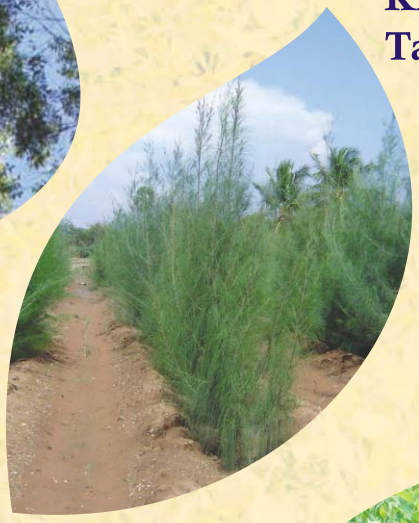
Transfer of
TREE CULTIVATION TECHNOLOGIES

to

Krishi Vigyan Kendras (KVKs) of
Tamil Nadu and Puducherry



INSTITUTE OF FOREST GENETICS AND TREE BREEDING
(Indian Council of Forestry Research and Education)
Coimbatore - 641 002

2014

Transfer of
TREE CULTIVATION TECHNOLOGIES

to
Krishi Vigyan Kendras (KVKs) of
Tamil Nadu and Puducherry

Compiled by

Dr. C. Buvaneswaran
Dr. V. Sivakumar
Mr. R.S. Prasanth, IFS
Dr. N. Krishna Kumar, IFS

INSTITUTE OF FOREST GENETICS AND TREE BREEDING
(Indian Council of Forestry Research and Education)
Coimbatore - 641 002

2014

Published by
Institute of Forest Genetics and Tree Breeding
Coimbatore - 641 002.

Printing
Prdag Print
Coimbatore - 641 012.
Ph : 0422 3059034
E-mail : prdagprint@gmail.com

Dr. N. Krishna Kumar, IFS
Director and
Additional Principal Chief Conservator of Forests

वन आनुवंशिकी एवं वृक्ष प्रजनन संस्थान
भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद
पि.बी.नं. 1061 कोयम्बत्तूर 641 002
Ministry of Environment and Forests
Government of India
Institute of Forest Genetics and Tree Breeding
Indian Council of Forestry Research & Education
(An ISO 9001:2000 Certified Organisation)
P.B. No. 1061, R.S. Puram, HPO., Coimbatore - 641 002, Tamil Nadu, India

Foreword

Agriculture is one of the most important sectors for Indian economy and about 43 % of India's geographical area is used for farming activity but the share of Indian agriculture in the GDP has steadily declined over the years and the farming sectors are becoming unviable. There is, therefore, an urgent need to provide package of initiatives for transfer of technology, improving input use efficiency, promoting investments in agriculture and forestry both in private and public sectors and creating a favourable and enabling economic environment. The emerging needs in farming sector includes adoption of location specific skill and knowledge based technologies, promotion of greater value addition to agriculture and forest produce, forge new partnerships between public institutions, technology users and the corporate sector, harnessing IT effectively to realize financial sustainability and compete in the international market.

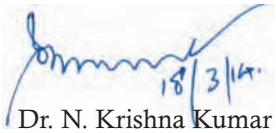
What is considered necessary today is revival of farming sector and making it more economically viable, ecologically sustainable and socially acceptable. In addition, assessment and refinement of the technologies before their transfer and a convergent approach involving various stakeholder institutions and various technology components relevant to the farmers in varying farming conditions and situations are considered important. The technology assessment and refinement should be based on participatory mode to ensure greater linkage between scientists and farming communities and continuous access to technologies developed by the research Institutes, academic Institutions and line departments. For this Krishi Vigyan Kendras (KVKs) of ICAR, Van Vigyan Kendras (VVKs) of ICFRE, Extension Centres of the State Forest department,

Tree Growers Societies and Farmers Clubs should coordinate and work with greater focus, attention, determination, commitment and result oriented for overall rural development through agriculture and forestry sectors. Today Agro-forestry is gaining greater impetus in all programmes of Government.

I am sure the **Workshop on Tree Cultivation Technologies** organized by the institute under the Networking of VVKs and KVKs will not only provide the needed convergent approach for transfer of appropriate technologies, products and services to the farming communities but will help in understanding the need in each sub sectors within farming sector and team building among forestry and agricultural scientists, extension workers on participatory way.

The manual on Tree Cultivation technologies will certainly benefit the participants and will be useful to the scientists, farming communities, academicians and institutions involved in tree farming.

I congratulate and compliment the efforts of Dr. V. Sivakumar, Scientist-E, GTB and the Nodal Officer for VVK and KVK network in Tamil Nadu and Shri R.S. Prashanth, IFS, Head, Forest Economics and Extension Division. I wish to thank the Director General, Indian Council of Forestry Research and Education (ICFRE) for the support and encouragement. I wish to thank Deputy Director General (Research), Deputy Director General (Admn.) and particularly Deputy Director General (Extn.), ICFRE for their support. We are extremely thankful to the Director General, Indian Council of Agriculture Research, Director (Extension Education), Tamil Nadu Agriculture University, Extension wing of Tamil Nadu Forest Department and scientists of all Krishi Vigyan Kendras in Tamil Nadu and Pondicherry for the conduct of the workshop. I also extend my thanks to the GCR, scientists and staff associated with the VVK and KVK network and demo village for organizing the workshop and bringing out this useful reading material.



Dr. N. Krishna Kumar
Director

Content

1 Cultivation Techniques for TEAK

K. Palanisamy
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : palanisamy@icfre.org

Site factors

Teak grows well in alluvial soils, fairly moist, warm, tropical climate with pH ranges from 6.5 to 7.5. Teak showed poor growth and form on dry sandy soil, shallow or hard pan soil, acidic, laterite, black cotton and waterlogged soils. It is a light demanding species relatively high light intensity, i.e. between 75 and 100% of sunlight for better growth and development. It occurs from sea level to an altitude of about 1200 m with 800-2500 mm rainfall regime and also grows in very moist areas with the annual rainfall of over 3,500 mm. Teak also grows in dry areas of Tamil Nadu, Rajasthan, Madhya Pradesh, Andhra Pradesh and Maharashtra. In the Indian Peninsula, teak experiences maximum temperatures up to 48oC and minimum about 2°C in the dry zone of Central India while in the moist parts of the Southern India (west coast), the maximum and minimum temperatures of teak distribution ranges from 43°C and 13°C respectively.

Planting stock

Generally stumps or seedlings are used as planting material. For stump preparation, the seedlings have to be maintained in the nursery for about one year. Then the seedlings are uprooted, all the leaves and secondary roots are removed and stumps (4 to 6 cm shoot with 15 to 20 cm tap root portion) were prepared. Stump planting is generally preferred and it is easy for transport. For seedling plantation, young seedlings are shifted to

polythene bags containing soil mixture and maintained in the nursery for 3 to 6 months

Seed collection, processing and Nursery techniques

Generally teak starts flowering 6 years after planting, but profuse flowering occurs after 15 years. Flowering occurs from June to September and fruits can be collected from November to January. Though teak produces profuse flowering the fruit set was very poor (1 to 2%), probably the coincidence south west monsoon with flowering which affects pollination. The fruits are yellowish and brownish in colour and the number of fruits varies from 1150 to 2800 per kg. A 40 year old tree produces an average about 3 kg fruits. Teak fruit contains 4 seeds, but mostly filled with 1 or 2 seeds only. After collection, the fruits are cleaned and then sun dried for 2-3 days and stored in bags. Teak seeds can be stored for up to two years around 12% moisture content in airtight containers.

Germination of teak is often poor due to dormancy. Pre treatment of the seeds by alternate wetting and drying of the seed for a week is required to break the dormancy before sowing. The seeds were kept in a gunny bag and dock the bag in water, preferably in a running stream, for 12 hours, then spread the seed in the sunlight to dry for 12 hours. This has to be repeated for one week. Further grading of fruits according to size help in improving germination. Germination increases with increase in size of fruits.The germination percentage varies from 30 to 50 % in moist teak and 5 to 10 % in dry teak. The seeds were sown in the raised nursery beds (10 x 1 x 0.3 m) prepared with soil and sand mixture. The nursery beds have to be watered regularly and covered with coconut leaf or paddy straw. Germination starts 10 to 15 days after sowing and continues up to 35 to 45 days. The paddy straw may be removed once the seed started germinating. The seedlings can be transplanted to polythene bags or it can be maintained in the nursery beds for 10 to 12 months for preparation of stumps.

Plantation management

A suitable land with good soil and rain fall of > 1200 mm may be selected for raising teak plantation. The land should be ploughed thoroughly and prepare pits (45 x 45 x 45 cm) in 2 x 2 m or 3 x 3 m or 3 x 4 m spacing before rainy season. Farm yard manure with soil mixture has to be prepared and filled in the pits. Seedlings are planted in the pits during rainy season. For stump planting crowbar may be used and pitting is not required. In the initial stage the plants have to be watered weekly, and regular weeding and pruning have to be done. The branches have to be removed periodically without affecting the main stem. Drip irrigation is beneficial in farm lands. Irrigation reduce the rotation period and also enhance the productivity. 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. The fertilizers are effective for enhancement of growth in young teak trees than mature trees. Thinning (removing alternate rows) is done 5 years and 10 years after planting in plantation raised with closer spacing (2 x 2m). Mechanical thinning is also needed. The interval of thinning cycle is at age of 5, 10, 15, 20 and 30 for 60 year rotation, in Kerala. Teak can also be planted in bunds in south and north direction in such way the agricultural crops get sufficient light. It was found that there was no significant variation in wood properties of young (25 to 30 years old) and mature teak (50 to 60 years old). Therefore teak plantation raised with good quality planting material or clones in good soil with limited irrigation and dry period with silivicultural practices can be harvested within 20 to 25 years. In Brazil and Malaysia teak is harvested at the age of 15 to 20 years. The teak growing in the canal areas in Thanjavur and Tiruvarur (Tamil Nadu) showed fast growth with good girth (> 150 cm)within 20 years and canal teak is harvested at the age of 30 years.

Agroforestry practices

Teak is one of the favoured silvicultural species by the farmers. It is planted in different models, combinations as well as in different spacements.

IFGTB has developed agroforestry models like, Agri-silvicultural models (Teak + casuarinas with agricultural crops maize, cotton, turmeric, tomato and chilly), Agri-silvi-horticulture model (Teak + coconut with agricultural crops plantain, turmeric, vegetables, maize and cotton) and Silvi-horticulture model (Teak-Gauva, Annona) (George, 2000). Under irrigated lands, silvipasture model was developed with Teak and Casuarina as tree component and Napier and Guinea as pasture components.

Yield

The average productivity of teak in Nilambur teak plantations was 2.85 $m^3 ha^{-1} year^{-1}$ in 53 years rotation period. In Indonesia the MAI at the harvest age (40 to 90 years) was 2.91 $m^3 ha^{-1} year^{-1}$(FAO, 1986). The productivity in moist semi deciduous forest in Ghana was 8-10 $m^3 ha^{-1} year^{-1}$(Oteng-Amoako andSarfo, 2005)while in Central America it was 8 to 12 $m^3 ha^{-1} year^{-1}$ (Arias, 2005). Recent studies conducted on teak growing in farmlands with irrigation, fertilizer application and management revealed the possibility of reducing the rotation period to 25 years with increase in productivity. The trees grow in farm lands grow faster and produce more biomass when compared to plantations in the forest areas. The quality of teak timber in farm land at 12 years was found to be similar to that of 20 years in forest land.

Important insect pest and diseases

Teak defoliator, *Hyblaea puera* and leaf skeletonizer, *Eutectona machaeralis* are considered to be the major pests in teak. These insects are known to occur on seedlings in nurseries and also in grown up trees in plantations. *H. puera* feeds on tender foliages during the early part of the growth season and *E. machaeralis* feeds on older foliage towards the end of the season. Making regular pest surveillance in nurseries and young plantations, particularly during rainy season when there is a new flush formation to detect the occurrence of the pest and removal and destruction

of larvae if the population is less. If the pest attack is severe it can be controlled by spraying of the foliage with the chemicals like monocrotophos or endosulfan 0.05-0.075% or neem based formulations (Neem azal 1%) at 10-12 days intervals can give good control. A virus (NPV) based formulation (biocide) is also available for management of the defoliator *H. puera*.

Uses

It has been extensively used for decking, deck houses, rails, bulwarks, hatches, weather doors and planking. The traders and timber users recognized several varieties of teak suitable for different end uses. The huge teak trees from Western Ghats region (high rain fall range) are used for structural needs like ship and boat building, construction and bridge building. Teak from Central Indian region is known for colour, texture and grains preferred for furniture and aesthetic needs. Teak wood of Godavari valley in Andhra Pradesh is used for furniture and cabinet making for its ornamental figuring. Teak wood markets and depots are available in all teak growing states in India.

2 Cultivation Techniques for Casuarina

A. Nicodemus
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : nico@icfre.org

Introduction

Casuarinas are a versatile group of plants with wide-ranging adaptability to grow in different environments and provide multiple end uses and services. They fix atmospheric nitrogen through a symbiotic association with the bacteria, Frankia. Casuarina wood with a high calorific value is a renowned fuel wood in the tropics. In India *Casuarina equisetifolia* was introduced during the 19th century and is now estimated to be under cultivation in around half a million hectares mainly in the Peninsular region. Apart from fuel, the wood is extensively used for papermaking and of late is a preferred choice for biomass-based power generation. The straight cylindrical stems find use in rural house building and as scaffolds in construction sites. It is the principal species for developing shelterbelts in coastal areas and windbreaks for protecting agricultural crops. It also plays a key role in reclaiming mined areas and afforesting nutrient-poor sites.

Nursery

Casuarina seeds are small consisting 5 to 6 lakh seeds per kg. But about half of them may actually be immature seeds which usually do not germinate. Germination is generally around 30% and about 30,000 to 100,000 seedlings are obtained from a kg of seed depending upon source of seed and nursery efficiency. Seeds are sown in raised sand beds (called 'mother beds') of the size 10 x 1 m. Generally no pretreatment is necessary

for casuarina seeds. In each bed about 250 g of seeds (50 g for *Casuarina junghuhniana*) are evenly spread by mixing with fine sand. They are overlaid with a thin layer of sand. The sand bed is covered with rice straw to prevent washing off of seedlings while watering. Water is provided through a rose can or a sprayer. A suitable repellent is applied along the periphery of the bed to prevent ants removing the seeds.

Germination and transplanting

Seeds start germinating from the 5th day and the straw is removed on the 7th day. They are grown in the mother beds for the next 3 to 4 weeks. After 4 weeks when the seedlings attain 8 – 10 cm height they are transferred either to a secondary bed or polythene bags. Secondary beds are also of the same size as the mother beds but in addition to sand, farm manure and soil (2:1:1) are also added to increase nutrient availability and water holding capacity. Seedlings pricked from the primary beds are transplanted in the secondary bed at approximately 4 cm apart. Seedlings are grown in the secondary beds for 3 months to obtain a height of 30 to 45 cm and a collar diameter of 3 to 5 mm. Growing seedlings in polybags and root trainers is better than bare root seedlings especially for planting in rainfed areas. Seedlings raised in containers establish well in plantations and record vigorous growth in the first year. Polybags (size: 15 x 7 cm) filled with a potting mixture of sand, farm manure and soil in a ratio of 2:1:1 are suitable for raising casuarina seedlings. Seedlings may attain plantable size within 2 months but can be maintained for another 4 to 6 months if planting is delayed.

Vegetative propagation

Outstanding casuarina trees can be propagated by rooting of young shoots ('sprigs'). Such plants produce uniform superior growth in plantations. Sprigs collelcted from selected trees are trimmed to 8-10 cm long and washed in a 5% solution of fungicide like Bavistin^{TM}. The lower

portion of the shoot is treated with a rooting hormone, Indole butyric acid (commercial name: Seradix B™). 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 and then transplanted into polybags or root trainers and grown in the same way as seedlings.

Inoculation of Frankia

Casuarina is a nitrogen-fixing tree through symbiotic relationship with an actinomycete called Frankia. It fixes atmospheric nitrogen in special structures in the roots called nodules. It is necessary to ensure infection of Frankia in casuarina seedlings for vigorous growth as well as to increase their adaptability to planting conditions. Frankia can easily be inoculated by adding topsoil from casuarina plantations to the mother beds. Alternatively it can be inoculated at the time of transplanting into secondary beds or containers by treating the seedlings with nodule extract of Frankia culture (N-fixer) supplied by IFGTB. Application of biofertilizers like phosphobacterium and *Glomus fasciculatum* also improve the seedling quality.

Planting and Tending Methods

Since casuarina is planted as bare-root seedlings, planting them just before or during the rains ensures high survival especially under rainfed conditions. Where irrigation is available, it is recommended to plant one month before the rain and provide water once or twice a week. This will help the plants to establish well before the arrival of monsoon and grow faster than those planted during the rain.

Land must be preferably disc ploughed twice. Pit size for planting container-raised plants (poly bag or root trainer) is 30 cm x 30 cm x 30 cm. The recommended spacing for realizing full potential of genetically improved planting stock is 1.5 x 1.5 m. Add a basal dose of 10 g of super

phosphate per pit before field planting of seedlings. Application of anti-termite solution (e.g. chlorophyriphos 1ml per litre of water) may be needed in red soils or where the problem has been encountered before. This may not be necessary in sandy soils in coastal areas. If no rain received immediately after field planting of seedlings, watering in alternate days is necessary for the first two weeks. The frequency may be reduced gradually to once or twice a week depending upon local conditions. Casualty replacement should be taken up only up to one month after planting. Four weedings needs to be carried out at 3, 6, 9 and 12 months or till the canopy closes whichever is later. Two prunings need to be taken up at 12 and 24 months. Fertilizer application is not necessary after planting if the land is fairly fertile. In low-nutrient soils DAP 100 kg per acre may be applied between 12 and 24 months.

Fertilizer Application

Fertilizer application is generally restricted to irrigated plantations and varies between regions and even among farmers. Fertilizers will have the maximum effect if applied during the peak growing period of 12 to 24 months. Farmers generally apply 50 kg of urea and 50 to 100 kg of DAP per acre one year after planting. Casuarina does not need large quantity of nitrogen fertilizer since it produces its own nitrogen with the help of the bacterium, Frankia. So it is recommended to apply 11 kg of urea and 94 kg of super phosphate at four stages: immediately after establishment, 6, 12 and 18 months after planting.

Pruning and intercropping

Pruning of side branches is usually carried out between first and second years and second and third years. The expenditure for pruning is met by the sale of pruned material. It is also a common practice to intercrop groundnut, water melon or pulse crops in the first year well before the tree crown starts closing in and cause shade effect to agriculture crop. The

plantation establishment cost is generally recovered from the agriculture crop. It also helps to keep the field weed-free.

Insect and disease incidence

Casuarina has only a few major insect and disease incidence which can lead to economic loss. The common insect problem in casuarina plantation is attack by the stem borer, *Indarbela quadrinotata*. The larvae dig up deep tunnels on the main stem and remain inside the tunnel during day time and emerge out in night and feed on the bark. Although the trees generally survive, the pole quality is affected by severe infection. Affected trees are also prone to breaking at the point of infestation during heavy wind. Chemical control of this insect is difficult since it resides within the tunnel. Insect attack can be prevented by planting varieties that are unaffected by the insect (e.g. Australia and Kenya).

Wilt or blister bark disease caused by *Trichosporium vesciculosum* results in drying up of trees followed by large scale death. Affected trees show symptoms of drying of leaves followed by 'blisters" on the main stem. At advanced stages these blisters burst open releasing black spores. The disease is not considered as a serious problem in plantations because it usually occurs in plantations older than 4 years age. There is no effective control measure once the infection occurred but removing and burning the infected tree can prevent further spreading of the disease. Australian, Kenyan and Malaysian provenances were found to be resistant to blister bark disease. The *C. junghuhniana* provenances from East Timor are also not affected by the disease.

Rotation Period and Yield

The commonly followed rotation period is 4 years with irrigation and 6 years under rainfed conditions. But the duration varies greatly in different areas and between farmers. In a few places of coastal Tamil Nadu irrigated casuarina is harvested as early as 2.5 years of age whereas Forest

Superior growth performance of IFGTB seed orchard seedlings compared to local seedlings

A well established plantation

A bare-root nursery of Casuarina

Department plantations without irrigation are retained up to 8 years. Wood production varies greatly across locations, cultivation techniques adopted and age at which harvested. Plantations with irrigation and fertilizer application yield 100 to 150 tonnes of air dried wood (up to 20 cm girth) per hectare (40 to 60 tonnes per acre) in 4 years. Under rainfed conditions an average yield of 75 to 100 tonnes per hectare is obtained in 6 years (30 to 40 tonnes per acre) depending upon soil quality and amount of rainfall during the cultivation period. IFGTB supplies high quality seeds from seed orchards which can improve yield up to 25% and the superior clones (IFGTB CE 1, CE2, CE3, CE4, CJ9 and CJ10) produce up to 50% more yield.

3 Cultivation Techniques for *Eucalyptus*

V. Sivakumar
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : sivav@icfre.org

Site factors

Eucalyptus camaldulensis is a common and widespread tree species. It is a best suitable tree species for the areas which received rainfall from 250 to 600 mm at the same time it can also grow well in high rainfall areas which receives as high as 1250 mm. The success of *Eucalyptus* is attributed to its superiority to other trees in production of wood on infertile dry sites, its tolerance of extreme drought and high temperature. This species occurs on a variety of soil types from red or black soils to sandy alluvial soils. It can also grow well in salt affected areas.

Planting stock

Seeds of IFGTB show about 15% improvement in growth when compare to other local seed sources as the seeds. Seeds are being collected from seed orchards established by IFGTB and sold to the farmers at the cost of Rs. 10000/- per kilo gram.

IFGTB has released four Eucalyptus clonal varieties viz., IFGTB-EC1, IFGTB-EC2, IFGTB-EC3 and IFGTB-EC4 for cultivation in Tamil Nadu and Andhra Pradesh. These clones are multiplied and supplied based on prior request. About 20% improvement in yield is expected from these clonal varieties.

Seed collection, processing and Nursery techniques

Seed are mixed with chaff and can be difficult to distinguish from chaff. Seeds weigh approximately 700 seeds/gram (Ralph, 2003). About

100 -500 germinant can come per gram of seed. The seeds with about 5% moisture content can be stored for more than 10 years if they are placed in hermetic containers at a temperature of 3 to 5 °C.

The texture of the medium of germination must be fine. A fertile mixture of soils with sand in a proportion of 1:1 must be used. Seed should be sown under shade on a free-draining and sterilized medium and covered very sparingly with inert material (e.g. sand). Seeds must be sowed deep enough to prevent uncovering when watered, but they must not be too embedded. The germination period for this method ranges from 4 to 5 days. The seedlings are lifted from the mother bed when they are 5 to 7 cm in height and transplanted in poly bags. Alternatively, seeds can also be planted directly into bags using special devices, such as syringes, to place two to four seeds in each bag.

Partial shade is needed after transplanting till six weeks. Plants reach plantable size of 30 cm in four to five months. Seedlings require periodic watering in the first stages of development. Common mistakes in propagation are over-watering and associated disease problems, over-shading and allowing the germinants to become too large for easy transplanting leading to malformed tap roots or root curling in the pots. To prevent damping off, cupric fungicides should be applied. About 1-2 lakhs seedlings can be obtained from 1 kg of seed in nurseries.

Plantation management

Weeding and burning of underbrush are recommended before planting. The ability of the species to compete with weeds is poor. In high rainfall areas, extensive weeding (2-3 times) must be applied until crowns close (2-3 years). Inadequate weed control may lead to complete failure of the planting.

A spacing of 3 m x 2 m (1667 stems/ha) is often applied for pulpwood. Wider spacing of 4 m and 2 m (1250 stems/ha) or 5 m x 2 m (1000 stems/

ha) are recommended when larger trees are required. For energy plantations, a spacing of 2x2 m is recommended.

Application of 100g of NP or NPK (3:2:1) fertilizer to each tree at planting to assist establishment of growth is common. Crown die-back during dry-season as a result of boron deficiency is prevalent in few places. A dosage of 10-20 g of borax per tree depending on soil type is applied.

In India, Eucalyptus is managed through clear-felling system followed by coppice rotation to a maximum of three times. After three rotations, the below ground biomass is taken out and replanted with seedlings.For pulpwood depending on the fertility and availability of water, the rotation can fixed from 5 year to 7 years.

Agroforestry practices

At a spacing of 3 x 2 m intercropping can be carried out for one year. In irrigated sites, shade loving crops can be cultivated during second year also. A wide range of crops can be grown when the spacing is 5 m x 2 m which supports intercropping up to three years.

Yield

In Tamil Nadu, about 25-30 t/ha at a rotation of 6-7 years was realized through seed raised plantations during early 1990's. Introduction of clones increased the yield up to 60-70 t/ha in six years rotation. Through site-clone matching, a yield of 100-150 t/ha was achieved in five years rotation depending on the fertility level of the soil.

Important insect pest and diseases

In the nursery, it is susceptible to diverse fungi causing damping-off, collar rot and leaf diseases. Attention to nursery hygiene and care not to over-water are preferable to chemical controls. Termites affect planted seedlings young trees and must be chemically controlled. *Eucalyptus* is

Eucalyptus in irrigated farm lands

Eucalyptus in dry lands

Eucalyptus intercropped with Black gram

severely attacked by an invasive gall insect (*Leptocybe invasa*) which lead to formation gall like structure in the midrip and petiole and young stem. The problem is severe in young seedlings and coppice shoots. Chemical treatments do not found to be suitable.

Uses

Wood is used mainly for poles, posts, fire wood, charcoal and paper pulp. It is also used for hardboard and particle board.

4 Cultivation Techniques for *Melia dubia*

Rekha R. Warrier
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : rekha@icfre.org

Site factors

The trees grow well in sandy loam, red and lateritic soils with an annual rainfall of 800 mm and above.

Seed collection, processing and Nursery techniques

Seed processing and pretreatments: Reports state very poor germination in Melia. Studies at IFGTB reveal germination as high as 60 per cent without any pretreatments. The drupes should be graded in water to remove floating seeds prior to sowing.

Nursery: *Seed sowing:* It is best to sow seeds during March – April. Cleaned and dried seeds should be sown in the open raised nursery beds, in drilled lines, 5 cm apart. Seeds do not germinate in sand. They have to be sown in soil: farm yard manure medium in the ratio 2:1. A 1:1 ratio can also be adopted. About 6-7 kg of dried drupes containing about 1500 numbers are required for one standard nursery bed. The seeds sown need to be watered regularly, 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.

Vegetative propagation: 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 need to be taken

for 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 conducive for rooting. About 75 per cent rooting can be obtained.

Note: The species is very sensitive to transplantation and hence care must be taken while prickling seedlings from bed or transplanting rooted shoots to bags.

Plantation management

A spacing of 5 x 5 m is optimal while a spacing of 8 x 8 m is ideal. Growth is enhanced with the application of fertilizers. Regular irrigation is required for fast growth of the trees. Initial growth is hastened with daily watering and application of fertilsers once in three months for the first three years. Under rainfed conditions, the growth is slow (almost 100 % less). The tree branches at 8-10 m from ground. Pruning every six months controls branching. The bole is straight, round, without any knots and without any buttress.

Agroforestry practices

Melia is a good agroforestry species and supports a variety of crops throughout its cultivation period. Ground nut, chilli, turmeric, blackgram, papaya, banana, melon, sugarcane, as inter crops are being successfully cultivated. The species performs exceedingly well when planted on bunds, attaining the harvestable size within four years.

Yield

The tree attains a volume of 15 cu. ft. at the end of 15 years and earns revenue of Rs. 350 per cubic foot from the 5th year onwards. Growth rate ranges from 20-25 cm per year when intensively managed and 6 to 8 cm per year in unmanaged plantations. It is expected to produce 12 to 15

Cuft. (0.4 - 0.5 cu.m) of timber in 5 years time. Presently Melia fetches Rs. 7300/- per tonne for billets of girth 50-120 cm girth and above Rs.370 per CFT (0.02 cu.m.) for trees which have attained a girth > 120 cm.

Uses

It is a good secondary timber and the most preferred species for plywood industry. The wood is also used for packing cases, ceiling planks, building purposes, agricultural implements, pencils, match boxes, splints, cattamarans, musical instruments and tea boxes as the wood is anti-termite by itself. Thus, the species has a ready and assured market due to its multipurpose utilities. The species is also highly adaptable. The species is in high demand by the plywood industries.

Melia planted by farmers

5 Cultivation Techniques for Ailanthus

D. Rajasugunasekar
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : sekardrs@icfre.org

Site factors

Ailanthus excelsa. *Roxb* is one of the medium sized, fast growing tree species within the genus *Ailanthus* belonging to the family Simaroubaceae. Arid to semi arid region *Ailanthus* is often found below 1,200 m msl with a mean annual rainfall of about 500-1900 mm. It grows in broad range of soil types including sandy soils and adapts to drought stress and tolerates a dry season of 4-6 months. In Tamilnadu it is distributed in four agro-climatic zones namely Western zone, North western zone, Cauvery delta zone and Southern zone.

Planting stock

Seeds of *Ailanthus excelsa* collected in selected Candidate Plus Trees (CPT's) from different agro climatic zones having 10-15% improvement in growth when compare to other local seed sources. The collected seed sources are multiplied and supplied based on prior request. The seeds collected by IFGTB are being sold at the cost Rs.1000/Kg. From one kg of seeds about 4000 healthy seedlings can be obtained.

Seed collection, processing and Nursery techniques

Flowers appear February – March in Central India and in April in north India but in South India December – February. The fruits ripen March to May. Ripe fruits are collected off the trees before these are blown away by the wind. Seeds are dried in the shade. Seed viability is very short and cannot be stored for the next year. Seed weight is 7500-10000/kg.

The nursery soil should be light, porous and well drained. Indofil may be mixed with the soil to avoid insects and ants. The seed beds should be well raised to allow drainage.(In the absence of beds seeds can also been sown in polybags). Seed sowing should be done in seed beds or mother beds. After broadcasting the seeds, cover the seed lightly with about 1 cm of sand. Only a mild watering is required. Excess water will lead to damping off disease in seedlings. The germination is epigeal that starts 8-14 days after sowing and complete in 40-45 days. No pre-treatment is required. After 3 weeks maintenance in 5-10cm can be transplanted into 10cmX20cm containers (Poly bags). The roots are very delicate and fragile and require special attention during transplantation. 15 gm of seeds are required for sowing 1 sq. m of bed. Mixing of seeds with ash or pulverized soil ensures uniform sowing.

Plantation management

A.excelsa prefers sandy and porous soils. It also established were on slopes and stony patches under suitable moisture conditions. Too much moist or water logged areas or area prone to frost should not be selected. After selecting and cleaning the site, pith in 30 cm^3 or 45 cm^3 pits and the soil is allowed to weather. Planting is to be carried out in the month of July or October based on the monsoon pattern in the region. For block planting nursery raised seedlings 6 to 10 months are used for planting in pits at a spacing of 3 x 3m or 5x 5m. The seedlings which attain height of 50-100 cm are suitable for planting. The root shoot ratio of 1:2 is considered good for stump planting. Row and line planting is carried out by planting saplings. Spacing 5m is maintained in of row or line planting. Regular watering and protection from browsing is required till the saplings get established. Thinning is generally required under block planting. The first silvicultural thinning may be carried out in the third or the fourth year when the tree attains a height of 6-8 m. Fencing is also needed in areas where the goats and sheep are to browsing it.

Agroforestry practices

Ailanthus excelsa can be raised in mixed plantations. In degraded, denuded and semi arid soils it is able to come up successfully with *Prosopis juliflora*, *P.cineraria.* A suitable mixture of tree species includes; *Acacia catechu*, *Albizia lebbeck, Acacia leucophloea, Azadirachta indica, Dolichandrone falcata, Shorea robusta, Acacia nilotica, Pongamia pinnata, Ziziphus mauritiana*, *Musa* spp.with some fodder grasses can also be planted with *Ailanthus excelsa.* Farm forestry of *A. excelsa* is more popular and is being practiced by the farmers. Trees are planted at the south and west boundaries of the fields. It is essential to have trees on the south and west borders of the farm so that the velocity of wind could be reduced. Hence in farm forestry, farmers more yield of crops and generating revenue from *A. excelsa* tree as well.

Yield

In Tamil Nadu, about 50-75 t/ha at a rotation of 5-6 years was realized through seed raised plantations with un irrigated conditions. But in the irrigated conditions the yield up to 120-135 t/ha in 5-6 years rotation.

Important insect pest and diseases

Defoliator viz, *Atteva fabriciella, A. niveigutta* and *Eligma narcissus;the b*orer *Batocera rufomaculata and the fungi* (leaf spot) *Cercospora glandulosa* and *Alternaria* spp are the major pests in *Ailanthus excelsa* cause severe damage. Seedlings are susceptible to damping off disease therefore heavy watering should be avoided and only optimum level of moisture should be maintained. The growth is retarded considerably in the month of January are the cold and weather. For controlling insect pests, spraying or dusting with BHC or endosulphan is carried out. Severe defoliation affects plant growth and may cause death of the plant. Application of 0.1% of endosulphan and malathion will manage the insect pest to a considerable extent. Application of 1% Hy-Act (Bio pesticide product of IFGTB) as a foliar spray reduces *Eligma narcissus* infestation about 65-70%.

Uses

A.excelsa is an indigenous species fast-growing tree species suitable for raising industrial plantations. More than 70% of the wood goes to the safety matches Industry. It is used for packing cases, fishing catamarans and floats. It is suitable for commercial plywood and Eri silk production as a host plant. There is an intensive research is being carried out by Central Muga Eri Research and Training Institute, Jhorhat, Assam. The Leaves of *Ailanthus excelsa* leaves are excellent source of Protein as well.

Ailanthus planted in farm lands

6 Cultivation Techniques for *Gmelina arborea*

A. Mayavel, J. Soosai Raj, B. Gurudev Sigh and N. Krishnakumar

Institute of Forest Genetics and Tree Breeding, Coimbatore

E-mail : mayavela@icfre.org

Site factors

Gmelina arborea is well adaptable to a wide range of soil and climatic conditions. It is a hardy plant and can be grown in both tropical and subtropical conditions. It grows up very well in red sandy loam soil with the pH of 5-8 and a high soil depth. It grows at an elevation of 0-1200 m MSL. it comes up very well humid climate with the optimum temperature range from 20-38C. The annual rainfall requirement is 750-4500 mm. It grows very well in the high sunshine with low shade areas.

Planting stock

The *Gmelina arborea* tree improvement programme was initiated in India during early 1990. Improved accessions and seeds from the clonal seed orchard is available in Rain Forest Research Institute, Jorhat. The seeds from superior CPTs are available at IFGTB.

Seed collection, processing and Nursery techniques

The mature fruits may fall from the tree while they are still green. Green fruits turn yellow within a week and after about two weeks from falling, they turn brown and black after about three weeks. It is best to collect the fruits when they are still green or yellow, as germination capacity of brown and especially black fruits is low. As all fruits do not fall and mature at the same time, fruits should be collected frequently, e.g. twice every week during the collection period, that may stretch over several months.

Transport of fruits to the processing site should be in open baskets or nets, not in plastic bags. In order to avoid fermentation, fruits should be brought to the cleaning area within 24 hours. This is especially important for fully ripe (yellow and brown fruits). As much care as possible should be taken to avoid damage to the fruits, since fermentation is more likely to start among damaged fruits. At the processing site, the fruits should be sorted into those that are ready for immediate processing (yellow and brown colour) and green and green-yellow fruits, which will benefit from after-ripening. After-ripening is done in the shade by spreading the fruits in a 10-15 cm thick layer until they have turned yellow. This may take up to one week. Depulping of small quantities of fruits can be done manually by mashing the fruits until the pulp is loose from the stone, and rinsing with water. For larger quantities of fruits depulping is normally done in a coffee-depulper. Soaking the fruits in water for 24 hours before depulping will facilitate the process. After depulping, the fruits are spread out on a wire-mesh tray and rinsed with water to remove juice and pulp. Normally traces of pulp will remain on the stones after depulping and further cleaning or polishing of the stones is required. This can be done either manually by rubbing the stones with sand and water or mechanically (also with sand) in a concrete mixer. Finally the stones are washed and dried well in the sun.

The seeds have no dormancy, and no pretreatment is required. However, soaking of the seed in cold water for 24-48 hours before sowing is recommended.

Gmelina arborea is propagated by both seeds and vegetative methods. Seeds are showed directly in the root trainer or raised beds can be 0.6m in height, 1m in within convenient length. The bed should be filled with sand up to height of 0.5 m. The seeds are closely placed the bed in a rows with a gap of 5cm. The beds are to be watered twice in a day with the help of rose cane. One kg of Gmelina seeds contain about 1500-2000 seeds. The

size of the seeds varies between the trees. Seeds normally germinate quickly and at high levels. Often the germination will be above 100% as more than one seed will germinate from each stone. The optimal temperature for germination is about 30°C and low temperature will reduce germination. The seedbed should be exposed to full sunlight as partly or full shade will reduce germination. After germination, the seedlings can be transplanted to containers.

Clonal propagation

Clonal propagation method plays an important role for multiplication of selected superior CPTs. It is one of the most convenient less expensive and successful methods. The cutting are collected in the early morning between 6 – 9 am and treated with 750 ppm Indole -3 Butyric Acid and the cuttings are immediately planted in the root trainer filled with the vermiculite . The root trainers placed inside the low cost poly tunnel or mist chamber. The internal temperature and humidity should be maintained at 26 – 36^0c and 80 – 100% respectively. The dried and dead cuttings are moved frequently removed to avoid spread of fungus. Rooting of cuttings are observed in 15 – 25 days after planting. About 3 months old cuttings used for establishing in clonal plantations.

The mini hedges of *Gmelina arborea* are established with rooted cuttings. The top of hedges that are pruned to accelerate more auxiliary shoots are production. The cuttings with 3 – 6 auxiliary shoot used for planting material productions.

Plantation management

The seedlings were planted in a pit of 45x45x45 cm with a basal application of 5 kg of FYM and 70 g of NPK complex fertilizer plus 10 g of borax. About 120 days old seedlings are used for planting. The seedlings are planted with the spacing of 3x3m to 5x5m. Establishing pulp wood and bio energy plantations 2X2 m spacing is adopted.

Pruning

Pruning is an important practice in the cultivation of *Gmelina arborea* in farm land, pruning decides the growth, clear bole and intercropping ability. Pruning of side branches is usually carried out in every six months. The pruned branches can be used as fire wood.

Thinning

Thinning is a another important practice to enhance the production of saw log. The thinning begins at 4-5 years of age for the woods, that are used for pulp productions. The alternative trees in the row are to be thinned, to avoid competition between the trees and maximize the growth.

Agroforestry practices

Growing of *Gmelina arborea* in agroforestry model is a commercial practice in TamilNadu. Some of the agroforestry models are Gmelina + Ground nut, Gmelina +Water melon, Gmelina +Pulses, Gmelina +Maize, Gmelina +Banana

Multi - tier cropping system also has been followed in Pudukkottai district of Tamil Nadu. Coconut + Gmelina + Banana + Pepper (pepper trained on the Gmelina trees).

Yield

The *Gmelina arborea* trees harvested 4 – 5 years after planting for pulp wood, Fire wood. The trees harvested at 10 – 12 years after planting for log productions. Under good management regime each trees yield about 1.5 to 2 tons. The total yield per hector is around 250 – 300 tones / Ha. The wood of *G. arborea* fetches Rs.8000/ton in local market.

Uses

The tree has immense potential for its timber and medicinal value. It is a preferred species by farmers, forest departments and ayurvedic

Block Pantation of *Gmelina arborea*

Agroforestry model:
Gmelina+ Peper+Banana

Agroforestry model:
Gmelina+ Cumbu

industries due to the multipurpose utility, rapid growth, and maximum economic returns. The *Gmelina arborea* wood is used for pulp, particle board, plywood, matches, carpentry and packing. It is also used for construction at boards, carwing and musical instruments. The leaves and fruits at Gmelina are used as a fodder, and also used for rearing silkworms. The species also planted in dangia system with short rotation crops, and also as a shade tree for coffee and coco.

7 Cultivation Techniques for *Neolamarckia cadamba*

A.Vijayaraghavan
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : avijay@icfre.org

Site factors

It is a large tree, frequently found in southern tropical semi evergreen forests, tropical moist deciduous forest and tropical fresh water swamp forest and distributed throughout the greater part of India and in Western Ghats in South, in Central Maharashtra - Sahyadris, in North Eastern part - Assam, lower hills of Darjeeling, Terai, Bihar, Orissa, in Singh bum valley and also in Andaman Islands. It is found below 1000 m altitude and normally where there is more than 1500 mm rain/year but it can also grow in dry areas with as little as 200 mm rain/year. It is very light demanding species and intolerant to frost. It can grow on a variety of soils and tolerates periodic flooding.

Planting stock

In India no tree improvement activities have been carried out. Recently IFGTB has initiated tree improvement work by selecting superior tress. Progeny trial with 45 progenies has been established in Maramalai Nagar, Chennai and few more progeny trials with more than 60 progenies will be established shortly. About six clones are selected and multiplication on large scale is in progress to establish clonal plantations.

Seed collection, processing and Nursery techniques

The ripened fruits are orange in colour, harvested from the trees during the months of September to December by climbing or shaking the branches

after spreading covers on the ground. The collected fruits can be allowed to rot for three to four days and pulp is washed off by hands in a bucket of water, seeds settled at the bottom are taken out and dried well. The fruits are rubbed to form a paste like slurry, which is passed through a 0.50 mm sieve plate and shaken vigorously. The blackish paste sieved through the plate is collected into a pan and dried to extract seeds. Average dry weight of each fruit is 11.5 gm and wet weight 50 gm. Each fruit on an average yields 456 mg of pure seeds. Other method is by cutting the fruits into small parts and allowing them to dry and after a few days crush the small parts and separate the seeds. One gram has around 23,000-25,000 seeds. The separated seeds are allowed to dry in shade and can be stored in air tight container for 9 months.

Nursery Technique: The sieved seeds need no pre-sowing treatment. Seeds of about 0.1g (about 2500 seeds) can be sown in galvanized or wooden trays filled with fine river sand and soil and treated with fungicide. The seeds are better mixed with sterilized sand before sowing. They are sown in February at the rate of about 0.2 gm of seed per m^2 of bed. Winter sowing is not successful. Percentage of germination is high. The germination of *A.cadamba* seeds in open beds is generally difficult. Therefore, plants are invariably raised in shaded beds to exclude insolation and splashing effects of rain water. Before sowing, the beds are thoroughly wetted and seeds are broadcast on the top taking care that seeds do not get buried in the soil, instead they are patted with hand. After sowing, watering is done with a fine rose can, frequently and sparingly, according to requirements as the young seedling are sensitive to both drought and excessive moisture. Germination takes place in about three weeks from the date of sowing. After germination shading is removed. The germination percentage is 60-90%. The seedlings from the tray can be pricked and transplanted in the poly bag container with fungicide after attaining a height of 5 cm. Shade cover is needed after transplanting. Growth is fast under tropical conditions and plants could reach plantable size (30 cm) in four to

five months. Seedlings require periodic watering in the first stages of development. Common mistakes in propagation are over-watering and associated disease problems, over-shading and allowing the germinants to become too large for easy transplanting leading to malformed tap roots or root curling in the pots. About 2 lakhs seedlings can be obtained from 1 kg of seeds in nurseries. Out planting is done with 35-50 cm high seedlings.

Vegetative propagation

It is observed that the treatment of IBA and NAA at 500 ppm is giving good results than other treatments. Hence to get more rooting and survival the vegetative cuttings of *N. cadamba* has to be treated with IBA 500 ppm and NAA 500 ppm.

Plantation management

It grows well in deep moist alluvial soils, often along river banks. The soil should be well drained and should not get affected by flood. The Kadam trees are planted at an espacement of 5 x 5m spacing during the monsoon season. To ensure successful establishment, seedlings should be planted with their balls of earth. Closer spacing leads to height growth which is not preferred much by pencil and ply wood industry. Wider spacing can be adopted to have more girth and also for intercropping during the initial period (1-2 years).

Agroforestry practices

It has no adverse effects on the crops sown as under storey if proper care is taken. For better results, the spacing adopted should be at least 5 x 5m/ 6 x 6m. Dry paddy can be cultivated up to 3 years without much difficulty. Once the trees are grown up, it is desirable to change the cropping pattern, i.e., ginger, turmeric etc besides vegetables, pine apple, arhar and pulses. Trees are also planted in the boundaries of the field. Hence in farm forestry, the farmers can get more yields of crops and generate revenue from *N. cadamba* tree as well.

Yield

In Tamil Nadu, about 70-100 t/ha at a rotation of 6-7 years was realized through seed raised plantations and it can be increased 10-15 % more by Introduction of clones and through site-clone matching in six years rotation depending on the fertility level of the soil. Approximate yield calculated by felling the trees in the plantation raised through seeds is as follows.

	Year (Rotation)	Number of trees	Wood yield (tons)	Sale price /tonne (‘)	Income (‘)
Tree	8	500	112 (500 x 225kg/tree)	7000	7,84,000

Approximate yield and income/ha under irrigated condition

Total Net benefit = Rs.7,84,000 (Total income)– Rs. 128050 (Cost incurred) = Rs. 6,55,950 (@ annual rate of income Rs. 81,994 per year.

Important insect pest and diseases

Caterpillars of moth *Arthroschista hilaralis* (pyralidae) and *Margaronia hilaralis* a common leaf rolling insect pest are reported. Chemical control with 0.051 B.H.C in water for the insect *Margaronia hilaralis* is reported. In India, a longhorn beetle, *Batocere numitor* (Coleoptera, Cerambycidae) bores in to the base of the stem of unhealthy trees.The main diseases reported are on nursery seedlings and include damping- off by *Fusarium* and *Pythium spp*. The fungus *Scytalidium lignicola* is found on living branches of *N.cadamba.* Apart from nursery diseases, which can be controlled by appropriate nursery practices and fungicides, there appears to be no major threat of disease.

Uses

The wood is extensively used for ceiling boards, light construction work, packing cases, planking, carving and turnery. The wood makes good

veneers and plywood suitable for the manufacture of commercial grade plywood and tea chest plywood. In Assam wood is mainly used in the plywood industries. It is also suitable for the manufacture of pencils, match boxes, and splints. Suitable for writing and printing paper giving 48.6% yield and over 6000 m breaking length. Brown wrapping paper can also be prepared by sulphate process. Fruits are edible. Bark used for relieving fever and extract of leaves are used for mouth gargle.

Neolamarckia cadamba plantation

8 Cultivation Techniques *Calophyllum inophyllum*

R. Anandalakshmi
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore
E-mail : lakshmir@icfre.org

Site factors

It grows in warm temperatures in wet or moderate conditions. It is not suited to high elevations, cool areas, or very dry conditions. Mean annual rainfall required is 1000 mm with summer, winter, or uniform rainfall patterns. Dry season duration (consecutive months with <40 mm rainfall) is 4–5 months. Mean annual temperature of 18–33°C is preferred with mean maximum temperature of hottest month of 22–37°C and mean minimum temperature of coldest month of 12–17°C.

It tolerates a wide range of soils. It grows best in sandy well drained soils in coastal areas but will tolerate clays, calcareous soils, and rocky soils. The soil is generally dry at the surface, but the water table is usually only a few decimetres down, although the water it taps is often brackish. It is also found higher up the rivers along river margins. The tree demands light and prefers full sun, and only less shade is tolerated. It is sensitive to frost and fire. It tolerates occasional waterlogging in coastal areas.

Seed collection, processing and Nursery techniques

In Tamil Nadu along the east coast ie. Cuddalore, Chennai, Nagai districts the fruit collection period is from July to September while it is during October to December in Kanya Kumari and Tirunelveli district. In Kerala along West coast mature fruits can be collected from July to September.

Pick fruits at appropriate maturity ie. pale yellow pericarp stage by plucking from the branches. Cut open the pericarp to release the seeds for raising nursery. Fresh nuts germinate after 60 days giving 95% germination when sown in mother bed under green shade net. Regular watering is essential. 30 days after germination the seedlings can be transplanted to polybags of size 12 x 25 cm. The seedlings need to be hardened for atleast tree months before field planting.

Plantation management

For plantation the spacing is usually 4 m x 4 m. Pit size is 2' x 2' x2'. Watering until two years is essential. Drip irrigation is preferable. Regular weeding is necessary until the crop is established especially once in six months interval. After three months of planting the soil need to enriched with 250 g neem cake / plant or 500 g farm yard manure. This can be repeated at one year interval. If termite problem exists in the soil, the plants can be provided with soil drenching of 500 ml (0.2%) chloripyriphos. At the end of two years pruning can be done so as to increase branching and thereby higher fruit yield.

Yield

It is one of the important TBO species with an annual average nut yield of 12 kg/ tree (5 year old) and 100 kg in 20 year old tree. Fruiting starts at 4-5 yrs. a five year old tree yields 3 kg kernel, ie.2.1L oil per tree. A 5 year old plantation with just 35 trees can yield 75 L oil, provided superior clones are planted. Less than 0.25 acres is sufficient for annual requirement of 75L oil. In 1 acre at 4x4 m 250 trees can be accommodated.

If kernel collection and processing done by a farmer:

Cost price of crude oil as per market rate	: Rs.55/L
Cost of 1 kg oilcake	: Rs.20/-

Calophyllum tree

Calophyllum plantation (18 months old)

Cost-Benefit

4 kg nuts give 1 kg kernel
1 kg. kernel costs Rs.30/-
Extraction cost for oil Rs.5/- (Rs.30-5)=Rs.25
Cost price of oil from 1 kg kernel: Rs.39/- for 700 ml.
Cost price of oilcake 400g: Rs.8/-
Hence from 1 kg kernel or 4 kg nuts the earning is Rs.47/-
Nut yield from one acre (250 trees): 3000 kg
Kernel yield from one acre (250 trees): 750 kg

Annual income from one acre: Rs.47 x 750 = Rs.35250/- in the fifth year. The income gradually increases as the tree matures.

Uses

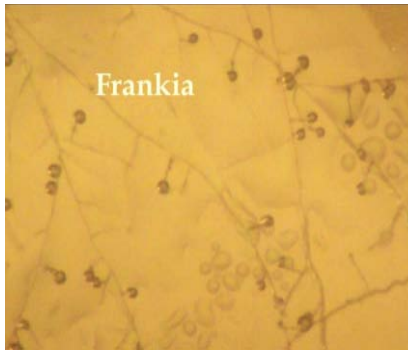
Calophyllum inophyllum is known as Punnai in Tamil. It belongs to the Clusiaceae family. It is a potential species valued for its seed oil. It is a good alternative to Casuarina as a beach windbreak, for soil stabilization and to control soil erosion. It is amenable for agroforestry and is also intercropped with Acacia spp.

Its kernel yields 50-70% oil which is directly being used as fuel in diesel engines without undergoing the trans-esterification process. Transesterified oil can also be used as biodiesel. Seed oil also called as Tamanu oil has medicinal uses in treating skin diseases and fetches high price ($4-$40/ 30 ml) in international market. With recently discovered plant properties like anti-HIV and anti-cancer active compounds, Calophyllum inophyllum can be placed amongst the most important multi-purpose trees.The timber of this species referred to a 'Bintagor' is of superior quality and is popularly traded in South-East Asian countries. It has demand for carving, furniture making, boat building, and flooring. It is a durable multi-purpose timber (density 560-900kg/m^3).

9 Application of N-fixer (an aqua product harbouring superior strains of *Frankia)* as plant growth promoter for Casuarinas

A. Karrthikeyan
Scientist
Institute of Forest Genetics and Tree Breeding, Coimbatore

Casuarinas are being cultivated in Pondicherry and Tamilnadu day by day due to its popularization as fuel wood species, nitrogen fixing capacity and potential for adaptation to diversified soil and climatic conditions. *Casuarina equisetifolia* and *Casuarinas junghuhniana* seedlings were raised under nursery level and also vegetatively propagated rooted stem cuttings using inert material (vermiculate). The roots of *C.equisetifolia* and *C. junghuhniana* produce root nodules where the actinomycete called *Frankia* fixes atmospheric N_2 which is essential nutrient for all plant metabolites activities. To promote and use this actinomycete IFGTB brought out a product called N fixer which contains superior strains of *Frankia.* The superior strains were identified based on their nitrogenase activity as well as their performance in Casuarinas at nursery and field conditions. The inoculation of N fixer (*Frankia)* resulted increased growth than non inoculated trees. Under experimental conditions N fixer results 100% of root nodule formation in the seedlings and cuttings of *C. equisetifolia* and *C. junghuhniana* by application of @ 5ml/ seedling. It contains 10^7/ ml. This N fixer was suggested to inoculate particularly for casuarinas to enhance growth and nutrient improvement.



N fixer inoculated cuttings and seedling of *C. equisetifolia* showing root nodules

N fixer inoculated seedlings of *C. equisetifolia* showing root nodules

10 "*Hy-Act*"- Biopesticide (seed oil based formulation developed from *Hydnocarpus pentandra)*

S. Murugesan, N. Senthilkumar, D. Suresh Babu and C. Rajeshkannan
Institute of Forest Genetics and Tree Breeding, Coimbatore

Ethnobotanical records indicate that *H.pentandra* oil possesses many medicinal properties, but no information on its pesticidal properties is available. Hence, the bioactivity was evaluated on the key insect pests of Teak, Ailanthus and Casuarina. Preliminary bioassay study conducted both in the laboratory and field conditions revealed that the oil possesses insecticidal properties against these pests. The oil formulation showed effectiveness in managing the insect pests in terms of larval mortality; *Hyblea purea* (80-90%), *Inderbella quadrinotata* (60-80%) and *Eligma narsisuss indica* (45-55%). The formulation is also found to act as feeding deterrents, growth inhibitors, repellents (or) oviposition inhibitors against the target insect species. Therefore, *H.pentandra* oil seed fractions were considered as promising biopesticide against these pests and the formulation named as **Hy-ACT (HyPSO 25 EC)** has been prepared and released.

1 (one) liter oil can be extracted from 5kg of seeds. The extracted oil was duly formulated with suitable combination ratios along with adjuvant. 100ml formulated '**Hy-Act'** can be mixed with 10 li of water to spray over 1.5-2.0 lakhs seedlings in order to contain aforementioned insect pests. 500 ml of '**Hy-Act'** may be needed for 1 ha of young 1-2 yrs old plantations. The cost of biopesticide 100ml bottle is Rs. 80/- only.

Hydnocarpus pentandra seeds were collected, processed, air dried and oil was extracted by organic solvent distillation. The bioefficacy of the oil

was analyzed by conducting a series of laboratory bioassays for larval mortality and antifeedancy. Each treatment with different concentrations ranging from, 250-1000 ppm & 1000-10,000 ppm was performed in 10 individual larva and 10 such replicates were made to minimize error in the experimental design. Based on the performance in the lab studies, the effective concentrations were used for further identification of individual compounds. The oil was subjected to fractionation by chromatographic techniques and the fractions were analyzed by TLC, HPLC and GC-MS-MS and the bioactive compounds were characterized and identified. The performance of the identified individual compounds was tested against key pests both in the lab and field conditions for making preformulations and application at nursery level. Based on the experiments conducted, suitable preformulations were developed and tested in comparison with neem formulation and synthetic pesticide. Based on the results obtained a product was developed with suitable formulation.


HypSO 25 EC
ஹைப-ஆக்ட்
விருக்ஷ நிவாரணி


ஹைப-ஆக்ட்
HypSO 25 EC
விருக்ஷ நிவாரணி

11 Growth promoting product – "*Tree Rich Biobooster*" (An alternate media for potting mixture)

S. Murugesan, N. Senthilkumar, N. Krishna Kumar, R. Lakshmi Devi, K. Ramesh, P. Manivachakam, C. Rajeshkannan **and** ***D. Suresh Babu***

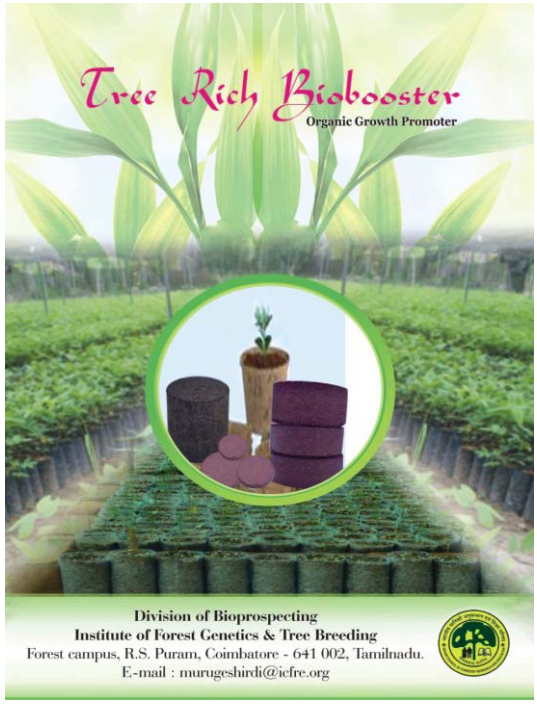
Institute of Forest Genetics and Tree Breeding, Coimbatore

Plantation forestry has tremendous scope for rural livelihood improvement and improvement of activities of wood based industries in the country. However, supply of quality planting stock to the farmers is the major bottle neck due to lack of micro and macro nutrients, insect pests, diseases and nematodes. Various nursery practices are available individually for pests, diseases and nutrient management however, integrated strategy to manage growth, pests and diseases is lacking, hence, the product **Treerich biobooster** has been developed for the production of quality planting stock for farm and plantation forestry. The developed product may be used as an alternate to potting media to raise nursery.

Treerich biobooster Pellets - Decomposed organic material along with FYM and other microorganisms in a suitable proportion was made into a disc/pellet of 60mm/25mm size with 50-60gms (EC-0.23, pH is 6.4). One pellet of the said size will expand to 12cm height with 6cm diameter after adding 350ml of water in a standard (6x15cm) polybag for raising seedlings. The total cost of the five pellet containing pack is Rs.30.

Biological products based on natural products derived from biomanures/microorganisms specific to their mode of action/function offer an ecological and effective solution to crop productivity, health and pest problems. Such bioboosters/bioinoculants are an alternative to synthetic molecules that continue to be used appropriately, particularly in

developing countries, threatening the environment and human health. There have been massive upsurges in chemical product use in recent years and increasing use, and often misuse, has led to increased problems of quality planting stock in terms of plant health and plant away from pest's pressure. New chemicals with improved properties are available but are beyond the means of many farmers in developing countries. The use of bioboosters which are highly safe and act as induced plant defenses has been proposed for many years. If produced, formulated and applied in appropriate ways, such treerich bioboosters can provide ecological and effective solution to production of healthy planting resources. In view of the experience gained by the researchers over the past one decade in the field of biofertilizers, biopesticide and made culture bank in the institute, it is essential to take up a research programme to further screen the effect of various bioinoculants as an Integrated Nutrient Management for the important forest tree species like Eucalyptus, Casuarina, Teak, Ailanthus, Gmelina and Neolamarckia species. Experience has shown that attention to the detail of bioinoculant application technology can yield significant improvement in performance of those planting stock in nurseries.


Tree Rich Biobooster
Organic Growth Promoter
Division of Bioprospecting
Institute of Forest Genetics & Tree Breeding
Forest campus, R.S. Puram, Coimbatore - 641 002, Tamilnadu.
E-mail : murugeshirdi@icfre.org


Tree Rich Biobooster
Organic Growth Promoter
Organic | Natural | Plant Product | No Soil
Bio Safety | Weightless | Compact
Insect and Disease Resistant
Institute of Forest Genetics & Tree Breeding
Forest Council of Forestry Research & Education
Coimbatore - 641 002, Tamilnadu

12 Biopesticide - *"Tree PAL ^{H}"*

S. Murugesan, N. Senthilkumar, D. Suresh Babu **and** ***C. Rajesh Kannan***

Institute of Forest Genetics and Tree Breeding, Coimbatore

Ethnobotanical records indicate that this oil possesses many medicinal properties. But no information on its pesticidal properties in terms of synergistic effect is available. Hence, the bioactivity was evaluated on the key insect pests of Ailanthus, Casuarina and Teak. Preliminary study conducted both in the laboratory and field conditions revealed that mixture of formulation possesses insecticidal properties against these pests. The oil formulation showed effectiveness in managing the insect pests in terms of larval mortality; *Hyblea purea* (80-90%), *Inderbella quadrinotata* (60-80%) and *Eligma narsisuss indica* (45-55%). The formulation is also found to act as feeding deterrents, growth inhibitors, repellents (or) oviposition inhibitors against the target species. Therefore, these fractions were considered as promising biopesticide against these pests and the formulation named as ***Tree PAL ^{H}*** has been prepared and released.

100 ml of ***Tree PAL ^{H}*** may be added to 10 litres of water and sprayed to infested plants at a week intervals. The requirement of *Tree PAL ^{H}* formulation per hectare of plantation is worked out to be 100 ml. 100 ml *Tree PAL ^{H}* can be mixed with 10li water to spray over 1.5 to 2.0 lakhs seedlings. 500 ml of *Tree PAL ^{H}* may be needed for 1 ha of young 1-2 yrs old plantations. The cost of biopesticide 100ml bottle is Rs. 80/- only.

The Institute of Forest Genetics and Tree Breeding (IFGTB) has been undertaking research on genetic improvement of commercially important forestry species such as teak, casuarina and eucalyptus which can contribute to the Green India Mission aiming for enhancing the quality and quantity of India's forest cover. IFGTB aims to enhance the productivity through

genetic improvement, silvicultural interventions and protection from pest and disease. In this context, biopesticide based plant protection specific to target pests offer an eco-friendly and effective solution to insect problems. The potential of biopesticides an alternative to chemical pesticides has not been fully exploited so far. There have been massive upsurges, and increasing use and often misuse of chemical pesticides led to problem of insecticide resistance. In addition, it has also resulted in destruction there the problems of destruction of beneficial insects and other non-target organisms and toxic residues in the ecosystem affecting the overall environmental quantity. The Division of Bioprospecting of IFGTB is involved in developing biopesticides using non-edible tree borne oil seeds and providing support to tree improvement programme. The new biopesticide formulation ***Tree PAL*** ^{H} is a product developed by the research group of Division of Bioprospecting, IFGTB through intensive research and vigorous field testing.


Tree PAL
ட்ரீ பால்


Tree PAL

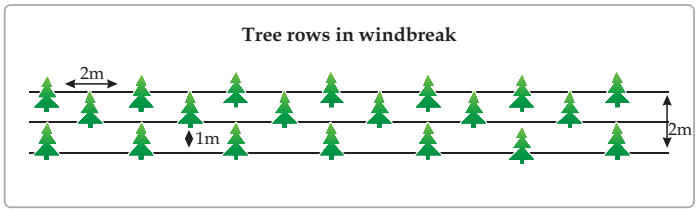
13 Windbreak Agroforestry systems with superior clones of *Casuarina junghuhniana*

C. Buvaneswaran, A. Nicodemus, R. Velumani, C. V. Vijayam, K. Vinothkumar and N. Krishna Kumar

Institute of Forest Genetics and Tree Breeding, Coimbatore

Superior Clones for Windbreaks: Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore has developed five productive clones of *Casuarina junghuhniana viz.* **IFGTB-WBC 6, IFGTB-WBC 8, IFGTB-WBC 9, IFGTB-WBC 17** and **IFGTB-WBC 18** exclusively suitable for windbreak Agroforestry system. These clones will have more number of branches, greater branch thickness, wider branch angle along with greater growth rate and biomass productivity and are suitable clones for windbreaks. Farmer's experience of cultivating plantain under windbreak agroforestry system with these superior clones of IFGTB also showed that there exist good compatibility of Casuarina and banana for co-cultivation of the both the crops.

Establishment of the model: After land preparation by ploughing and formation of three channels at distance of 1 m all along the boundary, within each channel, superior clones of Casuarina are planted at 2 m interval within the rows in 'Quincunxs' pattern. Thus the tree density will be around 600 trees per hectare. After planting of tree seedlings, rhizomes of plantain are planted inside the field in the 'Quincunxs pattern with 4 m distance within a row and 2 m distance between rows. Thus, the plantain density will be 2500 per ha.



C. Economics of the technology

Growth and Yield: Observation on growth parameters of top ranking superior clones of *Casuarina junghuhniana* under this windbreak agroforestry system in Kovilpalayam in Coimbatore district, Tamil Nadu revealed that the girth at breast height was 12.0 cm and total height was 6.0 m at the end of first year of the plantation. At this rate of growth, volume production will be 12.0 cubic metre per hectare. Estimated wood yield on fresh weight basis at harvest age of three years is 8.0 metric tonnes per hectare.

The average yield of plantain (Variety-Kadali) under windbreak agroforestry system obtained in the farm field in Kovilpalayam is 7.0 kg of fruit weight per bunch (after excluding the weight of fruit stalk (rachis)-which will be around 2.5 kg in kadali variety. It is observed that the fruit yield from plantain very adjoining to the tree rows was not affected by co-cultivation of superior clones of *Casuarina* junghuhniana and Kadali variety of plantain crop.

Expected Additional Income from the tree component

Location: Kovilpalayam, Coimbatore District	Year:2013
Particulars	**Values**
i) Cost of cultivation of tree component :	Rs. 6,000/-
ii) Benefits from tree component after three years:	
a) Income from pulpwood (@ Rs. 2300 per MT):	Rs.18,400/-
b) Income from branch wood –(@ Rs.1000 per MT)	Rs.2,500/-
iii) Net Additional income from tree component	Rs. 14,900/-

One year old growth of superior clones for windbreak Agroforestry system for protecting plantain crop from wind damage

One year old growth of superior clone selected exclusively for windbreak Agroforestry system by IFGTB in the farm field in Coimbatore district, Tamil Nadu

Normal growth of Banana crop adjoining to tree rows in windbreak

14 Bio-Inoculants for Native Tree Species in Nursery

V. Mohan

Institute of Forest Genetics and Tree Breeding, Coimbatore

The well known symbiotic relationships between plants and microbes are Plant Growth Promoting Rhizobacteria (PGPRs) and Arbuscular Mycorrhizal (MA) fungi. Use of these beneficial microbes as bio-inoculants/ bio-fertilizers would reduce the cost of chemical fertilizers involved in plantation programmes. The effective utilization of bio-inoculants for trees will not only provide economic benefits but also improve and maintain the soil fertility and sustainability in natural soil ecosystem. Among many native tree species, *Ailanthus excelsa, A. triphysa, Dalbergia latifolia, Gmelina arborea, Melia dubia* and *Neolamarckia cadamba* are some of the economically important fast growing. These species are being cultivated in agro-forestry system by farmers and industries for their end uses. The demand for forest products is increasing whereas the area under forests is declining. The depletion of forest cover leading to scarcity of fuel wood and food for man and animals coupled with increasing wasteland formation is a major concern of developing nations. Hence, an efficient production of quality seedlings of economically important native tree species is of paramount importance for better productivity in field.

Attempts were made to investigate the diversity status of beneficial microbes like Arbuscular Mycorrhizal (AM) fungi, nitrogen fixers (*Azotobacter* and *Azospirillum*) and phosphate solubilizing bacteria in association with six different fast growing native tree species *viz., Ailanthus excelsa, A. triphysa, Dalbergia latifolia, Gmelina arborea, Melia dubia* and *Neolamarckia cadamba* plantations in Kerala and Tamil Nadu. Total of 216 PGPR isolates from the rhizosphere samples of *A. excelsa* (69 isolates)*, A. triphysa* (12 isolates), *D. latifolia* (29 isolates), *G. arborea* (45 isolate), *M. dubia* (28 isolates) and *N. cadamba* (33 isolates) were identified. A total of

25 different AM fungal species *viz*. *Acaulospora* (4 species), *Gigaspora* (2 species) and *Glomus* (19 species) were isolated and identified from the rhizosphere of these selected 6 different native trees in various planatations. Pure cultures of all the beneficial microbes are maintained in the Institute's Germplasm Bank for further studies.

An experiment was conducted for screening of efficient PGPR isolates under *in vitro* for plant growth hormone (IAA) production and phosphate solubilization and the best and potential isolates were selected for nursery experiments. Some of the PGPR viz., *Azotobacter chroococcum, Azospirillum lipoferum, Bacillus megaterium, Bacillus subtilis, Pseudomonas fluorescens, Pseudomonas synxantha, Acinetobacter* sp., *Stenotrophomona*s sp. were reported for the first time in association with these fast growing native trees. DNA sequencing of selected isolates of PGPRs has been done and Nucleotide sequences of 13 different isolates of PGPRs (PSB and *Azospirillum*) were submitted to European Molecular Biology laboratory (EMBL) and National Center for Biotechnology Information (NCBI) Databases and obtained Accession numbers for the repository.

In the present study, liquid based formulation of PGPR biofertilizer product was made and inoculated to all the 6 different native tree species in nursery. It was found that multiple inoculation (AM fungi + Nitrogen fixer + Phosphate Solubilizing Bacteria) resulted in enhanced plant growth, biomass and seedling quality over single inoculation and uninoculated (control). Attempts were made for studying the persistence of inoculated beneficial microbes (both AM fungi and PGPR organisms) from the roots and rhizophsere samples of all the six different native tree seedlings and it was recorded that the inoculated tree species had better percent root colonization and soil spore population of AM fungi and population density of PGPR organisms. This study would enable and support organic tree nurseries and agro-farming. The bio-inoculants application in seedling stage may assist the seedlings to withstand dry land conditions and support the seedlings when out planted under agro-forestry and plantation systems.


Single inoculation of PGPRs and AM fungi to seedlings of *Dalbergia latifolia*


Multiple inoculation of PGPRs and AM fungi to seedlings of *Dalbergia latifolia*


Single inoculation of PGPRs and AM fungi to seedlings of *Ailanthus excelsa*


Multiple inoculation of PGPRs and AM fungi to seedlings of *Ailanthus excelsa*


Single inoculation of PGPRs and AM fungi to seedlings of *Ailanthus triphysa*

Multiple inoculation of PGPRs and AM fungi to seedlings of *Ailanthus triphysa*

Single inoculation of PGPRs and AM fungi to seedlings of *Gmelina arborea*

Multiple inoculation of PGPRs and AM fungi to seedlings of *Gmelina arborea*

Single inoculation of PGPRs and AM fungi to seedlings of *Melia dubia*

Multiple inoculation of PGPRs and AM fungi to seedlings of *Melia dubia*

15 Casuarina based '*Alley cropping*' system for higher economic returns

S. Saravanan

Institute of Forest Genetics and Tree Breeding, Coimbatore

Casuarina based alley cropping system was laid out in wider alleys in the spacing of 3x1m. Land was ploughed and watering channels were made to facilitate the irrigation to the systems and 30 cm^3 pits were dug for establishing Casuarina based alley cropping system. The density of Casuarina remained as 3333 trees/ha. Before planting of Casuarina, annual crops seeds were sowed. Planting of Casuarina clones or seedlings raised from seed orchards will give the better yield with uniform growth.

Studies conducted on socioeconomic aspects on tree cultivation in farmlands in Tamil Nadu and the study revealed that, among the reasons, for taking up tree cultivation, higher returns in short period pointed out by many farmers compared to agriculture cited as major reason and ranked first with greater mean score of 54.33 under 'Garrett Scoring Technique' (Garrett and Woodworth, 1969). 'Less risk' involved in tree cultivation ranked second and 'Less attention need' ranked third.

Yield and Economics of the system

From the established 'alley cropping' agroforestry system with Casuarina, the yield has been worked out for of pure casuarina, pure cotton and for casuarina-cotton based agroforestry system, for three years. The economic productivity of the model (Casuarina-Cotton) was also worked out and the average annual net income from this model is Rs. 41, 000/- Also, this Casuarina-Cotton based agroforestry system has been compared with pure Casuarina, pure agricultural component (cotton) and traditional land use. From the above model, the intercropping activities have been

carried out for three years and the yield was assessed. From the above model, the annual net come has been worked out and Casuarina based alley cropping system registered higher annual net income which is higher than the sole crops. The economic productivity of the model (Casuarina-Cotton) was also worked out and the average annual net income from this model is Rs. 41, 000/- Also, this Casuarina-Cotton based alley cropping agroforestry system has been compared with pure Casuarina, pure agricultural component (cotton) and traditional land use (rice cultivation) which gives a net income of Rs. 22, 800/-, Rs.24, 000/- and Rs.32,500/- respectively. The casuarina –cotton based alley cropping agroforestry system registered higher average annual net income compared to other sole crops and traditional agriculture.

16 Initiatives of Conservation and Commercialization of Rare Tamarind Genetic Resources

A. Mayavel, J. Soosairaj B. Gurudev Singh and N. Krishnakumar

Institute of Forest Genetics and Tree Breeding, Coimbatore

Indian Council of Forestry Research Education has launched a special scheme on Direct to Consumer to take the technological advancements made by ICFRE to stake holders. Under this programe the projects implemented by ICFRE having potential outreach have been selected for extending research finding to stakeholders. The project on "Selection and Conservation of red and sweet tamarind in southern india" was implemented by Institute of Forest Genetics and Tree Breeding during 2007-2010 have been selected under this programme.

Tamarind (*Tamarindus indica* L) is an important multipurpose tree species primarily grown for its fruits. The Fruit pulp is used as culinary ingredient in many south Indian foods. The timber is largely used for preparation of domestic articles, furniture and agriculture implements. The starch and oil extracted from seeds is widely used in textile and paint industry. Large variation in tree growth, canopy size, flowering pattern, fruit productivity, pulp colour and sweetness exists in tamarind. Based on the pulp colour tamarind has been delineated as red tamarind and brown tamarind. The red pulp colour in unripe fruits is due to presence of anthocyanin present cell vacuoles which is a natural water soluble, non toxic pigment. The high potential of red tamarind as biocolourant in food processing, pharmaceutical, brewery and confectionery industries to replace the use of carcinogenic inorganic colorants provide scope for large scale commercial utilization. Based on variation in acidity level in fruit pulp sweet and sour tamarind are recognized. The sweet tamarind pulp is

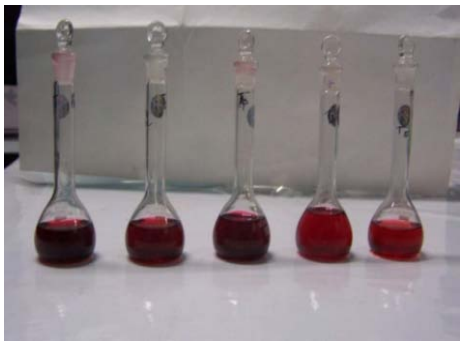
rich in minerals and vitamins and used for preparation of jam, jelly, candy and chocolate. The red and sweet varieties are rare mutants with scattered distribution preventing their commercial utilization. To conserve and utilize these rare and valuable genetic resources a project on Selection and conservation of Red and Sweet Tamarind have been implemented in IFGTB during 2007 to 2010.

Extensive surveys were carried out in Tamil Nadu, Karnataka, Andhra pradesh, and Puducherry to identify and select red and sweet tamarind trees. The project located 47 red tamarind trees with unripe fruit pulp containing anthocyanin ranging from 123.00 mg/l to 246.90 mg/l in comparison with normal brown tamarind pulp contained no anthocyanin similarly 30 sweet tamarind trees with pulp containing total sugar ranging from 30.50 % to 48.60 % as compared to 27.60 % in widely grown variety PKM-1. The Thailand sweet tamarind varieties available in the market contains 68.30 % of total sugar. The Institute of Genetics and Tree Breeding assembled 60 accessions of red and sweet tamarind in a germplasm bank at Kurumbapatti, Salam (District) in Tamil Nadu. This is the first initiative made to conserve these rare phenotypic variants of tamarind in the country.

Since the highly valuable phenotypic variants of red and sweet tamarind are have the potential for commercial utilization in various industries.it has been has been incorporated in Direct to Consumer Scheme. These variants will also be helpful for improving livelihood of rural people involved in tamarind cultivation and alleviate poverty through income generation and creating employment opportunities. Under this scheme a project on Production and supply of quality planting stock of Red and Sweet Tamarind to different stake holders has been initiated in Institute of Forest Genetics and Tree Breeding, Coimbatore during 2012-2013.

The red tamarind with high anthocyanine and sweet tamarind with high sugur and low acidity are being propagated through cleft grafting and approach grafting techniques for supplying to the stake holders.

Colour variation between unripe fruits of normal and red tamarind



Extraction of Anthocyanin from different growth stages of red tamarind

Quality Planting Stock Production of Red and Sweet Tamarind through Approach Grafting

Quality Planting Stock Production of Red and Sweet Tamarind through Cleft grafting

17 Tree Pest Management

John Prasanth Jacob

Institute of Forest Genetics and Tree Breeding, Coimbatore

Insect pests are detrimental to the vigorous growth and health of planting stock which ultimately affect the survival of out planted seedlings in the field. Development of pest management practices is an important priority area in forestry so as to produce healthy seedlings for attaining improved productivity. Timely and proper utilisation of the developed pest management package of practices could keep the pests at an innocuous level and reduce the high cost of containing the pest in outbreak situations and loss of planting material could be avoided. Pest management (in nurseries and plantations) relies mostly on monitoring to detect pest incidences and identify pest population levels. The key tactic is prevention. For this, information on pests and planning to prevent or reduce the pest incidence is required.

Based on the information about the periodicity of incidence, intensity of attack, nature of damage, biology of key pests and the influence of biotic and abiotic factors on pest build up, suitable management measures were standardized for some of the key pests by integrating cultural, mechanical, biological and chemical methods.

The following combinations of strategies are recommended for employing integrated pest management methods for tree pests in forest nurseries

No.	STRATEGY	METHOD
1	Initiate implementing pest management strategies well before pest incidence. Install light traps. Assessing pest abundance through sampling	Regular monitoring and early detection of pests with the help of Pest Calendar and identifying abundance level to take appropriate measures.

No.	STRATEGY	METHOD
2	Weed clearing, disposal of infested seedlings, hand picking or net collection of pests and destruction, pruning of affected areas.	Employing cultural and physical methods to minimize incidence and spread of the pest.
3	Delay pesticide application	Allowing build up of natural enemy population.
4	Applying commercially available bacterial, viral, fungal formulations.	Applying microbial formulations.
5	Prepare extracts with easily and commonly available plants through cost effective methods and apply.	Applying effective plant based extracts to minimize pest incidence and spread.
6	Host plant resistance	Identification and utilization of pest resistant/tolerant candidates.
	Applying need based safe and less persistent insecticides.	Pesticide application

Pest Calendar which documents various pests and their natural enemies will help in taking various prophylactic measures for management of insect pests. State Forest Departments, Corporations, NGOs and Farmers raising nurseries for plantation purpose will be benefited by the package of practices to manage pest problems in nurseries.

IPM MEASURES FOR KEY PESTS OF TREES IN NURSERY

IPM for insect pests of *Tectona grandis*

Hyblaea puera & Eutectona machaeralis

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	***Prophylactic:*** Regular monitoring throughout the raising period particularly soon after the monsoon rains. Install light traps to monitor and trap adult moths of *H. puera*.
< 6	LOW	***Mechanical:*** Leaves folded at the margins can be located and *H. puera* larva can be plucked every 10 days and destroyed. Spray of Neem oil or Pungam oil emulsion can be done 15-20 days interval to deter the caterpillars.
> 6 but < 12	MEDIUM	***Chemical:*** 0.05% monocrotophos or 0.076% dicholrvos can be sprayed.
> 12	HIGH	***Chemical:*** As above.

IPM for insect pests of *Casuarina*

Icerya purchasi

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	***Prophylactic:*** Regular monitoring throughout the raising period. Apply 12 % neem oil every 10-15 days interval.

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
< 6	LOW	***Mechanical:*** During low level infestations the scales can be scrapped off manually with a pair of sticks. ***Chemical:*** Spray of 0.06% dimethoate or 0.05% methyl demeton can control the pest.
> 6 but < 12	MEDIUM	***Chemical:*** As above.
> 12	HIGH	***Chemical:*** As above.

Ferrisia virgata

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	***Prophylactic:*** Regular monitoring throughout the raising period. Apply 12 % neem oil every 10-15 days interval.
< 6	LOW	***Mechanical:*** During low level infestations the scales can be scrapped off manually with a pair of sticks. ***Chemical:*** Spray of 0.06% dimethoate or 0.05% methyl demeton can control the pest.
> 6 but < 12	MEDIUM	***Chemical:*** As above.
> 12	HIGH	***Chemical:*** As above.

IPM for insect pests of *Melia dubia*

Red spider mite *Tetranychus urticae*

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	
< 6	LOW	***Mechanical:*** Infested leaves can be hand plucked and destroyed if the pest is at low to medium level. ***Chemical:*** Application of 12 % Neem oil emulsion pointed towards the under side of the leaves can reduce the population level. 2.5 ml of Dicofol per liter of water can be applied during severe infestation. Application of Propargate 0.1 ml/lit of water can also control the mites.
> 6 but < 12	MEDIUM	***Chemical:*** As above.
> 12	HIGH	***Chemical:*** As above.

***Ascotis selenaria* (Lepidoptera:Geometridae)**

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	
< 6	LOW	***Mechnical:*** Adult moths are attracted to light. Install Light traps with white lights soon after the rains to trap the adult. Prosophis trees are most preferred host. Lopping the branches or elimination of Prosophis trees from the vicinity nursery can control the incidence of Ascortis.

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
		Chemical: 0.05% Monocrotophos or 0.076% Dichlorvos.
> 6 but < 12	MEDIUM	***Chemical:*** As above.
> 12	HIGH	***Chemical:*** As above.

***Ferrisia virgata* (Hemiptera: Pseudococcidae)**

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	
< 6	LOW	***Mechanical:*** During low level infestations the scales can be scrapped off manually with a pair of sticks. Application of Neem oil, tobacco extract directed towards the underside of the leaves controlled the scales. ***Chemical:*** Spray of 0.06% dimethoate or 0.05% methyl demeton can control the pest.
> 6 but < 12	MEDIUM	***Chemical:*** As above.
> 12	HIGH	***Chemical:*** As above.

Thrips

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	***Prophylactic:*** Regular monitoring throughout the raising period. Apply 5% NSKE every 10-15 days interval. Bed arrangement alternatively with other

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
		species can be tried to reduce the spread of the pest.
< 6	LOW	***Chemical:*** Suitable microbial formulations of Verticillium lecanii can be applied to bring down the population. 0.06% dimethoate or 0.01% imidacloprid or 0.076% Dicholrvos can be sprayed.
> 6 but < 12	MEDIUM	***Chemical:*** As above.
> 12	HIGH	***Chemical:*** As above.

IPM for insect pests of *Ailanthus excelsa*

Eligma narcisus

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	***Prophylactic:*** Light traps can be installed to monitor adult insects. *A. malabaricus* and *A. triphysa* trees in the vicinity should be monitored since they act as alternate hosts and sustain nucleus populations and treatments like pesticide application or lopping of branches can done to reduce pest population.
< 6	LOW	***Mechanical:*** Hand picking and destruction of larva by immersing in a mixture water and kerosene at low level incidence of the pest. Pupal cases attached to the seedling stems can be detached and crushed.

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
> 6 but < 12	MEDIUM	***Chemical:*** 5% tobacco extract and 2% pungam oil can be sprayed alternatively in a gap of 15 -20 days. Suitable microbial formulations of *Beauveria bassiana* can be applied to bring down the population.
> 12	HIGH	***Chemical:*** 0.05% Monocrotophos spray or 0.076% Dicholrvos.

Atteva fabricella

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	***Prophylactic:*** Light traps can be installed to monitor adult insects.
< 6	LOW	***Mechanical:*** Infested shoot tips can be easily located and larvae can be hand picked and destroyed. Pupal cases attached to dry apical leaves can be collected and crushed.
> 6 but < 12	MEDIUM	***Chemical:*** 0.05% Monocrotophos spray or 0.076% Dicholrvos Suitable microbial formulations of *Beauveria bassiana* can be applied to bring down the population.
> 12	HIGH	***Chemical:*** 0.05% Monocrotophos spray or 0.076% Dicholrvos.

IPM for Common and miscellaneous pests

Myllocerus sp. & Grasshoppers

INSECTS / 50 SEEDLINGS	LEVEL	MANAGEMENT METHODS
Nil	0	*Prophylactic:* Regular monitoring and weeding of nursery.
< 6	LOW	*Mechanical:* Sweep net collection of beetles and grass hoppers should be done every week. Spray of Neem oil or Pungam oil emulsion can be done every 10 days to deter the insects.
> 6 but < 12	MEDIUM	*Chemical:* 0.05% monocrotophos or 0.076% dicholrvos can be sprayed.
> 12	HIGH	*Chemical*: As above.

18 Clonal propagation of Eucalyptus

V.K.W Bachpai

Institute of Forest Genetics and Tree Breeding, Coimbatore

Candidate Plus tree selection

The selection of the most desirable tree with characeteristics such as straightness of stem, annual growth rate, height, clear bole height, Girth at breast height, crown structure, bark peeling, disease resistance etc has to be considered

Once the trees are selected the following operations should be followed.

STEP 1: COPPICING OF SELECTED TREES

The selected group of trees may be coppiced with a slant cut about 15- 20 cm above ground level. The cut end should be given antifungal treatment (1gm of Red lead + 1 gm of copper carbonate in 1000 ml. linseed oil or blue copper). After 40 days, coppice shoots are ready for harvest. Each tree would yield 30 nodal cuttings. The shoots should be green, semi hard and fleshy. Type of cutting selected contributes a great deal to per cent success of rooting.

STEP 2: ROOTING PHASE

The shoots are severed from the mother plants, placed in a bucket of water and transported to cutting preparation area. The collected shoots are severed with secatures made into single node cutting with two buds and a pair of leaves. The leaf is reduced to less than half the original leaf size to minimize transpiration. The base of the prepared cuttings is treated with fungicide (0.1% Emision or 0.05% Bavistin). Immediately, the lower portion of the cuttings treated with indole butyric acid 4000 ppm in talcum powder (4g of Indole Butyric Acid in 1 kg of ordinary Talcum powder) by

dip smear treatment to stimulate the root formation. Following this, the cuttings are ready for planting in root trainers containing presoaked vermiculite as a rooting media. The cuttings are kept in polytunnels for about4-6 weeks until a good root system is developed and shoot growth starts.

STEP 3: HARDENING PHASE

The rooted cuttings are transferred from the polytunnels to single net shade house. Under the single net shade house they are maintained for 15 – 20 days. The rooted cuttings are watered regularly twice a day. The rooted cuttings are given a dose of NPK solution (1gm/lit). After 20 days the rooted cuttings are transferred to open nursery for exposing them for further hardening in direct sunlight. The cuttings are maintained in the nursery till they attain plantable height. On attaining plantable height the rooted cuttings are sent for planting

JUVNILE SHOOT ROOTING (MINI AND MICRO CUTTING TECHNIQUE)

Establishment of Mini-hedges : The Mini-hedges are established adjacent to the propagation nursery. Beds of standard size of 1m X 10m dimensions are prepared using desired potting media. Propagules are planted at an espacement of 20 cm x 20 cm. (200 stools per bed). The propagules are watered at regular intervals. Each propagule initially is supplied with 50 gms of NPK fertilizer. Periodic cultural operations like watering, weeding, pesticide application etc. are carried out at regular intervals for vigourous luxurious growth. The stools are maintained for a period of 180 days till the stools attain 10 mm to 15 mm collar diameter.

Mini hedges are established through two routes.

1. **Mini- cutting technique:** In this technique the mini clonal hedge consists of mini stumps obtained by rooting mini cuttings derived from the shoots propagated from the conventional cutting method.

2. **Micro-cutting technique:** In this technique the clonal hedge is raised from micro-propagated plants through tissue culture laboratory

Coppicing of Mini-hedges

The stools are coppiced at a height of 15 cm from ground level. The cut end should be given antifungal treatment (1gm of Red lead + 1 gm of copper carbonate in 1000 ml. linseed oil or blue copper). The coppiced shoots are watered regularly.

Collection of juvenile shoots

After 15 days, juvenile shoots are ready for harvest (5 cm to 10 cm). Each stool would yield 5-14 juvenile shoots. The advantage of juvenile shoot cutting is that shoots can be harvested every 15 days and rooted. The shoots should be green, semi hard and healthy. Type of cutting selected contributes a great deal to per cent success of rooting.

Rooting of juvenile shoots

The shoots are severed from the mother plants, placed in a bucket of water and transported to cutting preparation area. The base of the juvenile shoot is treated with fungicide (0.1% Emision or Bavistin 0.05%). Immediately, the lower portion of the juvenile shoot is treated with indole butyric acid 4000 ppm in Talcum powder (4g of Indole Butyric Acid in 1 kg of ordinary Talcum powder) by dip smear treatment to stimulate the root formation. Following this, the juvenile shoots are ready for planting in root trainers containing presoaked vermiculite as a rooting media. The cuttings are transferred to poly tunnels for 3-4 weeks until a good root system is developed and top growth starts.

Hardening procedure is the same as mentioned earlier for the conventional stem cutting method.

19 Clonal propagation of Casuarina

V.K.W Bachpai

Institute of Forest Genetics and Tree Breeding, Coimbatore

MACROPROPAGATION (ROOTING OF SPRIGS)

Selections / Clones can be propagated by rooting young shoots ("sprigs"). These plants produce uniform superior growth in plantations. In Casuarina rooting of sprigs is carried out in the following stages.

1 : COLLECTION OF SPRIGS

Sprigs are collected from the by severing them from lower branches of selected plants and place in a bucket of water and transported to cutting preparation area.

STEP 2 : ROOTING PHASE

The severed sprigs are trimmed to 8-10 cm length. While trimming care should be taken to avoid damage to the apical bud of the sprig. The base of the sprigs treated with fungicide 0.05% Bavistin. Immediately, the lower portion of the sprig is treated with indole butyric acid 2000 ppm in Talc powder (2g of Indole Butyric Acid in 1 kg of Talc powder) by dip smear treatment to stimulate the root formation. Following this, the cuttings were planted in root trainers containing presoaked vermiculite as a rooting media and kept under suitable environmental conditions for rooting in the polytunnels (35-38^{o}C and humidity at 90% RH).

STEP 3 : HARDENING PHASE

Hardening phase is similar to that of Eucalyptus.

Rooting of juvenile sprigs (mini cutting technique) for clonal Casuarina at a commercial scale have shown great potential of substituting, rooting

stem cuttings with technical and economical advantages. Clonal hedges are replaced by mini-hedges which provide high degree of juvenility of micro-propagated and vegetatively propagated plantlets.

Establishment of Mini-hedges : The Mini-hedges are established in raised bed under controlled conditions. Propagules are planted at an espacement of 20 cm x 20 cm. (200 stools per bed). The propagules are watered at regular intervals using drip irrigation facility. Fertigation of the stools is also done through the lateral of the drip irrigation system. Fertigation is carried out depending on the requirement (weekly). Periodic cultural operations like watering, weeding, pesticide application etc., are carried out at regular intervals for vigourous luxurious growth. The stools are maintained for a period of 180 days till the stools attain 10 mm to 15 mm collar diameter.

Mini- cutting technique (Macro propagated cuttings route)

In this technique the mini clonal hedge consisted of mini stumps obtained by propagules derived from shoots propagated by vegetative means.

Coppicing of Mini-hedges

The stools are coppiced at a height of 15 cm from ground level. The cut end should be given antifungal treatment (1gm of Red lead + 1 gm of copper carbonate in 1000 ml. linseed oil or blue copper).

Collection of juvenile sprigs

After 30 days, juvenile sprigs are ready for harvest (5 cm to 10 cm). Each stool would yield 4-6 juvenile sprigs. The advantage of mini cutting is that sprigs can be harvested every 20 days and rooted. The sprigs should be green, semi hard and healthy. Type of cutting selected contributes a great deal to per cent success of rooting.

ROOTING OF JUVENILE SPRIGS

The sprigs are severed from mini stools maintained in a raised bed, placed in a bucket of water and transported to cutting preparation area. The base of the juvenile shoot is treated with fungicide (Bavistin 0.05%). Immediately, the lower portion of the juvenile shoot is treated with indole butyric acid 2000 ppm in Talcum powder (4g of Indole Butyric Acid in 1 kg of Talc powder) by dip smear treatment to stimulate the root formation. Following this, the juvenile shoots are ready for planting in root trainers containing presoaked vermiculite as a rooting media. The cuttings are transferred to poly tunnels for 3-4 weeks until a good root system is developed and top growth starts.

Hardening procedure is the same as mentioned earlier for the conventional stem cutting method.

MAINTENANCE OF MINI HEDGES

Management mini hedges is utmost important for the success of enhancing rootability and quality planting stock production. For successful operational procedure of rooting cuttings monitoring of location, labour, maintaining identity of mini hedges and infrastructure is carried out. Harvesting decisions for collection of juvenile shoots were taken on the basis of growth performance of different clones.

Water culture method : The procedure used in China is independent of plant gender. In Florida, only male plants can be used. The Chinese procedure involves establishing a plantation of young trees that are cut near the soil-line to induce young shoots. Those shoots are harvested when they are 3 months of age or younger and 3-4 inches long. About 20 or 30 cuttings are placed in an ordinary opaque plastic 12 oz. cup with about 1 inch of rooting hormone solution (50 -100 ppm NAA or IBA). The cuttings soak for 24 hours. The cuttings are removed and placed in another cup with only tap water. The cups are placed outdoors in a shady place. The water is replaced daily. Rooting apparently occurs within 4- 6 weeks.

ROOTING OF JUVENILE SPRIGS IN POLYBAGS

Rooting of juvenile sprigs can also be carriedout successfully in polythene bags directly. Polythene bags of size 8 cm x 10 cm are filled using a potting mixture containing red soil, pallam sand and farmyard manure in the ratio 3:1:1. The steps of collection of sprigs, rooting, and hardening is similar to that of the steps followed for rooting the sprigs and rooting juvenile sprigs.

Of the methods discussed above nowaday mostly the propagation on large scale is carried out using the mini cutting technique and rooting the sprigs in poly bags. In both the methods cost effective poly tunnel technique is used.