-year-old Entire Transplants (ETPs) of previous year's nursery stock. About 20 cm long cuttings with 1 to 3 cm diameter are planted in fertile, well pulverised soil in the nursery at 60 x 60 cm to 80 x 60 cm spacing in January-February. Singling of shoots should be done after one month of planting in the nursery.



Q9. What is the irrigation schedule for poplar in the nursery?

Ans. Irrigation is done by flooding the nursery bed. Plants should be irrigated at least once a week for ten months (until October). Subsequently, the frequency can be reduced to once every two to three weeks.

Q10. What are the management practices adopted in the nursery for growing poplar?

Ans. Regular weeding and soil work should be carried out. Application of well decomposed farm yard manure @ 20 to 25 tonnes/ ha at the time of soil work is very effective. Application of urea @ 0.1 tonnes/ ha in two split doses should be applied during early May and early June. Shoots longer than 15 cm should be removed once every 30 – 45 days by cutting off close to the stem. Before the onset of the monsoon, shoots and leaves below 1 m height of the stem should be clipped off. Plants reach about 3 to 5 m height at the end of one year and are ready for outplanting.

Q11. What precautions should be taken to avoid insect pests and diseases in the nursery?

Ans. The cuttings should be immersed in clean water for 24 to 48 hours before planting. Pre-treatment with Bavistin (20 g per 100 L water) for 2 hours and Emisan (250 g per 50 L water) for 20 minutes should also be given to cuttings before planting. In termite prone areas, Chlorpyrifos 20 EC should be added @ 4 L/ha to the soil.

Q12. Which soil is most suitable for poplar planting?

Ans. Sandy loam soil is best for planting poplar.

Q13. What are the pre-planting operations to be adopted for poplar?

Ans. The best time to plant poplar in the field is January. Entire transplants are planted in 100–120 cm deep pits dug by augers. Farm yard manure (1 kg), single super phosphate (50g), muriate of potash (25g) and phorate (15g) per plant in the pit are applied at the time of planting for better growth.

Q14. What is the planting geometry of poplar in the field?

Ans. The species is suitable for block, boundary and row plantation. Spacing adopted for a block plantation is 5 x 4m or 4 x 4m spacing; on boundaries or as a row within a field, it is planted at 3m spacing.

Q15. Does poplar require irrigation?

Ans. Yes, poplar thrives only under proper irrigation and is usually planted in the agroforestry system, which is frequently irrigated. The first irrigation should be provided on the day of planting. Thereafter, one irrigation per week during the summer of the first year and one irrigation every fortnight during the summer of the second year onwards are essential. After the rainy season, irrigation may be done once every two weeks.

Q16. What is the best time for pruning?

Ans. The best time for pruning is December-January (extendable to February) when the trees are leafless.

Q17. How should pruning be done?

Ans. Pruning aims to remove multiple stems to allow growth of a single shoot. Side branches on lower 1/3 of the stem should be removed during the second and third years. Pruning should be close to the stem without leaving a stub on the stem so that the lower half of the tree stem remains clean.

Q18. What are the suitable crops that can be grown with poplar?

Ans. Kharif as well as rabi crops such as wheat, mustard, sugarcane, vegetables, pulses etc. can be grown in the field throughout the poplar's rotation.

Q19. In a block plantation, what crops can be grown with poplar?

Ans. In block plantation, the usual kharif crops can be grown for the first two years. Subsequently, shade-bearing crops like ginger, turmeric, etc. can be planted. Rabi crops can be grown as usual.

Q20. What are the popular agroforestry models with poplar as the tree component?

Ans. The following tree-crop models are practised by farmers: Poplar-wheat, poplar-maize, poplar-sugarcane, poplar-mustard, poplar-radish, poplar-turmeric, poplar-amorphophallus, poplar-lemon grass, poplar-mango-mustard, poplar-mango-turmeric, poplar-aloe vera, poplar-mung bean, poplar-banana, poplar-litchi, poplar-janera (fodder) and poplar-tobacco.

Q21. What is the rotation period of poplar?

Ans. The rotation period of *P. deltoides* under agroforestry in fertile soils and sufficient irrigation is about 6 years. In less intensively managed plantations, the rotation age is 8 to 10 years. With modifications in veneering machinery and intensive care, farmers can harvest it in 4 years.

Q22. What are the important clones of poplar available for planting?

Ans. Many clones are available in the market. Some of them are G-48, S7C8, S7C15, L-34, L-49, L-52 and WSL-series clones. ICFRE-IFP Ranchi released five clones for planting in Bihar: IFP-BPA-38 (Arambh), IFP-BPA-30 (Kshitij), IFP-BPA-33 (Rohini), IFP-BPA-34 (Khushi) and IFP-BPA-41 (Lakshmi). FS-series and AM-series clones of ICFRE-FRI are under field testing.

Q23. What is the expected economic returns from poplar cultivation?

Ans. The poplar+wheat+millet in boundary plantation accounted for net profit of Rs. 3.34 lakh/ha/year. For poplar+mustard+maize in boundary plantation, net profit of Rs. 1.55 lakh/ha/year were recorded. A net gain of about Rs. 17 lakhs and Rs. 19 lakhs per ha was observed from poplar - chitrak (*Plumbago zeylanica*) and poplar - shatavar (*Asparagus racemosus*) models respectively.



Q24. What is the potential demand of poplar in the market?

Ans. Poplar is in high demand in the plywood industries in Haryana, Punjab and Uttar Pradesh. The India plywood market reached a value of Rs. 195.8 billion in 2021-22, a substantial part of which was accrued from poplar. Looking forward, IMARC Group expects the market to reach Rs. 297.2 billion by 2027-28.

Q25. What is the market price of poplar wood?

Ans. The market price in 2023 is around Rs. 1300 per quintal in Yamuna Nagar, Haryana. However, the price fluctuates from year to year and was about Rs. 400 per quintal in 2018. The market price in other places is relatively low due to lack of poplar-based industries.



Poplar on boundary of field with rabi crop in Uttar Pradesh



Block plantation of poplar in Punjab



Poplar with wheat



Poplar Mango Turmeric Model in Bihar

Populus ciliata

Q1. What is the common name of *Populus ciliata*?

Ans. Pahari Pipal

Q2. What are the vernacular/ local names?

Ans. White Poplar, Pahari Pipal, Kramal, Safeda, Ban Pipal (Himachal Pradesh), Ulad (Ladakh UT), Biaon, Piplas, Pahari Pipal, Syan (Uttarakhand)

Q3. What type of tree is Pahari Pipal?

Ans. It is a moderate to large size tree (up to 36m height and 4m girth). It is a light demander, frost-hardy tree with vigorous pollarding and poor coppicing capacity.

Q4. What is the flowering and fruiting time of Pahari Pipal?

Ans. Pahari Pipal is a dioecious tree. Individual flowers are either male or female. Flowering takes place during March-April and fruiting during May-June.

Q5. What is its geographical distribution?

Ans. It is mostly found in the temperate and cold desert regions of the north-western Himalayan states.

Q6. What is the natural habitat for Pahari Pipal?

Ans. It is mostly distributed in Jammu & Kashmir and Ladakh Union Territories, Uttarakhand and Himachal Pradesh at an altitude of 1200m to 3500m above msl.

Q7. In which agroclimatic zones can Pahari Pipal be grown?

Ans. Agroclimatic zone 1.

Q8. What are the uses of Pahari Pipal?

Ans. Pahari Pipal is suitable for plywood, hardboard, packing cases, matches and crates. It is also used as fuel wood during harsh winters by local communities and extensively looped for fodder for goats and other livestock. The poles are used as beams by the local communities for roofing in cold desert regions.

Q9. What is the rotation period for Pahari Pipal?

Ans. 6 to 10 years.

Q10. Which agroforestry systems are suitable for Pahari Pipal?

Ans. *P. ciliata* is planted under agri silviculture and silvi-pastoral systems in temperate and cold desert regions.

Q11. What is the optimum spacing for Pahari Pipal in agroforestry practices?

Ans. Pahari Pipal is usually grown at a spacing of 5 x 4 m or 4 x 4 m or 3.5 x 3.5 m under block plantation and in boundary plantations, trees are planted 2-5 m apart or in paired-rows in zig-zag pattern.

Q12. How is Pahari Pipal propagated?

Ans. It is usually propagated through cuttings. Besides this, poplar sticks 1.0 – 1.5m long with 2.5 - 3.5 cm diameter are also directly planted along the field boundaries and field bunds.

Q13. What are the nursery practices for Pahari Pipal?

Ans. Shoot cuttings (20cm long) with 1.5 to 2.5 cm diameter are planted in nursery beds at a spacing of 15 x 20cm or 20 x 20cm during the lean season. The stock is kept in the nursery for 1-1½ years and subsequently, the Entire transplants are planted in the field during spring.

Q14. From where can the planting material of Pahari Pipal can be obtained?

Ans. No clones of *P.ciliata* are available, however, quality planting material of *P.ciliata* can be obtained from forest/farmers nurseries for planting under agroforestry systems.

Q15. Can Pahari Pipal be raised as boundary/block/bund plantation?

Ans. Pahari Pipal can be raised as boundary, block or bund planting

Q16. Does Pahari Pipal plantation require protection?

Ans. Limited degree of protection and after-care of transplanted seedlings is required during early years for better growth and survival.

Q17. Does Pahari Pipal require irrigation?

Ans. It grows better under irrigated conditions.

Q18. What is the economics of raising a Pahari Pipal plantation?

Ans. The biomass yields of *P. ciliata* range from 2.6 to 4.5 tonnes per acre in 8 to 10 years and currently operational plantings have yielded over 4 tonnes per acre. The economics from poplar wood is Rs. 1.5 lakhs ha⁻¹ yr⁻¹ with a benefit-cost ratio of 1:2.13 (with intercropping) and 1:1.92 (without intercropping).

Q19. What is the potential market demand for Pahari Pipal?

Ans. The demand for *P. ciliata* is low compared to *P. nigra* in cold desert areas of Himachal Pradesh and Ladakh Union Territory. The poles of this poplar are also used as roofing material for houses in the Trans Himalayan Region.



Populus ciliata based agroforestry system

Populus nigra

Q1. What is the common name of *Populus nigra*?

Ans. Black Poplar

Q2. What are the vernacular/ local names?

Ans. Black Poplar, Frast, Farsh, Sufeda, Kramal (north western Himalayas), Ulad (Ladakh)

Q3. What type of tree is Black Poplar?

Ans. It is a light demander, frost-hardy, deciduous tree species that have very good pollarding and moderate coppicing capacity.

Q4. What is the flowering and fruiting time of Black Poplar?

Ans. Black Poplar is a dioecious tree. Individual flowers are either male or female. Flowering takes place during March-April and fruiting during May-June.

Q5. What is the geographical distribution of Black Poplar?

Ans. It is mostly distributed in Jammu and Kashmir and Ladakh UTs, Uttarakhand and Himachal Pradesh at an altitude of 2700m to 3500m above msl, especially in temperate and cold desert regions of north-western Himalaya.

Q6. What is the natural habitat for Black Poplar?

Ans. *P. nigra* is an exotic species, native to temperate Europe, introduced to Himachal Pradesh, Jammu and Kashmir and Ladakh UTs.

Q7. In which agroclimatic zones can Black Poplar can be grown?

Ans. Agroclimatic zone 1.

Q8. What are the uses of Black Poplar?

Ans. It is suitable for making plywood, hardboard, packing cases, matches, and crates and also are severely looped for fodder for goats. The poles of *P. nigra* are also extensively used as beams by the local communities for roofing purposes in cold desert regions.

Q9. What is the rotation period for Black Poplar?

Ans. The rotation period of Black poplar is 6-10 years.

Q10. Which agroforestry system is implemented for Black Poplar?

Ans. It is planted under agri-silviculture and silvi-pastoral system in the temperate and trans-Himalayan region.

Q11. What is the optimum spacing for Black Poplar in agroforestry practices?

Ans. It is usually grown at a spacing of 5 x 4 m or 4 x 4 m or 3.5 x 3.5 m under block plantation and in boundary plantations, trees are planted 2-5 m apart or in paired-rows in zig-zag pattern.



Q12. How the Black Poplar is propagated?

Ans. The planting stock of *P. nigra* is raised using shoot cuttings in the nursery.

Q13. What are the nursery practices for Black Poplar?

Ans. The nursery practices for Black poplar are the same as for Pahari Pipal.

Q14. From where the planting material of Black Poplar can be obtained?

Ans. Clones of *P. nigra* are not available, however, quality planting material of *P. nigra* can be obtained from forest/farmers' nurseries for planting under agroforestry systems.

Q15. Can Black Poplar be raised as Boundary/Block/Bund plantation?

Ans. Black Poplar can be raised as Boundary, block or bund planting.

Q16. Does Black Poplar plantation require protection?

Ans. It needs limited degree of protection during the early year of plantation establishment.

Q17. Does Black Poplar require irrigation?

Ans. It is grown under irrigated condition

Q18. What is the economics of raising Black Poplar plantation?

Ans. The biomass yields range from 2.60 to 4.50 tonnes per acre in 8 to 10 years. Recent plantings have yielded over 4 tonnes per acre. The economics from poplar wood is Rs. 1.5 lakhs ha⁻¹ yr⁻¹ with a benefit-cost ratio of 1:2.13 (with intercropping) and 1:1.92 (without intercropping).

Q19. What is the potential market demand for Black Poplar?

Ans. There is high demand for the poles of *P. nigra* in cold desert areas of Himachal Pradesh and Ladakh Union Territory. The poles of this poplar are widely used as roofing material in house construction in the Trans Himalayan Region.



Populus nigra based Agroforestry System

Santalum album

Q1. What is the common name of *Santalum album*?

Ans. Indian Sandalwood

Q2. What are the vernacular/ local names?

Ans. Chandana (Sanskrit); Sufaid Chandan (Bengali); Suket (Gujarathi); Chandan (Hindi; Marathi; Punjabi); Srigandha (Karnataka); Candana (Malayalam); Sandanam (Tamil); Chandanmu (Telugu).

Q3. What type of tree is Sandalwood?

Ans. It is a small to medium sized, evergreen, light demanding, partially root parasite tree.

Q4. What is the flowering and fruiting time of Sandalwood?

Ans. The tree flowers twice a year (May and November) and mature fruits appear during December and June.

Q5. What is its geographical distribution?

Ans. Distributed in tropical deciduous and moist semi-deciduous forests south of Vindhya mountains, ascending to 1500 m altitude.

Q6. What is the natural habitat for Sandalwood?

Ans. Core natural habitat is peninsular India with major distribution found in southern parts of Karnataka and Northern parts of Tamil Nadu.

Q7. In which agro climatic zones Sandalwood can be grown?

Ans. Agro climatic zones 2,8,9,10, 13.

Q8. Which are the non-traditional Sandalwood growing areas where Sandalwood is grown?

Ans. Andhra Pradesh, Assam, Gujarat, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Telangana, Uttar Pradesh.

Q9. What are the uses of Sandalwood?

Ans. Heartwood light yellowish-brown, hard, close grained, strongly sweet scented, used for wood carvings, ornamental boxes, burning in religious places and functions as a perfume, the preferred wood for funeral pyres. Oil from heartwood and roots has outstanding fixative properties, excellent tenacity, blending ability and fragrance is an ingredient in the manufacture of a variety of highly attractive and expensive perfumes, scented candles, soaps and incense. The oil has a lot of medicinal properties and is used in pharma and aromatherapy. The leaves, bark and sapwood are also used for various purposes.

Q10. Does Sandalwood oil has medicinal properties?

Ans. The oil has an array of ethnomedicinal uses. The antioxidant and antihyperglycemic potentials of α -santalol in oil is well documented. The antimicrobial and anti-proliferative property of the oil is attributed to its phytoconstituents like α -santalol, sesquiterpenoids, and shikimic acid.

Q11. What is the rotation period for Sandalwood?

Ans. Sandalwood sourced from natural forest has a rotation period of 27-30 years while from cultivated sources the rotation is 15-20 years.

Q12. When does heartwood formation start?

Ans. Heartwood formation initiates by 6-8 years.

Q13. Does Sandalwood require a host and what should be the characteristics of a suitable host?

Ans. Being a partial root parasite, it needs a host throughout for better growth. Hosts are classified as primary hosts or pot hosts (at sapling stage) and long term or permanent hosts. The suitable primary hosts are *Cajanus cajan*, *Alternanthera* spp., *Mimosa pudica*. The permanent hosts are to be selected that are suitable to the local conditions and agroclimatic zones. Host should not compete with sandalwood tree, not heavily branch and have a large crown; not have allelopathic effects, not be a source of pests or pathogens, and must provide intermediate returns.

Q14. What are the most prominent long term hosts for Sandalwood?

Ans. Some of the prominent permanent hosts include species such as *Phyllanthus emblica* (amla/Indian gooseberry); *Mangifera indica* (mango); *Psidium guajava* (guava); *Punica granatum* (pomegranate); *Annona squamosa* (custard apple); *Zizyphus mauritiana* (ber); *Citrus limon* (lemon); *Moringa oleifera* (drumstick tree); *Murraya koenigii* (Curry leaf), *Carica papaya* (Papaya). Some of the tree species such as *Casuarina equisetifolia*, *Acacia nilotica*, *Dalbergia latifolia*, *Azadirachta indica* can also be good hosts for Sandalwood.

Q15. Which agroforestry system is suitable for Sandalwood?

Ans. Silvi-horti system.

Q16. What is the optimum spacing for Sandalwood in agroforestry practices?

Ans. Spacing depends on the soil fertility and the host preference. The ideal spacing is 5 × 5 m, but under certain situations, 4 × 6 m or 4 × 4 m spacing can also be adopted. However, narrow spacing (4 × 4 m) may lead to competition for light, water and nutrients between sandalwood and its intermediate and long-term hosts.

Q17. How is Sandalwood propagated?

Ans. *S. album* is propagated through seeds. Sandalwood flowers and fruits twice a year -September to October and March to April. The fruits are depulped and seeds are pretreated with 500 ppm Gibberellic acid for 16 hrs.

Q18. What are the nursery practices for Sandalwood?

Ans. Pretreated seeds are sown in sand beds and germination is initiated in 21 days. Seedlings are transplanted at 2 to 4 leaf stage into 1500cc polybags with soil, sand and FYM in the ratio of 1:2:1 (v/v) ratio or 270cc root trainers with potting medium consisting of sand, soil, compost, burnt rice husk and charcoal in the ratio of 25:15:50:5:5. By the end of six months, quality seedlings of one foot height and 3mm collar diameter are ready for field planting. ICFRE-IWST, Bengaluru has standardised the entire process of producing healthy/quality seedlings through root trainers/polythene bags.

Q19. From where can the seeds of Sandalwood be obtained?

Ans. ICFRE-IWST, Bengaluru. Seeds sourced from Marayoor Sandal Reserve are sold by Kerala Forest Research Institute, Peechi.

Q20. Can Sandalwood be raised as boundary/block/bund plantation?

Ans. Sandalwood can be raised as boundary, block or bund planting. Predominantly, sandalwood is raised as block plantations.

Q21. Does a Sandalwood plantation require protection?

Ans. It needs intensive protection methods as it is liable for theft considering its high value for heartwood.

Q22. Does Sandalwood require irrigation?

Ans. The species can be grown both in irrigated and unirrigated conditions.

Q23. What is the economics of raising Sandalwood plantation?

Ans. Sandalwood-based agroforestry is financially viable based on the Equivalent Annual Income (EAI) and Land Expectation Value (LEV). The B/C ratio of 3.3 in 15 years and 1.9 in 20 years (at a 15% discount rate) and the IRR of 33% in 15 years and 21.62% in 20 years also indicate the financial viability of Sandalwood cultivation. Of the total cost, nearly 50% is the protection cost in private plantations. Field data to support most of these values are awaited. Generally, Sandalwood heartwood initiation starts by the end of 6 or 8 years with considerable variability for this trait. At the end of the rotation period of 20 years it is expected to produce 10 to 15 kg heartwood. A tree yielding 15kg heartwood and 6kg mixed wood was valued at Rs. 22,000/-. Karnataka Soaps and Detergents Limited (KSDL) has fixed rates at Rs 6400/kg for heartwood, Rs 2000/kg for mixed wood, Rs 80/kg for sapwood and Rs 30/kg for bark and chips.

Q24. What is the potential market demand for Sandalwood?

Ans. The projected market demand of sandalwood oil is more than 1 billion USD and is predicted to reach USD 197 million by the end of 2026. It is estimated that the demand of oil and heartwood in India would be 250 tonnes by 2040.





Sandalwood with Casuarina as host



Sandalwood with Papaya as host



Sandalwood with Mango as host

Gmelina arborea

Q1. What are the common names of *Gmelina arborea*?

Ans. Khamer, White Teak

Q2. What are the vernacular/ local names?

Ans. Gamhar, Khamer, Khumbhari, Sewan (Hindi), Bhadrarni, Gambhari, Gandhari, Kasmari, Krishnavrintaka, Sarvatobhadra (Sanskrit), Kumla, Kumalamaram, Ummithekku (Tamil), Gumartek, Gummadi (Telugu), Kumil, Kumbulu, Kumishu, Pokki (Malayalam) and Kulimavu, Kumbuda, Shivane (Kannada).

Q3. What type of tree is Khamer?

Ans. It is a medium to large sized, fast growing deciduous tree.

Q4. What is the flowering and fruiting period of Khamer?

Ans. Flowering takes place during February to April when the tree is more or less leafless whereas fruiting starts from May onwards up to June.

Q5. What is its geographical distribution?

Ans. It is indigenous to India and occurs naturally in latitudes ranging from 5° to 30°N and longitudes 70° to 110°E with an altitudinal range of 50 to 1300 m. It is found in both dry and moist deciduous forests.

Q6. What is the natural habitat of Khamer?

Ans. It is found in the dry and mixed deciduous forest types of Uttar Pradesh, Punjab, West Bengal, Assam, Andhra Pradesh, Odisha, Tamil Nadu, Kerala, Karnataka, Maharashtra, Gujarat and Madhya Pradesh.

Q7. In which agroclimatic zones can Khamer be grown?

Ans. The tree can be grown in the zones 9,10,11 and 12.

Q8. What are the uses of Khamer?

Ans. The wood is mainly used for furniture and construction purposes, pulp, particle board, plywood, matches, carpentry and packing cases, boards, carving and musical instruments. Leaves are used as a fodder for cattle, rearing silkworms. The trees are grown as a shade tree for coffee and cocoa. The wood bark and root is used for preparation of various ayurvedic products as it is a component of *Brihad Panchamoola*.

Q9. What is the rotation period for Khamer?

Ans. *G. arborea* can be harvested 4 to 5 years after planting for paper and pulp industries. If the end use is timber, the trees can be harvested at the end of 10 – 12 years.

Q10. Which agroforestry system is implemented for Khamer?

Ans. Agri-silvi and silvi-horti system.

Q11. What is the optimum spacing for Khamer in agroforestry?

Ans. The recommended spacing under agroforestry systems starts from 4 x 4m to 6 x 6 m based on the soil type, irrigation facility and nature/type of intercropping.

Q12. How the Khamer is propagated ?

Ans. *G. arborea* is propagated both by seeds and vegetative means. Seeds are sown directly in root trainers or raised beds. Prior to sowing, seeds should be treated with GA₃ (200 ppm) for better germination. The seeds are short-lived.

Q13. What are the nursery practices for Khamer?

Ans. Pretreated seeds are sown in sand beds and germination initiates within 10-12 days, Seedlings are transplanted at 2 to 4 leaf stage to 1000cc polybags with soil, sand and FYM in the ratio of 1:2:1.

Q14. Where can the QPM of Khamer be obtained?

Ans. QPM of Khamer can be procured from ICFRE-TFRI, ICFRE-IFGTB, ICFRE-IFP and ICFRE-RFRI. The ICFRE-IFGTB has developed high yielding clones. Multi-site testing of the clones is underway. The institute is supplying quality planting stock (seedlings) from seed orchards also.

Q15. Can Khamer be raised as boundary/block/bund plantation?

Ans. Yes, Khamer can be raised as boundary, block or bund planting. Predominantly, Khamer is raised as block plantations.

Q16. Do Khamer plantations require protection?

Ans. During the initial stages of establishment, it is easily susceptible to browsing by domestic animals. Hence sufficient protection should be provided.

Q17. Does Khamer require irrigation?

Ans. Yes, it grows well under irrigated conditions.

Q18. What is the economics of raising a Khamer plantation?

Ans. *Gmelina* is easily marketable due to its timber quality. The economics has been calculated based on the growth in farmers' fields of Madhya Pradesh. Under intensive management, *Gmelina* produces pulpwood @120-150 tonnes/ha with good management practices and fetches Rs. 8,000 / tonne. Well grown *Gmelina* (12-15 years) fetches Rs. 15,000-18,000 / tonne in the timber market.

Q19. What is the potential market demand for Khamer?

Ans. *Gmelina* has been widely planted in the past two decades to meet domestic demands of wood. Sawmills report a higher consumption of *G.arborea*, almost on par with teak due to higher recovery and easy workability.



Block plantation of *Gmelina arborea*



Gmelina with *Zea mays*



Gmelina with *Cajanus cajan*



Tectona grandis

Q 1. What is the common name of *Tectona grandis*?

Ans. Teak

Q 2. What are the vernacular/ local names?

Ans. Sagwan (Hindi), Thekku (Malayalam), Sagwan (Marathi), Saguan (Kannada), Singuru (Oriya), Tekkumaram (Tamil), Adaviteeku (Telugu).

Q 3. What type of tree is teak?

Ans. Teak is a large deciduous light demanding tree, attaining a height of 40 m, and girth of more than 1.5m.

Q 4. What is the flowering and fruiting time of teak?

Ans. Flowering occurs from June to September and fruits can be collected from November to January. Teak starts flowering at the age of six years. Profuse flowering occurs after 15 years.

Q 5. What is the geographical distribution of teak?

Ans. Teak is native to India. It occurs naturally below 24°N latitude in a variety of habitats and climatic conditions ranging from arid areas with only 500 mm to very moist forests with up to 5,000 mm of annual rainfall. Teak grows in regions with an average rainfall of 1,250–1,650 mm with a 3–5 month dry season.

Q 6. In which agroclimatic zones can teak be grown?

Ans. 2, 3, 7, 8, 9, 10, 11 and 12.

Q 7. Why is teak the most preferred wood?

Ans. Teak is a versatile wood of high strength, flexibility during woodworking, high resistance to rot and weather elements and low shrinkage ratio. The wood is used for ship and boat building, wood flooring, wood panelling, carving, furniture, veneer, window frames and indoor and outdoor structural beams. The teak wood has been used for decking, deck houses, rails, bulwarks, hatches, weather doors and planking.

Q 8. What is the rotation period for teak?

Ans. The rotation period of teak in India varies according to the site conditions, environmental factors and management. In Madhya Pradesh teak plantations have 80 years rotation, 50 to 60 years in Kerala and 40 years in Maharashtra. Canal bank plantations in Tamil Nadu have a 40 year rotation. Presently, efforts are on to reduce the rotation age to 25 years with increase in productivity in farmlands using clonal material and through silvicultural interventions such as irrigation, fertilizer application and management.

Q 9. What are the suitable agroforestry practices and intercrops for teak?

Ans. Teak is one of the most important and preferred tree species largely planted by farmers in different planting systems such as block, bund, and paired row system of planting along with different agriculture and horticulture crops. It is planted in different models, combinations and espacements. The popular agroforestry models practised in India are presented here.

Agroforestry models involving teak as the major tree crop

S.No.	Name of Agroforestry systems	Details of systems
1	Agri- silvicultural model	Teak + casuarina with agricultural crops: maize, cotton, turmeric, tomato and chilly
2	Agri-silvi-horticulture model	Teak + coconut with agricultural crops plantain, turmeric, vegetables, maize and cotton Teak+ maize, cotton, turmeric, tomato +Guava, or Annona
3	Horti –Silvicultural model	Teak + coconut, sapota
4	Silvipasture model	Teak and Casuarina as tree components and Napier and Guinea as pasture components

Q 10. What are the effective silvicultural techniques to be adopted in Teak?

Ans. A suitable land with good soil and rainfall of > 1200 mm may be selected for raising teak plantations. The plants are planted in pits of size 45 x 45 x 45 cm in 2 x 2 m or 3 x 3 m or 3 x 4 m spacing. During the establishment phase, the plants have to be watered weekly with regular weeding. The branches have to be removed periodically without affecting the main stem. Application of 50 g of urea and 30 g of super phosphate after six months and 75 g of urea and 60 g of super phosphate after 24 months of planting increases the growth rates. Thinning (removing alternate rows) is done 5 years and 10 years after planting in plantations with closer spacing (2 x 2m). Teak can also be planted in bunds in the south and north direction.

Q 11. Are there differences in the wood properties of short and long rotation teak?

Ans. It is reported that there was no significant variation between wood properties of young (25 to 30 years old) and mature teak (50 to 60 years old). Therefore teak plantations raised with good quality planting material or clones in good soil with limited irrigation and dry period with silvicultural practices can be harvested within 20 to 25 years. In Brazil and Malaysia, teak is harvested at the age of 15 to 20 years and is imported to India. The teak growing in the canal areas in Thanjavur and Tiruvarur (Tamil Nadu) shows fast growth with good girth (> 150 cm) within 20 years and canal teak is harvested at the age of 30-40 years.

Q 12. How is teak generally propagated?

Ans. Teak is generally propagated through seeds and stumps derived from seedlings.

Q 13. What are the nursery practices for propagation through seeds?

Ans. Pre treatment of seeds by alternate wetting and drying for a week improves germination to 30 to 50%. The seeds are sown at 1 to 1.5 cm depth in the raised open nursery beds of



- size 10 x 1 m (sand, soil and manure) and watered regularly. Germination starts 15 days after sowing and continues up to 50 days.

Q 14. What is the most popular planting material used in Teak?

Ans. Apart from seedlings, stumps are also used in planting.

Q 15. Do we have identified seed sources to obtain quality seeds of teak?

Ans. Yes. About 5000 ha of seed production areas and 1000 ha of clonal seed orchards has been established in India by different state forest departments in different teak growing states.

Q 16. What is the status of clonal teak in India?

Ans. Clonal teak plantations, an essential aspect of teak wood production, are underrepresented in India. The ICFRE-IFGTB has developed a tissue culture protocol for large scale multiplication of selected teak genetic resources. Field testing of tissue culture raised teak clones is under progress and early results showed the superior performance of clones in farm forestry plantations. The tissue culture teak seedlings are available for commercial sale from ICFRE-IFGTB to the stakeholders.

Q 17. Does teak require irrigation?

Ans. Teak responds well to irrigation. Drip irrigation is beneficial in farm lands, enhances productivity and reduces the rotation period.

Q 18. What is the economics of raising a teak plantation?

Ans. The mean annual increment of the Geographical Indicator tagged Nilambur teak plantations of Kerala ranges from 0.97 to 5.64 cu m/ha/year, and the average productivity is 2.85 cu m/ha/year in a 53 year rotation period. The benefit cost ratio was 1:9.31 in horti-silvicultural agroforestry system at the end of 17 years, and at the end of 28 years, the benefit-cost ratio was 3.23. In a three-tier agroforestry system for paddy growing areas, the benefit cost ratio was 5.30 (Handa, 2019).

Q 19. What is the potential market demand for teak?

Ans. The production of teak in India is considered to be less than 3% while the demand against this calculates up to more than 50%. With increasing prices due to low harvests in India (around 50,000 cu m/annum) and significant demand, imports have been increasing. From 2009 to 2019, India imported about 10 million cu m of round wood and 900,000 cu m of sawn/chipped teakwood.



Row planting of IFGTB teak clones in Tamil Nadu (left) and Chattisgarh (right). Teak Turmeric Agroforestry Model

Azadirachta indica

Q1. What is the common name of *Azadirachta indica*?

Ans. Neem

Q 2. What are the vernacular/ local names?

Ans. Neem (Hindi), Veppu (Malayalam), Nimba (Marathi), Vepamaram (Tamil), Vepa (Telugu), Bevu (Kannada)

Q3. Why is the Neem tree considered so important?

Ans. Neem has been used since ancient times as an insecticide, insect repellent, oral dentifrice, and in traditional medicine to treat malaria, diabetes, worms, and cardiovascular and skin diseases. The species was designated as the "Tree of the Twenty-first Century" by the United Nations due to its versatile nature, potential uses, and global importance. Plantations of Neem on a large scale can help rehabilitating degraded forest area and vast tracts of wastelands as well as greening the environment.

Q4. What is the natural habitat for Neem?

Ans. Neem grows well in arid, semi-arid and sub humid region of India and has been found suitable for planting in more than 300 mm annual rainfall. However, Neem does not tolerate frost and is not fit for growing at higher altitudes where temperature goes below 4°C for prolonged periods.

Q5. What is the geographical distribution of Neem?

Ans. The number of trees growing in India is estimated to be 25 million with the highest in Uttar Pradesh (55.7%), followed by Tamil Nadu. (17.8%) and Karnataka (5.5%). The other part of India where neem tree is growing naturally or habituated includes Rajasthan, Andhra Pradesh, Gujarat, Assam, Bihar, Delhi, West Bengal, Haryana, Maharashtra, Madhya Pradesh, Punjab, Odisha, Andaman and Nicobar Islands.

Q6. In which agroclimatic zones can neem be grown?

Ans. It can be grown in agroclimatic zones of 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14.

Q7. What are the commercial uses of the neem tree?

Ans. Neem is a multipurpose species, an eco-friendly and bio-degradable pesticide, organic fertilizer, used in cosmetics and toiletries, traditional medicines, pharmaceuticals and to a small extent in the furniture industry. The wood is moderately heavy with uneven grains, durable and not easily attacked by insects. Timber is medium refractory and seasons well even when sawn wet. The wood is used as posts, beams, door / window frames, small furniture, carts, axles, ship and boat building, helms and oars, oil mills, cigar boxes, carved images, toys and agricultural implements.

Q8. How is Neem propagated?

Ans. Neem is propagated through seeds. However recently clonal stock have also been made available through rooting of cuttings and tissue culture.

Q9. When does Neem fruit and flower?

Ans. The tree flowers once a year in April –May and fruits mature from June –July.

Q10. What are the nursery practices for propagation Neem?

Ans. Fresh matured yellow fruits are pre-soaked for 24 h in cold water. Removal of the endocarp increases its germination capacity. During July - August, de-pulped seeds are sown at 2.5 cm depth and at 2 to 5 cm distance and lightly covered with soil. After 15 to 21 days of sowing, germinated plants are pricked out and transplanted in 10 x 25cm poly bags (1:1:1; FYM: Sand and Clay). Germination of neem seeds varies from 15% for stored seeds and 85% for fresh seeds. After 3 to 6 months, the seedlings are ready for field planting.

Q11. Does neem require irrigation?

Ans. The species can be planted both in rainfed areas and in irrigated conditions. The species has been successfully introduced even in regions with low rainfall of 200-250 mm. Watering is essential during the first two years for proper establishment of the seedlings where rainfall is scanty.

Q12. What is the rotation period for neem?

Ans. The rotation age varies with management practices. The rotation age for timber can be for 20-25 years extending to 40-50 years in arid and semi-arid regions. For fuel wood it is usually 8-15 years.

Q13. Which are the common agroforestry systems adopted for Neem?

Ans. Both block and border (bund) planting are adopted.

Q14. What is the optimum spacing used for planting Neem?

Ans. Four- to six-month-old seedlings may be planted in the field at 6 x 6 m, 10 x 10 m or 5 x 16 m spacing in a block plantation. A distance of 5 m between plants is adopted for bund planting.

Q15. What are the intercrops for Neem agroforestry system?

Ans. Pearl millet, mung bean, cowpea, soyabean, cotton, cluster bean, wheat, barley, mustard, castor oil are usually intercropped with neem in traditional agroforestry practices by farmers especially in the arid and semi-arid regions.

Q16. What are the silviculture practices recommended for Neem?

Ans. Neem seedlings should be pruned after five years and two-third lopping in a year is best for leaf fodder and inter-crop yield production.

Q17. Are there any high yielding varieties of Neem available?

Ans. The ICFRE-FRI has released six high yielding neem varieties namely, FRI-IFFCO-112, FRI-IFFCO-107, FRI-IFFCO-547, FRI-IFFCO-108, FRI-IFFCO-109, FRI-IFFCO-M6 suitable for northern India. These varieties are readily available at ICFRE-FRI. ICFRE-AFRI and ICFRE-IFGTB also provide high quality seedlings of neem to stakeholders.

Q18. What are the special features of the varieties released by ICFRE-FRI?

Ans. The six improved varieties of neem are reported to start flowering from 3rd years onwards and have high oil content (average 38 %) and azadirachtin (average 8522 ppm) content.

Q19. What is potential market value for neem and its products?

Ans. Urea coated with neem oil has been given priority by the Government of India to minimize the losses of nitrogen, enabling farmers to earn more vis-à-vis help in reducing subsidy by up to Rs. 6,500 crore. The Government has removed the cap on neem coated urea which can now be produced 100%. The market value of timber is between Rs. 800 to Rs.1200 per cubic feet. On an average, neem seed yields 30% to 40% oil content and is widely used in pharmaceutical preparations. Neem oil rich in azadirachtin is used as insect repellent. Neem bark yields 12 -14% tannin and neem cake is an excellent organic fertilizer. India occupies first place in production of neem seeds and annually about 4 lakh tonnes of seeds are produced which yields 0.9 lakh tonnes of neem oil and 0.35 lakh tonnes of neem cake.

Q20. Is there any market available for purchase of Neem fruits?

Ans. The urea manufacturing firms purchase neem fruits. Collections centres have been opened by IFFCO and NFCL in Northern and Central India and the price of fruit varies from Rs. 15 to Rs. 22 per kg.



Neem based agroforestry in Rajasthan



Bund plantation neem on farmland in Gujarat

Aquilaria malaccensis

Q1. What are the common names of *Aquilaria malaccensis*?

Ans. Agar tree, Agarwood, Malayan Eaglewood.

Q2. What are the vernacular/ local names?

Ans. Agar (Hindi), Attar (Urdu), Aghil (Tamil), Aguru (Sanskrit, Telugu, Kannada), Agor (Bengali), Sasi (Assamese).

Q3. What are the characteristics of an agar tree?

Ans. It is a tropical evergreen tree 18-20 m tall. It can attain a height of 40 m and a diameter of about 60 cm.

Q4. What is its geographical distribution?

Ans. Agar tree is native to South-East Asia and widely distributed from the foothills of Himalayas to the rainforests of Papua New Guinea.

Q5. What is the natural habitat of agarwood?

Ans. India is the home to three species of *Aquilaria*. Of these, only two are agarwood producing. *A. khasiana* is found in Khasi Hills of Meghalaya. *A. malaccensis* is native to the North Eastern states and West Bengal. It grows at elevations from a few metres to about 1000 m above sea level. It can grow on a wide range of soils, including poor sandy soil. *A. macrophylla* is restricted to the Nicobar islands and is not considered in the agarwood category.

Q6. In which agroclimatic zones can agarwood grow?

Ans. Agroclimatic zones 2, 3, 4, 10 and 12.

Q7. Which are the non-traditional agarwood growing areas?

Ans. Kerala, Tamil Nadu, Karnataka, Maharashtra, Uttar Pradesh, Bihar.

Q8. What are the uses of agarwood?

Ans. The essential oil extracted from agarwood is valued for religious practices, aroma industry, medicine, as a tea, and as an air freshener and purifier. It is also used in ornament making like bead strings, carvings, wines, burial and death rites, etc.

Q9. Does agar oil has medicinal properties?

Ans. The oil has anti-rheumatic, anti-inflammatory, analgesic, carminative and stomachic properties. The oil can help detoxify the body, clean out excess salt and uric acid, repair damaged skin cells, and have anti-oxidant properties. It is also useful in relieving delivery pain and treating attention deficit disorder.

Q10. In which agroforestry system is the agarwood commonly found?

Ans. Silvi-horti-pastoral system.

Q11. How is the agar tree propagated?

Ans. Mainly through seeds.

Q12. What is the flowering and fruiting time of agarwood?

Ans. June to August.

Q13. What is the viability of the seeds?

Ans. Seeds are viviparous, as they germinate while still attached to the tree. They are recalcitrant and remain viable for a very short period of time, around one week. Therefore, they should immediately be sown in seed beds.

Q14. What are the nursery practices for agarwood?

Ans. Seed germination is epigeal. Seeds are sown in sand beds or in root trainers containing a soil, sand, and well-decayed cow dung mixture (1:1:1) at a depth of 1–1.5 cm. Germination starts after six days and completes within one month. When the seedlings are 3-5 cm tall (after 40–45 days), they are transplanted into polythene bags. Seedlings are ready for field planting once they are 30 – 35 cm tall.

Q15. From where the seeds of Agar tree can be obtained?

Ans. Seeds can be obtained from the home gardens of upper Assam. Graded seeds give better results.

Q16. Can agarwood be raised as boundary/block/bund plantation?

Ans. Agarwood is mostly raised as block plantations, though it can be raised as boundary, block or bund crop. In tea gardens of upper Assam, it is also grown as a shade tree. It can also be grown as avenue trees and in home gardens due to its canopy.

Q17. What is the best planting time, method and spacing?

Ans. Agar plantations are established during May to September. Saplings are planted in 50 x 50 x 50 cm pits and staking is done to keep the seedlings upright. Spacing of 2.5 x 2.5 m is ideal spacing for block and 2.5 m distance for boundary plantation.

Q18. What is the requirement for manures and fertilisers in Agar tree plantation?

Ans. Prior to planting, FYM may be applied at 10-15 kg per pit, and watering should be done until the establishment of the saplings. In the second year, NPK in the ratio 10:10:4 is applied at 200 g/tree followed by 400 g/tree and 500 g/tree in the third and fourth years, respectively. From the sixth year onwards, an additional dose of nitrogenous fertiliser of 400–500 g per tree per year may be applied. Fertiliser should be applied along with decomposed cow dung/ FYM and should preferably be applied in two splits, one during the onset of the monsoon and the other at the cessation of the monsoon. This splitting enables easy insect borer invasion followed by fungal infection.

Q19. What after-care is to be adopted after planting?

Ans. Weeding is to be carried out regularly, with hoeing around the seedlings at a radius of 50 cm once in 3-4 months.



Q20. Does Agar tree require irrigation?

Ans. Agarwood can be grown both in irrigated and unirrigated conditions.

Q21. Does Agar tree plantation require protection?

Ans. It needs intensive protection methods as it is liable for theft considering its high value for wood.

Q22. What are other plant species that can be grown along with the Agar tree?

Ans. Agar tree may be grown in combination with patchouli, sarpagandha, jatropa, pepper, tamul, coconut, sugandhmantri, kalmegh, gathion, and other agricultural crops. Turmeric, ginger, pineapple etc. may be planted leaving about 50 cm around the plant base. Tree species like Gamari, Kadam, titasopa may also be planted along with agarwood trees.

Q23. What is the harvesting schedule of Agar trees?

Ans. Age, growth rate, wood volume or physiological maturity does not govern the harvesting time. Only the infected trees that produce agarwood and oil are harvested, as the growth of these trees is often arrested due to physiological imbalance. Such trees exhibit considerable signs of infection and are considered ready for harvesting. There is no specific schedule for harvesting, which can be done throughout the year. However, harvesting during February to May is found to be the best, due to the maximum concentration of oil and low amounts of waxy substances in the wood.

Q24. How does resin formation take place in the agar tree?

Ans. Agarwood is the resinification of accumulated oleoresins caused by microorganisms. When the stem is injured or bored by the larvae of a stem borer, *Zeuzera conferta*, then infection by the fungus occurs. The borer makes tunnels inside the tree trunks. Fungi enter the plant through this pore, creating either vertical or-zigzag tunnels inside the stem, which serve as the initial sites of infection. The fungal infection takes a long time to mature, and 50 year old trees have the highest concentration of oil (2.5-5.0 kg/tree)

Q25. What are the external symptoms for identification of Agarwood formation in trees?

Ans. Appearances of borer holes and oozing of watery substances from new borer holes, accumulation of frass at the base of the tree, small spindle-shaped marks on the trunk caused by the closing of borer holes due to growth of host tissue, longitudinal cracks or fissures on the trunk/bole and appearances of hordes of ants in the fissure and formation of ant nests. Overall, the infected tree is distinct from a healthy tree, displaying a poor crown with dried and decayed branches, an uneven bole with stunted growth, swelling or depression, and sometimes canker formation on the bole/tree, creating a hollow sound when hammered, and smaller and yellowish leaves.

Q26. In which area the agarwood trees naturally infected?

Ans. Trees are naturally infected in its natural habitat, particularly in Golaghat, Jorhat, Sivasagar districts of Assam and few areas of Nagaland adjoining Assam border.

Q27. How is artificial inoculation done in agar trees?

Ans. A common practice for early infection is wounding the trunk of the tree to facilitate the formation of agarwood. This is done just before spring by making a deep slanting cut

in the tree trunk with a sharp knife (*Dao*). Injuries facilitate infection and create a stress condition that helps spread the infection. Under favourable climatic conditions, this practice yields better results. These cut injuries serve as initial sites of fungal infection. A 20-year old tree produces only 5–10 kg of distillable wood without any treatment. Mechanical injuries produce more than 30 kg in about 2 years.

In artificial inoculation, 6–8 holes of 1.0–1.5 cm diameter are made on the tree trunk at a distance of 30 cm, followed by the inserting of suitable inoculum, and the holes are plugged with cotton for 6-7 months. The holes are reopened later to provide a suitable environment for a fungal infection. In this method, essential oil production starts after 9–10 months.

Q28. Is there any inoculum available for artificial induction of agarwood?

Ans. ICFRE-RFRI, Jorhat has released fungal inocula for artificial of Agarwood in *A. malaccensis* for marketing in the brand name of product “Sasi Inoculant”. It is available in two forms i.e. liquid and paste. The product can be purchase from ICFRE-RFRI, Jorhat, Assam.

Q29. What is the procedure to use Sasi Inoculant?

Ans. On the tree trunk (aged 8 to 10 years), using a drill machine, almost 10 to 15 holes are to be made spirally, one foot apart. The inoculum is introduced into the holes using a syringe and then plugged. After two years the trees are ready for harvest.

Q30. Has the Sasi Inoculant been used by farmers?

Ans. The Sasi Inoculant, sold by ICFRE-RFRI was used to infect 1000 trees in Tripura (8 districts), 184 trees in Meghalaya (6 districts) and 659 trees in North Bengal (2 districts). Farmers of Tripura and Meghalaya sold such artificially inoculated agar trees at a rate of Rs. 90,000/- per tree.

Q31. Can the technology for production of Sasi Inoculant be transferred to private agencies?

Ans. ICFRE-RFRI, Jorhat may enter into licence agreement with any commercial laboratory interested in production and marketing of Sasi Inoculant.

Q32. What is the optimum age for inoculating agar trees?

Ans. The tree should be about 6-8 years.

Q33. What is the estimated economics of cultivation per hectare?

Ans. Considering the harvest at the end of 15 years, the total expenditure for cultivation would be about 20 lakhs while the total return expected is about 2.3 crores. This situation prevails when the trees are in a block plantation with ~2000 trees per hectare.

Q 34. How is agarwood graded in the market?

Ans. The agarwood has different qualities or grades; similarly, essential oil (Oud oil) is also categorised into grades. The price varies depending on the quality. The major grades are:

1. *Boya* –Fat extracted from the uninfected wood. Extracted from a young tree, it fetches cheaper rates.
2. *Dum* – Oud oil extracted from mildly infected wood, mostly due to natural injuries. It is obtained from the broken ends of branches of young trees.



3. *Kolagachi* – Oud oil extracted from naturally infected wood. It is the highest quality oil in international trade.
4. *Batali mal*– A naturally infected wooden piece separated using batali (an indigenous chisel). They are in demand in perfumery.

Q 35. What is the market demand for agarwood?

Ans. Referred to as “Liquid Gold”, oud is distilled into an essential oil. In its purest form, oud oil can cost up to \$80,000 per litre. The global market for agarwood is estimated at \$32 billion. By the end of 2029, the market is expected to double to \$64 billion.



Agar trees in *Baree* system-mixed plantation



Agar trees in mixed plantations



Agar trees in block plantations



Agar trees in Tea garden

Vachellia nilotica (*Acacia nilotica*)

Q1. What are the common names of *Vachellia nilotica* (*Acacia nilotica*)?

Ans. Desi babul, gum arabic tree.

Q2. What are the vernacular/ local names?

Ans. Baval, babool, kalo baval, ram baval, gum-arabic.

Q3. What type of tree is babul?

Ans. It is a medium-sized thorny almost evergreen, straight or crooked tree with dark-blackish-brown, irregularly, longitudinally fissured bark. It attains a height of 20-25 m but may remain a shrub in poor growing conditions.

Q4. What is the flowering and fruiting time of babul?

Ans. Yellow coloured flowers appear during June to September and pods ripen during April to May.

Q5. What is the geographical distribution of babul?

Ans. *V. nilotica* trees can grow from sea level up to an altitude of 2000 m, on a wide variety of soils and climatic conditions. Natural babul forests are generally found in Maharashtra, Gujarat, Andhra Pradesh, Rajasthan, Haryana and Karnataka.

Q6. In which agroclimatic zones can babul be grown?

Ans. Babul can be grown in 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 zones.

Q7. What are the uses of Babul?

Ans. Babul yields timber, fuelwood, bark gum and fodder leaves. Timber is used for construction, agricultural implements, and sports and athletic goods. The wood makes excellent fuel, and the calorific value of heartwood is 4946 kcal/kg. The wood yields a high grade charcoal. The bark and pods of the tree is used for tanning by local tanneries. The tree yields a black gum known as Amravati gum or Indian gum arabic which is used for matches, ink paints, calico-printing.

Q8. Can babul be used in restoration programmes?

Ans. Yes, the species is used extensively on degraded saline/alkaline soils (pH 9) and soluble salt content below 3%. It can withstand tannery effluents, and colonises waste heaps from coal mines. Over 50,000 hectares of the Indian Chambal ravines were rehabilitated with *A. nilotica* by aerial seeding.

Q9. What is the rotation period for babul?

Ans. Trees can be harvested for timber after 20 years and for fuelwood from the 3rd year onwards.

Q10. Which agroforestry system is adopted for babul?

Ans. Agri-silvi system.

Q11. What is the optimum spacing for babul in agroforestry?

Ans. The ideal spacing is 5 × 5 m.

Q12. How is babul propagated ?

Ans. Babul is propagated through seeds. The seeds can be pretreated by soaking in cold water for 48 hours at room temperature; or immersing the seeds in hot water at 80°C and allowing it to soak until cool; or keeping the seed in moist cow dung heap for 2 to 3 days; or in concentrated sulphuric acid 10 to 14 minutes. Treated seeds are sown immediately.

Q13. What are the nursery practices for propagation of babul?

Ans. The treated seeds are sown during February and March in nursery beds either by broadcast sowing or dibbling, or in polythene containers. Two or three treated seeds are sown in each bag, about 1.5 cm deep. The soil mixture used in polythene bags is soil and compost in a 2:1 ratio. Germination commences one to three weeks after sowing and completes in a month's time.

Q14. Where can seeds of babul be obtained?

Ans. The seeds can be procured from forest nurseries and ICFRE institutes.

Q15. Can babul be raised as boundary/block/bund plantation?

Ans. Babul can be raised as boundary, block or bund planting. Predominantly, babul is raised as block plantations

Q16. Does Babul require irrigation?

Ans. It can be grown both in irrigated and unirrigated conditions.

Q17. What is the economics of raising babul plantation?

Ans. Under the paddy based agroforestry system a B/C ratio of 1.47 was recorded. The net income from the system over a ten-year period was computed as Rs 1.4 lakhs per hectare and at an IRR of 33% (at 12% discount rate).

Q18. What is the potential market demand for babul?

Ans. The species is in high demand in Rajasthan and Gujarat, especially in the handicraft industry. The farmers get Rs. 1000 per tree (> 15 years) and Rs. 0.3 to 0.9 lakhs/ha, depending on the stocking rate that makes the system economically viable.



Cluster bean with *A. nilotica* in traditional agroforestry in Rajasthan



Wheat with *A. nilotica* in traditional agroforestry in Rajasthan

Eucalypts

Q1. What are the commonly grown Eucalypts grown in India?

Ans. *Eucalyptus tereticornis* Sm., *Eucalyptus camaldulensis* Dehn. and the interspecific hybrids between the two species.

Q2. What are the vernacular/ local names?

Ans. Nilgiri and Safeda. Individually, *Eucalyptus tereticornis* is known as Mysore gum while *Eucalyptus camaldulensis* is called Red gum or River red gum. The term eucalypt implies species of genus *Eucalyptus*.

Q3. What type of a tree is a Eucalypts?

Ans. Eucalypts are fast growing, medium- large sized (up to 20-50 m height and up to 2 m girth), light demander species. They are moderately salt and drought tolerant and relatively fire resistant.

Q4. What is the flowering and fruiting time of Eucalypts?

Ans. The trees flower during July-August and fruiting occurs during September-October.

Q5. What are the suitable growing conditions for Eucalypts?

Ans. It grows under a wide range of climatic/soil conditions from warm to hot, sub-humid to humid and from good to degraded soils. It is the most suitable tree species for areas which receive 250 to 600 mm annual rainfall, although it can also grow well in high-rainfall areas (about 1250 mm). The average mean annual temperature required is 10-27°C, and the mean maximum temperature 22-42°C.

Q6. Does Eucalypts naturally grow in India?

Ans. Eucalypts are exotic tree species.

Q7. In which agroclimatic zones can they be grown?

Ans. Agroclimatic zones 1,3,4,5,6,7,8,9,10,11,12 and 13.

Q8. What are the uses of Eucalypts?

Ans. It is used in heavy engineering construction, such as railway sleepers. The leaves are used for the production of *Eucalyptus* oil. The other most important uses of *Eucalyptus* wood are for paper and pulp, plywood, construction, furniture, planks, poles, and agricultural implements. Green saw wood is used for boxes, pallets, bins, plank mouldings and scaffolds, the dried one is used as raw material for manufacture, moldings, and carpentry.

Q9. Do Eucalypts have medicinal properties?

Ans. The leaves produce oil which is used as a pharmaceutical, antiseptic, repellent, flavouring and fragrance agent. The oil comprises of α -pinene and 1,8-cineole as major constituents. The leaves are also a good source of ursolic and betulinic acid, which has wide range of pharmacological activities and therapeutic uses.



Q10. Which agroforestry system is adopted for Eucalypts?

Ans. Agri silviculture system.

Q11. How are Eucalypts propagated?

Ans. Eucalypts are usually propagated through seeds. Clones are propagated through cuttings.

Q12. What are the nursery practices for propagation through seeds?

Ans. Eucalypts are grown in the nursery by mixing the fresh, healthy seed with sand in a ratio of 1:1. Line sowing is done in nursery beds, 2-3 cm deep at 10 x 5 cm spacing. The seedlings, on germination, are shifted to polybags from the mother bed when they are 5 to 7 cm tall. Seedlings are ready to plant at the size of 30 cm in 4-5 months.

Q13. Where can the seeds of Eucalypts be obtained?

Ans. The seeds of different *Eucalyptus* species can be procured from ICFRE-FRI and ICFRE-IFGTB on prior demand.

Q14. What are the vegetative methods for propagation of clones?

Ans. Eucalypts are propagated vegetatively from coppice shoots, micro and mini-cuttings. Vegetative parts collected for propagation require a treatment of fungicide (0.1% Emisan or 0.05% Bavistin), followed by dipping in Indole Butyric Acid (4000 ppm). The cuttings are planted in root trainers, and maintained at high temperature (25-30°C) and humidity (80-90%) under control conditions. The cuttings root after 20-25 days and are shifted to hardening chambers for 20 days and later to open conditions before planting in field.

Q15. How are *E. hybrids* multiplied in the nursery?

Ans. Hybrids are raised vegetatively on a commercial scale using mini cuttings. The softwood cuttings from vegetative multiplication gardens are planted in mist chambers and after rooting, the plants are transplanted to root trainers.

Q16. Can Eucalypts be raised as boundary/block/bund plantation?

Ans. Eucalypts can be raised as boundary, block or bund planting.

Q17. What is the optimum spacing for Eucalypts in agroforestry practices?

Ans. The spacing recommended for Mysore gum trees are 3m×3m or 4m×2m for block and 2–5m for boundary plantation. 5 m x 2 m spacing supports intercropping up to 3 years in Agri-silviculture system.

Q18. Do Eucalypts plantations require protection?

Ans. It needs protection from wild and domestic cattle during the initial year of plantation establishment.

Q19. Do Eucalypts require irrigation?

Ans. Eucalypts can be grown both in irrigated as well as unirrigated conditions. They require periodic watering during the early stages of establishment.

Q20. Name some important clones of Eucalypts?

Ans. ICFRE-FRI released a hybrid clone FRI-EH-001 with a productivity of more than of 30 m³ per hectare per year. Clones IFGTB-EC-1 to IFGTB-EC-11, IFGTB-EH1, IFGTB-EH2 have been released by ICFRE-IFGTB for fast growth and resistance to gall infestation. During 2014-2019, 3750 ha of *Eucalyptus* plantations were planted using these high yielding clones yielding an additional farm income of around Rs. 30 crores to farmers due to increased wood production. Several private sector companies produce and sell *Eucalyptus* clones to the farmers. ITC clones are also popular among tree growers.

Q21. What is the rotation period for Eucalypts?

Ans. The rotation age depends upon the end use. Three to four year old trees are used for poles and as pulpwood, 6–8 years for plywood and 8-10 years for timber.

Q22. Do Eucalypts plantations require more water than other commercial tree species?

Ans. Eucalypts require 785 litres of water to produce one kg of total biomass, which is very low compared to Acacias (1,323 litres/kg), Dalbergia (1,484 litres/kg) and agricultural crops such as paddy rice (2,000 litres/kg) and cotton (3,200 litres/kg).

Q23. What is the yield of different *Eucalyptus* based agroforestry system.

Ans. Based on different agroforestry models developed by ICFRE, a rotation of 5 to 6 years can produce 3500 to 4000 quintal biomass per ha under block plantation with a spacing of 3 x 2 m. In bund plantations, with wheat/ paddy as the main crop, the a yield of 192 quintal and 210 quintal biomass per ha respectively could be obtained.

Q24. What are the economic returns expected from a *Eucalyptus* agroforestry system?

Ans. A tree can produce about 260 t/ha of biomass under agroforestry and 50–80 t/ha in boundary plantation. Under irrigated conditions a net income Rs. 0.95 to 1.25 lakhs ha / yr can be obtained. In the *Eucalyptus* silviblock model with 3 x 2 m spacing, the yield of *Eucalyptus* timber was 3523 q/ha. The net profit at a discount rate of 12% was Rs. 13.80 lakh with a B:C ratio of 2.25. In the *Eucalyptus* – wheat model with 3 m spacing, the yield of *Eucalyptus* was 325q/ha. The net profit at a discount rate of 12% was Rs. 4.49 lakhs with a B:C ratio of 1.14. In a *Eucalyptus* – paddy bund model with a distance of 3m, the yield of *Eucalyptus* was 325q/ha and 210q/ha for paddy. The net profit at a discount rate of 12% was Rs. 5.12 lakh with a B:C ratio of 2.38.

Q25. What is the market price of *Eucalyptus* wood?

Ans. The price of *Eucalyptus* wood in the market during February 2023 is around Rs. 300-500 per quintal (www.commodityinsightsx.com).





Eucalyptus with Sugarcane



Growth of *Eucalyptus* in agroforestry system



Eucalyptus in bund with wheat

Dalbergia sissoo

Q1. What are the common names of *Dalbergia sissoo*?

Ans. Shisham, Sissoo

Q2. What are the vernacular names of *Dalbergia sissoo*?

Ans. Hihu, Sisu, (Assamese) Shisku (Bengali), Shisham (Hindi), Agar, Shimshape, Shimshupa, Biridi (Kannada) Irupul, Iruvil, Oivala-sesba (Malayalam), Sissu, (Manipuri), Shisham (Marathi), Sisau (Nepali), Aguru, Agurushinshupa, Dhira, Dhumrika (Sanskrit), Gettesissoo, Nakkarkattai, Yettle, Nukkukatai (Tamil), Errassisso, Errassisu, Kara (Telugu), Sheesham (Urdu).

Q3. What type of tree is sissoo?

Ans. Sissoo is a medium to large deciduous tree with well-developed crown, thick bark and crooked stem.

Q4. What is the geographical distribution of this species?

Ans. Shisham occurs naturally throughout the sub-Himalayan tract and outer Himalayan valley from the Indus to Assam, usually at elevations of about 900 m, sometimes occurring up to 1500 m but occasionally ascending to 1500m.

Q5. In which agroclimatic zones can shisham be grown?

Ans. In the agroclimatic zones of 1, 2, 3, 4, 5, 7, 8, and 14, shisham can be grown

Q6. In which states is the species popular?

Ans. It is a prominent species of the middle Gangetic plains and is cultivated in Punjab, Haryana, Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Chhattisgarh, Maharashtra and lower hills and outer valleys of Uttarakhand and Himachal Pradesh.

Q7. What are the uses of shisham?

Ans. It is a multi-purpose tree and produces timber, fuel, fodder and also used medicinally in traditional therapy. The wood is suitable for making handles, for striking tools, scooping, cutting and shaping tools. It is good timber for windows and doors of houses. It is a preferred species for building railway coaches, trucks and lorry bodies.

Q8. How is shisham multiplied in the nursery?

Ans. Mostly through seeds. The seeds ripen during autumn. There are about 16000-18000 pods or 50,000-53,000 seeds/kg. The sowing season in north India is generally February to early March. The pods, each containing one seed, are sown and lightly covered with earth. Germination is rapid and completes within a month. Plants are ready for outplanting during monsoon.

Q9. How is shisham planted in the field?

Ans. It is planted in pits of size 30 x 30 x 30 cm during the onset of monsoon. The soil should be drenched with Chlorpyrifos 20 EC (@ 4 L/ha) in termite-prone areas.

Q10. What is the suitable spacing for shisham in the field?

Ans. The species should be planted at 5 x 5 m under block plantation or at a distance of 3 to 4 m on bunds.

Q11. Does shisham require irrigation?

Ans. The species survives well in porous soil with adequate moisture, mostly along rivers and streams in the Himalayan tract. Under agroforestry it can be grown without irrigation, however, irrigation during the first summer season is required to ensure better survival and growth.

Q12. What are the agricultural crops grown with shisham?

Ans. During the initial stages, crops like wheat, maize, mustard, millet, sesame and soybean, etc. can be grown. After 2 or 3 years, shade bearing crops like mung, ginger, turmeric, etc. can be grown in block plantations.

Q13. What is the rotation period of shisham?

Ans. The rotation of the natural crop in Uttar Pradesh is about 60 years, though under irrigated conditions, it is about 20 years.

Q14. Are there any high-yielding clones available for *Dalbergia sissoo*?

Ans. ICFRE-AFRI, Jodhpur has recently released three high yielding clones of Shisham - AFRI-DS1, AFRI-DS2 and AFRI-DS4. These clones are suitable for plantation in hot semi-arid and sub-humid tracts of Gujarat and uplands of Rajasthan.

Q15. What is the expected yield and monetary gains from ICFRE-AFRI Shisham clones?

Ans. For a 25-year rotation period of these clones, the total wood yield is expected to be 284 cum/ha (cubic metres per hectare) and a merchantable log yield of 84 cum/ha. A total income of Rs. 29.40 lakhs is estimated from the merchantable logs. An additional income from minor timber and fuelwood is estimated at Rs. 7.0 lakhs (@ Rs. 5/Kg for 140 tons/ha fuelwood). The gain from planting these improved clones developed by ICFRE-AFRI is estimated at Rs. 12.52 lakhs/ha with a mean annual benefit of Rs. 50,000/ha.

Q16. Is there any disease resistant variety of Shisham?

Ans. ICFRE-FRI released a variety viz. FRI-DS-14 resistant to dieback disease.

Q17. How much economic returns are obtained from shisham cultivation?

Ans. The mean annual increment (MAI) for a 20-year-old, non-irrigated plantation in the eastern plain region comprising UP, Bihar and Odisha was 11.2 m³/ha on good sites, 8.4 m³/ha on fair sites, and 5.9 m³/ha on poor sites. At the end of 20 years the system yielded a B:C ratio of 2.35.

Q18. What is the demand of shisham in the market?

Ans. The price of the *D. sissoo* wood in the domestic market is Rs. 800/- 1200/- Cft (cubic feet), depending on the quality and distance to source.



D. sissoo with wheat in Punjab



D. sissoo with Mustard in Punjab

Phyllanthus emblica (*Emblica officinalis*)

Q1. What are the common names of *Phyllanthus emblica*?

Ans. Aonla, emblic myrobalan, Indian gooseberry

Q2. What are vernacular names for Indian gooseberry?

Ans. Amla (Hindi), Amalaka (Sanskrit), Nelli (Malayalam, Tamil), Amalakamu (Telugu), Amlai (Bodo) Heikru (Manipuri).

Q3. What type of tree is Aonla?

Ans. It is a small to medium sized deciduous tree, reaching 8 to 18 m in height, and is known for its edible fruit. The tree has a crooked trunk and spreading branches. The leaves are simple, nearly stalkless, and closely set along slender branchlets.

Q4. What is the geographical distribution of Aonla?

Ans. The species is indigenous to the Indian sub-continent and distributed in deciduous forests in the greatest part of India. In India, its commercial cultivation is very common in Uttar Pradesh. Its intensive plantation is being done in the salt-affected areas of Uttar Pradesh.

Q5. What type of habitats is suited to grow Aonla?

Ans. It survives unusually cold winters in its natural habitat and often shows a remarkable ability to recover from cold injury. The tree can grow up to 1800 m altitude and can tolerate temperature up to 46°C.

Q6. In which agro-climatic zones does it grow well?

Ans. It can grow in the agroclimatic zones of 1, 2, 3, 4, 5, 6, 7 and 8.

Q7. In which states of India is it suitable for adoption in agroforestry?

Ans. Uttar Pradesh, Andaman and Nicobar Islands, Assam, Madhya Pradesh, Manipur, Odisha, Rajasthan, Gujarat, Tamil Nadu, Kerala, Maharashtra and Himachal Pradesh.

Q8. What are the uses of Aonla?

Ans. The fruit, rich in vitamin C and pectin, is highly medicinal and is edible fresh, pickled, or cooked. It is one of the most highly valued fruits in the Indian Systems of Medicine and is considered diuretic, laxative, antiarrhoeal, antipyretic, antiscorbutic, antitumor, astringent, expectorant, hypoglycemic, and ophthalmic. It is one of the major components of Chyawanprash, an important health promoting formulation. The red coloured wood is hard but flexible, though highly subject to warping and splitting. It is used for minor construction, furniture, implements, gunstocks, hookahs, and ordinary pipes. The wood also serves as fuel and a source of charcoal. The tannin-rich bark, fruits and leaves, are employed in conjunction with other fruits of various species of *Terminalia* called myrobalans. The dried fruit yields ink and hair dye and, due to its detergent properties, is sometimes used as a shampoo.

Q9. From which year does the tree start yielding fruits?

Ans. A well-managed tree of seedling origin starts yielding fruits in the third year and yields up to an age of 70 years. Grafted plants usually start fruiting in the first year.

Q10. What are best agroforestry practices?

Ans. The species can be used in agri-horticulture, silvi-horticulture and silvi-pasture systems.

Q11. What are suitable intercrops?

Ans. Green gram, black gram and sesame can be grown in *Kharif* season while in some cases depending upon soil type and irrigation facilities mustard or chickpea can also be grown during *Rabi* season. Vegetables (tomatoes, cauliflower, brinjal and onion), ginger, turmeric, flowers, pulses, grasses (*Napier grass*, *Sabai grass*) and a few medicinal /aromatic plants are well suited for intercropping in aonla orchards.

Q12. Which are the promising varieties used by farmers?

Ans. Varietal improvement works on Aonla was done at Narendra Dev University of Agriculture and Technology, Faizabad and in GAU, Gujarat. Narendra Aonla (NA) varieties namely Kanchan (NA 4), Krishna (NA 5), NA 6, Neelam (NA 7), NA 8, NA 9 and Balwant (NA 10) are commercially cultivated. Banarasi Chakaiya, Francis (Hathi Jhool), Anand- 2, Lakshmi-52, BSR-1 are other promising varieties.

Q13. How is Aonla propagated and planted?

Ans. Grafted or budded plants are planted 4-5 m apart under a square system of layout during July-August or February. Pits of 1-1.25 m size are dug 2 months prior to planting. Each pit is filled with thoroughly mixed and well composted farmyard manure, one kilogram of neem cake or 500 g bone-meal. In sodic soil, each pit is filled with 5-8 kg of gypsum as a soil amendment along with 20 kg sand. In the centre of each square of aonla plants, ber, guava and lemon are usually planted.

Q14. What is the recommended spacing for its planting?

Ans. The recommended spacing is 5 x 5 m for block planting and 8 x 8 m for agroforestry system.

Q15. What are the management prescriptions in plantations?

Ans. The tree coppices and pollards fairly well. Coppiced shoots grow vigorously, and is considered most suitable for the production and collection of tanbark on a commercial scale. Aonla trees do not require regular pruning. However, main branches should be allowed to appear at a height of 1 m above ground level during the early years.

Q16. What are the irrigation requirements of Aonla?

Ans. Aonla is mostly grown as rainfed and can tolerate drought conditions. Irrigation may be provided at an interval of 10-15 days in summer during the first 3-4 years.

Q17. What is the economics (yield and B/C ratio) of the species?

Ans. Grafted Aonla, when planted at a spacing of 8 x 8 m, starts fruiting after 3-4 years. It can give approximately one quintal fruit per tree and can yield up to 1.50 quintal fruits per tree at the age of 10 years. The market price of Aonla fruits is Rs. 3000-4000 per quintal. Farmers can earn an income of Rs. 3-4 lakh /ha by selling the fruits. The B: C ratio of an Aonla based agri-horticulture system (Aonla + green gram/black gram), increased from an initial 1.84 to 3.28 at the end of seven years. A B:C ratio of Aonla + Turmeric, Aonla + Ginger (*Zingiber officinale*), Aonla + Arbi (*Colocasia esculenta*) has been calculated as 6.29, 3.44 and 3.20, respectively.

Q18. What is the market demand?

Ans. In 2022, the global Aonla extract demand was US \$ 37.8 billion and by 2032, it is estimated to increase by US \$ 77.34 billion.



Aonla-pigeon pea Agroforestry



Fruiting in Clone NA-7

Neolamarckia cadamba

Q1. What are the common names of *Neolamarckia cadamba*?

Ans. Kadam, Kadamb, Burflower tree.

Q2. What are its vernacular names?

Ans. Kadamb (Sanskrit), Kodom (Bangla), Vellaikkatampu (Tamil), Katampu (Malayalam), Kadabe, Kadava (Kannada), Rudraskamba (Telugu), Banphar (Mizo), Roghu (Assamese).

Q3. What type of tree is Kadamb?

Ans. Kadamb is a large, deciduous (or sometimes evergreen), fast-growing species with spreading branches, reaching 17 m height and 25 cm diameter within 9 years under normal growth conditions. A mature tree can attain 20 to 30 m height and 50 to 100 cm diameter. The tree has a straight stem that is more or less cylindrical, with a somewhat regular bole and a round open crown with drooping branches.

Q4. What is the geographical distribution of the species?

Ans. The species occurs naturally in the sub-Himalayan tract at latitudes from 9° to 27°N; from Nepal eastward to Bangladesh, India (Assam and Chotanagpur plateau).

Q5. What type of habitats does it prefer?

Ans. It prefers moist, warm regions, often on alluvial ground, along rivers, and in swampy areas and tolerates periodic flooding.

Q6. In which agroclimatic zones does Kadamb grow well?

Ans. It can grow in the agroclimatic zones of 2, 3, 4, 8, 9 and 12.

Q7. In which states it is grown in agroforestry?

Ans. Assam, Bihar, Jharkhand, Orissa, Andhra Pradesh, Andaman, Karnataka, Kerala, Uttar Pradesh, Madhya Pradesh.

Q8. What are the uses of Kadamb?

Ans. Kadamb wood is used in matchstick boxes, tea boxes, bobbins, veneer, plywood, crates, and furniture. Its logs are used for dugout canoes, roof structures, light construction, and joinery work. The pulp is sometimes mixed with other, generally long-fibred materials to produce medium quality paper. Leaves and bark have medicinal properties.

Q9. What is the rotation period of Kadamb?

Ans. A rotation of 5 to 7 years is sufficient to produce pulp and matches. For wood production suitable for plywood, felling can start at the age of 8–10 years. Thus, the species easily qualifies as a potential short rotation species.

Q10. Is Kadamb suited for agroforestry systems?

Ans. Kadamb provides higher growth and economic returns under agroforestry systems due to its fast growth, compatibility with annual crops, higher economic returns from wood as well as from intercropping activities, and the multiple uses of wood.

Q11. What are the suitable crop combinations for Kadamb?

Ans. Recommended crop combinations are paddy, mustard, lentils, cabbage, cauliflower, pointed gourd, bottle gourd, and fodder. Mixed planting with fruit trees like mango, guava, ber, and litchi is also observed. Paddy can be cultivated during the first three years. Once the trees are grown, it is desirable to change the cropping pattern, i.e., ginger, turmeric etc., besides vegetables, pineapple, arhar, and pulses.

Q12. What is the appropriate spacing for the species under agroforestry?

Ans. For better results, the spacing adopted should be at least 5 x 5m or 6 x 6m.

Q13. How can Kadamb be propagated and what are the nursery practices?

Ans. The seeds are minute and embedded in the fleshy fruit. Successful extraction of seeds from ripe fruits involves air drying, crushing and sieving. The fruits are soaked in an open area until rotten, ground by hand into a thick slurry, air-dried and sieved serially. The traditional method of seed extraction involves rubbing the dried fruits against a rough surface of a simple device until only the receptacle remains. The disintegrated fruit parts are collected and passed through a fine sieve (hole size about 0.5 mm). Due to their small size, the seeds are mixed with fine sand (1:10) and sown in seedbeds. Direct sowing is not very successful. The germination rate is above 90%. Clonal propagation through semi hardwood cuttings and air layering can also be done.

Q14. What planting stock should be used by the farmers?

Ans. Systematic tree improvement work is in the inception and evaluation stages in India by ICFRE (IFGTB and IFP) and Forestry Colleges of Kerala and Tamil Nadu. The farmers may obtain seeds from identified sources of State Forest Departments and ICFRE institutes.

Q15. Which type of planting is suitable for Kadamb?

Ans. Kadamb is suitable for boundary, block or bund planting.

Q16. Does it require irrigation?

Ans. Irrigation at the establishment stages is beneficial.

Q17. What is the economics of Kadamb cultivation?

Ans. A yield of 70-100 t/ha at 6-7 years rotation under irrigated conditions has been realized in Tamil Nadu. In a 20-year rotation, the total yield including thinnings was 23 cu m/ha/year. A tree of 50 cm diameter yields 2.5-3 cu m of wood under well managed conditions. The B/C ratio in agroforestry is around 1.5.

Q18. What is the market demand?

Ans. The wood has market demand and can be sold to the pencil or ply industry for around Rs. 5,000 to 7,000 per tonne and Rs. 450 to Rs. 500 per cubic feet if the girth is more than 23 inches. Kadamb wood furniture forms a share in India's wood exports.



N. cadamba trees in agroforestry system

Bombax ceiba

Q1. What are the common names of *Bombax ceiba*?

Ans. Semal, Indian kapok, Red Silk cotton tree

Q2. What are its vernacular names?

Ans. Shalmali (Sanskrit), Katseori (Bangla), Boroga, Borogadamara (Kannada), Shalmali (Marathi), Elva Maram (Tamil), Elavu (Malayalam), Similikonta (Oriya), Buruga (Telugu), Himila (Assamese).

Q3. What type of tree is Semal?

Ans. Semal is a lofty, fast-growing, deciduous tree with tall, clean, cylindrical bole having hard prickles at base and horizontally spreading branches arranged in whorls. The tree reaches up to 40 m in height with a clear bole of 24-30 m.

Q4. What is the geographical distribution of the species?

Ans. The species is widely distributed almost throughout India up to 1200 m elevation. It is absent in the arid regions of Rajasthan and Gujarat. It grows sporadically in mixed deciduous forests in the sub-Himalayan region, lower valleys and even in Sal forests.

Q5. In which agroclimatic zones does it grow well?

Ans. It grows well in agroclimatic zones of 2, 3, 4, 5, 7, 8, 9, 10 and 12.

Q6. In which states can it be grown in agroforestry?

Ans. Assam, Bihar, Jharkhand, Orissa, Andhra Pradesh, Karnataka, Kerala, Uttar Pradesh, Madhya Pradesh, West Bengal.

Q7. What are the uses of Semal?

Ans. As Semal has rapid growth and volume production, the soft, light, and whitish wood has great demand as matchwood and is suitable for light plywood.

Q8. Has it got medicinal values?

Ans. The species possesses astringent, cooling, stimulant, diuretic, aphrodisiac, demulcent, and tonic properties. Plant parts like flowers, young root, gum, leaves, shoots, and bark have medicinal properties and are used as treatments for various conditions and diseases like cholera, fractures, toothache, coughs, urinary problems, influenza, and snake bites, among others.

Q9. What is the rotation period of Semal?

Ans. A rotation of 5-7 years is sufficient to produce pulp and matches, 8-10 years for plywood production and 15-20 years for timber.

Q10. What are the best agroforestry practices and crop combinations for Semal?

Ans. Semal is suitable for introduction in the agroforestry system (in agri-silviculture and silvi-horticulture) due to its clear bole and self-pruning ability. The species is planted with paddy in Assam and Odisha. Other compatible crops include potato, mustard, mung bean, colocasia. Mixed planting with horticultural crops like mango, jackfruit and aonla is also possible.

Q11. What is the appropriate spacing for the species under agroforestry?

Ans. The recommended spacing for the species is at least 6 x 6 m or 8 x 8 m.

Q12. How can it be propagated and what are the nursery practices?

Ans. Simal can be raised by direct sowing of seeds, planting of entire seedlings as well as stump planting. Clonal propagation through shoot cuttings and tissue culture is also done with varied success rates. Freshly collected seeds (separated from floss by putting them in a gunny bag and thrashing with a stick until the seeds get separated) give best germination without any pre-treatment.

Direct sowing in raised seed beds and transplanting 5cm tall seedlings to individual containers and field planting after 12 months is advised. Entire planting has been found successful in regions with comparatively high rainfall. One to two year old tall plants after pruning all leaves except the young ones at the tip are used for raising plantations. For stump planting, stumps are prepared from 1 to 2 years old nursery raised seedlings, keeping only 4 cm of shoot and 30 cm of root and pruning all side roots.

Q13. Is superior planting material identified for Simal?

Ans. Grafted/seedling seed orchards and seed production areas have been established in Arunachal Pradesh, Kerala and Rajasthan. Plus trees and superior seed sources have been identified by ICFRE-IFP and West Bengal Forest Department.

Q14. Which type of planting is suitable for Simal?

Ans. It is suitable for boundary, block or bund planting.

Q15. Does it require irrigation?

Ans. Irrigation at the initial establishment stage is beneficial.

Q16. What is the yield of Simal?

Ans. At 6 to 7 years rotation, it is estimated to yield around 100 t/ha.

Q17. What is the market demand for Simal?

Ans. The wood has a demand in the match or plywood industry. The value for the wood is around Rs. 250 to Rs. 300 per cubic feet. Rectangle wood planks of 2 inch thickness costs Rs. 500 per square feet.



Moringa oleifera

Q1. What are the common names of *Moringa oleifera*?

Ans. Sahjan, Munga, drumstick tree, Moringa

Q2. What are its vernacular names?

Ans. Shobhanjana (Sanskrit), Sojna (Bangla), Saragavo (Gujarati), Muringa (Malayalam), Sujna, Shevga (Marathi), Murungai (Tamil), Sojina (Assamese).

Q3. What type of tree is Moringa?

Ans. It is a small, fast-growing, evergreen or deciduous tree that usually grows up to 10 or 12 m in height. It has a spreading, open crown of drooping, fragile branches, feathery foliage of tripinnate leaves, and thick, corky, whitish bark.

Q4. What is the geographical distribution of Moringa?

Ans. Moringa is indigenous to the Himalayan foothills of South Asia from northeastern Pakistan to northern West Bengal in India and northeastern Bangladesh where it is commonly found from sea level to 1,400 m on recent alluvial land or near riverbeds and streams.

Q5. In which agroclimatic zones does Moringa grow well?

Ans. It grows well in agroclimatic zones of 2, 3, 4, 5, 7 and 8.

Q6. What are the areas of cultivation?

Ans. The cultivation of Moringa in India occurs mainly in the southern states of Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh. It is also cultivated in Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, West Bengal and Uttar Pradesh.

Q7. What are the uses of Moringa?

Ans. The leaves, fruits, flowers and pods have high nutritive and medicinal value. The leaves are rich in protein, vitamins A and C, beta carotene, potassium, calcium, iron and phosphorus and a good source of natural antioxidants. The kernel has 30-42% oil content and is used as a lubricating oil and vegetable cooking oil. Seed extracts are found to be very effective as a primary coagulant for water treatment in addition to control of microbial activity.

Q8. From which year does Moringa start fruiting?

Ans. Fruits can be harvested from planted seedlings from the second year onwards. When the plant is grown from cuttings, the fruits can be harvested 6–8 months after planting.

Q9. Which are the suitable intercrops that can be grown along with Moringa?

Ans. It is often intercropped with maize, sunflower, cassava, pumpkin, tomato, radish and other vegetable crops. Sunflower is particularly recommended for helping to control weed growth.

Q10. Are there any agroforestry models developed for Moringa?

Ans. *M. oleifera* is common in homesteads, around cattle sheds, and on farm boundaries, fences and village waste lands and as an intercrop with beans, peas, peanut/groundnut, lentils, millets and cereals. Agri-silvi-horticulture system with maize-*Casuarina equisetifolia*-Moringa has been recommended.

Q11. How is Moringa propagated and what are the nursery practices?

Ans. It can easily be grown from seeds and cuttings. Seeds should be planted 2 cm deep in the soil and germinate within 1-2 weeks. Both direct planting and transplanting can be done for the plantation of the species. In direct planting, plant 2 or 3 seeds in each hole, 5 cm apart. Two weeks after germination, or when the seedlings reach four to six inches tall (10 to 15 cm), retain the healthiest seedling in the ground and remove the rest. For transplanting, seeds can be grown in pots or seed beds. Cuttings between 45 and 100 cm long and 4 and 10 cm wide should be collected from the woody parts of the branches and can be planted directly or in plastic pots in the nursery.

Q12. What is the ideal spacing used for planting Moringa?

Ans. The recommended spacing for fruit production is 3 x 3 m and high density planting at 1.5 x 1.0 m spacing for leaf production.

Q13. Which are the promising varieties available for Moringa?

Ans. Varieties such as Periyakulam 1 and 2 (PKM -1 and 2), Jaffna (Yazhpanam), Chavacheri (introduced from Sri Lanka), Chemmurugai have long been cultivated in south India. These along with new varieties such as Oddanchathiran (ODC), AMAR 32, KM1, GKVK 1, 2, 3, Dhanaraj, Bhagya (KDM-1), Konkan Ruchira, and Anupama are suitable for pod production.

Q14. Which type of planting is suitable for Moringa?

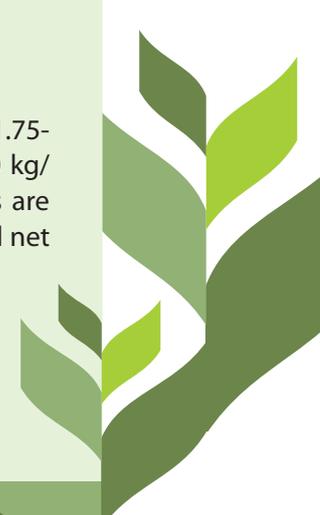
Ans. Moringa is suitable for boundary, block or bund planting. It is also planted in homesteads.

Q15. Does it require irrigation?

Ans. It can be grown both under both irrigated and unirrigated conditions.

Q16. What is the economics of Moringa cultivation?

Ans. The pod yield is 50 - 55 tonnes of pods/ha (220 pods/tree/year). The B/C ratio of 1.75-2.50 has been estimated for pod production. Additionally, leaf yield can be 5-10 kg/tree/year. This is equivalent to > 10,000 kg/ha/year at 3 x 3 m spacing. Farmers are also engaged in small scale commercial cultivation for leaf production with annual net income of about Rs. 1.2 lakhs/hectare.



Q17. What is the market demand of Moringa?

Ans. The global market size for the Moringa product market is valued at \$5.5 billion and is expected to grow at an exponential rate. It is segmented into tea, oil, seeds, and leaf powder, with leaf powder having the largest share. Pods are commercial products sold at national and local markets. The Moringa market from leaf powder is expected to exceed USD 6 billion by 2025 on account of increasing demand in the dietary supplement and food applications.



M. oleifera tree with pods



M. oleifera in farmers field for leaf production

Melia azedarach

Q1. What are the common names of *Melia azedarach*?

Ans. Bakain, Chinaberry tree, pride of India

Q2. What are the vernacular names of Bakain?

Ans. Mahanimb (Sanskrit), Bakarjam (Bangla), Bevu (Kannada), Bakan nimb (Marathi), Malaivembu (Tamil), Malaveppu (Malayalam), Kali yapa (Telugu), Ghora Neem (Assamese)

Q3. What type of tree is *M. azedarach*?

Ans. It is a medium size (12-16 m) to large deciduous tree reaching up to 45 m; with a spreading crown and sparsely branched limbs. Bark smooth, greenish-brown when young, turning grey and fissured with age.

Q4. What is the geographical distribution of the species?

Ans. The species is native to the Indian sub-continent growing naturally in sub-Himalayan tract.

Q5. In which agroclimatic zones does Bakain grow well?

Ans. It grows well in agroclimatic zones of 2, 4, 6, 9 and 10.

Q6. In which states can it be grown in agroforestry?

Ans. Assam, Bihar, Karnataka, Maharashtra, Odisha, Punjab, Haryana, Telangana, and Andhra Pradesh.

Q7. What are the uses of Bakain?

Ans. *M. azedarach* wood, resembling mahogany, is used to manufacture agricultural implements, furniture, plywood, boxes, poles, and tool handles. It has termite resistance qualities and is therefore used in cabinet making and in construction. Leaves are highly nutritious and are lopped for fodder. Fruit stones make ideal beads and are used in making necklaces and rosaries.

Q8. What is the rotation period of Bakain?

Ans. Bakain has a rotation age of 6-12 years.

Q9. Which are the suitable intercrops that can be grown with Bakain?

Ans. Bakain is a promising agroforestry species. Suitable intercrops are wheat, sugarcane and foxtail millet. Under optimal conditions, the tree grows fast with foxtail millet. Wheat, barley and green fodder berseem can be cultivated successfully with *M. azedarach*. Silvopastoral model with *Stylosanthes hamata* (Stylo), is promising under rainfed conditions in Jharkhand.

Q10. How is Bakain propagated?

Ans. The tree is propagated through seeds.

Q11. What is the ideal spacing adopted for planting Bakain?

Ans. The spacing varies for block and bund/boundary planting. For block planting, 4 x 4 m spacing is adopted and 3 m distance is suitable for bund planting.



Q12. What are the necessary requirements for field planting?

Ans. Planting can be carried out in pits of size 45 x 45 x 45 cm. At the time of planting, FYM at 5t/ha and 60:60:40 NPK/ha should be provided. Side branches should be pruned. Manual weeding is required in the initial years.

Q13. What planting stock can be used by the farmers?

Ans. Clones are not available. Quality seeds are available with SAUs/AICRP Centers/State Forest Department nurseries.

Q14. What are the irrigation requirements of Bakain?

Ans. One or two protective irrigations during prolonged drought conditions should be supplied.

Q15. What is the economics of Bakain cultivation?

Ans. A yield of about 30.5 t/ha can be obtained in an agroforestry system. The B/C ratio ranges from 1.27 to 1.96.



M. azedarach- foxtail millet agroforestry system

Hardwickia binata

Q1. What are *Hardwickia binata* commonly called?

Ans. Anjan, Indian Blackwood

Q2. What are its different vernacular names?

Ans. Anjan (Sanskrit, Hindi), Kammara (Kannada), Kamara (Marathi), - Aacha, Karachi (Tamil), Yepi (Telugu), Aacha, Achamaram (Malayalam)

Q3. What type of tree is *H. binata*?

Ans. *H. binata* is a medium to large sized deciduous tree reaching up to 9 - 30 m height and 0.9 - 3 m girth (at breast height). In isolated situations, or on poor soils, the tree tends to branch low and produces a short bole.

Q4. What is its geographical distribution?

Ans. Anjan is considered endemic to India, Pakistan and Nepal. In India, it is naturally distributed up to 760 m altitude in temperature range of 10°C to 48°C and annual rainfall between 250 to 1000 mm.

Q5. In which agroclimatic zones does it occur?

Ans. It occurs in 3, 4, 5, 6, 7, 9, 9, 10 and 13.

Q6. In which states is it suitable for cultivation?

Ans. Uttar Pradesh, Bihar, Andhra Pradesh, Karnataka, Maharashtra, Chhattisgarh, Madhya Pradesh and Tamil Nadu.

Q7. What is its utilisation?

Ans. The wood is perhaps the hardest and heaviest in India used for beams and mine props, bridge and house construction, agricultural implements, carts and wheel work. It is close grained, difficult to season but fairly durable. The bark yields a strong fibre largely employed for making ropes. Oleo-resin extracted from the heart wood is used in the manufacture of varnishes.

Q8. What is the rotation period of species?

Ans. Trees are generally grown for timber and the rotation age ranges between 8-40 years. In agroforestry the trees can be extracted after 10 years.

Q9. What are the best agroforestry practices and suitable intercrops for Anjan?

Ans. *H. binata* based agroforestry models are common in central India as boundary plantation. This was introduced in western dry region to enhance fodder production to feed the domestic animals. Block plantation with suitable crops combination provides higher land productivity and improves soil fertility. It is grown in agrisilviculture (*H. binata* + wheat; *H. binata* + black gram; *H. binata* + mustard; *H. binata* + Soybean + mustard) and silvipasture system (*H. binata* + *Cenchrus ciliaris*; *H. binata* + *Ziziphus mauritiana* + *Cenchrus ciliaris* + *Stylosanthes seabrana*). In arid regions, intercrop combinations with *Vigna radiata*, *Pennisetum glaucum*, *Sesamum indicum* and *Cyamopsis tetragonoloba* have been reported.

Q10. What is the suitable spacing for agroforestry?

Ans. Spacing of 10 x 3 m and 5 x 3 m has been recommended in agroforestry.

Q11. How can it be propagated?

Ans. *H. binata* is easily propagated through seeds. Seeds collected during April and May retain good germinative capacity for a year. A pretreatment of water soaking for 24 h before sowing enhances germination up to 75%. One-year-old nursery grown healthy seedlings are uprooted and stumps produced for planting. Vegetative propagation by air layering is also successful.

Q 12. What planting material should be used by the farmers?

Ans. Identified seed stands with State Forest Departments like Andhra Pradesh, Tamil Nadu and Karnataka could serve as seed sources.

Q13. Which type of planting is suitable for Anjan?

Ans. Boundary, block or bund planting can be adopted.

Q14. What is the requirement for irrigation?

Ans. It can be grown both under irrigated and unirrigated conditions.

Q15. What is the yield and economics of Anjan cultivation?

Ans. A yield of 9.9 kg/tree (dry weight) after 8 years has been reported. In natural forests trees in mature stands yield 381.64 kg/tree and 236.60 tonnes/ha. In agroforestry systems, *Rabi* sorghum yielded 52% higher than in no-tree control when the trees were 6-7 years old. The B: C ratio of *H. binata* plantation is 1.91.

Q15. What is the market demand?

Ans. The market rate of Anjan wood is approximately Rs.3000 – 3500/ton with minor fluctuations.



Hardwickia binata tree under agroforestry

Swietenia macrophylla

- Q1.** What is the common name of *Swietenia macrophylla*?
- Ans.** Mahogany.
- Q2.** What type of tree is mahogany?
- Ans.** It is an evergreen tree that grows 30-40m in height and 3-4m in girth with a clear bole height of 20-25m and buttress at the base.
- Q3.** Where is its geographical distribution?
- Ans.** Mahogany is native to South America and was introduced during the 18th century. It is naturalised in Kerala, Tamil Nadu and West Bengal.
- Q4.** Which states have commercial plantations of mahogany?
- Ans.** Commercial plantations are found in Kerala, Tamil Nadu, West Bengal and Maharashtra.
- Q5.** In which agroclimatic zones can mahogany be grown?
- Ans.** It can grow in agroclimatic zones 3, 7, 8, 9, 10 and 12.
- Q6.** What are the suitable soil conditions for mahogany cultivation?
- Ans.** It can grow in all kinds of soils, except saline, sodic and waterlogged soils.
- Q7.** What are the uses of mahogany?
- Ans.** The medium weight wood has a reddish or pinkish color, giving it an attractive appearance. It is used in construction, plywood, high-end furniture, and cabinetry. It is found suitable for panelling, farming, flooring, automobiles, the interior trim of boats, radio and phonograph cabinets, the bodies of musical instruments, moldings, and ornaments.
- Q8.** What is the rotation period for mahogany?
- Ans.** Though the economic rotation for mahogany plantations is defined to be around 25-40 years, it is harvested in 15-20 years in private farms and plantation areas.
- Q9.** Which agroforestry system is suitable for mahogany?
- Ans.** Agri-silviculture system.
- Q10.** What is the optimum spacing for mahogany in agroforestry practices?
- Ans.** The recommended spacing for the agroforestry system is 4x4 m with field crops being raised during the initial 2-3 years.
- Q12.** What are the suitable intercrops in a mahogany-based agroforestry system?
- Ans.** Pumpkin, maize, sugarcane, banana, fodder grasses, pulses, chilli, drum-stick and leafy vegetables are common intercrops.
- Q13.** Is pruning required for mahogany?
- Ans.** Yes, pruning is usually done for the first three years.



Q14. What is the thinning schedule for mahogany?

Ans. First thinning is applied between 5-10 years. Multiple thinnings are suggested for closely spaced stands (3x3m; 2x3m). For stands with high initial planting density (2x3m), four thinnings are recommended. For 3x3m spacing, 2-3 thinnings appears to be essential whereas in a wider spacing (4x4m), only one thinning is recommended.

Q15. How is mahogany propagated in the nursery?

Ans. Mahogany is propagated through seeds. Mature fruits (capsule) of mahogany are available during December – April with each capsule containing 10 to 15 winged seeds. The fresh seeds are soaked overnight in the water and sown in the nursery beds (10x1m) in river sand. The seeds germinate in 10 to 25 days, with germination rates varying from 70 to 100 percent. The seedlings are planting ready in 4-6 months.

Q16. From where can seeds of mahogany be obtained?

Ans. Identified seed sources are available with the state forest departments of Kerala, Tamil Nadu and West Bengal. Many private agencies also supply mahogany seeds and plants.

Q17. Can mahogany be raised as boundary/block/bund plantation?

Ans. Mahogany can be planted as a boundary, block or bund planting. However, it is mostly grown as block plantations.

Q18. Does mahogany require irrigation?

Ans. Mahogany can be cultivated both with and without irrigation. For better establishment in dry conditions, irrigation must be provided during the first two years.

Q19. What is the timber yield of mahogany?

Ans. If maintained well, it is estimated that mahogany can attain a maximum mean annual increment (MAI) of 38.1 m³/ha/year and volume up to 572 m³/ha in 15 years on good soils, and an MAI of 19.7 m³/ha/year and volume up to 493 m³/ha on medium-quality soils. In case of 30 years rotation, it can grow to an average height and diameter of 24.4 m and 35.4 cm, respectively, and yield a total volume of 583 m³/ha, including thinning in moderate sites.

Q20. What is the potential market demand for mahogany?

Ans. India imported mahogany wood to the tune of US\$53.86 million in 2018, with the demand on the rise.



Mahogany +Cucumber based agroforestry model in Pune, Maharashtra

(Source - Mr. Mahesh, M/s Mahogani Vishwa Agro Pvt. Ltd. Pune)



Mahogany +Sugarcane based agroforestry model in Pune, Maharashtra

(Source - Mr. Mahesh, M/s Mahogani Vishwa Agro Pvt. Ltd. Pune)

Grewia optiva

- Q1.** What is the common name of *Grewia optiva*?
- Ans.** Bihul.
- Q2.** What are the vernacular/local names of *G. optiva*?
- Ans.** Bhimal, Bhiunal, Dhaman, Bihul(Hindi); Bheemal, Bhevul, Syaal Phusre, Chiple, Phorsaa (Nepali); Dhanvanah, Todana (Sanskrit).
- Q3.** What type of tree is *G. optiva*?
- Ans.** Small to medium sized, deciduous tree which grows up to 9-12 m in height. It is a strong light demander and requires complete overhead light for its optimum growth.
- Q4.** What is the flowering and fruiting time of *G. optiva*?
- Ans.** The tree flowers in April to September and mature fruits appear during October and December.
- Q5.** Where is its geographical distribution?
- Ans.** It grows in the Himalayas from Jammu & Kashmir UT to Nepal. It also grows in Punjab and extends to Bengal.
- Q6.** What is the natural habitat for *G. optiva*?
- Ans.** Sub-tropical zone upto an elevation of about 2000 m.
- Q7.** In which agro-climatic zones can *G. optiva* be grown?
- Ans.** Agro-climatic zones 1 and 6.
- Q8.** Where are the *G. optiva* growing areas in India?
- Ans.** Himachal Pradesh, Jammu & Kashmir UT Uttarakhand, Punjab and Uttar Pradesh
- Q9.** What are the uses of *G. optiva*?
- Ans.** Traditionally, it is lopped (50%) and pollarded for nutritious fodder (15-20% protein) during December-March and for fuelwood. Fibres are extracted from branches and used for making ropes. Branches are used for making baskets and paper production. The green bark is used as shampoo for cleaning the hairs. Crushed bark extract is used to treat indigestion and gastric issues, as well as a lubricant during difficult childbirth. It is used in worship, rituals and religious ceremonies.
- Q10.** What is the rotation period for *G. optiva*?
- Ans.** The tree is maintained for leaf fodder supply. The rotation age could be considered as 15-20 years.
- Q11.** What are the suitable agroforestry systems for the species?
- Ans.** Agri-silviculture, horti-silvipasture and silvipastoral systems
- Q12.** How is *G. optiva* propagated?
- Ans.** The species is propagated from seed, cuttings and stumps.

Q13. What are the nursery practices for *G. optiva*?

Ans. In the nursery, seedlings are raised by sowing seeds in March-April. The seeds are sown at about 2 cm depth in lines 15 cm apart, for which 250 gm seed is required for each square meter of the nursery bed. About 65–80% germination is achieved in 15 days.

Q14. What are the optimum spacing requirements of *G. optiva* in agroforestry?

Ans. The spacings recommended are 3 × 3 m for block plantations, 4 to 5 m for single-row planting along the fields. For hedge rows, a close spacing of 0.5 × 1 m is ideal.

Q15. What are the major intercrops in the agroforestry systems?

Ans. In an agri-silviculture system it can be intercropped with wheat, rice, tomato, capsicum, mustard, potato, black gram, rajma, maize, cabbage, cauliflower, soybean and vegetable beans. In silvopastoral systems, it is grown with grass species such as *Arundinella*, *Chrysopogon*, *Themeda*, *Heteropogon*, *Alpuda*, *Dichanthium*, *Panicum*, *Ischaemum*, *Chloris*, *Imperata* and *Cymbopogon*.

Q16. From where can planting material of *G. optiva* be obtained?

Ans. Quality planting material can be obtained from the nurseries of forest departments.

Q17. Can *G. optiva* be raised as boundary/block/bund plantation?

Ans. The tree is often planted in field bunds and boundaries of the fields.

Q18. Does *G. optiva* require irrigation?

Ans. It can be grown in irrigated and unirrigated conditions.

Q19. What is the economics of raising *G. optiva* in an agroforestry system?

Ans. In Himachal Pradesh mid hills, under *G. optiva* based agrihorti-silviculture (200 trees/ha) and agrisilviculture (1000 trees/ha) systems with components as Peach + *Setaria* + *Withania somnifera*/*Mucuna pruriens*/*Ocimum sanctum* or *Setaria* + *W. somnifera* / *M. pruriens*/*O. sanctum*, *G. optiva* (3-4 year old, pollarded at 1.5 m above ground) provides green fodder ranging from 4.55 to 5.83 q/ha and branch wood of 5.33 to 5.57 q/ha under the former system and 7.40 to 11.40 q/ha and 9.20 to 11.20 q/ha under the latter system.

Q20. What is the yield of *G. optiva*?

Ans. The yield is reported to be 11 ton/ha from a two- year-old plant.

Q21. What is the potential market demand for *Grewia optiva*?

Ans. Demand for fibre of Bhimal in the local markets of the Himalayan region is high with small scale industries entering into commercial ventures.



G. optiva based agroforestry system

Bauhinia variegata

Q1. What is the common name of *Bauhinia variegata*?

Ans. Kachnar.

Q2. What are the vernacular/local names of *B. variegata*?

Ans. Raktkanchan (Bengali); Kachanal, Kachnar (Hindi); Kanchanaara, Ulipe, Kovidaara (Kannada); Kanchan (Marathi); Koiralo(Nepali); Kachnal (Punjabi); Kovidaar, Chamarik, Kuddal (Sanskrit)

Q3. What type of tree is *B. variegata*?

Ans. It is a small to medium sized deciduous tree with good coppicing ability. It grows up to 15 m in height, is moderately light-demanding, frost and drought-hardy, and withstands rocky situations.

Q4. What is the flowering and fruiting time of Kachnar?

Ans. The tree flowers in February to April and mature fruits appear during August and September.

Q5. What is its geographical distribution?

Ans. It is distributed throughout India.

Q6. What is the natural habitat for *B. variegata*?

Ans. It grows in tropical and subtropical climates with hot, dry summers and mild winters to an elevation of 1200 m.

Q7. In which agro-climatic zones can Kachnar be grown?

Ans. Agro-climatic zones 1, 5 and 6.

Q8. Where is *B. variegata* cultivated?

Ans. It is commonly cultivated in Himachal Pradesh, Uttarakhand, Punjab, Jammu and Kashmir, Uttar Pradesh.

Q9. What are the uses of Kachnar?

Ans. Branches are lopped and pollarded as fodder for sheep, goats and cattle and also used as fuel. Fibres are extracted from stems and used for making ropes. The wood is used for agricultural implements, and the bark is used for tanning. Almost all the parts find uses in traditional medicine against ailments such as leprosy, piles, asthma, ulcers, liver complaints, snake bite, skin diseases, wound healing, obesity, stomatitis, dyspepsia, and flatulence. It is used as a tonic, astringent, and laxative as well.

Q10. What is the rotation period for *B. variegata*?

Ans. The tree is maintained for leaf fodder supply. The rotation age could be considered as 15-20 years.

Q11. Which agroforestry system is suitable for Kachnar?

Ans. Agri-silviculture and silvipastoral systems.



Q12. How is Kachnar propagated?

Ans. It can be propagated by seeds by cuttings or planting stumps.

Q13. What are the nursery practices for *B. variegata*?

Ans. In the nursery, seedlings are raised by sowing seeds at about 1 cm depth in lines 20-25 cm apart. About 95% germination is obtained in 6-7 days. When the seedling attains a height of 10-15 cm it is ready for field planting.

Q14. What is the optimum spacing requirement for *B. variegata* in agroforestry?

Ans. The recommended spacing is 4 x 4 m or 5 x 5 m.

Q15. What are the major intercrops suitable along with Kachnar?

Ans. In agri-silviculture system it is intercropped with wheat, rice, tomato, capsicum, mustard, potato, maize, cabbage, cauliflower, soybean and vegetable beans, while in silvipastoral system it is planted along with grass species.

Q16. From where can planting material of Kachnar be obtained?

Ans. Quality planting material can be obtained from the nurseries of forest departments..

Q17. Can Kachnar be raised as boundary/block/bund plantation?

Ans. The tree is often planted in bunds and boundaries of the fields.

Q18. Does *B. variegata* require irrigation?

Ans. It can be grown both in irrigated and unirrigated condition

Q19. What is the average yield of *B. variegata*?

Ans. The average annual fodder yield per tree is 15-20 kg.

Q20. What is the potential market demand for *B. variegata*?

Ans. It mostly caters to the requirements of the domestic market. The flowers and buds are priced at Rs. 70-100/kg in the local market. The tree yields a gum that is used as an adhesive and industrial product. The bark of this tree is extracted for its medicinal properties, and ropes are also made. The estimated annual trade is 100-200 metric tonnes for its main use as an herbal raw drug.



Sugarcane, Kachnar & *Eucalyptus* Agroforestry model

Senegalia catechu (*Acacia catechu*)

Q1. What is the common name of *Senegalia catechu*?

Ans. Black Cutch Tree

Q2. What are the vernacular/local names of *S. catechu*?

Ans. Khair, Khayar, Madan, Payor, Priya-sakh (Hindi); Khayer (Bengali); Kher (Gujarathi); Dant-dhavan, Kaachu, Kadu (Kannada); Khyar (Nepali); Gayatrin, Khadira, Pathi-drum (Sanskrit); Cenkarungali (Tamil); Khair (Urdu).

Q3. What type of tree is *S. catechu*?

Ans. It is a small to medium sized deciduous, thorny tree which grows up to 15 m in height. It is a strong light demander, tolerates moderate shade and has good coppicing ability.

Q4. What is the flowering and fruiting time of *S. catechu*?

Ans. The tree flowers in April to August and mature fruits appear during September and October.

Q5. What is its geographical distribution?

Ans. It is distributed throughout India except in temperate and very humid regions.

Q6. What is the natural habitat of *S. catechu*?

Ans. It is common in the drier regions of sub-Himalayan and outer Himalayan tracts between altitudes of 900 to 1,200 m from Jammu to Assam.

Q7. In which agro-climatic zone can Khair be grown?

Ans. It can be grown in agro-climatic zones of 1, 4, 6, 8, 9, 12 and 13.

Q8. Which are the Khair growing areas?

Ans. Himachal Pradesh, Jammu & Kashmir UT, Uttarakhand, Uttar Pradesh, Bihar, Punjab, Haryana, Maharashtra, Gujarat, Madhya Pradesh.

Q9. What are the uses of *S. catechu*?

Ans. It is the chief source of katha and cutch. Timber is used for house construction, making rice pestles, oil and sugarcane crushers, ploughs, tent pegs, sword handles, and the keels and knees of boats. Leaves are excellent fodder. The seeds are rich in protein. The tree is a host for the lac insect. The bark exudes a light gum of very good quality and is one of the best substitutes for gum Arabic. It is also used in traditional medicine to cure chronic diarrhoea and dysentery, piles, uterine haemorrhages, hemoptysis, leucorrhoea, gleet, atonic dyspepsia, mercurial salivation, ulcerated gums, chronic bronchitis, etc.

Q10. What is the rotation period for *S. catechu*?

Ans. The rotation period is approximately 20 years.

Q11. In which agroforestry system is *S. catechu* grown?

Ans. Silvipastoral land use systems. The spiny branches act as a live fence.

Q12. How is *S. catechu* propagated?

Ans. The plant is propagated from seeds, cuttings or stumps.

Q13. What are the nursery practices for Khair ?

Ans. Plants are raised through seeds during February and March. Two seeds are sown per poly bag at a depth of 1.5 cm. The germination percentage varies from 70 to 80%. Three to four month old seedlings of height 50 to 60 cm are planted in the field in 30 cm³ pits.

Q14. What are the optimum spacing requirements of *S. catechu* in agroforestry?

Ans. The spacing recommended is 4 x 4 or 5 x 5 m.

Q15. What is the suitable girth for harvesting?

Ans. Trees with a girth of 60–120 cm are suitable for harvesting.

Q16. What are the major intercrops?

Ans. Grass species such as *Arundinella*, *Chrysopogon*, *Themeda*, *Heteropogon*, *Alpuda*, *Dicanthium*, *Panicum*, *Ischaemum*, *Chloris*, *Imperata* and *Cymbopogon* are planted as intercrops under silvipastoral systems.

Q17. From where can seeds of *S. catechu* be obtained?

Ans. Quality planting material of *S. catechu* can be obtained from the nurseries of forest departments.

Q18. Can Khair be raised as a boundary/block/bund plantation?

Ans. Khair can be raised as boundary, block or bund planting.

Q19. Does *S. catechu* require irrigation?

Ans. It can be grown in irrigated and unirrigated conditions.

Q20. What is the yield of katha from *S. catechu*?

Ans. Kattha is a white substance found in Khair wood. The liquor on distillation of katha is cutch. Trees felled in autumn and winter, having higher girth, which are gnarled and crooked give higher yields of katha than straight ones. Freshly felled trees also give higher yields than dried ones. The yield of heartwood is 50–75 cu m at 60 years and 4–6 tonnes of katha is obtained.

Q21. What is the economics of raising *S. catechu* plantations?

Ans. It is a traditional agroforestry system, a 25-30 year old tree fetches an average price of Rs 1,000 per quintal of heartwood. One quintal of the heartwood yields up to 6 kg of katha priced at Rs 500 per kg.

Q22. What is the potential market demand for *S. catechu*?

Ans. About 63,000 tonnes of khair wood in India is annually consumed for the manufacture of cutch and katha. The estimated trade is 500-1000 MT per year with a market rate of Rs. 750-1600/kg. In India, Khair wood markets and depots are available in Haryana, Uttar Pradesh, Uttarakhand, Maharashtra, Gujarat, Bihar and Madhya Pradesh states.



Khair based agroforestry system

Salix alba

Q1. What is the common name of *Salix alba*?

Ans. White Willow

Q2. What are the vernacular/local names of *S. alba*?

Ans. Vivir (Kashmir), Bis, Bhushan, Madnu (Punjab), Malchang (Ladakh), Beauns, Malchang, Shaun (Himachal Pradesh).

Q3. What type of tree is *S. alba*?

Ans. It is a medium size to a large deciduous tree with olive-green, yellow, or purple branches, growing up to 10–30 m tall with a trunk up to 1 m diameter. It is light demander, frost hardy, pollards vigorously and has good coppicing ability.

Q4. What is the flowering and fruiting time of *S. alba*?

Ans. Flowers appear in April-May and fruits mature in June-July.

Q5. What is its geographical distribution?

Ans. *S. alba* is distributed in Jammu and Kashmir, Union Territory of Ladakh, Uttarakhand, and Himachal Pradesh

Q6. What is the natural habitat for *S. alba*?

Ans. It grows at an altitude of 1400 to 3500 m above mean sea level, especially in temperate and cold desert regions.

Q7. In which agro-climatic zone *S. alba* can be grown?

Ans. It grows well in agro-climatic zone - I

Q8. What are the *S. alba* growing areas?

Ans. Himachal Pradesh, Uttarakhand, Ladakh, and Jammu & Kashmir

Q9. What are the uses of *S. alba*?

Ans. It is widely used for the preparation of cricket bats, baskets, decorative articles, handicrafts, fodder, fuel wood, and in cottage industries.

Q10. What is the rotation period for *S. alba*?

Ans. The length of a rotation period is 15-20 years. The rotation period is 2–5 years (5–7 production cycles) for wood chips and 6–15 years for firewood.

Q11. *Salix alba* is grown in which agroforestry system?

Ans. Agrisilviculture and silvopastoral systems.

Q12. How is *S. alba* propagated?

Ans. The planting stock of *S. alba* is obtained through vegetative propagation using shoot cuttings in the nursery.

Q13. What are the nursery practices for *S. alba*?

Ans. Shoot cuttings of size 20–25 cm with a diameter of 1–1.5 cm are planted in the nursery beds during February–March at a spacing of 15 x 20 cm or 20 x 20 cm for the raising of quality planting stock. The best potting media is soil: sand: FYM in the ratio of 1:1:1. Plants are kept in the nursery for 1-1½ years and subsequently, Entire transplants are planted in the field from November to March.

Q14. What are the optimum spacing requirements of *S. alba* in agroforestry?

Ans. It is grown on field boundaries at a distance of 4 to 5m.

Q15. What are the major intercrops?

Ans. The crops like peas, potato, rajma, cauliflower, cabbage, buckwheat, duck wheat, barley, wheat, mustard, sorghum, maize, etc are grown in agriculture fields under the agri-silviculture system. The grasses namely *Medicago sativa*, *Trifolium repens*, *Festuca pratensis*, and *Dactylis glomerata* usually grow as an understorey in the silvi-pastoral system.

Q16. From where can quality planting material of *S. alba* be obtained?

Ans. Quality planting material of *S. alba* can be obtained from forest nurseries.

Q17. Does *S. alba* require irrigation?

Ans. It is grown under irrigated conditions.

Q18. What is the economics of raising *S. alba* plantation?

Ans. The biomass yield for *S. alba* is 12.69 to 11.20 t/ha in Jammu and Kashmir. The cost of cultivation of willow yields a net present value of Rs. 2.14 lakhs/ha/year for wood with a benefit-cost ratio of 2.66 (without intercropping), 2.68 (Intercropping with sorghum) and 2.71 (intercropping with maize). The average fuel wood production is 150-250 kg/ tree and fodder is 15-25 kg/ tree, respectively.

Q19. What is the potential market demand for *S. alba*?

Ans. The demand is quite high since it is used for cricket bats in Kashmir Valley. It fetches Rs. 1000/bat. Even if the clefts are sold at Rs. 500 per piece, a farmer gets at least Rs. 15000 per tree.



S. alba based Agroforestry systems

Prosopis cineraria

Q1. What are the vernacular/common names of *Prosopis cineraria*?

Ans. Khejri (Rajasthani), Khijro (Gujarathi), Shami (Hindi), Jammi (Telugu), Janti, Jand (Punjabi), Vanni (Tamil and Malayalam).

Q2. What is the extent of geographical distribution of Khejri?

Ans. Khejri is an important species of the Indian Thar desert. It occurs naturally in the dry and arid regions in western India. It is predominantly found growing naturally in Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Telangana and Andhra Pradesh. It is well adapted in zones covering the western plains.

Q3. How hardy is the Khejri tree?

Ans. It is an extremely drought tolerant species and it may perform well in areas with annual rainfall 150-400 mm with dry seasons of eight months or more and withstand rainfall as low as 75 mm.

Q4. What are the main features of the Khejri tree?

Ans. *P. cineraria* is a small tree, 3–5 m tall with bipinnate leaves and thorny branches. Flowering of small creamy-yellow starts in January and reaches full bloom during February - March. Fruit setting starts from April and matures in May.

Q5. What are the uses of the Khejri tree?

Ans. Khejri is a versatile and multipurpose nitrogen fixing tree species. It provides shade, fuel, fodder, improves soil, and stabilises sand dunes. It is suitable for dryland agroforestry in India. Pods are eaten as a vegetable. The flowers are valuable for honey production. The bark is used in leather tanning and produces an edible gum. During the extremely dry summer months, when the majority of trees are leafless, the tree produces leaves. The leaves are excellent source of nutritious fodder, readily consumed by many animals including goats and camels. The tree coppices readily, and pollarding in alternate years increases the fodder yield. Sun dried leaves can be stored for later use as fodder. Khejri provides excellent firewood and charcoal. The wood is hard, durable, and has a variety of uses like constructing house, making of boat frames, posts and tool handles.

Q6. What is the rotation period of Khejri?

Ans. The rotation period is not defined as it is primarily not a timber species. It is more than 60-70 years old owing to its very slow growing nature.

Q7. What are the best agroforestry practices for Khejri?

Ans. It is part of the traditional agroforestry systems in the drier parts of India. Khejri casts very light shade and therefore an ideal agroforestry species. It can be grown in boundaries and block plantations. Traditional agroforestry practices involving pearl millet, mung bean, cluster bean, sesame, wheat, gram, mustard, cumin, isabgol etc. give higher yields of crops in association with Khejri.

Q8. What are the standard nursery practices for Khejri?

Ans. In dry storage, seeds remain viable for decades and establish well with 80-90% germination. Pre-treatment by soaking seeds in tepid water for 24 hours is recommended to enhance

germination. The round end of the seed may also be scarified by nicking or scratching it with a knife. Six month old seedlings are transplanted to the field at the onset of the rainy season.

Q9. Is vegetative propagation practised in Khejri?

Ans. Propagation of Khejri is difficult by cuttings, however treatment with rooting hormones has been successful for propagation through cuttings. Propagation by roots suckers and by air layering has also been reported.

Q10. What are the standard silvicultural practices adopted for Khejri?

Ans. For agroforestry and silvopastoral systems, tree densities of 50-100/ha are recommended. Owing to the slow initial growth rate, one or two weeding are necessary during the first year. Early pruning facilitates straight growth. The tree respond well to irrigation.

Q11. What are the sources for Quality Planting Material (QPM) for Khejri?

Ans. ICFRE-AFRI and Forest Department of Rajasthan provide high quality seedlings of Khejri to stakeholders. Central Institute of Arid Horticulture (CIAH), Bikaner and CAZRI, Jodhpur provide budded thornless dwarf variety (Thar Shobha).

Q12. What is the economics of raising Khejri?

Ans. The tree attains height of 3-5 m in 5-6 years with an average diameter of 6 cm. A average tree yields about 45 kg of dry leaf fodder per year. One kilogram of dried pods of khejri, considered a superfood, fetches Rs. 500–600 in the local market. It reaches about Rs. 2000 in the international market.

Q13. What is the market demand of Khejri?

Ans. The Thar desert in Rajasthan is the most densely populated desert in the world. With crop production in this region being unstable and risky, growing Khejri trees is a lucrative proposition. It constantly provides regular additional income through fruits and fodder sales. Relatively higher returns are obtained when crops are grown in association with Khejri than in a monocropping system. Being a crucial component of the traditional agroforestry systems of dry tracts, this tree continues to be preferred to meet increasing demand for fuelwood, fodder and progressive desertification.



Pearl millet and Moong with *P. cineraria* in traditional agroforestry in Rajasthan

Tecomella undulata

Q1. What are the vernacular names of *Tecomella undulata*?

Ans. Rohida (Hindi), Rakhtroda, Rakta rohida (Marathi), Chalachhada (Sanskrit), Marwar Teak, Desert Teak. It is the only species in the genus *Tecomella*.

Q2. What is its geographical distribution of Rohida?

Ans. It is an indigenous tree of the desert regions of Shekhawati and Marwar in Rajasthan. It occurs naturally in Maharashtra, Gujarat, Rajasthan, Punjab and Haryana.

Q3. In which agroclimatic zones is it grown?:

Ans. It is predominantly found in zone 14, and scattered in 6, 8 and 13.

Q4. What are the suitable habitats for Rohida?

Ans. Rohida is widely adapted to arid regions. It grows well in areas where irrigation is not possible, and is a popular species in arid zone agroforestry. The tree can grow on both flatas well as undulating terrain, including gentle hill slopes and sometimes in ravines as well. It thrives very well on stabilised sand dunes, which experience extreme low and high temperatures. It grows in areas of scanty rainfall, which is almost as low as 150–500 mm annually. It can with stand extreme low temperatures (0 to -2°C) during winter and high temperatures (48–50°C) in summer. Rohida is drought, frost, fire and wind hardy. It thrives well on drained loamy to sandy loam soils having a pH in the range of 6.5–8.0. It is a strong light demander.

Q5. What are the main uses of the species?

Ans. Rohida produces high quality timber and is referred to as marwar teak. Twigs and branches are used for fencing and firewood. Cattle and goats eat leaves and camels, goats and sheep consume flowers and pods. It plays an important role in soil-binding and helps in stabilising shifting sand dunes.

Q6. What is the rotation period of Rohida?

Ans. It has not been clearly defined as it is a slow growing tree, but good quality timber can be obtained from a 30-year-old tree.

Q7. What are the best agroforestry practices and suitable intercrops?

Ans. Rohida is a well accepted tree in the traditional agroforestry system of the north-western dry region of India. The tree grows in community land, forestland and Orans (sacred groves) in association with Khejri, *Capparis decidua*, *Maytenus emarginata*, *Ziziphus* spp. and *Salvadora* spp. In agricultural land, it usually grows in association with Khejri. Traditional agroforestry practices by farmers in this region involve intercropping with pearl millet, mung, cluster bean, wheat, gram, mustard, cumin, isabgol, etc. Six month to one year old seedlings are planted at a spacing of 6 x 6m or 6 x 9m. The plants are pruned after three years.

Q8. Where can quality planting material of Rohida be obtained ?

Ans. ICFRE-AFRI, Jodhpur raises saplings from identified sources. The Rajasthan Forest Department also provides high quality seedlings of Rohida to stakeholders.

Q9. What is the market demand for Rohida?

Ans. The demand for Rohida timber is very high in the local market for carving and furniture. However, being the state tree of Rajasthan, there is a total ban on felling owing to its endangered status. The market value of timber ranges from Rs. 1400 to Rs. 1800/c.ft.



Pearl millet with *T. undulata* in tradition Agroforestry in Rajasthan



Mung bean with *T. undulata* in tradition Agroforestry in Rajasthan

Ziziphus mauritiana

Q1. What are the common names of *Ziziphus mauritiana*?

Ans. Ber, Indian jujube.

Q2. What is the geographical distribution of Ber?

Ans. Ber is found in Haryana, Punjab, Uttar Pradesh, Rajasthan, Gujarat, Madhya Pradesh, Bihar, Maharashtra, Andhra Pradesh and Tamil Nadu.

Q3. Which are the Ber growing areas in India?

Ans. Bharatpur, Jaipur and Jodhpur districts (Rajasthan); Hisar, Rohtak, Jind, Panipat, Mohinder garh and Gurgaon (Haryana); Sangrur and Patiala districts (Punjab); Banaskantha and Sabarmati (Gujarat); Bijapur and Bellary (Karnataka); and Tirunelveli, Ramanathapuram, Dharmapuri and Salem (Tamil Nadu).

Q4. What are the most suitable habitats for ber?

Ans. Ber is distributed in the arid and semi-arid regions of India. It thrives well on laterite, medium black soils with good drainage, or sandy, gravelly, alluvial soils of dry riverbeds. Ber is commercial cultivated in areas extending up to 1,000 m. Cultivation becomes less economical above this elevation. The species survives in high temperatures (as high as 50°C) and minimum shade temperatures (7° to 13° C). However, it is not frost tolerant.

Q5. How is ber propagated?

Ans. Ber can be propagated through seed, stump, root suckers and coppice.

Q6. What are the nursery practices of ber?

Ans. Germination in ber can be improved by soaking seeds in sulfuric acid. Germination can be quickened to 7 days by carefully cracking the endocarp. Ber seedlings do not tolerate transplanting, therefore the best alternatives are to sow the seeds directly in the field or to use polythene tubes in the nursery bed.

Q7. How are ber varieties propagated?

Ans. For improved cultivars budding is the easiest method of vegetative propagation. Wild varieties of ber are usually used as the root-stock. Rootstock is raised from seeds. Seedlings are ready for budding in 3 to 4 months.

Q8. What are the silvicultural practices to be adopted for a successful plantation?

Ans. The recommended spacing is 7 x 7 m or 8 x 8 m. Wider spacing is preferred in areas with high rainfall where canopy development is vigorous. The production is maximised by the application of both farmyard manure and commercial fertilisers. Fruit production begins from the 4th year with full production in the 10th to 12th year. Irrigation should be done immediately after planting, and once in 4-5 days up to 3 months until the plants establish in the field. No further irrigation is required.

Q9. Does training and pruning improve fruit production in ber?

Ans. Yes, it is essential to train ber trees during the first 2 - 3 years as the trees tend to grow horizontally and downwards, resulting in a spreading bushy form with long slender branches. Annual pruning is important because fruits are produced based on the current

season's growth. Regular pruning induces sufficient new growth ensuring a good crop year. A 25% pruning during the dormant period is usually sufficient.

Q10. What are the uses of ber tree?

Ans. Ber is a hardy multipurpose tree valued for its leaf fodder, fuelwood, fruit, lac, and thorny twigs for fencing. Fruits are highly nutritious and can be consumed fresh, dried, candied, pickled, as juice, or as butter. It is a rich source of vitamin C. The leaves serve as fodder for sheep and goats and food for silkworms. Ber produces hard, fine-grained, reddish in color, low quality timber that is used for domestic purposes. The branches are used as framework in house construction. Ber makes good charcoal. This thorny tree makes a good live fence and is an excellent agroforestry tree to use in hedges and serves as host for lac insects (*Kerria lacca*). High quality ber shellac is used in fine lacquer work.

Q11. What is the rotation period of ber?

Ans. Since it is not a primary timber, the rotation period is not defined, but is above 15-20 years.

Q12. What are the best agroforestry practices and suitable intercrops?

Ans. Boundary or block planting can be adopted. Agricultural crops like mung bean, moth bean and cluster bean (guar), can be grown without much reduction in crop yield during the first three years. Mung and guar are planted during *Kharif* and methi during *Rabi* seasons. With the advancing age of ber, due to tree-crop competition, yield is reduced.

Q13. What are the major varieties of Ber available?

Ans. Based on ripening period, ber varieties are classified as (a) Early ripening (February) : Gola, Seb, Safeda, (b) Mid season (1st - 3rd week of March.): Kaithali, Reshmi. (c) Late ripening (4th week of March-mid April.): Umran, Kantha, Elaichi.

Q14. Where can the major varieties of Ber be obtained?

Ans. CAZRI, Jodhpur, Central Institute of Arid Horticulture (CIAH), Bikaner, KVKs in Rajasthan and Gujarat provide high yielding varieties and grafted saplings of Ber.

Q15. What is the economics and market demand of growing ber?

Ans. Ber is highly remunerative in a rainfed system. The demand for ber is high in the local market. Dry leaves fetch Rs. 25–30 /kg, and fuel wood sells for Rs. 40–70 /kg. The yield for the early variety is 100 kg/tree, for the midseason variety, 150 kg/tree, and for the late variety, 200 kg/tree. The fruits sell at Rs. 2500 per quintal across varieties.



Mung with grafted Ber in Rajasthan

Dalbergia latifolia

- Q1. What are the local/vernacular names by which *Dalbergia latifolia* is known in India?**
Ans. The local names of *D. latifolia* are Black rosewood, Bombay black wood, Black wood, East Indian rosewood, Indian palisandre, Java palisandre, Roseta rosewood (English); Sitsal, Bhotheula, Shisham, Bide, Beete, Chava (Hindi); Jetregi, Chinnayegi (Telugu); Swetasal, Sitsal (Bengali).
- Q2. What are the names by which *D. latifolia* wood is traded?**
Ans. *D. latifolia* is traded by the names of East Indian Rosewood, Rosewood, Bombay Blackwood and Indian rosewood.
- Q3. Is Rosewood suitable for agroforestry systems?**
Ans. Rosewood fixes nitrogen and enriches the soil. The leaf litter decomposes slowly releasing nutrients gradually to the soil. These characteristics make the tree highly suitable for agroforestry systems.
- Q4. Where is the natural distribution of Rosewood in India?**
Ans. Rosewood is found scattered throughout the dry deciduous forests of the Indian peninsula. Its natural range stretches from the sub-Himalayan tracts of Oudh, Bihar, Sikkim, Bengal, Odisha and most parts of central and southern India. Its best growth occurs in the Western Ghats forests of Karnataka, Kerala, and Tamil Nadu.
- Q5. In which agroclimatic zones does Rosewood occur?**
Ans. The species naturally occurs in the forest areas of agroclimatic zones 7, 8, 9, 10, 11 and 12. The species can be cultivated outside forest areas in these zones.
- Q6. What are the major uses of Rosewood?**
Ans. The highly valued heartwood varies in colour from light golden brown to shades of light purple with dark streaks, or deep purple with distant black lines. The wood is very hard and is difficult to work because of its high density. The wood is fragrant and commands a high price. It is used to make premium-grade furniture, paneling, veneers, and interior and exterior joinery. Secondary uses of the wood include; knife handles, musical instruments, calico-printing blocks, mathematical instruments, agricultural implements, and boat keels and screws.
- Q7. What are the medicinal uses of Rosewood?**
Ans. Tannins extracted from the bark of Rosewood are used to produce medicines for the treatment of diarrhoea, worms, indigestion, and leprosy. The tannins are used to produce an appetiser.
- Q8. What is the rotation period followed for Rosewood?**
Ans. The tree is usually harvested at a rotation age of 30-40 years.
- Q9. What are the types of agroforestry systems being practiced involving Rosewood?**
Ans. Rosewood is suitable for Agri-silvi, silvi-horti and silvi-horti-agri systems. The horticulture species planted along with Rosewood includes mango, annona (sitaphal), jackfruit, aonla

and guava. Rosewood is also used as a permanent host tree in Sandalwood plantations and as a shade tree in coffee plantations of Karnataka, Tamil Nadu and Kerala.

Q10. What are the suitable intercrops for Rosewood based agroforestry systems?

Ans. During the initial three years millets like ragi are suitable. Afterwards when the canopies begin to close, shade tolerant crops like ginger and turmeric are planted.

Q11. What is the optimum spacing for Rosewood in agroforestry systems?

Ans. A spacing of 3 x 2 m or 6 x 2 m is suitable for growing intercrops. In pure plantations, a spacing of 2.5 x 1.2 m or 1.8 x 1.0 m is adopted to prevent forking and induce clear bole formation.

Q12. What techniques are used in propagating Rosewood?

Ans. Rosewood is usually propagated through seeds. Root cuttings and stump sprouts can be used for raising clonal plants. Seeds from seed orchards or seed production areas are collected for raising quality planting stock. Soaking the seeds in plain water for 24 hours hastens germination. Seedlings are tended in nursery for a year following which they become ready for field transplanting.

Q13. Can Rosewood be raised as boundary/block/bund plantation?

Ans. Rosewood is suited for boundary and block plantation.

Q14. Does Rosewood require irrigation?

Ans. Rosewood can be grown in both irrigated and rainfed conditions.

Q15. What is the expected yield of timber at the rotation age?

Ans. A 40 year old tree is expected to yield 20 cubic feet of wood.

Q16. What is the potential market demand for Rosewood?

Ans. Rosewood is classified into various classes based on its quality and girth class, and the price of rosewood is fixed accordingly. The current price of Rosewood timber ranges between Rs.5500/cft to Rs.10000/cft. India exported rosewood worth US\$ 2 million during 2020-21.



Rosewood based Silvi-Horti-Agri system



Irrigated Rosewood based agroforestry system

Ailanthus excelsa

- Q1. What is the common name of *Ailanthus excelsa*?**
Ans. Indian tree of Heaven.
- Q2. What are the vernacular/ local names for *A. excelsa*?**
Ans. Perumaram (Tamil, Malayalam), Doddamara (Kannada), Maharukh (Hindi).
- Q3. What is its geographical distribution?**
Ans. It is native to central, western and southern India and part of Sri Lanka. It is widely cultivated in semi-arid and subtropical regions.
- Q4. Which are the states in which Maharukh is grown?**
Ans. It is grown in Kerala, Tamil Nadu, Karnataka, Telangana, Madhya Pradesh, Gujarat, some coastal districts in Andhra Pradesh and Gunjam, Puri districts in Orissa along road-sides and in gardens.
- Q5. What are the uses of Maharukh?**
Ans. Maharukh is known for its use in the match industry and as a fodder. Leaves are highly palatable for sheep and goats and extensively used in Rajasthan. Wood is used for making plywood in Rajasthan and Gujarat.
- Q6. At what age can the trees be harvested?**
Ans. The wood of Maharukh can be harvested at 6 to 8 years for safety match splints.
- Q7. What is the optimum spacing for Maharukh?**
Ans. In block planting, 6 x 6 m spacing can be adopted. Maharukh is often planted in the boundary at 8-10 m distance.
- Q8. What are the intercrops which can be taken up with Maharukh in agroforestry?**
Ans. Wheat, millets, barley, and mustard are the common intercrops. The species can be grown with a suitable mixture of other species - *Acacia catechu*, *A. leucophloea*, *A. nilotica*, *Albizia lebbbeck*, *Prosopis juliflora*, *P. cineraria*, *Azadirachta indica*, *Dolichandrone falcata*, *Pongamia pinnata* and *Ziziphus mauritiana*.
- Q9. How are seedlings of Maharukh produced?**
Ans. Seeds of Maharukh are sown in mother beds without any pretreatment. Germination starts in 8 to 14 days after sowing and completes in 40 to 45 days. Seedlings are susceptible to damping off and root rot. Timely and regular weeding of the nursery beds increases survival percentage and growth. The seedling (30 to 45 days old) can be transplanted into 10 x 20 cm polybags containing soil: sand: FYM in the ratio of 3:2:1.
- Q10. Can Maharukh be grown under rainfed and dry land conditions?**
Ans. Maharukh is suitable for low rainfall areas receiving mean annual rainfall of 600 to 800 mm. However, it requires irrigation during the initial years of planting.

Q 12. What will be the economic returns from cultivation of Maharukh?

Ans. At the end of six years, under rainfed conditions, the wood yield from 1000 trees is approximately 250 tonnes fetching a net income of Rs. 4.0 lakhs. Under irrigated conditions, wood yield is 500 tonnes with a net income of Rs. 8.4 lakhs.

Q13. What is the market demand for Maharukh?

Ans. The current monthly production of matches in the country is 125 lakh bundles, which requires 1,20,000 MT of softwood. To ensure a continuous supply of raw material with a 6 year rotation period, about 57,000 acres of growing stock is required.



A block plantation of Maharukh

Leucaena leucocephala

Q1. What is the common name of *Leucaena leucocephala*?

Ans. Subabul.

Q2. What are the vernacular/ local names?

Ans. Safed babool (Hindi), Subabul (Bengali), Naattu Cauvindal (Tamil), Kainti, Kantisubabul (Telugu); Nagarjun, Rajokasundiri (Oria); Kubabhul (Marathi); Ippilippil, Subabul (Malayalam)

Q3. What type of tree is Subabul?

Ans. It is a medium to large sized, evergreen, fast-growing tree.

Q4. What is the flowering and fruiting time of Subabul?

Ans. The tree flowers during October-November and mature fruits appear during November - December.

Q5. What is the geographical distribution of the species?

Ans. It is native to southern Mexico and northern Central America. It is naturalized throughout the tropics including India.

Q6. Where is Subabul cultivated in India?

Ans. It is grown successfully in Madhya Pradesh, Chhattisgarh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu.

Q7. What are the suitable habitats for Subabul?

Ans. Its natural habitat is plains and degraded forests.

Q8. In which agro climatic zones can Subabul be grown?

Ans. The species can be grown in zones 7, 8, 9, 10, 11 and 12.

Q9. What are the uses of Subabul?

Ans. The species is utilised for fuelwood and pulpwood. It is used as a support for climber crops and the leaves are used as a green manure and fodder. It fixes nitrogen in the soil and helps improve soil fertility.

Q10. Is Subabul good for land reclamation?

Ans. Yes, being a drought tolerant species, it establishes well on disturbed and degraded sites. Further, the nitrogen fixing ability ameliorates poor soils.

Q11. What is the rotation period of Subabul?

Ans. Subabul has a rotation period of 2.5 years for pulpwood.

Q12. Which agroforestry system is implemented for Subabul?

Ans. Silvi-agri system is the most suited for pulpwood and energy plantations.

Q13. What is the optimum spacing for Subabul in agroforestry systems?

Ans. The spacing recommended for pulpwood is 2 x 2m while 4 x 4m spacing is adopted for agroforestry systems.

Q14. How is Subabul propagated?

Ans. Subabul is raised through seeds in containers or nursery beds. Seeds are pretreated by soaking them overnight in water. Seeds are sown 4 cm apart in parallel rows, spaced 25 cm apart. The seed beds are trenched and filled with sand and FYM to provide adequate drainage and to minimise root damage during transplanting. The best time for sowing is March-April.

Q15. What are the nursery practices for Subabul?

Ans. Seedlings can be transplanted to the field when they are nodulated and about 15-30cm tall. A raised seedbed of well-drained and fertile soil is prepared on cement or impermeable floor for growing bare root plants. For container-raised seedlings, pre-treated seeds are sown in 22 × 10 cm polythene bags containing soil mixture and compost in a ratio 2:1. Regularly shifting of bags is necessary as the taproots strike the ground very fast.

Q16. Where can the seeds of Subabul be obtained?

Ans. Seedlings can be procured from ICFRE-IFGTB, ICFRE-TFRI and CRIDA, Hyderabad.

Q17. Can Subabul be raised as Boundary/Block/Bund plantation?

Ans. Subabul can be raised as Boundary, block or bund planting. Predominantly, Subabul is raised as block plantations.

Q18. Does Subabul plantation require protection?

Ans. Yes, since it is a good fodder crop, it is easily browsed.

Q19. Does Subabul require irrigation?

Ans. Irrigated/unirrigated – can be grown both in irrigated and unirrigated condition

Q20. What is the economics of raising Subabul plantation?

Ans. Average yield of dry matter ranges from 3 to 30 tonnes per hectare per year. Intensive management could potentially replace green fodder requirements of 20 dairy cows. A net income of Rs. 67,680 ha/yr can be obtained on degraded lands.



Leucaena based agroforestry system

Q21. What is the potential market demand for Subabul?

Ans. It is highly demanded by paper industries @ Rs 3900 per ton, and also serves as fodder and fuelwood.

Buchanania cochinchinensis (B. lanzan)

Q1. What are the common names of *Buchanania cochinchinensis* ?

Ans. Char, Achar, Chironji

Q2. What are the vernacular/ local names?

Ans. Chironji, Charoli, Priyal, Kath Bhilwa (Hindi), Charoli (Gujrati), Karaka (Tamil Nadu), Sara Chttu, Morli (Telgu), Nurkal (Kannada), Cheru (Malayalam), Chirongi (Arab), Char, Chareli (Marathi), Almondette, Cuddapah almond (English)

Q3. What type of tree is Chironji?

Ans. Chironji is a deciduous tree with a straight bole, tomentose branches, attaining a height of 18 m. The plant is found growing in lowland forests, and dry and moist deciduous forests, semi-evergreen forests, open and dry forests, The plant thrives well on sandy and sandy-loam soils. can and can survive harsh climatic conditions. Chironji is a moderately light demander, fairly drought resistant, and a poor coppicer.

Q4. What is the flowering and fruiting time of Chironji?

Ans. Flowering occurs during March and April, and the fruit is generally harvested in April–June.

Q5. What is the geographical distribution of Chironji?

Ans. It is commonly distributed throughout Burma, Nepal, and India. In India, it is mostly found in Northern, Western, and Central India up to an altitude of 1200 m and is endemic to the dry deciduous forests.

Q6. What is the natural habitat of Chironji?

Ans. It is found in the tropical deciduous forests of north, west, and central India. Plants may be seen in the forest areas of Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Maharashtra, Bihar, Jharkhand, Orissa, Andhra Pradesh, and Gujarat.

Q7. In which agroclimatic zones Chironji can be grown?

Ans. The tree can be grown in agroclimatic zones of 4, 5, 7, 8, 9, 10, 11 and 12.

Q8. What are the uses of Chironji?

Ans. The species has various medicinal uses, including digestion, boosting immunity, enhancing cardiac functioning, treating wounds and ulcers, purifying blood, enhancing skin quality, reducing pain and inflammation, regulating diabetes, and improving cognitive function.

Q9. Does Chironj oil have medicinal properties?

Ans. The fruits and seeds contain a bulk of essential oils and bioactive constituents like flavonoids, galactosides, 8-cineole, camphene, myrcene, triglycerides, sabinene, Y-terpinene

and tannins. These are used in the cosmetic, therapeutic and food industries. The seed has about 50–52% oil known by the name 'char'. The oil can be used as a substitute for almond or olive oil for cooking purposes, and the whole kernel can be used as sweet meat. It is used in enhancing digestion, cardiac functioning, skin quality, boosting immunity,, treating wounds and ulcers, purifying blood, reducing pain and inflammation, regulating diabetes, and improving cognitive function.

Q10. By what age *B. cochinchinensis* start bearing fruits?

Ans. Seeds origin plants bear fruits from 10-11 years and grafted plants from 6-7 years.

Q11. Which agroforestry system is suitable for Chironji?

Ans. Silvi-horti system.

Q12. What is the optimum spacing for Chironji in agroforestry practices?

Ans. The ideal spacing suitable for agroforestry is 8 × 8 m.

Q13. How is Chironji propagated in the nursery?

Ans. Seeds are sown in raised nursery beds. Freshly collected seed should be sown in the well drained nursery beds in May and June. No pre-treatment of the seed is required. The seeds are sown 0.5 to 1 cm deep, and the germination normally starts within 10–15 days and gets completed in 30 days. Freshly collected seed can give as high as 85% germination, but it progressively falls with the passage of time. The growth of seedlings is slow. One or two season old may be transplanted into the field. It is better to sow the seeds directly in big sized polythene bags and keep these in the nurseries for a period of two years, as the seedlings are delicate and may result in considerable mortality while transplanting from seed beds.

Q14. From where can the seeds of Chironji be obtained?

Ans. The seeds can be procured from ICFRE-TFRI and Forest Department nurseries.

Q15. Are cultivars of Chironji available?

Ans. Through improvement programmes at Central Horticultural Experiment Station (CHES), Godhra, cultivar Thar Priya (CHESC-7), CHESC-2 and CHESC-4 has been found promising as a dwarf, high-yielding, short-rotation cultivar of Chironji. The planting material can be obtained from CHES, Godhra.

Q16. Can Chironji be raised as a boundary/block/bund plantation?

Ans. Chironji can be raised as boundary, block or bund planting.

Q17. Does Chironji plantation require protection?

Ans. Yes, it needs intensive protection methods as it is liable for theft.



Q18. Does Chironji require irrigation?

Ans. It can be grown both in irrigated and unirrigated condition

Q19. What is the economics of raising Chironji plantation?

Ans. A mature tree gives about 5 kg kernels per year; an orchard with 100 trees can produce more than 300 kg kernels per ha per year with a gross return of Rs. 2.5 to 3.0 lakh.

Q20. What is the potential market demand for Chironji ?

Ans. India produces around 7000 – 10,000 metric tonnes of Chironji annually. Market share of Chironji in MP and CG is 40%, in Bihar it is 40% and in Odisha it is 20%. Its price varies and depends on its size and quality. In the local markets, Chironji fetches around Rs.500 -750 per kg, while the same fetches around Rs.1500 per kg in the international market.



Buchanania based silvi- pasture model

Pongamia pinnata (*Millettia pinnata*)

- Q1. What are the common names of *Pongamia pinnata*?**
Ans. Indian beech tree, Karanj, Pongam oil tree.
- Q2. What are the vernacular name of *P. pinnata*?**
Ans. Karanj (Hindi), Honge (Kannada), Minnari, Pongam, Ungu (Malayalam), Ponga Maram (Tamil).
- Q3. What is the geographical distribution of Karanj?**
Ans. It is native to eastern and tropical Asia. A native oil yielding tree species, it is distributed throughout India.
- Q4. Which Indian states are suitable for planting Karanj?**
Ans. Jharkhand, West Bengal, Bihar, Chhattisgarh, Andhra Pradesh, Odisha, Madhya Pradesh, Rajasthan.
- Q5. When does Karanj start bearing seeds?**
Ans. Seeds can be obtained from the 5th year of planting.
- Q6. What are the major uses of Karanj?**
Ans. Its seed yields an oil, which is used in lamps, leather tanning, soap making and as a lubricant. The seed oil cake is used in agricultural farms as an animal feed, bio-pesticide, and bio-fertilizer. It is also in biofuel production and in traditional medicine.
- Q7. Which agroforestry models are suitable with Karanj?**
Ans. Silvo-horticulture, agri-silviculture, silvo-pasture.
- Q8. What are different crops that can be cultivated with Karanj?**
Ans. Karanj can be cultivated with vegetable crops such as chilli, cauliflower, tomato and pea, black pepper, ginger, turmeric, areca nut, Napier grass.
- Q9. Can Karanj be raised as boundary/block/bund plantation?**
Ans. Karanj can be planted in boundary, block or row plantation
- Q10. What are different methods to propagate Karanj?**
Ans. Karanj can be propagated through seeds, grafting, branch cutting and root suckers.
- Q11. Is it possible to store seeds of Karanj?**
Ans. When stored, seeds of Karanj remain viable for one year.



Q12. What is the best nursery practice for Karanj?

Ans. Fresh seeds are sown directly in polybags of 20 x 15 cm filled with soil, sand and FYM in the ratio of 2:1:1. Seeds germinate in 10-15 days. Seeds can also be sown in mother beds and then shifted to polybags after 30 - 40 days of germination.

Q13. What is the appropriate age of seedlings for planting ?

Ans. Six- to eight-month-old seedlings of height more than 2 feet are suitable for planting.

Q14. Does Karanj require irrigation?

Ans. It can be grown in both irrigated and unirrigated conditions but watering during the summer months for the first two years improves survival and shows good growth.

Q15. What is the yield of a tree and the oil content of the seeds?

Ans. A well grown-up tree of 5 to 10 years can yield 10-50 kg seeds per tree depending on seed year. The seeds contain 20-25 percent oil.

Q16. What is the market demand of Karanj?

Ans. The demand of Karanj oil is high especially in animal feed, personal care industry, nutraceuticals, toiletries and pesticides. India has been exporting Karanj oil to various countries. The quantity of export ranges between about 768 kg to 1685 kg annually from 2004 to 2016. The price of the seeds is fixed at Rs. 19 per kg (2019) under the MSP scheme of the Ministry of Tribal Affairs (MoTA).

Vachellia tortilis (*Acacia tortilis*)

Q1. What are the common names for *Vachellia tortilis*?

Ans. Israeli Babool, also often known as “umbrella thorn” for its distinctive spreading crown.

Q2. Where is *Vachellia tortilis* distributed?

Ans. Native to Africa, it has only been planted since 1972 in arid regions of India.

Q3. In which states is Israeli Babool adopted?

Ans. Israeli Babool is one of the most planted species in the arid regions of Rajasthan, Gujarat and Haryana to control sand dune shifting.

Q4. What are the uses of *V. tortilis*?

Ans. The species is considered more useful than many indigenous species growing in the arid zone of India due to its drought hardiness and fast growth. It produces firewood, leaves, and pods as fodder for cattle, camels, goats and sheep. It plays an important ecological role, acting as a soil-binding tree, and helps stabilise shifting sand dunes. It is a potential species for afforestation of shifting sand dunes, refractory sites, hill slopes, ravines, and lateritic soils. It has been grown successfully in shelterbelts with *Azadirachta indica*.

Q5. What is the rotation period of the species?

Ans. Not defined but more than 20-25 years.

Q6. What are the nursery and silvicultural practices for *V. tortilis*?

Ans. It easily regenerates from seed. A mature tree produces over 6000 pods annually, each with 8–16 seeds. Seeds can be extracted by pounding the pods, which are then winnowed and cleaned. The hard-coated seeds remain viable for several years under cool, dry conditions. Seed pre-treatment by soaking in sulphuric acid for 20–30 minutes or in boiled water is required to enhance germination.

Seeds can be sown in the ground in 1 cm deep holes or in the nursery in long root trainers. Seedlings are ready to be outplanted after 3–8 months. On marginal sites, initial seedling growth is often slow but quickens once roots have reached a water source. For best growth, plants should be weeded and protected from browsing animals for the first three years.

Q7. What are the suitable intercrops and silvicultural techniques for growing *V. tortilis*?

Ans. *V. tortilis* is a nitrogen fixing tree. Poor herbaceous growth under *V. tortilis* has been reported. Yields of mungbean and sorghum are increased when lateral roots of *V. tortilis* are trenched.

Q8. From where can one get Quality Planting Material (QPM) of *V. tortilis*?

Ans. ICFRE-AFRI and forest department of Rajasthan provides quality seedlings of Israeli Babool to the stakeholders.



Q9. Can *V. tortilis* be raised as a boundary/block/bund plantation?

Ans. It is more suited as a shelterbelt on the boundary/ bund of farmlands.

Q10. What is the market demand for *V. tortilis*?

Ans. The market demand for timber, particularly in the handicraft sector, is promising. After wood has been seasoned, it becomes valuable. The dense, red wood makes very good charcoal and fuelwood (4360 cal/kg). For fuelwood production trees are planted at 3 x 3 m spacing and coppiced. Over 50 tonnes of wood per ha can be harvested after 10–12 years.



Pearl millet association with *V. tortilis* on bund in tradition agroforestry in Rajasthan



Sesame with *V. tortilis* in traditional agroforestry in Rajasthan

Morus alba

Q1. What are the common names of *Morus alba*?

Ans. Mulberry, White mulberry, Common mulberry or Silkworm mulberry

Q2. What are the vernacular/ local names?

Ans. Shahtoot/ Toot/ Keemu (Hindi), Tula (Sanskrit), Shetun (Gujarati), Kambli chedi, Mussuketi (Tamil).

Q3. What type of tree is Mulberry?

Ans. It is a moderate-sized deciduous and shade-tolerant tree species.

Q4. What is the flowering and fruiting time of Mulberry?

Ans. Tree flowers in April to May and edible fruits ripen during June to August,

Q5. What is the geographical distribution of Mulberry?

Ans. Jammu and Kashmir and Ladakh, Himachal Pradesh, Uttarakhand up to Assam. In Plains Andhra Pradesh, Punjab, Haryana, Rajasthan, Madhya Pradesh, Maharashtra, Kerala, Karnataka and Tamil Nadu and ascends to an elevation of 1200m.

Q6. What is the natural habitat for Mulberry?

Ans. *M. alba* is available in wild and cultivated forms throughout India.

Q7. In which agroclimatic zones can Mulberry be grown?

Ans. Mulberry can be grown in agroclimatic zones 1, 2, 4, 5, 6, 10, 11, 12 and 14.

Q8. What are the uses of Mulberry?

Ans. The leaves are a nutritious fodder, and small wood is used as fuelwood. The tree produces wood used in sports equipment like hockey sticks, tennis and badminton rackets, and cricket bats. The species is widely cultivated as a source of primary food for rearing silkworms, which produce silk.

Q9. Does mulberry fruit/leaf have medicinal or nutritional properties?

Ans. The raw mulberry fruits, weighing about 100 g provide 43 kcal, 44% of the Daily Value (DV) for vitamin C, and 14% of the DV for iron, among other nutrients. The fruit improves digestion, lowers cholesterol, helps with weight loss, increases blood circulation, builds bone tissues, and boosts the immune system. The fruits of the mulberry also help to prevent certain cancers, slow down the ageing process, lower blood pressure, protect the eyes, and improve the overall body metabolism.

Q10. What is the rotation period for Mulberry?

Ans. The rotation period is 10 to 12 years for utilising the wood for bent instruments and sports equipment.



Q11. What is the best period for fodder collection and harvesting Mulberry?

Ans. During the lean period of May to September, it can be pollarded at 5 to 6 feet height for obtaining nutritious fodder.

Q12. Which agroforestry system is implemented for Mulberry?

Ans. Mulberry is suitable for agri-silviculture, silvi-pastoral and agri-silvi-pastoral and sericulture-based agroforestry systems.

Q13. What are the intercrops used in Mulberry based agroforestry?

Ans. The most suitable intercrops for Mulberry based agroforestry are rice, wheat, soybean, pulses, beans, vegetables and forage crops like hybrid Napier and Setaria grass.

Q14. What is the optimum spacing for Mulberry in agroforestry practices?

Ans. Spacing depends on soil fertility. Generally, the trees are grown at 3 × 3m spacing for fodder and at a distance of 2 - 3m on field bunds and boundaries.

Q15. How is Mulberry propagated?

Ans. Mulberry can be easily propagated through seeds as well as through branch cuttings.

Q16. What are the nursery practices for Mulberry?

Ans. During June and July, the seeds are collected and soaked in water for 24 hours before sowing. Clonal propagation is carried out through softwood or hardwood cuttings. The cuttings are treated by quick dip method with rooting hormone, viz., 2000 mg/litre of IBA. The treated cuttings are placed in root trainers with rooting media of sand, soil and farmyard manure (1:1:1) and kept inside a mist chamber.

Q17. Which method of propagation is most suitable for higher growth, survival and yield of Mulberry plants?

Ans. Propagation through vegetative methods gives better survival and true to type plants with superior growth and quality similar to the parent clone.

Q18. Are clones of Mulberry available?

Ans. Some of the Mulberry clones / varieties developed by different institutes working on sericulture include Kanva 2, MR 2, S 30, S 36, S 54, DD (Viswa), V1, S 13, S 34, RFS 135, RFS 175, S 1635.

Q19. Can Mulberry be raised as boundary/block/bund plantation?

Ans. Mulberry can be grown on field boundaries, bunds, contours and terraces.

Q20. Does Mulberry plantation require protection?

Ans. Mulberry plantations require protection from browsing animals during the early years of establishment.

Q21. Does Mulberry require irrigation?

Ans. Mulberry can be grown both under irrigated and rainfed conditions.

Q22. What is the economics of raising Mulberry plantation?

Ans. A medium sized trees can produce 10-15 kg of green fodder/year/tree. 22-30 kg of green fuelwood/year/tree and 80-120 kg wood as a bole from main trunk. In silvi-pastoral system a tree can yield 8 t ha⁻¹ yr⁻¹ of green tree fodder and 24 t ha⁻¹ yr⁻¹ of green grass forage as compared to only 6 t ha⁻¹ yr⁻¹ green fodder yield from degraded grassland. A medium sized tree can produce 10-15 kg of green fodder/year/tree. The net income of a degraded grassland is Rs. 12000 to 14000 ha⁻¹yr⁻¹ in the initial years, which increases up to Rs. 30000 to 35000 ha⁻¹yr⁻¹ registering a B:C ratio of 1.50 to 2.10 on a cycle of 10 years.

Q23. What is the potential market demand for Mulberry?

Ans. The silk industry has always been significant for the Indian economy, as it provides high profits and employment. Almost 90% of the world's commercial silk production is mulberry silk. As per the Ministry of Textiles (2019), the total area under Mulberry plantations is about 224000 ha and they produce 22 MT of raw Mulberry silk. In the future, the demand for mulberry silk is expected to increase through domestic production due to mulberry horizontal expansion.



Senegalia senegal (*Acacia senegal*)

Q1. What are the common names of *Senegalia senegal*?

Ans. Kumat, Kumbat.

Q2. What is the geographical distribution of *S. senegal*?

Ans. The gum arabic tree is native to Western Sudan, Nigeria and the Arabian Peninsula.

Q3. What is the geographical distribution of *S. senegal*?

Ans. *S. senegal* is cultivated in arid regions of (Delhi, Rajasthan, Gujarat, Punjab, Haryana).

Q4. What are the suitable conditions for the growth of *S. senegal*?

Ans. Gum arabic trees grow where annual rainfall is in the range of 380 to 2280 mm, and annual mean temperatures between 16 and 27°C. It cannot survive frost but is tolerant to drought.

Q5. What are the uses of *S. senegal*?

Ans. Gum Arabic has industrial and culinary uses. It is a rich source of dietary fibres in addition to its widespread use in food and pharmaceutical industries as a safe thickener, natural emulsifier, and stabilizer. Dried seeds are edible. The wood has a high calorific value. Leaves and pods are browsed by sheep, goats and camels. The heartwood is used for making carts and wheels, agricultural implements, and tool handles. It has remedial properties that help to remove toxins from the body and cure skin inflammation, bacterial and fungal infections through application. It has been used for desertification control, the re-establishment of a vegetative cover in degraded areas, mine land reclamation, sand dune fixation, and wind erosion control.

Q6. By what age does *S. senegal* start producing gum?

Ans. The gum yield is low in trees 5 to 10 years of age, increases to reach its peak at 15 years of age, and then decreases at the age of 20 years. The average yield per tree is 250 g per season.

Q7. How is *S. senegal* propagated?

Ans. Freshly matured pods are collected from December to February. The seeds are to be soaked in warm water for 24 hours and sown directly in a polybag measuring 12.5 cm x 25 cm filled with a soil mixture (1:1:1; FYM: Sand: Clay). Regular watering is required for germination and seedling growth.

Q8. What are the best Agroforestry practices?

Ans. Seedlings of six to one year old are planted at 6 m x 6m, 9m x 9m or 12m x 10m spacing in an agroforestry system.

Q9. From where can one get quality planting material (QPM)?

Ans. AFRI, Jodhpur and forest department of Rajasthan provide quality seedlings of Kumat.

Q10. Can Kumat be raised as boundary/block/bund plantation?

Ans. Kumat can be planted in boundaries as well as in blocks.

Q11. What are the different crops that can be cultivated with Kumat?

Ans. It is valued in agroforestry systems where it is combined with crops such as millet, sorghum, sesame, and groundnut. Crops like pearl millet, mung bean, moth bean, cluster bean, wheat, barley, cumin and mustard can grow without much loss in crop yield up to 5 years.

Q12. What is the economics of Kumat cultivation?

Ans. The gum tapped from the trees, and the dry boiled seeds are the main sources of revenue. Local market rates of the dry boiled seed is Rs. 80-100 /kg and the gum is sold at Rs.1000 to 1500 per kg.

Q13. What is the market demand of the species?

Ans. On the basis of gum type, gum arabic was valued at US\$ 201.1 million in 2019 and is expected to grow at a CAGR of 5.2% by 2027.



Pearl millet with *S. senegal* in Rajasthan



Wheat with *S. senegal* in Rajasthan

Bamboos

Q1. How many species of bamboo are there in India?

Ans. India is very rich in bamboo diversity. One hundred and thirty six species (125 indigenous and 11 exotic) are reported under 23 genera.

Q2. Why is bamboo referred to as Green Gold?

Ans. Bamboos are becoming increasingly important in the global economy. They are regarded as a renewable natural resource because of their fast growth, and capability of regeneration after harvest without the need for replanting. Along with the variety of uses it can be put to, it is highly renewable, sustainable, and easy to grow.

Q3. Which are the commercially important bamboo species?

Ans. The National Bamboo Mission (NBM) has classified ten species namely *Bambusa tulda*, *B. bambos*, *B. balcooa*, *B. cacharensis*, *B. polymorpha*, *B. nutans*, *Dendrocalamus asper*, *D. hamiltonii*, *Thyrostachys oliveri*, *Melocanna baccifera* as commercially important.

Q4. What are the major uses of bamboos?

Ans. More than 1500 uses of bamboo have been reported thus far. It is used in the pulp and paper industry, as a wood substitute, in building and construction, in homes and crafts, in cottage industries, in food production, in the packing industry, and as a source of material for handicrafts like toys, musical instruments, fences, and animal feeds, in addition to other things like building and construction. Shoots of some species are also used as a vegetable and for making pickles. Bamboo plywood is also very popular because of its aesthetics. Production of bio-ethanol from bamboo is the most recent addition to this list.

Q5. What are the common edible bamboo species?

Ans. *Dendrocalamus strictus*, *D. asper*, *D. hamiltonii*, *D. giganteus*, *D. membranaceus*, *D. brandisii*, *Bambusa balcooa*, *B. bambos*, *B. nutans*, *B. tulda*, *B. vulgaris* and *Phyllostachys* sps.

Q6. What is the geographic distribution of bamboo in India?

Ans. In India, bamboos are found in all the states except Kashmir. It grows from sea level to 4000 m elevation, from very high rainfall areas to areas of scant rainfall in Rajasthan. According to the FSI report (2021), the total bamboo bearing area of the country is estimated to be 15.0 million ha. Madhya Pradesh has the largest area of bamboo (1.84 million ha), followed by Arunachal Pradesh (1.57 million ha), Maharashtra (1.35 million ha), and Odisha (1.12 million ha).

Q7. What soil types are suited for bamboo cultivation?

Ans. Generally, bamboo grows well in sandy loams to loamy clay types of soils. It prefers usually well-drained soils which are neutral to marginally acidic for its luxuriant growth. Most of the bamboos thrive well from mean sea level to 4000 m, in temperatures ranging from 8.8° C to 36° C and annual rainfall of 1270-4050 mm.

Q8. Are identified sources or Candidate Plus Clumps (CPC) of bamboo available?

Ans. ICFRE has selected 497 CPCs of different bamboo species (*B. balcooa*, *B. nutans*, *B. nutans*, *B. tulda*, *B. vulgaris* green, *B. bambos*, *Thyrsostachys oliveri*, *D. giganteus*, *B. multiplex*, *B. striata*, *B. jaintiana*, *Dendrocalamus stocksii* and *Melocanna baccifera*).

Q9. What is the most common method of bamboo propagation?

Ans. Bamboos can be propagated both by seed and vegetatively. Propagation through seeds is the easiest and cheapest method. However, most of the bamboo species do not flower annually and take a long number of years to flower. Therefore, vegetative methods are extensively used.

Q10. Why are bamboo seeds not available regularly?

Ans. Many important Indian bamboo species have a 40-50 year flowering cycle. Most of them flower and fruit only once in their lifetime. This is called monocarpic flowering. The entire clump dies after flowering and seeding. Further, it is not possible that the next flowering event can be predicted. Hence predicting the availability of seeds is a constraint in bamboos.

Q11. What is the viability of bamboo seeds?

Ans. Bamboo seed viability is poor. It is categorised as a short-lived seed. The viability reduces drastically after 3-4 months of collection.

Q12. If available, what are the nursery practices for bamboo seed germination?

Ans. Whenever seeds are available they can be germinated in nursery beds. To screen sound seeds, they are put into water and the floating seeds discarded. The sinkers are sown in nursery beds in the mixture of soil, sand and FYM in the proportion of 1:1:1. Germination starts within 7 to 10 days. Seedlings are pricked out at the four leaf stage and transplanted into poly bags or nursery beds. Planting in the field is done as soon as the monsoon begins.

Q13. What are the different vegetative propagation methods practised in bamboos?

Ans. Vegetatively bamboos are propagated through rhizome, culm cuttings, branch cuttings and tissue culture.

Q14. Do we need to provide protection to the plantations?

Ans. Bamboo plantations need protection from domestic cattle and wild animals. It would be prudent to fence the site to prevent grazing animals during the establishment period. Trenches also can be made along the periphery of the plantation to prevent entry of animals.

Q15. What is the spacing to be adopted when establishing a bamboo plantation?

Ans. Closely cultivated clumps create congestion with less workable space. Different bamboo species require different spacing based on their clump size, growth patterns and objective of plantation. For medium size bamboos particularly *Bambusa*, a spacing of 5 x 5m to 7 x 7 m is recommended. But for larger clump forming bamboos like *Dendrocalamus giganteus* 10 x 10 m spacing or 100 plants per hectare is appropriate.



The spacing also depends on the purpose of the plantation. If the purpose of the plantation is shoot harvesting, soil stabilization or control of erosion then the spacing can be reduced to 3 x 3 m or 1100 plants per hectare.

Q16. What are the management practices to be adopted to increase clump formation in bamboo plantations?

Ans. Depending on the type of rhizome growth, the bamboos may be clump forming or non-clump forming. The establishment period of bamboo varies depending on the propagules used. In case of rhizome / offsets, the establishment period is 3-5 years and for seedling it is 5-7 years. For ensuring high productivity, regular management is required. This can be done through following practices:

- Weeding is done at least twice a year for the initial 2 years after rain and at the end of the wet season.
- Soil loosening around the clumps 1-2 times every year
- Mulching to reduce loss of moisture due to evaporation from the planting pits.
- Soil mounding or heaping fresh soil around the clump every year before the emergence of a new culm. This prevents exposure of the rhizomes to sunlight.
- Pruning the thorny/thick branches in species like *Bambusa bambos*, *Bambusa balcooa*, *Dendrocalamus hamiltonii* reduces clump congestion and helps in keeping the clump in working condition.
- Thinning must be done every year before the rains beginning with the third year.

Q17. Do bamboos require fertilizer application?

Ans. Productivity increases when yearly manuring and fertilisers are provided. Methods of application, kind, dosage, and timing are to be considered while providing the fertiliser to the clumps, as they vary with species.

Q18. What is the optimal harvesting schedule for bamboos?

Ans. Harvesting of bamboo culms can begin from the third year of establishing a plantation. The felling must be completed before the emergence of new shoots.

Q19. What are the precautions to be followed while harvesting bamboo culms?

- Ans.**
- i. No clump is considered harvestable unless it contains more than eight mature culms.
 - ii. The age of the culms to be felled should be 3 years and older.
 - iii. In a mature clump, six culms from the current season and eight culms from the previous year are retained.
 - iv. Selective harvesting is preferably done every year.
 - v. Tending operations are done along with felling by cutting malformed, dead, diseased, or otherwise useless culms, stumps, and climbers.
 - vi. Under no circumstances is the felling done during the rainy season to prevent fungal infections.

Q20. Which of the following is preferred to raise bamboo plantations - seedlings or vegetatively propagated plants?

Ans. Plantations raised from seeds have the advantage of being harvested until the next flowering period, which usually ranges between 35 and 60 years. Though productivity from plantations raised from vegetatively propagated material of superior genotypes is higher, the duration of the plantation depends on the history/origin of the mother clumps used for propagation.

Q21. What is the average yield of culms from a bamboo plantation?

Ans. A one-hectare plantation accommodates 400 clumps when planted at a spacing of 5 x 5 m. From a properly managed 5-6 years old plantation, approximately 8 poles can be obtained from one clump every year. Thus, from one hectare, 3200 poles can be harvested annually.

Q22. What is the cost of cultivation of a bamboo plantation?

Ans. The total cost required for establishment of bamboo up to the 5th year would be Rs. 3 lakhs/ha. From the first year onwards, cash inflow starts, with a gross return of 3.5 to 5 lakhs /ha. The B-C ratio for bamboos is 1: 1.91 indicating its cultivation to be a profitable venture.

Q23. What is the market demand for bamboos?

Ans. The pulp and the paper industry and the bamboo craft sector are the two major areas of bamboo resources. The global market size was valued at \$65.8 billion in 2021 and is projected to reach \$99.8 billion by 2031, growing at a CAGR (Compound Annual Growth Rate) of 4.1% from 2022-31.



Some of the commercially important bamboo species commonly adopted in agroforestry in different parts of the country are elaborated here

Dendrocalamus strictus

Q1. What are the common/vernacular names of *Dendrocalamus strictus*?

Ans. Male Bamboo, Lathi bans, Bans

Q2. What is the geographical distribution of *D. strictus*?

Ans. It is found in plains and sub-Himalayan tract in deciduous forests over large areas in India except in north Bengal, Assam, moist regions of West Coast and very dry regions in Rajasthan and adjoining areas.

Q3. Where is *D. strictus* cultivated in India?

Ans. It is widely cultivated in Uttar Pradesh, Gujarat, Bihar, West Bengal, Jharkhand, Odisha, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Telangana, Shiwalik/sub-Himalayan region of Uttarakhand, Haryana and Punjab, and to a less extent in other states.

Q4. What are its major uses?

Ans. The poles are used for house construction, scaffolding, baskets, mats, agricultural implements, handicrafts, furniture, pulp, paper, etc. It is also being promoted for engineered bamboo products, (bamboo scrimber and laminated bamboo), mat board, biochar, activated charcoal, charcoal, etc.

Q5. What is the optimal age for harvest of its culms?

Ans. The culms can be harvested after 4 years in cultivated land and after 5 years in uncultivated land. Subsequently, mature culms within the clump can be identified and removed every year, and the clump can be maintained until flowering, which is usually at 20–65 year intervals.

Q6. What are the species which can be intercropped with *D. strictus*?

Ans. A wide variety of agricultural crops of the agro climatic region, other than paddy, can be grown under block plantations during the initial few years, while shade bearing crops such as turmeric can be grown till the canopy begins to close. In bund planting, all types of agricultural crops can be grown all the time.

Q7. What are the major operations to be carried out for a successful bamboo plantation?

Ans. Planting should be done at the onset of the monsoon. Pit size of 45 x 45 x 45 cm is ideal. One-year-old plants are planted in the pits. Weekly irrigation during the first summer season and fortnightly irrigation during the remaining dry spells until two years of age help in attaining greater survival and growth. The soil should be loosened around the clumps in a radius of one metre twice a year and earthed up around the clump. Pruning of lateral branches of culms, removal of mature culms, and cleaning should be done every year to prevent congestion, improve aeration, and facilitate easy extraction of

culms. The cleaning operation involves the removal of damaged, dying or dead culms and high clumps. Roots should be pruned beyond a 2.5 m distance from clumps to reduce the adverse effect on agricultural crops due to competition. Application of chlorpyrifos 20EC in 2 ml per litre kills adult termites and white grubs and reduces infestation levels.

Q8. What is the most common propagation method for *D.strictus*?

Ans. Macroproliferation is the most preferred and reliable method for propagation as the availability of seed remains uncertain and seed longevity is short. Offset planting is also practised.

Q9. What is the spacing adopted in the agroforestry?

Ans. For a block plantation, the spacing recommended is 5 x 5 m. If intercropping is taken up, it may be planted at 12 x 8 m spacing. For boundary/bund planting 3.5 - 4 m distance may be maintained between adjacent plants.

Q10. Does the species require irrigation?

Ans. The species attains best survival and growth under irrigated conditions. Though it also thrives under rainfed conditions, irrigation at least once a fortnight during the first summer improves survival.

Q11. How profitable is *D.strictus* cultivation?

Ans. After four years, *D. strictus*-wheat-urad model gave returns of Rs. 2 lakhs/ha through harvest of culms (2000 culms @ Rs. 100/culm). Against an overall expenditure of ~1.0 lakh at the end of four years, the net income was 2.14 lakhs/ha with a benefit:cost ratio of 2.30.



Dendrocalamus stocksii

Q 1. What is the common name of *Dendrocalamus stocksii*?

Ans. Marihal bamboo

Q 2. What are the vernacular/ local names?

Ans. Chivari, Mes (Maharashtra); Konda, Oor-shema, Marihal bamboo (Karnataka); Manga (Goa).

Q 3. What is the characteristic feature of *D.stocksii*?

Ans. It is medium-sized, stout, solid, thornless bamboo, with strong clumps, and easily manageable.

Q 4. What is its geographical distribution?

Ans. It is endemic to the Central Western Ghats and found in Kerala, Karnataka, Goa, and Maharashtra.

Q 5. In which agroclimatic zones can *D.stocksii* be grown?

Ans. It can be grown in zone 12.

Q 6. What are the uses of *D.stocksii*?

Ans. The market potential of this species is increasing in the furniture industry. It is the preferred bamboo among boatmen. It is used for a variety of modern household furnishings, including benches, cots, tables, sofa sets, chairs, and outdoor furniture. It is also used to create scaffolding, farm tools, horticulture stakes, and handicrafts.

Q 7. What is the rotation period for *D. stocksii*?

Ans. Harvesting starts from the 3rd year onwards through selective felling of mature culms.

Q 8. Which agroforestry system is implemented for *D. stocksii*?

Ans. Agri-silviculture system.

Q 9. What are the suitable intercrops in a *D. stocksii*-based agroforestry system?

Ans. Finger millet, sweet potato, pumpkin, fodder grasses, pulses, chilly, and leafy vegetables. They can be grown as intercrops for 2-3 years.

Q10. Is thinning required for *D. stocksii*?

Ans. Yes, periodic thinning of dead, diseased and bended culms needs to be removed as a part of clump management for high productivity.

Q11. When is the flowering and fruiting time of *D. stocksii*?

Ans. It flowers sporadically. However, it does not produce viable seed.

Q12. How is *D. stocksii* propagated in the nursery?

Ans. It is propagated vegetatively. ICFRE-IWST has standardized macro-propagation techniques for mass multiplication. Tissue culture protocols are also developed.

Q13. Can *D. stocksii* be raised as boundary/block/bund plantation?

Ans. *D. stocksii* can be raised as a boundary or block.

Q14. What is the optimal spacing to be adopted for *D. stocksii* in a block plantation and agroforestry?

Ans. The recommended spacing for block plantation is 3 x 3m and 4 x 4m while in agroforestry systems it is spaced at 10 x 10m and 10 x 12m.

Q15. Does *D. stocksii* require irrigation?

Ans. It can be grown both in irrigated and unirrigated condition. However, irrigation is required for higher productivity.

Q16. What is the economics of raising *D. stocksii* plantation?

Ans. The initial investment (which is for five years) is about Rs. 1.0 lakh/ha/year. Returns can be expected from the fifth year, with five culms per clump initially which increases to 10 culms per clump from the sixth year onwards. A 20-foot culm costs between Rs. 80 and Rs. 120. From a commercial plantation, potential revenue of Rs. 2.2 lakhs in the 5th year and around Rs. 4.5 lakhs/year from the 6th year onward can be expected with a yield of 5630 culms. Over the plantation's 40-year lifespan, an annual net income of Rs. 2.2-2.7 lakhs is predicted.

Q17. What is the potential market demand for *D. stocksii*?

Ans. It is reported that in the Sindhudurg district (Maharashtra) alone, around 5000 truckloads (1200–1400 poles/truckload) of *D. stocksii* worth Rs. 40 crores is harvested annually. Bamboo processing units such as Konkan Bamboo and Cane Center (KONBAC), Kudal, Maharashtra, Bamboo Pecker, Bangalore and Uravu, Wayanad are the major buyers.



Agroforestry model - *D. stocksii* + Finger millet in Maharashtra

(Source - Dr. A.D. Rane, College of Forestry, Dapoli, Maharashtra)



Clumps of *D. stocksii* in farm boundary in Sindhudurg, Maharashtra

(Source - Dr. A.D. Rane, College of Forestry, Dapoli, Maharashtra)

Bambusa balcooa

Q1. What are the common/ vernacular names of *Bambusa balcooa*?

Ans. Female bamboo, Beema bamboo, bhaluka, balku, boro baas.

Q2. What is its geographical distribution?

Ans. The species is native to north eastern India.

Q3. What are the suitable agroclimatic zones for the species?

Ans. Lower Gangetic plains and eastern Himalayan region.

Q4. In which areas has the species been introduced?

Ans. Jharkhand, Bihar, West Bengal Eastern Uttar Pradesh, Orissa, Maharashtra, Tamil Nadu.

Q5. What is the suitable soil type for this species?

Ans. It grows in a wide range of soil types; however maximum productivity has been reported in heavy textured soil with good drainage.

Q6. Under what climatic conditions is the growth of the species optimum?

Ans. Growth is profuse in tropical and tropical to sub tropical conditions.

Q7. What are the potential uses of *B. balcooa*?

Ans. Building materials for houses, bridges, fishing floats, frames of rickshaw hoods, baskets, wood chip industry, paper pulp, shoots are consumed as vegetables and leaves are used as fodder.

Q8. What is the growth rate of *B. balcooa*?

Ans. Full culm length is attained within 2-3 months of shoot emergence and the culm matures in 3-4 years.

Q9. What is the harvesting age for *B. balcooa*?

Ans. The tender shoots are harvested within 3 weeks of emergence for edible purpose. For commercial purposes, 3-4 year old culms are harvested.

Q10. What are suitable intercrops in *B. balcooa* based agroforestry system?

Ans. Maize, Colocasia, cow pea, soyabean, pineapple, banana, ginger, turmeric are grown as intercrops up to fourth year.

Q11. How is the species propagated?

Ans. Propagation is through rhizome, culm cuttings (two nodal) and tissue culture.

Q12. What is the suitable spacing for *B. balcooa*?

Ans. Spacing depends on the induce. For edible shoots, a spacing of 5 x 5 m, for culm production 7 x 7 m and for intercropping 12 x 10 m is recommended.

Q13. Can *B. balcooa* be raised as boundary/block/bund plantation?

Ans. The species is preferably planted on the boundary and bund.

Q14. Does the species require irrigation?

Ans. Irrigation is required during the initial stages of establishment.

Q15. What is the potential yield of *B. balcooa*?

Ans. The species produces 500 to 700 poles per hectare per year.

Q16. What is the economics of raising *B. balcooa* plantation?

Ans. The total expenditure from establishment up to the 5th year is approximately Rs. 3.0 lakhs/ ha. The gross returns per hectare from the fifth year onwards is Rs. 5.0 lakhs. The B-C ratio of 1: 1.91 of the sole crop indicates that its cultivation is profitable. The B-C ratio of Balcooa with pineapple is 7, with banana 3.89 and with turmeric 4.07.

Bambusa vulgaris

Q1. What is the common name of *Bambusa vulgaris*?

Ans. Golden bamboo

Q2. What are the vernacular/ local names?

Ans. Peela bans/ Hara Baans, Bidiru, Yellow Bamboo

Q3. What is the characteristic feature of *B. vulgaris* ?

Ans. *B. vulgaris* is woody grass having long internode with hollow culms.

Q4. What is the flowering time of *B. vulgaris* ?

Ans. The flowering cycle is 35 years.

Q5. What is the geographical distribution of yellow bamboo?

Ans. *B. vulgaris* is widely cultivated throughout the north-eastern region and central part of India.

Q6. What is the natural habitat of yellow bamboo?

Ans. *B. vulgaris* grows mostly on river banks, road sides, wastelands, and open ground, generally in the low altitudes. It is a preferred species for erosion control. It grows best under humid conditions, but can tolerate unfavourable conditions like low temperatures and drought.

Q7. What are the uses of yellow bamboo?

Ans. Yellow bamboo is used for construction of houses, huts, boats, fences, props and furniture; as raw material for paper pulp; shoots are rarely used as a vegetable or as livestock fodder.

Q8. When can the first set of culms be harvested ?

Ans. Harvesting can start from the fifth year onwards in the case of homesteads. In case of commercial plantations, harvesting must be done only from the sixth year. A regular felling of few culms is the common practice. In some cases, the whole clump is removed, allowing the growth of new culms.

Q9. How is the yellow bamboo propagated ?

Ans. It is easily propagated vegetatively, by clump division, rhizome, stem and branch cuttings, layering and tissue culture.

Q10. What are the nursery practices for *B. vulgaris*?

Ans. Yellow bamboo cuttings can be raised directly on nursery beds and are allowed to grow for a year. These seedlings can be transplanted directly into the field. In rhizome planting method, one-year old culms with roots are dug out and cut to one metre height. These culms should be planted during the monsoon.

Q11. From where can planting material of *B. vulgaris* be obtained?

Ans. Seedlings can be procured from ICFRE institutes.

Q12. Can *B. vulgaris* be raised as boundary/block/bund plantation?

Ans. *B. vulgaris* is predominantly raised as block plantations.

Q13. Does *B. vulgaris* plantation require protection?

Ans. It is easily browsed; hence protection is required during the initial stages of establishment.

Q14. Does *B. vulgaris* require irrigation?

Ans. Yes, Irrigation is required during its establishment period. In drier areas, with rainfall less than 800 mm, it has been found that mulching around seedlings encourages growth through reduced evaporation of soil water.

Q15. What is the economics of raising *B. vulgaris* plantation?

Ans. The average sale price per culm is Rs 100. With 2500 clumps per hectare, the initial cost of investment and maintenance is Rs. 2.5 lakhs. From the 5th year onwards, the gross returns would be Rs. 2.5 lakhs /ha.

Q16. What is the potential market demand for *B. vulgaris*?

Ans. The current demand of bamboo for various purposes is estimated at 26.69 million tonnes as against supply of 13.47 million tonnes.



B. vulgaris plant



B. vulgaris based agroforestry system

Bambusa tulda

Q1. What are the common names of *Bambusa tulda*?

Ans. Bengal bamboo, Indian Timber Bamboo

Q2. What type of grass is *B. tulda*?

Ans. It is a tall, dull green culmed bamboo turning greyish green when mature. It constitutes a few closely growing culms that grow to a height of 6–23 m.

Q3. What is the flowering time of *B. tulda*?

Ans. *B. tulda* normally flowers gregariously once in 30 years.

Q4. What is its geographical distribution?

Ans. It is native to India.

Q5. What is the natural habitat for *B. tulda*?

Ans. *B. tulda* is a tropical lowland bamboo. It grows as an undergrowth in moist alluvial flat lands, valleys, along streams or river banks and in mixed deciduous forests, up to an altitude of 1500 m.

Q6. In which agroclimatic zones can *B. tulda* be grown?

Ans. It can be grown in the Eastern Himalayan Region, Eastern Plateau and Hills Region,

Q7. What are the uses of *B. tulda*?

Ans. *B. tulda* culms are used for construction, scaffolding, furniture, boxes, basketry, mats, household utensils, handicrafts and as raw material for paperpulp. The young shoots are edible but taste slightly bitter, therefore are preferably pickled.

Q8. Which agroforestry system is suited for *B. tulda*?

Ans. Block plantation / agrisilviculture system.

Q9. What are the optimum spacing for *B. tulda* in agroforestry?

Ans. The bamboos are planted at a spacing of 5 x 5 m. The inter-space is utilized for growing annual crops. The most common crops are soya bean, niger, mustard, wheat, urd, arhar, ginger, turmeric, shade tolerant variety of sweet potato, cinnamon, etc.

Q10. How is *B. tulda* propagated ?

Ans. It is easy to propagate vegetatively, by clump division, rhizome, stem and branch cuttings, layering and tissue culture.

Q11. What are the nursery practices for *B. tulda*?

Ans. Cuttings can be raised directly on nursery beds and are allowed to grow for a year. These plants can be transplanted directly into the field. In propagation through rhizome planting, one-year old culms with roots are dug out and cut to one metre height. These culms are planted during the monsoon.

Q12. From where can the planting material of *B. tulda* be obtained?

Ans. Seedlings can be procured from ICFRE institutes.

Q13. Can *B. tulda* be raised as boundary/block/bund plantation?

Ans. *B. vulgaris* is predominantly raised as block plantations.

Q14. Does *B. tulda* plantation require protection?

Ans. Yes, the seedlings and new leaves are palatable, hence need to be protect from browsing.

Q15. What is its rotation period?

Ans. Harvesting can start from the fifth year onwards in the case of homesteads. In case of commercial plantations, harvesting must be done only from the sixth year. A regular felling of few culms is the common practice. In some cases, the whole clump is removed, allowing the growth of new culms.

Q16. What is the economics of raising *B. tulda*?

Ans. Average annual income of Rs. 35,200 is expected over a 10-year period, starting from the fifth year with a B:C ratio of 2.1.

Schizostachyum dullooa

Q1. What is the common name of *Schizostachyum dullooa*?

Ans. Dollu bamboo

Q2. What are its vernacular names?

Ans. Dullooa, Dolo Banh, Lepcha (Assamese), Wadroo (Meghalaya).

Q3. What are the characteristics of *S. dullooa*?

Ans. It is a thin walled, small tufted clump forming bamboo species with height 6 - 9 m, diameter 6 to 8 cm, internode length 2.5 – 7.5 cm and wall thickness of 40 - 45 cm.

Q4. What is the geographical distribution of this bamboo?

Ans. The species is distributed in the moist semi-evergreen forests of northeast India (Assam, Sikkim, Meghalaya, Tripura and Mizoram) to Sylhet, Chittagong and Chittagong hill tracts of Bangladesh commonly from sea level to 1,200 m. This is a dominant bamboo species in the successional fallows of northeast India and forms the overriding vegetation in tropical and subtropical hill slopes in which it grows. This is one of the important bamboo species after *Melocanna baccifera* in the hill tracts of Cachar district, Assam.

Q5. In which agroclimatic zones does it occur?

Ans. It occurs in zones 2 and 3.

Q6. What are the states of adoption for *S. dullooa*?

Ans. Assam, West Bengal, Sikkim and recently in Uttar Pradesh by ICFRE-ERC Prayagraj.

Q7. What are its uses?

Ans. This small tufted clump forming bamboo species caters to different domestic purposes of local villagers e.g., fencing, house construction, roofing and making different crafts. Moreover, the culm is used for preparation of traditional foods during harvest festivals in North East India. It is used in making flutes and is the most preferred species for kite making especially in Gujarat and Rajasthan during the annual kite festival.

Q8. What is the rotation period of the species?

Ans. The bamboo is generally cultivated for traditional food production or for making different crafts in the recent past such as musical instruments and kite fabrication. Culms are selectively harvested from the clumps after 2 years.

Q9. What is its potential in agroforestry and what are the suitable intercrops?

Ans. It is possible to raise a plantation adjacent to the cropland, provided a reasonable space (minimum 5 m) is maintained. Additional protection can be provided by trenching or by a rhizome barrier. Intercropping with ginger, chillies, turmeric and shade loving medicinal and aromatic crops is taken up in the initial years, before the clumps attain maturity and canopy formation is complete. If the plantation is at a wider spacing, intercropping is continued for a longer duration.

Q10. What is the recommended spacing?

Ans. A spacing range of 5 x 5 m to 7 x 7 m is suitable for good growth.

Q11. How is it propagated?

Ans. The species is propagated through rhizomes, culms and branch cuttings.

Q12. Which type of planting is the species suitable for?

Ans. It is suitable for boundary plantation such as windbreaks or shelter belts, though block or bund plantations exist.

Q13. What is the economics of its cultivation?

Ans. A yield of 2000 culms/ha/year can be attained after three years of planting. Cost of cultivation is meagre involving minimum inputs and maximum output.

Q14. What is the market demand of dollu bamboo?

Ans. The demand in the domestic markets is high. Products like 'mudda' fetches around Rs. 500-1000 based on its size and product quality. Other products such as musical instruments, kite fabrication, bamboo fishing traps fetch a good sum. Fermented bamboo shoots fetch Rs. 100-1000. Fermented juices are also sold at Rs. 30-50 per bottle. When used as a scaffold, the price per culm is Rs. 50-100.



Schizostachyum dullooa– Individual clump (left) and new plantation (right)

Home Garden Agroforestry

Q1. What is Home Garden Agroforestry?

Ans. Home garden refers to a traditional form of agroforestry. It involves combining multiple species of economic value, such as trees, shrubs, vines, and herbaceous species, near or around the home, frequently in conjunction with livestock.

Q2. How did the concept of Home Garden originate?

Ans. Home gardens have existed since prehistoric times. Whenever hunters and gatherers unintentionally or on purpose scattered seeds after eating them near their campsites, it resulted in the development of home gardens.

Q3. What is the structure and composition of a Home garden?

Ans. A home garden comprises an integrated vegetation system of different layers that coexist but does not have a definite structure. The multistorey canopy is formed due to diversified vegetation components such as trees, bamboos, annuals, creepers etc., and these components are not placed or spaced in any definite pattern.

Q4. What are the functions of Home gardens?

Ans. A home garden's primary function is to provide necessary produce for daily use and provide extra income. These gardens are renowned for their consistent yields of variety of products, on an annually sustainable harvesting basis with low input requirements. Above all, home gardens also have sociocultural functions.

Q5. What are the benefits of Home garden Agroforestry?

Ans. The home garden is a typical example of a farming system that combines multipurpose production functions that improve food supply, and broaden the variety of foods. Home gardens help in gaining daily access to fresh vegetables and fruits, resulting in enhanced and balanced nourishment.

Q6. Where in India is Home Garden Agroforestry majorly practised?

Ans. It has been a way of life in all North Eastern states and Kerala. It is adopted to a small extent in Himachal Pradesh, Karnataka, Tamil Nadu and the Andaman and Nicobar Islands.

Q7. Which is the popular agroforestry system in the North East?

Ans. In North East India, though shifting cultivation is the most common practice, *Baree* –Home Garden in the vernacular is also popular. The *Baree* can be categorised into three types – Integrated (commonly *Baree*), Fenced (*Meroni*) and Riverine (*Paam*). The species richness and density of *Paam* and *Meroni* is less when compared to the *Baree*. The composition of the *Baree* is grains, vegetables, fruits, and medicinal plants besides timber, bamboo and cash crop. Agarwood also forms an important component of the *Baree*.

Q8. What type of Home Garden agroforestry system exists in Kerala?

Ans. In Kerala, the most common type is a four-tier structure in which coconut is the dominant and important tree crop. Other perennials include areca nut, black pepper,

cocoa, cashew, jackfruit, mango, wild jack and tree species such as teak, *Thespesia* and *erythrina*. Most homesteads also rear livestock such as cattle and poultry.

Q9. What are the characteristics of the Home Garden agroforestry system in Tamil Nadu?

Ans. In Tamil Nadu, home gardens are found in high rainfall areas. With agricultural crops, varied multipurpose trees and shrubs are also planted. Livestock rearing is also common.

Q10. What are the components of a Home Garden in the Andaman and Nicobar Islands?

Ans. Home gardens are managed as a three-tiered structure in the Andaman Islands. Areca and coconuts occupy the top layer. The second layer consists of neem, jackfruit, and mango, while the bottom tier is made up of spices like pepper, nutmeg, cinnamon, small fruit trees like lemon, and pineapple.

Q11. What are the important components of Home Garden agroforestry system in Himachal Pradesh

Ans. The three main components of home garden in agroforestry in the hills of Himachal Pradesh are annual crops, trees and animal husbandry.

Q12. How does Home garden Agroforestry provide Ecological Security?

Ans. The fundamental element of ecological security is symbiotic coexistence. The complexity of the structural arrangement along with species diversity mimic the composition and function of a tropical forest ecosystem. Moreover, it serves as a habitat for other biodiversity components. The Home Garden thus offers significant ecological security.

Q13. How does Home garden Agroforestry help in maintaining nutrient recycling?

Ans. Nutrient recycling significantly contributes to a home garden's ecological sustainability by optimising the use of readily accessible resources. Harvested biomass loses nutrients, therefore, organic manure, leaf litter, and stem flow make up for it. The top soil receives a mulching cover from the litter as well and enriches the soil through humus accumulation. Manure from livestock and poultry is a source of fertiliser.

Q14. What are the advantages of Home Garden Agroforestry?

Ans. Home garden Agroforestry is stabler than monoculture agriculture because it is diverse. By cultivating a range of crops, farmers are shielded from economic risk and drastic price changes caused by shifts in supply and demand. A consistent flow of income, whether for consumption or sale, is ensured through harvests of various species throughout the year. The system relies mostly on easily and readily available local resources. Therefore, dependence on expensive external inputs or technology are meagre. Family labour is mostly used in home gardens and large land holdings present opportunity for the local population.

Q15. List of few Home garden Agroforestry systems in North Eastern states

Ans. ***Areca nut-Coconut based Agroforestry Systems***

Aquilaria based Agroforestry Systems

Livingstonia based Agroforestry Systems - Other species used in place of *Livingstonia jenkinsiana* are *Areca catechu*, Bamboos, *Spondias pinnata*, *Shorea assamica* etc.



Orange lemon based Agroforestry Systems

Eri-Muga based Agroforestry Systems: *Phoebe goalparnsis*, *Ailanthus excelsa*, *Heteropenex fregens*, *Manihot esculenta*, *Ricinus communis*, *Litsea serrata*, *Litsea monopetela*, Bamboos, and other fuel wood species are commonly grown in this system.

Tea based Agroforestry Systems: *Aquilaria malaccensis*, *Albizia lebbeck*, *A. procera*, *Cassia nodosa*, *S. seamia*, *Piper betel*, *Piper nigrum* and other shade trees are common in this system.

Bamboo-Areca-betel based Home Garden Agroforestry Systems: Different bamboo species such as *Bambusa tulda*, *B. balcooa*, *B. pallida*, *Dendrocalamus hamiltonii* etc. are present.



**POPULAR
AGROFORESTRY
MODELS
DEVELOPED
BY ICFRE**



Popular agroforestry models developed by ICFRE

Agroforestry models developed for various agro-climatic zones of India

Trans Himalayan Region

It covers the areas of Ladakh, Lahaul-Spiti and Kinnaur (Himachal Pradesh). Models suitable for the regions:

- i. Salix (*Salix fragilis* and *S. alba*) and poplar (*P. euphratica*, *P. alba*, *P. nigra*) based agroforestry model
- ii. Apple (*Pyrus malus*) based horti-medicinal model

Western Himalayan Region and Indo-gangetic Plains

It covers the areas of Jammu, Kashmir, Himachal Pradesh, Punjab, Haryana and the hilly region of Uttarakhand. Models suitable for the regions:

- Melia (*Melia composita*)-Aonla (*Embllica officinalis*) based agri-silvi-medicinal model
- i. Poplar (*Populus deltoides*) based agri-silviculture model
 - ii. Poplar (*Populus deltoides*) based silviculture-medicinal model
 - iii. Melia (*Melia composita*) based agri-silviculture model
 - iv. Eucalyptus (*Eucalyptus tereticornis*)-Wheat (*Triticum aestivum*)/Paddy (*Oryza sativa*) silvi-block model
 - v. Poplar (*Populus deltoides*)-Wheat (*Triticum aestivum*) agroforestry model

Eastern Himalayan Region

The Eastern Himalayan region includes Arunachal Pradesh, hills of Assam, Sikkim, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and Darjeeling district of West Bengal. Models suitable for the regions:

King chilli (*Capsicum annuum*)-Areca nut (*Areca catechu*) based horti-spice model

- i. Gmelina (*Gmelina arborea*) based agri-silvi agroforestry model

Gangetic Plain Region

It covers the areas of Uttar Pradesh, Bihar and West Bengal. Models suitable for the regions:

- i. Poplar (*Populus deltoides*)-Wheat (*Triticum aestivum*) agri-silviculture model
- ii. Poplar (*Populus deltoides*)-Maize (*Zea mays*) agri-silviculture model
- iii. Poplar (*Populus deltoides*)-Banana (*Musa paradisiaca*) silvi-horticulture model
- iv. Poplar (*Populus deltoides*)-Turmeric (*Curcuma domestica*) agri-silviculture model
- v. Poplar (*Populus deltoides*)-Jimikand (*Pachyrhizus erosus*) silvi-horticulture model

Plateaus

Models suitable for the regions:

- i. Teak (*Tectona grandis*)-Turmeric (*Curcuma domestica*) silvi-medicinal model
- ii. Bamboo (*Dendrocalamus* species) based silvi-agri model
- iii. Bach (*Acorus calamus*)-Paddy (*Oryza sativa*) agri-medicinal model
- iv. Flemingia (*Flemingia macrophylla* and *F. semialata*) based silvi-agri-lac model
- v. Agri-lac culture model
- vi. Babul (*Acacia nilotica*)-Paddy (*Oryza sativa*) model
- vii. Sandalwood-Teak-*Eucalyptus*-Redsanders based silvi-agri model
- viii. Sandalwood (*Santalum album*) based agroforestry model

Western Dry Region

The area covers Rajasthan, West of the Aravalli's, Gujarat and Dadar-Nagar Haveli. Models suitable for the regions:

- i. *Hardwickia binata* based agroforestry model
- ii. *Emblica officinalis* based agroforestry model
- iii. *Colophospermum mopane* based agroforestry model
- iv. *Prosopis cineraria*-*Zizyphus mauritiana* agroforestry model

Coastal Plains and Ghats

This covers the area of Coromandal and northern Circar coasts of Andhra Pradesh and Orissa, Malabar and Konkan coastal plains and the Sahyadris. Models suitable for the regions:

- i. Casuarina (*Casuarina equisetifolia*)-Maize (*Zea mays*) agri-silviculture model
- ii. Casuarina (*Casuarina equisetifolia*)-Moringa (*Moringa oleifera*)-Maize (*Zea mays*) agri-silvi-horticulture model
- iii. *Acacia auriculiformis*-Napier grass silvi-pasture model
- iv. *Tectona grandis*-*Phaseolus mungo* agri-silviculture model
- v. *Acacia mangium*-Beans (*Vigna* species) agri-silviculture model
- vi. *Acacia mangium* -Pepper (*Piper nigrum*) silvi-horticulture model
- vii. *Casuarina* spp. based windbreak agroforestry model

Brief discription of different models

Melia (*Melia composita*)-Aonla (*Emblica officinalis*) based Agri-silvimedical Model

Suitable areas: Degraded lands in Punjab. The soil neutral to slightly alkaline and sandy loam in texture.

Tree component: Melia (*Melia composita*), Aonla (*Emblica officinalis*)

Intercrops: Sarp Gandha (*Rauwolfia serpentina*), Ashwagandha (*Withania somnifera*) agriculture crops: wheat (*Triticum aestivum*), masoor (*Lens culinaris*) and groundnut (*Arachis hypogea*)

Expenditure and Income for different Melia models

Sl. No.	Model	Expenditure	Income
1	Melia-Sarpgandha-Masoor block plantation	Rs. 7,87,755	Rs. 20,96,858
2	Aonla-Sarpgandha-Masoor block plantation	Rs. 7,7,508.	Rs. 21,65,39
3	Melia-Ashwagandha-Groundnut-Wheat block plantation	Rs. 9,38,235	Rs. 22,15,63
4	Aonla-Ashwagandha-Groundnut-Wheat block plantation	Rs. 9,31,510	Rs. 22,99,939

Poplar (*Populus deltoides*) based agri-silviculture model

Suitable areas: Alluvial and sandy loam soils in Indo-gangetic alluvial plain of Uttar Pradesh, Uttarakhand, Haryana and Punjab

Tree component : *Populus deltoides* (5x4 m spacing) or boundary plantation

Intercrops: Seasonal agriculture crops like turmeric, sugarcane, wheat, paddy, potato, bajra/millet, chari, barseem, satavar, chitrak.

Expenditure and Income for different Poplar models

Sl. No.	Model	Expenditure	Income
1	Poplar-Sugarcane-Turmeric block plantation	Rs. 1,81,711	Rs. 5,55,807
2	Poplar- Sugarcane- Wheat- Chari block plantation model	Rs. 1,30,750	Rs. 4,53,150
3	Poplar-Sugarcane-Wheat-Chari-Potato-maize-bajra block plantation model	Rs. 2,18,083	Rs. 5,61,985
4	Poplar-Sugarcane-Potato-Barseem-Chari block plantation model	Rs. 1,71,067	Rs. 5,15,095
5	Poplar-Paddy-Wheat boundary plantation model	Rs. 1,25,862	Rs. 3,04,291
6	Poplar-Sugarcane-Wheat-Paddy boundary plantation model	Rs. 1,20,862	Rs. 3,30,539
7	Poplar-Satavar block plantation model	Rs. 3,24,716	Rs. 21,98,550
8	Poplar- Chitrak block plantation model	Rs. 2,55,274	Rs. 19,67,300

Melia (*Melia composita*) based agri-silviculture model

Suitable areas: Degraded lands in Punjab. The soil neutral to slightly alkaline and sandy loam in texture.

Tree component: *Melia composita*; Spacing - 4x5 m, 4x6 m and 5x5 m

Intercrops: Wheat

Economics: The total expenditure of Melia-wheat-maize block plantation Rs. 3,54,939 with total income of Rs. 27,97,111

Eucalyptus (*Eucalyptus tereticornis*)- Wheat (*Triticum aestivum*)/ Paddy (*Oryza sativa*) silvi-block model

Suitable areas: well drained clayey alluvial soil, red alluvial soil and sodic soil
Income from different models.

Tree component: *Eucalyptus tereticornis*

Intercrops: Wheat, paddy

Net profit

Eucalyptus silvi block model with 3x2 m spacing – Net profit of Rs.13.8 Lakh (@discounted rate of 12%)

Eucalyptus Wheat bund model with 3 m spacing – Net profit of Rs.4.49 lakh (@discounted rate of 12%)

Eucalyptus Paddy bund model with 3 m spacing - Net profit of Rs. Rs. 5.12 lakh (@ discounted rate of 12%)

Teak – turmeric silvi medicinal model

Suitable areas – in Central and Southern India with well drained sandy soil condition with optimum irrigation during its early period (first 1-2 years).

Tree component: Teak

Intercrops: Turmeric

Income: Total expenditure Rs. 1.50 lakh/ha and the income from Turmeric (Rs. 1.80 lakh) and from teak (~6.80 lakh).

Bamboo (*Dendrocalamus* species) based silvi-agri model

Suitable areas – in Central India with well drained sandy soil condition with optimum irrigation during its early period (first 1-2 years).

Tree component: Bamboo

Intercrops: Wheat, black gram

Income: Total expenditure Rs. 0.96 lakh/ha and the income from black gram and wheat is Rs.0.40 and 0.70 lakh, respectively, while from bamboo it is Rs.2.00 lakh.

Babul-paddy silvi-agri model

Suitable areas – in Central India with sodic and alkali soils having pH of 7-8.

Tree component: *Acacia nilotica*

Intercrops: Paddy

Income: Total expenditure Rs. 70,000 per ha with net income of Rs 3 lakhs per ha.

Melia (*Melia dubia* based) agroforestry models

Suitable areas: Various agroclimatic zones of Tamil Nadu.

Tree component: *Melia (Melia dubia)*

Intercrops: Groundnut (*Arachis hypogea*), tapioca (*Manihot esculenta*), gingelly (*Sesamum indicum*), castor (*Ricinus communis*) and maize (*Zeamays*)

Income: Total expenditure Rs. 1,00,500 per ha with net income of Rs 4 lakhs per ha.

Casuarina –Green gram based Agri-silviculture system

Suitable areas: Clay loam and Red loamy soils in deccan plateau, east and west coastal tracts of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Odisha and Gujarat.

Tree component: *Casuarina equisetifolia* or *Casuarina junghuhniiana* (4 x 2 m or 4 x 1 m spacing) or boundary plantation. 4 years rotation.

Intercrops: Seasonal agriculture crops like black gram, red gram, horse gram, beans, turmeric, tomato, millets, cotton, ground nut.

Income: Total expenditure Rs. 24,000 per ha with net income of Rs 1.51 lakhs per ha.

Casuarina – Moringa - Maize based Agri-Silvi-Horticulture system

Suitable areas: Clay loam and Red loamy soils in deccan plateau, east and west coastal tracts of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Odisha and Gujarat.

Tree component: *Casuarina equisetifolia* or *Casuarina junghuniana* (7 x 2 m spacing). Casuarina and Moringa are planted alternatively in tree rows. 3 years rotation.

Intercrops: Seasonal agriculture crops like maize, black gram, red gram, horse gram, beans, turmeric, tomato, millets, cotton, ground nut

Income: Total expenditure Rs. 27,000 per ha with net income of Rs 2.42 lakhs per ha.

Acacia auriculiformis – Napier grass based Silvi-Pasture system

Suitable areas: Red loamy and lateritic soils in deccan plateau, of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, and Odisha.

Tree component: *Acacia auriculiformis* (7 x 4 m spacing). 4 years rotation.

Intercrops: Fodder crops like Napier grass, fodder maize, Cenchrus grass, fodder sorghum

Income: Total expenditure Rs. 78,000 per ha with net income of Rs 3.50 lakhs per ha.

Teak – Black gram based Agri-Silviculture system

Suitable areas: Alluvial and loamy deep soils in states of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Madhya Pradesh, Maharashtra and Odisha.

Tree component: Teak (8 x 4 m spacing). 5 years rotation.

Intercrops: Annual crops like black gram, maize, red gram, horse gram, beans, turmeric, tomato, millets.

Income: Total expenditure Rs. 45,500 per ha with net income of Rs 2.88 lakhs per ha.

Acacia mangium - Beans Agri-Silviculture system

Suitable areas: Red loam and Lateritic soils in states of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh and Odisha.

Tree component: *Acacia mangium* (4.5 x 4.5 m spacing). 6 years rotation.

Intercrops: Annual crops like beans, black gram, maize, red gram, horse gram, turmeric, tomato,



milletts.

Income: Total expenditure Rs. 2.15 lakhs per ha with net income of Rs 4.83 lakhs per ha.

Acacia mangium - Pepper based Silvi-Horticulture system

Suitable areas: Red loam and Lateritic soils at mid- and high altitudes in states of Kerala and Karnataka.

Tree component: *Acacia mangium* (4 x 3 m spacing)..

Intercrops: Cash crop – pepper or vanilla as creeper on tree component. Cardamom, ginger, yams, tapioca as intercrops. Intercropping period – 20 years.

Income: Total expenditure Rs. 9.1 lakhs per ha with net income of Rs 29.52 lakhs per ha.

Casuarina (Windbreak clones) - Banana based Windbreak Agroforestry system

Suitable areas: Clay loam and Red loam soils of banana growing regions and fruit orchards in south, central and western states of India.

Tree component: Windbreak tree varieties of Casuarina released by ICFRE-IFGTB (Planted in three row all around the boundary; 1 m distance between rows and 2 m spacing between trees within the rows in 'Quincunx' or 'Zig-zag' pattern. 4 x 3 m spacing). 4 years rotation.

Intercrops: Crops inside the windbreaks can be banana, red gram, lemon, citrus fruits, moringa, mango, any fruit crops.

Income: Total expenditure Rs. 52,000 per ha with net income of Rs 2.51 lakhs per ha.

Casuarina -Black gram based Paired-row Silvi-agriculture

Suitable areas: Clay loam and Red loamy soils in deccan plateau, east and west coastal tracts of Tamil Nadu, Kerala, Karnataka, Andhra Pradesh, Odisha and Gujarat.

Tree component: Casuarina Hybrid clone (CH2) (Agroforestry model adopted is "Paired-row Agroforestry Systems". The distance between the paired-row was 4 m and the distance between trees in the paired-row was 1m x 1m). 3 years rotation.

Intercrops: Seasonal agriculture crops like black gram, red gram, horse gram, beans, turmeric, tomato, millets, cotton, ground nut.

Income: Total expenditure Rs. 94,000 per ha with net income of Rs 1.71 lakhs per ha.

Neem and Black gram based dry land Silvi-agriculture agroforestry system

Suitable areas: Clay loam and deep clay soils in dry tracts in Tamil Nadu, Karnataka and Andhra Pradesh.

Tree component: Neem (8 x 4 m). 20 years rotation for trees. Intercropping period – 5 years.

Intercrops: Annual crops like black gram, chilly, horse gram, cotton and millets, cotton, ground nut.

Income: Total expenditure Rs. 1,24,000 per ha with net income of Rs 6.76 lakhs per ha.

Felling and Transit Regulations

Government of India
Ministry of Agriculture, Cooperation & Farmers Welfare Department of Agriculture,
Cooperation & Farmers Welfare (Natural Resource Management Division– SMAF)

State wise list of Trees Species free from Felling and Transit Regulations growing on Non forest area /private land in following States and UTs as received from MoEF & CC.

S.No.	Name of States/UTs	Status
1.	Andaman & Nicobar Islands	<ul style="list-style-type: none"> Transit Permit is required for transit of forest produce in A & N Islands and no exemption for any sps. has been provided in the Regulation.
2.	Assam	<ul style="list-style-type: none"> No Felling Permission (FP) is required for home grown bamboo. No Transit Pass (TP) is required. Certificate from Gram Panchayat is required.
3.	Andhra Pradesh	<ul style="list-style-type: none"> NO FP. All spp exempted. NO TP, All spp exempted.
4.	Arunachal Pradesh	<ul style="list-style-type: none"> No FP is for bonafide use except commercial use No TP is required except commercial and other use
5.	Bihar	<ul style="list-style-type: none"> Tree sps currently exempted from Transit Regulations (as on 27.02.2009) Poplar, <i>Eucalyptus</i>, Kadamb, Gamhar, Mango, Litchi, Toddy palm, Khajur, Bamboo sps (Except <i>Dandrocalamus strictus</i>), Semul. Some more sps are in process to be exempted.
6.	Chandigarh	<ul style="list-style-type: none"> No interstate transit permit is being issued by Forest Department as no forest check posts have been established. The permission for felling of trees on private /non forest land is given only in two cases, i.e either for any development work or trees are dangerous to human life or property. As such no tree sps. is exempted under this.
7.	Chhattisgarh	<ul style="list-style-type: none"> Timber Sps that have been exempted from transit regulations are Poplar, Casuarina, Su-babul, Israili babul, Vilayati babul, Manziium , Nilgiri
8.	Delhi	<ul style="list-style-type: none"> Since land is a premium commodity in Delhi, farmers generally do not practice agroforestry here. Sps. like Poplar, Kikar and <i>Eucalyptus</i> have been proposed for exemption. So FP is required.
9.	Goa	<ul style="list-style-type: none"> No FP. Omitted Bamboo from the definition of tree. NO TP. All types of bamboo grown in private areas (non forest areas) will not fall under the purview of forest produce and hence transit permit for bamboo felled from private areas are exempted
10.	Gujarat	<ul style="list-style-type: none"> Nilgiri, Subabul, Saru, Champa, Laxmanfal , Ramfal, Sitafal, Asopalav, Pendula, Nagkesar, Nagchampha, Falsa, Ingorio/Angarea, Kamrakh, Kadhipatta, Limbu, Chikotru, Bijoru/Turanj, Narangi, Mausambi, Maharuk, Rukhdo, Motoarduso, Limdo, Neem, Bakan, Bakan, nim, Irani nim, Nimbara, Limbara, Mahanim, Mahogany, Bordi, Bor, Khati bor, Ghulbor, Liehi, Lilchi, Aritha, Aritha, Amba, Kadvo Saragavo, Saragavo, Agathin, Segto, Agastin, Desi Baval, Goras amlili, Gando baval, Ganda baval , Bottle Brush, Jamphal, Dadam, Chikoo, Boralli/Mursal/ Vakal/ Varasd/ Bakul, Saptaparni, Champo, Safed champo, Liar/ Nani/ Gundi/ Nagod, Nirgund/ Nargundi, Lingur Nirgudi, Ambla, Fanas, Pipli/papri, Shetur, Haredo, Harero, Poplar, Golden cane palm, Oilplam

11. Himachal Pradesh	<ul style="list-style-type: none"> • Kala Siris/Ohi/Sriris, Kachnar/ Karial, Safeda, Kimu/ Chirmu, /Shahtoot/ Tut/Mulberry, Poplar, Indian Willow/Biuns,Kuth, Kala Zira, Japanese Shehoot/paper mulberry, Paik, /Koi,/ Kosh/Kunis/ Kunish/Nyun, Khirk/ Khadki, Darark/Bakin, Fagoora/ Phagoora/Tiamble/timla/ tirmal/anjiri/ cluster fig/goolar, Toon, Jamun, Teak/Sagun/Sagwan, Arjun, Semal, Shalmaltas, Bihul/ Beul/ Bhimal/ Bhiunal/Dhaman, Paza/ Padam, Kamala/ Raini/Rohan/Rohini/ Sinduri, Aam (Mango wild variety), Rishtak/Ritha/Dode
12. Haryana	<ul style="list-style-type: none"> • Some sps are exempted from regulations under Punjab Land Preservation Act, 1900. These are <i>Eucalyptus</i>, Poplar, Ailanthus, <i>Eucalyptus</i> and <i>Acacia tortilis</i>. There is no transit rules applied for timber sps.
13. Jharkhand	<ul style="list-style-type: none"> • <i>Eucalyptus</i> (Safeda), Poplar, Casuarina, Maha Neem, Baken Kadmb, Subabool, Silver Oak, Israeli Babool Vilayati Babool, Babool, Plam, Ber, Munga, Mulberry, Guava, Nimboo, Santra, Mosambi, Ashok.
14. Jammu & Kashmir	<ul style="list-style-type: none"> • Kikar, Bel, Siris, Champ, Neem, Malugarh, Kakrad, Palas, Amaltus/ Karangal, Sisoo/Tali, Dhamman, Nili Gulmohar, Akhrot(khod), Kehbal jhingar, Baronkal, Bilati Kikar, Safeda, Poplar, Robin, Chitta banddha, Rondu banddha, Sagwan, Arjun, Beheda, Tun/Toon, Bana, Dhoi.
15. Karnataka	<ul style="list-style-type: none"> • <i>Acacia hybrid</i>, <i>Acacia mangium</i>, Tree of Heaven, Rain tree, All Cassias except Golden Rain tree, Cashew, Christmas tree, Arecanut, Casuarina, India Beef wood, Lemon, Ornage, Coconut, Coffee, Mayflower, Indian coral tree, <i>Eucalyptus</i>, Glyceridia/ Quick stick, Silver Oak, Rubber, Jacaranda, Sausage tree, Subabul, Umbrella tree, Sapota/Chikoo fruit, Melia, Indian Cork tree, Drumstick, Mulberry, Curry leaf tree, Peltoform, Purple bauhinia, Pagoda tree, False Ashoka, Guava, Sesbania, Hummingbrid tree, Paradise tree, African tulip , Tabebula, Trumpet tree
16. Kerala	<ul style="list-style-type: none"> • Species for Ply wood Vellappine, Kurangandi/Narivenga/Mundani, Karakily/ Kalpine, Kulamavu/ Kulirmavu/Ooravu, Pali/Palendinjan, Thellipine/Undapine, Kulavu, Red Cedar, Poon/Punna/Punnappa, Veditlavu/Mullampali, Charu, Pothundi/Perunthondi, Cheeni, Nedunar, Vallabham/Varangu, Chorapine, Chemmaram, Champakam, Cherukonna, Mulliam, Neeramruthu, Peenary, Kumbil, Veembu, Gnavel, Kattunelli, Vakka, Thavala • Species for Matchwood : Aspin/Kanala/Nasakam, Elavu/Poola, Pala/ Mukkampala, • Species for Bobbin wood : Vellakil, Manjakdambu, • Species for pencil wood : Venkotta, Perumtholi/Poochakadmbu, Attuthekku /Cadambu, • Species for packing wood: Kara/ Bhadraksham, Amazham, Aval, Arayanjili, Kalaveppu/Malaveppu, Vatta/Uppathi, Fire wood : Palvu (Jack), Parankimavu (cashew), Kattadi (Casuarina), Poovarasu (Poovarasu), Mavu (Mango tree),Puli (Tamarind tree), Nattupunna (Nattupunna), Aanjili(Aanjili), Vaka (Vaha- species), Poovam, (Poovam), Konna, Thanni (Thanni), Uthi (Uthi), Aal Jatikal (Ficus species), Matti, Murukku, Elappu (Iloia) and Kodamuli (Koadampuli)
17 Lakshadweep	<ul style="list-style-type: none"> • NO FP. IFA or any Forest Act is not enforced in Lakshadweep. Also, Bamboo is not grown anywhere in Lakshadweep. Therefore amendment in IFA or any Forest Act does not arise in this state. • No TP

18. Madhya Pradesh	<ul style="list-style-type: none"> • Neelgiri, Casuarina, Poplar, Subabul, Israili Babul, Vilayati Babul, Australian Babul, Babul, Khamer, Maharukh, Kadamb, <i>Cassia siamea</i>, Gulmohar, Jacaranda, Silver oak, Plam, Ber, Mulberry, Katahal, Amrood, Nimbu, Santra, Mussambi, Munga, Molshri, Ashok, Putranjiva, Imli, Jamun, Mango, Saptarni, Kaitha, Jungle Jalebi, Petltaphorum, Neem, Bakain, Sissoo, Karanj, Palash, Safed Sirus, Pipal, Bargad, Gular, Rubber, Semal, Kapok, Chirol, Gliricidea, Rimjha, meithi Neem, Gurhal, Jasoun, Conifers, imported Timber Species.
19. Maharashtra	<ul style="list-style-type: none"> • Nilgiri trees, Babhul, Subabhul, Prosopis, Ashok, Drumstick, Sindi, Orange, Chiku, Bhendi, Acacia, Poplar, Lac, <i>Casuarina equisetifolia</i>, Rubberwood
20. Meghalaya	<ul style="list-style-type: none"> • Meghalaya being a Hilly state, there is no Agroforestry at all, since percentage of states land covered by agriculture is very small. If any blank inter- state movement of timber is permitted, state will lose meagre resource of forests under control of the State Government.
21. Mizoram	<ul style="list-style-type: none"> • Kothal, Tung, <i>Eucalyptus</i> spp., Mulberry, Neem, Rubber tree, Imli, Silver Oak, Subabul, Mango, Guava, Coconut, Citrus, Areca nut
22. Manipur	<ul style="list-style-type: none"> • No Felling Permission (FP) is required • No Transit Pass (TP) is required for home grown within state. • TP is required outside state
23. Nagaland	<ul style="list-style-type: none"> • Aam, Korei, Walnut, Neem, Alder, Manipur Sim, Kadam, Hollock, Khokan, Teak, Gamari
24. Odisha	<ul style="list-style-type: none"> • Bada chakunda, Sana Chakunda, Jhaun, Sliver Oak, Patas/Nilgiri, Sunajhari/Acacia, Subabul, Kaitha, Ambada, Batapi, Oau, Sajana, Karamanga, Sahada, Plam tree, Debadaru, Bhersunga, Gohira, Giliricidia, Paladhua, Coconut
25. Punjab	<ul style="list-style-type: none"> • "Forest produce" shall specifically mean timber (converted or otherwise), firewood, charcoal, katha and resin, but shall not include Non Timber Forest Produces (NTFPs) like bamboos and agro-forestry species such as <i>Populus</i> spp., <i>Eucalyptus</i> spp., <i>Melia azedarach</i> (Drek), <i>Morus alba</i> (Mulberry), <i>Leucaena leucocephala</i> (Subabul), <i>Casuarina</i> spp., <i>Grevillea robusta</i> (Silver Oak), <i>Acacia mangium</i>, <i>Melia dubia</i> (Malabar Neem), <i>Prosopis cineraria</i> (Khejri), <i>Salix alba</i> (Indian willow), <i>Gmelina arborea</i> (Gamari) or any other species declared by the State/ authorized agency as agro-forestry species from time to time.
26. Rajasthan	<ul style="list-style-type: none"> • Casuarina, Australian babul, Khamer, Caaia Siamea, Gulmohar, Jaccaranda, Silver oak, Plam, Ber, Mulberry, Katahal, Amrood, Sehjana, Molshri, Ashok, Putranjiva, Imli, Jamun, Saptarni, Kaitha, Jungle Jalebi, Petaphorum, Bakain, Karanj, Safed Sirus, Semal, Kapok, Churel, Mithi neem
27. Sikkim	<ul style="list-style-type: none"> • No permission for felling of trees on any private or Forest land has been granted. If anyone wishes, he have to apply to Block Officer.
28. TamilNadu	<ul style="list-style-type: none"> • Mesquite, Casuarina, Subabul, Palmyrah, Dadops, Umbrella thom, White Back Acacia/ Paniced Acacia, Maharuch, Maharukh/East India Walnut/Siris, Cashew, Kadam, Jack, Neem/Margosa, Red silk cotton/ Kapok, Sappan, Cassia, white silk cotton tree/kapok, Sissoo, Coral tree, <i>Eucalyptus</i>, Gamari, Rubber, Sea Hibiscus, Mohua, Mango, Persian Lilac, Malabar Neem, Morinda /Suranji, Manila/ Tamarind, Pongam/ Indian Beach, Rain tree, Mahogeny, Jamun/Indian cherry, Tamarind, Esperanza, Indian Portia tree/Indian Tulip, Red Cedar/Toon, Silver Oak.



29. Telangana	<ul style="list-style-type: none"> (i) <i>Eucalyptus</i>, Neelagiri, Jama oil (ii) Casuarina, Sarugudu, Sarvi, Saru (iii) Poplar (iv) Subabul (v) Israeli Babool (vi) Seema, Thumma (vii) Australian babul (viii) Gummaadi teak (ix) Pddamanu (x) Kadamb, (xi) Seema/Tangedu (xii) Jacaranda (xiii) Silver oak (xiv) Regu, Ber (xv) Mulberry (xvi) Jama, Guava (xvii) Orange and related species, (xviii) Munga (xix) Ashok/ Naramamidi (xx) Mahaputrajivi/Putrajeevi (xxi) Edakulapala (xxii) Turakavepa (xxiii) Kanuga (xxiv) Rubber / Seemamarri (XXV) Tella Tumma (xxvi) Gliricidea/Seema/Kanuga (xxvii) Tella Tumma (xxviii) Kaivepaku (xxix) Mandara (xxx) Conifers (chir, Kail, Deodar, Pine species) (xxxi) Tati, Tadi, Palmyrah (xxxii) Sapota (xxxiii) Coconut, Kobbari, Tenkai, (xxxiv) Cashew , Jeedimamidi (xxxv) Semma, Chinta, ((xxxvi) Raint ree, Nidragannreru, (xxxviii) Mango, Mamidi (xxix) Panasa, Jackfruit
30. Tripura	<ul style="list-style-type: none"> Tree species like Mango, Litchi, Drumstick, Guava, Rubber and bamboo are exempted from extraction from private land. Bamboo sps. have been exempted from transit permits both from Private and Forest land. Transport of Timber is also permitted.
31. U.P.	<ul style="list-style-type: none"> Aru, Casuarina, Jangal Jalebi, Poplar, Babool, Vilayati Babool, Rabania, Siris, Su-babool, Kathber, Jamun, <i>Eucalyptus</i>, Dhak Palas, Paper Mulberry, Ber, Sainjana, Shah toot, Mango (Desi, Tukhmi or Kalmi)
32. Uttarakhand	<ul style="list-style-type: none"> 27 tree species have been exempted from the provision of Tree protection Act, 1976. This includes fodder and small timber species that are being used in small scale industries, animal husbandry, agricultural implements and allied activity. Other 07 tree species like Walnut , Neem, Oak , Ficus (Peepal and Banyan) and Deodar have been placed in the restricted category and felling permission can be granted only in case of dead or dangerous trees.

***For Assam in addition to species mentioned in serial no. 2 of Gol notification following species have been exempted from felling and transit regulation**

Tree species exempted from felling and transit rules within State under Assam Trees Outside Forests (Sustainable Management) Rules 2022 (published on 09.12.2022)

- | | |
|--|---|
| 1. Aam (<i>Mangifera indica</i>) | 31. Malabar Neem (<i>Melia dubia</i>) |
| 2. African Tulip tree (<i>Spathodea campanulata</i>) | 32. Mangium/Black wattle (<i>Acacia mangium</i>) |
| 3. Ahat (<i>Ficus religiosa</i>) | 33. Manipuri urohi (<i>Parkia roxburghii</i>) |
| 4. Ajhar (<i>Lagerstroemia speciosa</i>) | 34. Mokka Teteli (<i>Samanea saman</i>) |
| 5. Akashmoni (<i>Acacia auriculiformis</i>) | 35. Mulberry (<i>Morus alba</i>) |
| 6. Alder Tree (<i>Alnus glutinosa</i>) | 36. Pagoda tree (<i>Styphlonobium japonicum</i>) |
| 7. Amlokhi (<i>Phyllanthus emblica</i>) | 37. Palmyra Palm/Taal (<i>Borassus sps</i>) |
| 8. Ashoka (<i>Saraca asoca</i>) | 38. Paniol (<i>Flacourita jangomas</i>) |
| 9. Atlas Nona (<i>Annona reticulata</i>) | 39. Paradise Tree (<i>Simarouba glauca</i>) |
| 10. Bottle brush (<i>Callistemon viminalis</i>) | 40. Poplar (<i>Populus spp</i>) |
| 11. Cashewnut (<i>Anacardium occidentals</i>) | 41. Putranjiva (<i>Putranjiva roxburghii</i>) |
| 12. Casuarina (<i>Casuarina equisetifolia</i>) | 42. Radhachura (<i>Cassia javanica</i>) |
| 13. Christmas Tree (<i>Araucaria columnaris</i>) | 43. Ronga chandan (<i>Adenantha pavonina</i>) |
| 14. Coconut (<i>Cocos nucifera</i>) | 44. Rubberwood tree (<i>Hevea brasiliensis</i>) |
| 15. Debdaru (<i>Polyalthia longifolia</i>) | 45. Silver Oak (<i>Grevillea robusta</i>) |
| 16. Eucalyptus (<i>Eucalyptus obliqa</i>) | 46. Simul (<i>Bombax ceiba</i>) |
| 17. Hilika (<i>Terminalia chebula</i>) | 47. Siris (<i>Albizia lebbeck</i>) |
| 18. Hitkura/Kothiya Korai (<i>Derris robusta</i>) | 48. Som (<i>Machilus gamblei</i>) |
| 19. Indian Cork Tree (<i>Millingtonia hortensis</i>) | 49. Subabul (<i>Leucanea leucocephala</i>) |
| 20. Indian Coral Tree (<i>Erythrina variegata</i>) | 50. Tamul/Areca Nut tree (<i>Areca catechu</i>) |
| 21. Indian Rubber Tree (<i>Ficus elastica</i>) | 51. Teteli (<i>Tamarindus indica</i>) |
| 22. Isreali Babul (<i>Acacia tortilis</i>) | 52. Vilayati babul (<i>Prosopis juliflora</i>) |
| 23. Jacaranda (<i>Jacranda mimosifolia</i>) | 53. Walnut (<i>Juglans regia</i>) |
| 24. Jamun (<i>Syzygium cumini</i>) | 54. Ghoraneem (<i>Melia azaderach</i>) |
| 25. Kadam (<i>Neolamarckia cadamba</i>) | 55. Karpur (<i>Cinnamomum camphora</i>) |
| 26. Kathal (<i>Artocarpus intergrifolia</i>) | 56. Sanchi (<i>Aquilaria malaccensis</i>) and/or any other species of the genus <i>Aquilaria</i> from which essential oil and other derivatives are extracted |
| 27. Koroch (<i>Pongamia pinnata</i>) | 57. Boga Chandan (<i>Santalum album</i>) |
| 28. Krishna Chura (<i>Delonix regia</i>) | |
| 29. Leteku (<i>Baccaurea ramiflora</i>) | |
| 30. Madhuriam (<i>Psidium guajava</i>) | |

***For Bihar in addition to species mentioned in serial no. 5 of Gol notification following species has also been exempted from felling and transit regulation vide Notification No.**

संख्या- वन विक्रय-38/2000/प0व0, पटना-15, दिनांक 21.02.2017

बिहार काष्ठ एवं अन्य वन उत्पाद (अभिवहन विनियमन) (संशोधन) नियमावली, 2017 के अनुसार 'बिहार काष्ठ एवं अन्य वन उत्पाद (अभिवहन विनियमन) नियमावली, 1973" के नियम-3 के उप-नियम (3) का संशोधन-उप-नियम (3) में वृक्षों की सूची की क्रम संख्या 10 के बाद निम्नलिखित क्रम संख्या 11 से 27 जोड़ी गई हैं:-

S. No.	Tree Name	Botanical name
1	Israeli Babul	<i>Acacia tortilis</i>
2	Vilayati Babul	<i>Prosopis juliflora</i>
3	Gumohar	<i>Delonix regia</i>
4	Ber	<i>Ziziphus jujuba</i>
5	Amrud	<i>Psidium guajava,</i>
6	Mithi Neem	<i>Murraya koenigii</i>
7	Jacaranda	<i>Jacaranda mimosifolia</i>
8	Subabul	<i>Leucaena leucocephala</i>
9	Shehtoot	<i>Morus alba</i>
10	Ashok	<i>Polyalthia longifolia, Saraca asoca</i>
11	Casuarina	<i>Casuarina equisetifolia</i>
12	Silver Oak	<i>Grevillea robusta</i>
13	Palm	<i>Palm spp.</i>
14	Nimbu, Santra, Mausami	<i>Citrus spp.</i>
15	Peltoform	<i>Peltophorum pterocarpum</i>
16	Rubber	<i>Ficus elastica</i>
17	Rimjha, Safed Babul	<i>Acacia leucophloea</i>

Agro-Climatic Zones in India Categorised by the Planning Commission

The Planning Commission has categorised 15 agro-climatic zones in India, taking into account the physical attributes and socio-economic conditions prevailing in the regions.

I. Western Himalayan Region:

The Western Himalayan Region covers Jammu and Kashmir, Himachal Pradesh and the hill region of Uttarakhand.

Topography and temperatures show great variation. Average temperature in July ranges between 5°C and 30 °C, while in January it ranges between 5 °C and -5 °C. Mean annual rainfall varies between 75 cm to 150 cm; in Ladakh, however, it is less than 30 cm. There is alluvial soil in the valleys of Kashmir, Kullu and Dun, and brown soil in the hills.

The valley floors grow rice, while the hilly tracts grow maize in the kharif season. Winter crops are barley, oats, and wheat. The region supports horticulture, especially apple orchards and other temperate fruits such as peaches, apricot, pears, cherry, almond, litchis, walnut, etc. Saffron is grown in this region.

The high altitude alpine pastures, locally known as 'dhoks' or 'margs', are used by the Gujjars, Bakarwals and Gaddis to rear their sheep, goats, cattle and horses. The economy is largely agrarian.

The main problems of this region are poor accessibility, soil erosion, landslides, inclement weather, inadequacy of marketing and storage facilities. The population is generally rural-based and poor.

Research in better seeds and extension service for agricultural development are required.

II. Eastern Himalayan Region:

The Eastern Himalayan Region includes Arunachal Pradesh, the hills of Assam, Sikkim, Meghalaya, Nagaland, Manipur, Mizoram, Tripura, and the Darjeeling district of West Bengal. The topography is rugged. Temperature variation is between 25 °C and 30 °C in July and between 10 °C and 20 °C in January. Average rainfall is between 200-400 cm. The red-brown soil is not highly productive. Jhuming (shifting cultivation) prevails in the hilly areas.

The main crops are rice, maize, potato, tea. There are orchards of pineapple, litchi, oranges and lime.

Infrastructural facilities in the region need to be improved and shifting cultivation controlled by developing terrace farming.

III. Lower Gangetic Plain Region:

West Bengal (except the hilly areas), eastern Bihar and the Brahmaputra valley lie in this region. Average annual rainfall lies between 100 cm-200 cm. Temperature in July varies from 26 °C to

41 °C and for January from 9 °C to 24 °C. The region has adequate storage of ground water with high water table.

Rice is the main crop which at times yields three successive crops (Aman, Aus and Boro) in a year. Jute, maize, potato, and pulses are other important crops. Planning strategies include improvement in rice farming, horticulture (banana, mango and citrus fruits), pisciculture, poultry, livestock, forage production and seed supply.

IV. Middle Gangetic Plain Region:

The Middle Gangetic Plain region includes large parts of Uttar Pradesh and Bihar. The average temperature in July varies from 26 °C to 41 °C and that of January 9 °C to 24 °C average annual rainfall is between 100 cm and 200 cm. It is a fertile alluvial plain drained by the Ganga and its tributaries. Rice, maize, millets in kharif, wheat, gram, barley, peas, mustard and potato in rabi are important crops.

Alternative farming systems, and utilising chaur lands for pisciculture are some measures to boost agricultural production.

Reclamation of user lands, wastelands, and fallow lands for agriculture and allied activities (agro-forestry, silviculture, floriculture etc.) should be done.

V. Upper Gangetic Plains Region:

In the Upper Gangetic Plains region come the central and western parts of Uttar Pradesh and the Haridwar and Udham Singh Nagar districts of Uttarakhand.

The climate is sub-humid continental with temperature in July between 26 °C to 41 °C and temperature in January between 7 °C to 23 °C. Average annual rainfall is between 75 cm-150 cm. The soil is sandy loam. Canal, tube-well and wells are the main source of irrigation. This is an intensive agricultural region wherein wheat, rice, sugarcane, millets, maize, gram, barley, oilseeds, pulses and cotton are the main crops.

Besides modernising traditional agriculture the region needs special focus on dairy development and horticulture. Strategies should include developing multiple mixed cropping patterns.

VI. Trans-Ganga Plains Region:

This region (also called the Satluj-Yamuna Plains) extends over Punjab, Haryana, Chandigarh, Delhi and the Ganganagar district of Rajasthan. Semi-arid characteristics prevail over the region, with July's mean monthly temperature between 25 °C and 40 °C and that of January between 10 °C and 20 °C.

The average annual rainfall varies between 65 cm and 125 cm. The soil is alluvial which is highly productive. Canals and tube-wells and pumping sets have been installed by the cultivators and the governments. The intensity of agriculture is the highest in the country.

Important crops include wheat, sugarcane, cotton, rice, gram, maize, millets, pulses and oilseeds etc. The region has the credit of introducing Green Revolution in the country and has adopted modern methods of farming with greater degree of mechanisation. The region is also facing the menace of waterlogging, salinity, alkalinity, soil erosion and falling water table.

Some steps that may be required to make agriculture in the region more sustainable and productive are:

(i) Diversion of some rice-wheat area to other crops like maize, pulses, oilseeds and fodder; (ii) Development of genotypes of rice, maize and wheat with inbuilt resistance to pests and diseases; (iii) Promotion of horticulture besides pulses like tur and peas in upland conditions; (iv) Cultivation of vegetables in the vicinity of industrial clusters; (v) Supply of quality seeds of vegetables and planting material for horticulture crops; (vi) Development of infrastructure of transit godowns and processing to handle additional fruit and vegetable production; (vii) Implementation of policy and programmes to increase productivity of milk and wool; and (viii) Development of high quality fodder crops and animal feed by stepping up area under fodder production.

VII. Eastern Plateau and Hills:

This region includes the Chhotanagpur Plateau, extending over Jharkhand, Orissa, Chhattisgarh and Dandakaranya. The region enjoys 26 °C to 34 °C of temperature in July, 10 °C to 27 °C in January and 80 cm-150 cm of annual rainfall. Soils are red and yellow with occasional patches of laterites and alluviums. The region is deficient in water resources due to plateau structure and non-perennial streams. Rainfed agriculture is practised growing crops like rice, millets, maize, oilseeds, ragi, gram and potato.

Steps to improve agricultural productivity and income include cultivation of high value crops of pulses like tur, groundnut and soyabean etc. on upland rain-fed areas, growing crops like urad, castor, and groundnut in kharif and mustard and vegetables in irrigated areas, improvement of indigenous breeds of cattle and buffaloes, extension of fruit plantations, renovation including desilting of existing tanks and excavation of new tanks, 95.32 lakh ha of acidic lands through lime treatment, development of inland fisheries in permanent water bodies, and adopting integrated watershed development approach to conserve soil and rain water.

VIII. Central Plateau and Hills:

The region is spread over Bundelkhand, Baghelkhand, Bhandar Plateau, Malwa Plateau, and Vindhyaal Hills. Semi-arid climatic conditions prevail over the region with temperature in July 26 °C to 40 °C, in January 7 °C to 24 °C and average annual rainfall from 50 cm-100 cm. Soils are mixed red, yellow and black.

There is scarcity of water. Crops grown are millets, wheat, gram, oilseeds, cotton and sunflower. In order to improve agricultural returns, measures to be adopted are water conservation through water saving devices like sprinklers and drip system; dairy development, crop diversification, ground water development, reclamation of ravine lands.

IX. Western Plateau and Hills:

Comprising southern part of Malwa plateau and Deccan plateau (Maharashtra), this is a region of the regur (black) soil with July temperature between 24 °C and 41 °C, January temperature between 6 °C and 23 °C and average annual rainfall of 25 cm-75 cm. Wheat, gram, millets, cotton, pulses, groundnut, and oilseeds are the main crops in the rain-fed areas, while in the irrigated areas, sugarcane, rice, and wheat are cultivated. Also grown are oranges, grapes and bananas.

Attention should be paid to increasing water efficiency by popularizing water saving devices like sprinklers and drip system. The lower value crops of jowar, bajra and rainfed wheat should give way to high value oilseeds. Five percent area under rain-fed cotton and jowar could be substituted with fruits like ber, pomegranate, mango and guava. Improvement of milk production of cattle and buffalo through cross-breeding along with poultry development should be encouraged.

X. Southern Plateau and Hills:

This region falls in interior Deccan and includes parts of southern Maharashtra, the greater parts of Karnataka, Andhra Pradesh, and Tamil Nadu uplands from Adilabad District in the north to Madurai District in the south. The mean monthly temperature of July varies between 25 °C and 40 °C, and the mean January temperature is between 10 °C and 20 °C. Annual rainfall is between 50 cm and 100 cm.

It is an area of dry-zone agriculture where millets, oilseeds, and pulses are grown. Coffee, tea, cardamom and spices are grown along the hilly slopes of Karnataka plateau.

Some of the area under coarse cereals may be diverted to pulses and oilseeds. Horticulture, dairy development and poultry farming should be encouraged.

XI. Eastern Coastal Plains and Hills:

In this region are the Coromandel and northern Circar coasts of Andhra Pradesh and Orissa. The mean July temperature ranges between 25 °C and 35 °C and the mean January temperature varies between 20 °C and 30 °C. The mean annual rainfall ~ varies between 75 cm and 150 cm.

The soils are alluvial, loam and clay and are troubled by the problem of alkalinity. Main crops include rice, jute, tobacco, sugarcane, maize, millets, groundnut and oilseeds. Main agricultural strategies include improvement in the cultivation of spices (pepper and cardamom) and development of fisheries.

These involve increasing cropping intensity using water-efficient crops on residual moisture, discouraging growing of rice on marginal lands and bringing such lands under alternate crops like oilseeds and pulses; diversifying cropping and avoiding mono-cropping; developing horticulture in upland areas, social forestry and dairy-farming.

XII. Western Coastal Plains and Ghats:

Extending over the Malabar and Konkan coastal plains and the Sahyadris, the region is humid with the mean July temperature varying between 25 °C and 30 °C and mean January temperatures between 18 °C and 30 °C. The mean annual rainfall is more than 200 cm.

The soils are laterite and coastal alluvial. Rice, coconut, oilseeds, sugarcane, millets, pulses and cotton are the main crops. The region is also famous for plantation crops and spices which are raised along the hill slopes of the Western Ghats.

The agricultural development must focus attention on raising of high value crops (pulses, spices, and coconut). Development of infra- structural facilities and promotion to prawn culture in brackish water should be encouraged.

XIII. Gujarat Plains and Hills:

This region includes the hills and plains of Kathiawar, and the fertile valleys of Mahi and Sabarmati rivers. It is an arid and semi-arid region with the mean July temperature reading 30 °C and that of January about 25 °C. The mean annual rainfall varies between 50 cm and 100 cm.

Soils are regur in the plateau region, alluvium in the coastal plains, and red and yellow soils in Jamnagar area. Groundnut, cotton, rice, millets, oilseeds, wheat and tobacco are the main crops. It is an important oilseed producing region.

The main strategy of development in this region should be canal and groundwater management, rain water harvesting and management, dry land farming, agroforestry development, wasteland development and developing marine fishing and brackish/back-water aquaculture development in coastal zones and river deltas.

XIV. Western Dry Region:

Extending over Rajasthan, West of the Aravallis, this region has an erratic rainfall of an annual average of less than 25 cm. The desert climate further causes high evaporation and contrasting temperatures—28 °C to 45 °C in June and 5 °C to 22 °C in January. Bajra, jowar, and moth are main crops of kharif and wheat and gram in rabi. Livestock contributes greatly in desert ecology.

The main areas needing a thrust for development are rainwater harvesting, increasing yield level of horticultural crops like water melon, guava and date palm, adopting high quality germ-plasm in cattle to improve their breed; and adopting silvi-pastoral system over wastelands.

XV. Island Region:

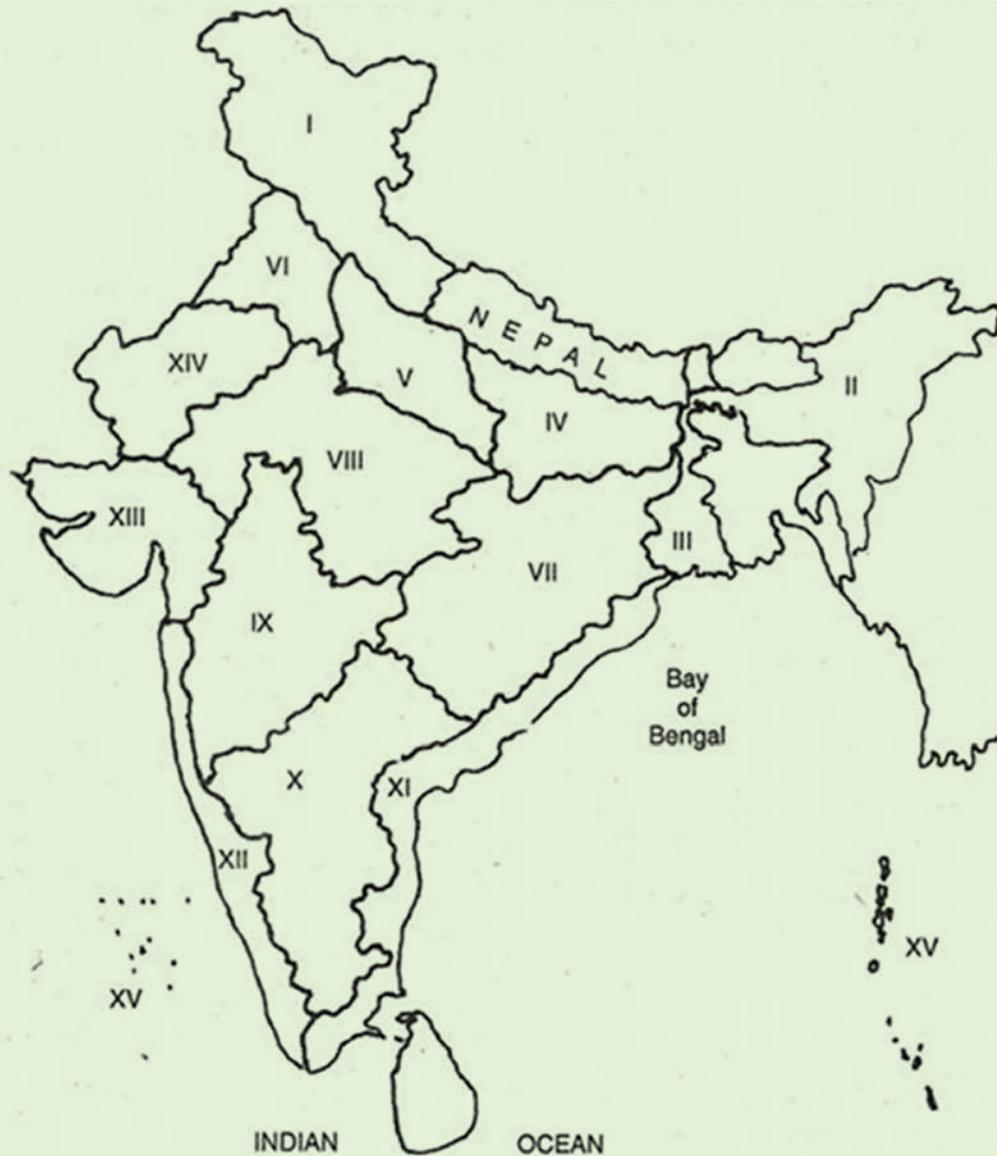
The island region includes Andaman-Nicobar and Lakshadweep which have typically equatorial climate (annual rainfall less than 300 cm; the mean July and January temperature of Port Blair being 30 °C and 25 °C respectively). The soils vary from sandy along the coast to clayey loam in valleys and lower slopes.

The main crops are rice, maize, millets, pulses, arecanut, turmeric and cassava. Nearly half of the cropped area is under coconut. The area is covered with thick forests and agriculture is in backward stage.

The main thrust in development should be on crop improvement, water management and fisheries. Improved variety of rice seeds should be popularised so as to enable farmers to take two crops of rice in place of one. For fisheries development multi-purpose fishing vessels for deep sea fishing should be introduced, suitable infrastructure for storage and processing of fish should be built up, and brackish water prawn culture should be promoted in the coastal areas.



MAP SHOWING AGRO-CLIMATIC REGIONS



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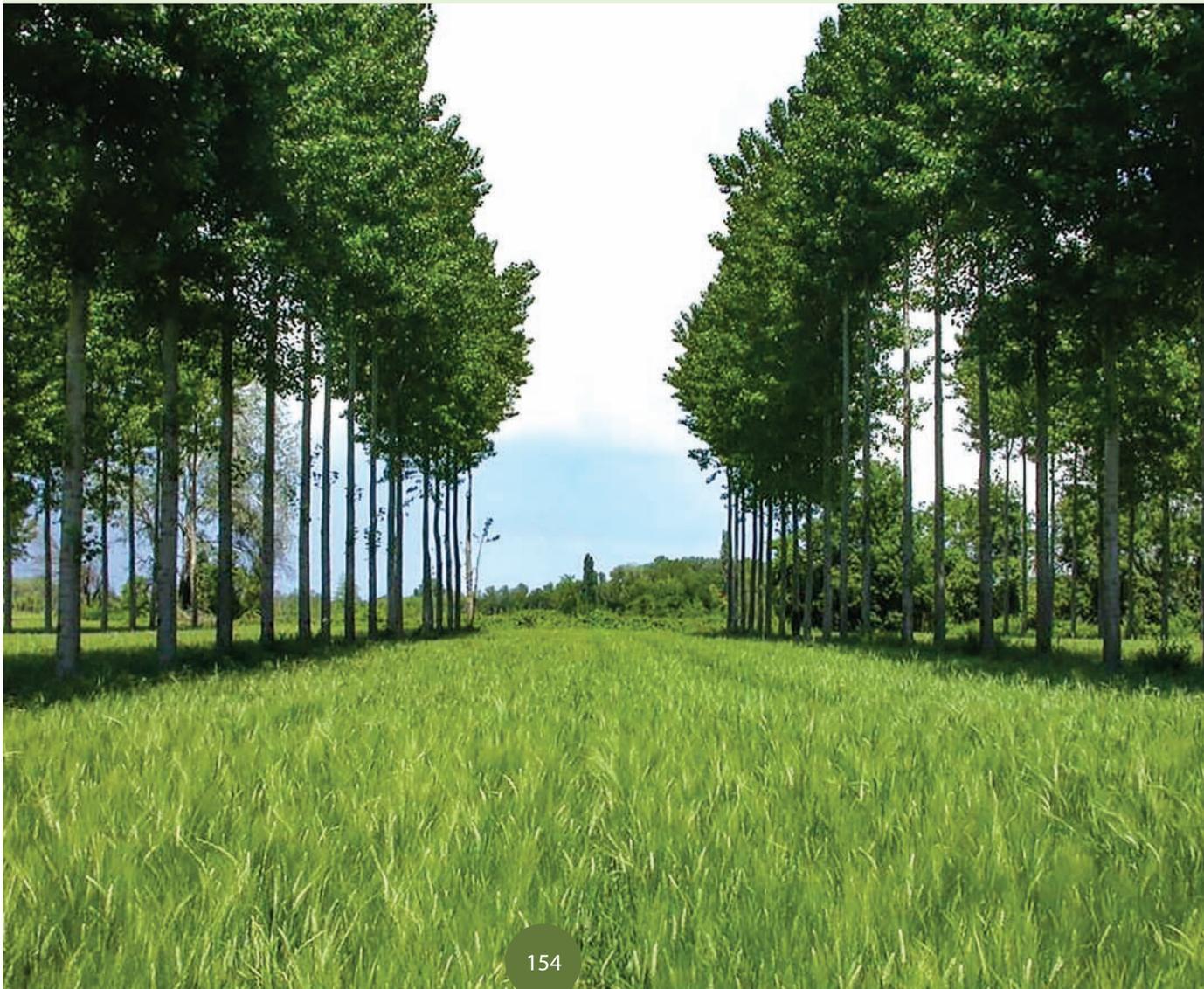
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