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SEED HANDLING AND NURSERY PRACTICES FOR SELECTED FOREST TREES OF KERALA

K.C. Chacko
C. Mohanan
K.K. Seethalakshmi
George Mathew

Kerala Forest Research Institute
Peechi 680 653, Kerala, India
Website: http://www.kfri.org

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(Final Report of the Research Project KFRI 255/96)

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K.C. Chacko
Division of Silviculture
C. Mohanan
Division of Plant Pathology
K.K. Seethalakshmi
Division of Plant Physiology
George Mathew
Division of Entomology

Kerala Forest Research Institute
Peechi 680 653, Kerala, India
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ABSTRACT OF PROJECT PROPOSAL

1. Project No. : KFRI 255/96

2. Title : Seed handling and nursery practices for selected forest trees of Kerala

3. Objectives:

   i) To develop a package of practices for seed handling and nursery management for selected forest tree species.

   ii) To produce a field manual of nursery practices for important forest tree species.

4. Date of commencement : 1 April 1996

5. Scheduled date of completion : 31 March 1999
   (Extended up to 31 December 1999 vide letter No. 33-45/96-ICFRE(R) dated 10/09/1999)

6. Project Team

   Principal Investigator : K.C. Chacko (Division of Silviculture)

   Investigators : C. Mohanan (Division of Plant Pathology)
   K.K. Seethalakshmi (Division of Plant Physiology)
   George Mathew (Division of Entomology)

   Research Fellows : S. Abdul Kader
   (12/03/1997 to 31/12/1999)
   R. Anil Chandran
   (12/05/1998 to 31/12/1999)

7. Funding agency : ICFRE
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8. Budget : Rs. 13,00,000/-

ABSTRACT

Seeds of six tree species viz. *Hopea parviflora, Melia dubia, Swietenia macrophylla, S. mahagoni, Terminalia crenulata* and *T. paniculata,* were collected from different seed zones in Kerala State and seed handling practices such as methods of seed collection, transport, processing, storage, pre-sowing treatments and seed testing procedures improved. Seedling production technology was also standardized for these species. Seed pathological studies were carried out on nine more species. Based on the information generated from the studies and those gathered from the literature, a field manual of seed handling and nursery practices for 30 forest species of Kerala was prepared. The manual covers the following species: *Acacia nilotica, Acrocarpus fraxinifolius, Ailanthus triphysa, Albizia lebbeck, A. odoratissima, Anogeissus latifolia, Azadirachta indica, Cassia fistula, Dalbergia sissoides, Gmelina arborea, Grewia tiliaefolia, Haldina cordifolia, Hopea parviflora, Lagerstroemia microcarpa, Melia dubia, Mimusops elengi, Neolamarkia cadamba, Pterocarpus marsupium, Schleichera oleosa, Swietenia macrophylla, S. mahagoni, Syzygium cumini, Tectona grandis, Terminalia arjuna, T. bellirica, T. chebula, T. crenulata, T. paniculata, Vateria indica* and *Xylia xylocarpa.*

1. INTRODUCTION

Quality of planting stock is one of the major factors determining the rate of establishment and growth of plants in the field. Among different types of propagules used in plant production, seeds enjoy popularity. Good quality seeds are required for production of good quality seedlings. Seed quality can be ensured through collection of seeds from genetically (= phenotypically) superior stands and handling them scientifically till they are sown. Though seed handling and nursery practices of several forestry species are known, several details on seed technological and plant production aspects are lacking. Moreover, for many species, the information lies scattered, and hence needs collation into a readily usable form. It was in this context that the present project was initiated with the following objectives:

(i) To develop a standard package of practices for seed handling and nursery management for selected forest tree species.

(ii) To publish relevant information in the form of a field manual.

In all, six species (*Hopea parviflora* Bedd., *Melia dubia* Cav., *Terminalia crenulata* Heyne *ex* Roth, *T. paniculata* Roth, *Swietenia macrophylla* King and *S. mahagoni* (L.) Jacq.) were chosen for detailed studies under the first objective; and nine additional species viz., *Lagerstroemia microcarpa* Wt., *Pongamia pinnata* (L.) Pierre, *Grewia tiliaefolia* Vahl, *Terminalia bellirica* Roxb., *Xylia xylocarpa* Taub., *Pterocarpus marsupium* Roxb., *Cassia fistula* L., *Wrightia tinctoria* (Roxb.) R. Br. and *Holoptelea integrifolia* (Roxb.) Planch. for seed health investigations.

The manual prepared under the second objective contains 30 important tree species, which includes all the 6 species studied in detail, the 9 species subjected to health investigations and additional 15 species.

2. SPECIES STUDIED

2.1. SPECIES STUDIED IN DETAIL FOR SEED HANDLING AND NURSERY PRACTICES

2.1.1. *HOPEA PARVIFLORA* BEDD.

Description of the tree

Hopea parviflora (Iron wood of Malabar), is a very large, handsome, evergreen, straight-boled tree attaining 30-37 m height and 4.6 m in girth, with a clear bole of about 21 m. The crown is conical when young, but becomes more rounded and very dense when the tree is mature. It is endemic to the Western Ghats of India and is quite common in the forests of Karnataka, Kerala and in Tirunelveli district of Tamil Nadu. It thrives at elevations ranging from almost sea level to about 1100 m (FRI, 1980). In evergreen and semi-evergreen forests, it grows along riverbanks up to 900 m (Balasubramanyan *et al.*, 1985).

The wood is extremely durable even when in contact in ground or seawater and is resistant to attack of termite and many decay fungi. The timber is used for various construction purposes and also as decorative wood (CABI, 1998).

Although the tree is evergreen, it loses a portion of its old leaves at the onset of the dry season from December-January up to April-May. Simultaneously, the tree develops new leaves (FRI, 1980) and the tree is never leafless.

Flowering and fruiting

Flowers small, cream-coloured, in grey-tomentose panicles, appearing during January-February and the fruits ripen in May-June. Prolific seeding occurs once in 4

to 6 years and such years are invariably followed by one or two years of comparative sterility and the same number of moderate seed years (FRI, 1980).

Seed technological aspects

Seeds (fruit with two straw-coloured wings is considered as seed) are collected from the tree when the green wings turn brown, by shaking and plucking off the seed. They are transported moist in perforated polythene bags and open-weave sacks as cool as possible but not below 18°C (Tompsett and Kemp, 1996). Mechanical removal of wings enables easier handling and ensures contact of the seeds with the soil (FRI, 1980; Tompsett and Kemp, 1996; Sunil Kumar and Sudhakara, 1998).

H. parviflora seeds are classified as recalcitrant (Tompsett and Kemp, 1996). It is recommended to keep the seeds at harvest moisture content in media such as sawdust and perlite (Appanah and Turnbull, 1998). Seeds were successfully stored under low temperature (10°C) up to 40 days with out significant reduction in viability (Sunil Kumar and Sudhakara, 1998). Tompsett and Kemp (1996) reported that the seeds could be stored for 104 days with 84% viability at 18°C and 41% moisture content in sealed polythene bag which was ventilated weekly.

Insect infestation is a major problem with seeds. The scotylid, *Cocotrypes dactyliperda* Fabr. is reported to attack fruits and seeds of *Hopea* spp. Similarly the weevil, *Monophes dipterocarpi* (Marshall) feeds on the fruits and seeds of a related species, *Hopea acuminata* (Sen Sarma *et al.*, 1994).

Tree seed is vulnerable to attack by fungi, bacteria, actinomycetes, viruses and nematodes, with fungi the most important group of organisms causing loss of

viability. Due to the ambient tropical temperatures and humidity, which encourage the development and growth of pathogens, seeds of most tropical tree species are vulnerable to their attack. Microorganisms affect the developing fruit, invade the seeds and thus reduce the amount of healthy seeds. When the seed falls to the ground, they are subjected to further invasion by forest floor decay organisms. Seeds under storage are also affected by an array of storage fungi. Information on seed pathology of tropical tree species is meagre. Mohanan and Sharma (1991) collated the available information on seed health problems of tropical and temperate species in India, and no information is available on this aspect of *H. parviflora*.

Plant production

The seeds are viable for a short period and hence should be sown soon after collection. Freshly collected seeds are dibbled on raised shaded nursery beds. Overhead shade is necessary during initial stages. Seedlings come up well in open beds and polybags. Weeding and watering should be given judiciously. Planting can be done by wildings also. One or two year old nursery raised seedlings are usually used for planting and has given good results than direct sowing (FRI, 1980).

No information is available on vegetative propagation of the species.

2.1.2. *MELIA DUBIA* CAV.

Description of the tree

Melia dubia (Malabar neem wood) is a fairly large deciduous tree attaining a girth of 1.2-1.5 m and a height of about 20 m with a spreading crown and a cylindrical straight bole of about 9 m (FRI, 1981). A tree of girth of 4.25 m has also been observed inside KFRI campus at Peechi.

It is usually seen in deciduous hill forests in the Northern circars, Nallamalai hills and the Western Ghats from South Kanara southwards. It is a tree of the eastern Himalayas, ascending up to 1800 m above m.s.l in North Bengal and in the Khasi and Cachar hill tracts. It is also found in the Peninsula from the Ganjam hills southwards to Tirunelveli in the east and from the Konkan southwards in the west and also occurs in Sikkim and Bhutan.

The tree is leafless for a short time from December-February. The new leaves appear in February-March along with the flowers (FRI, 1981).

Flowering and fruiting

Flowers appear during January-February and the fruits ripen during October-February (FRI, 1981).

Seed technological aspect

The seeds of *M. dubia* are difficult to germinate because of the very hard endocarp. Results of earlier attempts to hasten germination were discouraging (FRI, 1981). Due to this reason *M. dubia* has not been used in reforestation programmes (Nasayao *et*

al., 1992). The separation of nuts from pulp in a Dybvig Seed Cleaner before storage and sowing is shown to be an efficient means of extraction. For the most effective use of this macerator it was recommended that a capacity of seven litre be used (Amata and Wasuwanich, 1986). Germination is hastened by splitting the seeds longitudinally with a sharp bill-hook before sowing. Burying the seeds in a pit in a nursery beds for about a year also had given encouraging results. It has also been found that soaking the seeds in cold water for a week is very effective in accelerating and improving germination; however a report of 50% germination within a period of 48 days (FRI, 1981) is really surprising and unbelievable. An investigation carried out under nursery conditions in Sri Lanka showed that fruit cleaning (removal of the pericarp after it had rotted) and a two-week soaking and drying process substantially increase germination capacity (Tilakaratna, 1991). It was also found that heating of seeds at 50°C in a drying oven for 24 hours, then soaking in cold water for 15 minutes gave better early germination than the seed with other treatment; seeds started germination 15 days after sowing. Although, not yet a total success, it produced some signal for indepth studies, in seed technology of *M. dubia* (Nasayao *et al.*, 1992).

Plant production

For raising seedlings in the nursery, the seeds after collection are pounded in a wooden mortar to remove the pulp. They are then spread out in the seedbed, covered with a 7.5cm layer of leaf litter and burnt. Immediately after the burn, the seeds are covered with a 7.5-10 cm layer of earth and watered copiously (FRI, 1981).

Entire planting and stump planting of both nursery raised and natural seedlings are used for stand establishment (FRI, 1981).

No information is available on vegetative propagation of the species.

2.1.3. *TERMINALIA CRENULATA* HEYNE EX ROTH

Description of the tree

Terminalia crenulata (Laural) is a large, deciduous tree with a long clear bole, spreading crown with characteristic thick, dark grey coloured bark with deep longitudinal fissures exfoliates in rectangular flakes. Twigs, leaves, inflorescence, hypanthium and fruits are glabrescent (Bahadur and Gaur, 1980). Some are of opinion that both *T. tomentosa* and *T. crenulata* are the same species. However, these two species differ from each other morphologically and in their distribution pattern. While *T. crenulata* is widely distributed in South-West India, especially in the Eastern Ghats and in Central India. The laurel wood, which is exported from India comes from *T. crenulata* only (Bahadur and Gaur, 1980). However, it can not be distinguished from the former on the basis of their wood structure and silvicultural characters and most of the references on *T. tomentosa* probably include *T. crenulata* also. Separate treatise on *T. crenulata* is limited to a few publications on seed characteristics, germination, etc. The *T. crenulata* timber is strong, hard and heavy and is widely used for buildings, beams, furniture, tool handles, water wheels and underwater constructions. Pollarded trees are used in tassar silkworm culture (CABI, 1998). In favourable localities, it attains a girth of 4.2 m and a height of over 30-36 m. It is distributed in Eastern, Central, Southern and Western India and also in Myanmar. But mostly found in West coast of India extending to South India. It occurs in the tropical semi-evergreen forests, moist and dry tropical forests and montane sub-tropical forests. The tree sheds

their leaves during January or February and by March or April and in dry places as early as February, though the dead leaves sometimes hang on the trees for some time. The new foliage begins to appear in April-May (FRI, 1984).

Flowering and fruiting

The flowers of *T. tomentosa* appear in June to August in Northern India. *T. crenulata* flowers soon after new flushing during May-June in Southern part of India and in Assam. Mature ripe fruits are available from March-May (FRI, 1984).

Seed technological aspect

Seed is usually abundant in most years. However, good seed years occur at varying intervals. The best time for seed collection is just after the tree becomes leafless, generally during April-May. The seeds can be easily collected from clean ground. In West Bengal, the seeds are usually collected from the trees by lopping off the branches. The fruits are dried in the sun for 3 or 4 days and stored in gunny bags in a dry well-ventilated shed up to May-June (FRI, 1984). Fruits can be stored for one year but it results in low germination percent (Dent, 1948). The seeds do not require any special treatment before sowing. Untreated seeds give up to 64% germination (FRI, 1984). It has also been reported that soaking in water as well as slight crushing of the seeds before sowing increases the germination percent (Howard, 1937; FRI, 1984). The ovaries soon after fertilization are often attacked by a *Cynips* resulting gall formation which are very much look like fruits (FRI, 1984). So far, no information is available on seed health problems of *T. crenulata*. However, Tiwari and Sharma

(1981) recorded few spermoplane microbes on *T. myriocarpa*.

Plant production

For raising the seedlings in nursery, seeds are dibbled 7.5 cm x 7.5 cm apart in shaded beds soon after collection with the top end (that attached to the twig) downwards. It was believed that sowing the seed with half of it exposed is beneficial. Germination takes place in two weeks. The beds are regularly watered and weeded, the seedlings ready for transplanting early in the rainy season.

The fruits are also sown on a layer of leaves and grass, in order to raise them above the ground and prevent damage from rotting. The seed germinates readily after a good fall of rain and the seedlings are easy to lift with out damage to the root. To obtain good and quick germination, seeds are heaped together and watered daily. When the seeds begin to sprout, they are removed and sown. The beds should not be shaded till germination begins and then should be shaded immediately. Casualities in the nursery sometimes occur due to damping-off disease. Application of a strong solution of potassium permanganate or other fungicide gives a lower percentage of mortality (FRI, 1984).

Vegetative propagation using branch cuttings of the tree was found unsuccessful (FRI, 1984).

2.1.4. *TERMINALIA PANICULATA* ROTH

Description of the tree

Terminalia paniculata is a very large deciduous tree usually attaining a height of 24-27 m and a girth of 1.8-2.1 m with a bole of 10.5 m. In favourable localities, it reaches up to 30-36 m in height and 3-3.6 m in girth, with a clear bole of up to 15 m. It occurs in the Western Ghats from Kolaba (Maharashtra) extending southwards through North and South Kanara to Malabar, Coorg and Travancore (Kerala). It also occurs in the areas of the Eastern Ghats as a smaller tree in Western Andhra Pradesh, Tamil Nadu and Karnataka. Most frequently it occurs in Valleys and on lower slopes, preferring fairly moist situations, from 1050 m to 1200 m sea level.

Leaves are usually shed in the hot weather. But the tree is hardly ever quite leafless. The tree is in minimum foliage in February-March (FRI, 1984).

Flowering and fruiting

The season of flowering varies with locality. There seems to be one pre-monsoon and one late monsoon flowering season, the latter may extend up to December. Usually, these extend from April to May and from August to September. It also covers different periods from July to December. The small white flowers appear in bushy pubescent panicled spikes. The fruits ripen from December-May (FRI, 1984).

Seed technological aspect

The seeds are largely infertile and thus germinative capacity is very low. Seed infertility is partly attributed to a weevil *Nanophyes terminaliae*, which attacks the

flowers and young fruits (FRI, 1984). Insect pollination is regarded as important in *Terminalia* (Srivastava, 1993).

No pre-sowing treatment is necessary for germination. Untreated seed germinates well and soaking the seed in boiling water is definitely harmful. The seeds were better stored in gunny bags.than in sealed tins, for about five months (FRI, 1984).

Plant production

Direct sowing is not satisfactory usually on account of the high percentage of infertility in the seed. Only the best method of raising the species is stump planting. Because of high infertility, for raising seedlings in nursery beds, the seeds may be sown thickly (FRI, 1984).

Vegetative propagation trials using branch cuttings were not successful (FRI, 1984).

2.1.5. *SWIETENIA MACROPHYLLA* KING

Description of the tree

Swietenia macrophylla (American mahogany) is a large evergreen (but in many places in Kerala it is deciduous for about a week), exotic tree with an umbrella shaped crown frequently reaching heights of over 30 m and diameters of over 1.5 m. The bole is cylindrical and is often buttressed. Mahogany timber is highly prized for its colour and workability (FRI, 1981; Mayhew and Newton, 1998). It was introduced from Honduras into India in 1872. It thrives well in many parts of India, including West Bengal, Bihar, Orissa, Maharashtra, Kerala, Karnataka, and Tamil Nadu. It was

planted chiefly in southern India at low elevations, usually in the moist deciduous forest in areas with a rainfall of 1500-5000 mm (FRI, 1981). The wood is used for construction work, boat building, musical instruments, models and pattern making (CABI, 1998). In Kerala, *S. macrophylla* is distributed abundantly throughout the State.

Flowering and fruiting

The tree usually flowers just after new flushing. The fruits mature in 10-11 months (Mayhew and Newton, 1998). Under favourable conditions, it starts producing seeds after 9-12 years of growth (Pukittayakame *et al.*, 1995; CABI, 1998). Mature fruits are generally available during February-April, in India (FRI, 1981).

Seed technological aspect

Seed productivity of mahogany fluctuates considerably from year to year. The reasons for such fluctuations are not clearly understood, but may reflect variation in flowering phenology, or failure of pollination or fertilization (Mayhew and Newton, 1998).

Plant production

Seedlings can be produced easily from seeds. Seeds should be sown horizontally. Seeds are sown at 5 x 10 cm in nursery beds and seedlings transplanted to polythene bags when they are 15 cm height. Seeds can also be sown directly into pots, with one seed per pot. It may be necessary to sow more than one seed per pot if the germination percentage is low. Seeds are also sown in trays to a depth of 2 cm. Seedlings are ready

for pricking out when the first seed leaves appear. In general, the seed should still be attached to the shoot at the time of pricking out (Mayhew and Newton, 1998; CABI, 1998).

Vegetative propagation using leafy cuttings of sizes between 6.5 cm and 7.5 cm has given better survival rates when IBA was applied, although the cuttings took 11 weeks to root. Micropropagation is also successful (Mayhew and Newton, 1998).

2.1.6. *SWIETENIA MAHAGONI* (L.) JACQ.

Note: This species was not included in the project. As it has close resemblance with S. macrophylla, it was also studied in less detail.

Description of the tree

Swietenia mahagoni (Cuban mahogany) is a medium to large evergreen tree attaining a height of 30 m and a girth of 4.5 cm. But in India, it is entirely deciduous or semi-deciduous tree. It is restricted to the West Indian Islands of Cuba, Jamaica, Haiti, San Domingo, the Bahamas and the Florida Keys, growing mostly in valleys at lower elevations. It was introduced into India in 1795. In India, it is planted in West Bengal, Bihar, Orissa, Uttar Pradesh, Maharashtra, Andamans, Tamil Nadu, Karnataka and in Kerala. It is slower growing than *S. macrophylla* (FRI, 1981).

The tree sheds its leaves in February and produces new leaves in March-April. The wood is hard, reddish-brown and is used for furniture, shipbuilding, interior decoration, etc. (FRI, 1981).

Flowering and fruiting

S. mahagoni produces flowers during April-May, soon after leaf flushing. The fruits ripen during October-December (FRI, 1981).

Seed technological aspect

S. mahagoni generally produces seed, at the age of 30-40 years. Natural reproduction of the species has not been observed in India for want of sufficiently large stands. Usually, the seeds are collected in October-November. Under natural conditions, the seeds are viable for about 3 months (FRI, 1981).

Plant production

The plants are usually raised in baskets and planted out when about 30 cm high. Potted plants may be held over in the nursery for an extra year or more without any adverse effect on the subsequent planting. Older stock may actually give slightly better growth. Seedlings and saplings are damaged by insects, animals like, deer, pigs and monkeys (FRI, 1981).

Vegetative propagation using leafy stem cuttings (Howard *et al.*, 1988) and micropropagation (Venketeswaran *et al.*, 1988) has been successful.

2.2. SPECIES STUDIED FOR PATHOLOGICAL INVESTIGATIONS

2.2.1. *LAGERSTROEMIA MICROCARPA*

Description of the tree:

Lagerstroemia microcarpa commonly known as 'Benteak' is a moderate to large sized deciduous tree attaining a height of up to 30 m and a girth of 2.4 m to 3 m with a clean, cylindrical bole of 12-15 m. It is common in mixed moist deciduous forests along the west coast of the Indian Subcontinent up to an altitude of 1200 m (CABI, 1998). In the Western Ghats, it occurs in moist deciduous and semi-evergreen forests up to 900 m from the Dangs in Gujarat Southwards to Travancore in Kerala, ascending the hill ranges of Karnataka and Tamil Nadu in moist mixed deciduous forests. It is easily distinguishable from its associates in the forest by the peculiar colour and smoothness of its bark. The tree is leafless for a time in the hot season. Wood is used for all purposes. Some insects and few fungi have been recorded on tree (FRI, 1984). The leaves are used as a green manure in areca nut plantations (CABI, 1998).

Flowering and fruiting:

The small, white flowers appear from April to June and the fruits ripen in the cold season. The small, light seeds fall early in the hot season and germinate at the beginning of the rains; they are carried by the winds to some distance from the tree (FRI, 1984).

Seed technological aspects

The ripe capsules are collected from the tree before they dehisce and are dried in the sun, with a cloth spread over them to prevent the tiny, winged seeds from being blown away by wind. The seeds are separated cleaned and stored in gunny bags in well-ventilated sheds (FRI, 1984). About 2,00,000 – 2,70,000 seeds weigh a kilogram (CABI, 1998). Seeds stored in gunny bags keep well up to six months. Seeds smeared with wood-ash and stored keep up to three months (FRI, 1984). Seeds storage behaviour is orthodox (CABI, 1998). Pre-treatment of seed is not necessary, as untreated seed gives higher germination percentage than seed treated with cold, hot or boiling water (FRI, 1984).

2.2.2. *PONGAMIA PINNATA*

Description of the tree:

Pongamia pinnata is a moderate sized, almost an evergreen tree in the moister localities but deciduous in the drier localities for a short period between March-May. It attains a height of up to 18 m and a girth of up to 1.5 m. It is common throughout the greater parts of India in the plains and chiefly along the streams and rivers. It also grows wild in the tidal and beach forests of Sunderbans and along stream banks as well as in the dunes along the seashore. It is considered to be a native of the Western Ghats, ascending up to 1200 m. It is also cultivated commonly along canal banks, roadside avenues and bunds (FRI, 1983; Luna, 1996). Wood is not of good quality and is used mostly as fuel. The seeds, leaves and roots yield oil of medicinal value. The fruits are edible (CABI, 1998).

Flowering and fruiting:

The tree starts bearing flowers and pods at the age of 4-7 years. Flowering takes place from April-July. The pods ripen from February-May in the following year (FRI, 1983).

Seed technological aspects

The ripe pods are collected from the trees from April to June. The seed ripening differs in different localities from February to March according to climatic conditions (Luna, 1996). Pods are generally one seeded (Luna, 1996), however, two seeds per pod were recorded. Pods are dried in the sun, thrashed by mallets to separate out the seed and dried in shade before storage (Luna, 1996). Seeds are easily extracted from the pods by light hammering or pressing a knife along the sutures (FRI, 1983). The production of seed per tree may vary considerably from 9 kg to 90 kg. The seeds do not store well due to its high oil content (Luna, 1996), however, they retain their viability atleast for a year if carefully stored (Dent, 1948). Dry fruits weigh 460-530 and seeds 810-1480 per kg. Germination percentage varies from 60 to 89 and one kg of seeds may be expected to yield about 1000 plants in the nursery. Pre-treatment is generally not required. Insects, particularly belongs to the order Coleoptera attacks the seed and the flower (FRI, 1983).

2.2.3. *GREWIA TILIAEFOLIA*

Description of the tree:

Grewia tiliaefolia is a moderate sized to large deciduous tree reaching up to 12 m height and 1-1.5 m girth. In favourable localities, as in the Western Ghats, it attains 24

m height and 2 m girth. It is distributed in the semi-evergreen, moist and dry deciduous forests of India up to 1200 m elevation. It sheds its leaves from March-May and the new leaves appear in April-May (FRI, 1981). The wood is heavy, strong and elastic, and is used for many construction purposes; it is also used for furniture, as the grain is often decorative. The bark and wood have medicinal uses; the bark also yields a cordage fibre. It has potential as a multipurpose tree in agroforestry systems. The fruit is edible and has an acidic flavour (CABI, 1998).

Flowering and fruiting:

It flowers from February to August and fruits from May to October, with a slight variation depending on the locality (FRI, 1981).

Seed technological aspects:

Seeds ripen at the end of rains and they do not retain viability for long, but can be stored atleast for 4 months under natural conditions (FRI, 1981). Seed storage behaviour is intermediate (CABI, 1998). Pre-sowing treatment is not necessary, since untreated seeds have given better germination than those treated in cold, hot or boiling water (FRI, 1981).

2.2.4. *TERMINALIA BELLIRICA*

Description of the tree:

Terminalia bellirica commonly known as 'belleric myrobalan' is a large, handsome deciduous tree with a straight tall bole and buttressed at the base attaining a height up to 50 m (CABI, 1998) and 3 m girth (FRI, 1984). It is widely distributed throughout

India except in the arid regions (FRI, 1984). In the Western Ghats, it is common in the moist deciduous and semi-evergreen forests up to 900 m elevation (Balasubramanyan *et al.*, 1985). In Northern India, the leaves fall from November to January depending upon the locality, the leaf falling early in the dry areas and vice versa. The new foliage appears from April-May. In South India, leaf fall commences from December till March (FRI, 1984). The timber is not durable in exposed situations, but it does have good strength properties and can be used for house construction after appropriate treatment. The fruits are a source of tanstuffs and dyestuffs. The kernels of the fruit can be eaten, although they can have a narcotic effect. The fruits are used medicinally in India (CABI, 1998).

Flowering and fruiting:

The scented flowers appear from April to June. The fruits ripen from November-February; they hang on the tree for sometime and fall down during the cold and hot seasons. The fruits are generally devoured by animals and are never allowed to lie on the ground. Immature fruits are damaged by insects (FRI, 1984).

Seed technological aspects:

Freshly fallen fruits are collected from the ground. The pulp is removed and the seed dried in the sun before storage. The seeds retain viability for one year (Dent. 1948). Seeds are recalcitrant (CABI, 1998). Fresh fruits weigh 66 per kg. The depulped seeds after drying weigh 440 per kg. The germinative capacity is from 54 to 69% (FRI, 1984).

2.2.5. *XYLIA XYLOCARPA*

Description of the tree:

Xylia xylocarpa, commonly known as Irul is a medium to large sized deciduous tree attaining 30 m height and 2.7 m girth with a clear bole of 9 m. It occurs gregariously throughout the deciduous and semi-evergreen forests of the Western Ghats up to 600 m elevation (FRI, 1983). The wood is hard and strong, often used in construction work. Even though difficult to work with because of hardness, the durability of the wood makes it preferable as a construction timber. The potential as a plantation crop and its ability to atmospheric nitrogen deserves more research attention (CABI, 1998).

Flowering and fruiting:

The leaves fall in February and the new leaves appear in March or April, the flowers appearing at the same time (FRI, 1983). Flowering sometimes continues up to May (CABI, 1998). Thick flat pods ripen during December and remain on the tree till the hot season. The seed falls in March-April.The pods dehisce on the tree, the hard woody valves bursting open elastically, and curving backwards to eject the seeds (FRI, 1983; CABI, 1998).

Seed technological aspects:

The ripe pods are collected from the tree as soon as they begin to dehisce in March-April (FRI, 1983; CABI, 1998). The seeds are also gathered from the ground soon after they fall. The pods are then spread out in the sun in cloth bags to open and the seeds are collected, dried and stored in a dry place. The seeds may keep well for atleast one year (Dent, 1948) and however, studies conducted in Tamil Nadu indicate

that the seeds are good only up to 3 months (CABI, 1998), either in gunny bags or airtight tins. About 3200-4000 seeds weigh per kg. The germination percentage is 31-95. Seeds are eaten by weevils, squirrels, monkeys and wild boars (FRI, 1983) and even by man also. Seeds presoaked in cold water germinate in 4-11 days giving 70% to 90% germination (CABI, 1998).

2.2.6. *PTEROCARPUS MARSUPIUM*

Description of the tree:

Pterocarpus marsupium is a tall deciduous tree attaining a height of 30 m and 5 m girth. It is found scattered in the moist and dry deciduous forests of India (FRI, 1983). In the Western Ghats, it occurs in moist, dry deciduous and semi-evergreen forests up to 1300 m elevation (Balasubramanyan *et al.*, 1985). The tree is nearly evergreen, being leafless only for a very short time in the hot season in April-May. The new leaves appearing in May-June (FRI, 1983). Wood is used for furniture making, cabinet works, joinery, carving, flooring, plywood and boat building. Oils and gums are also extracted. The resinous exudates from the stem, the bark, leaf juice and the gum all have medicinal properties. It is also used to obtain bark products, fodder and green manure, and is suitable for use in agroforestry and revegatation. It is often grown as an ornamental, or for shade and amenity purposes (CABI, 1998).

Flowering and fruiting:

The fragrant yellow flowers appear among the young light green foliage from May to August, sometimes later, even up to October. Sometimes flowering is noticed at other

times of the year also. The pods ripen from December-March. The pods are light yellow brown and usually one seeded. Seeds are attacked by insects (FRI, 1983).

Seed technological aspects:

Good seed years are produced at intervals of 2-3 years. The ripe pods are collected in February-May by beating of the trees or from the ground. The pods weigh 1620 per kg. Seed extraction from pods is difficult due to hardness of pods therefore they are used as such. However, clean extracted seed gives quicker and better results. Properly dried pods store well for 9-12 months (FRI, 1983). Seed storage is orthodox (CABI, 1998). The germination percentage is 75-80%. Germination takes place in 2-4 weeks or even longer owing to the hardness of the pods. Experiments have shown that germination can be hastened to some extent by any one of the following methods. (i) Cutting across and soaking the ends of pods in water for a few days prior to sowing. (ii) By placing alternate layers of pods and dead leaves in a pit, flooding it with water till germination starts and then sowing pre-germinated pods in the nursery. (iii) Soaking the pods in slurry of cowdung or in camphor water or plain cold water for various periods of time before sowing. (iv) The seeds tied up in a cloth or gunny bag and soaked in water 24 hrs, the excess water allowed to drain off. After 2-3 days, the germinating seeds are taken out and used for sowing. (v) Soaking the clean seeds after extraction prior to sowing reduces the germination period to a few days. Experiments inTamil Nadu, however, have shown that untreated seed gives the highest percentage of germination (Luna, 1996).

2.2.7. *CASSIA FISTULA*

Description of the tree:

Indian laburnum, *Cassia fistula* is a medium-sized to large deciduous tree attaining 8-12 m height and 48-75 cm in diameter. It is one of the most wide spread forest trees in India, usually occurring in deciduous forest through out and ascending to 1220 m. It is not gregarious but is scattered in mixed deciduous forests. It is often cultivated in gardens for its beautiful flowers (FRI, 1983). It can also be planted for restoration of degraded lands. Since it is not palatable to domesticatedanimals, it may be suitable for reforestation of areas, which have become overgrazed. Wood is heavy and durable. Wood is used for wheels and shafts of carts, turnery, tool handles, ploughs, harrows and rollers, house building posts, rice pounders etc. Flowers and seeds have been reported to have fungicidal and pesticidal properties, respectively. The roots, bark, seeds and leaves are used in traditional medicine (CABI, 1998).

Flowering and fruiting:

The bright yellow flowers appear in long pendulous racemes with new leaves chiefly from April-July. However, flowering was noticed in September-October particularly in dry years. The long cylindrical pods develop rapidly, ripen during December and continue to March-April. The ripe pods hang from the tree and fall during April-May and continuing to fall in the following months. More over, old pods may often be found on the trees in September or later along with the new half-grown green pods (FRI, 1983).

Seed technological aspects

Ripe pods are collected off the trees in March-April and the seeds separated from the soft pulp and washed with cold water, before drying for storage. The damaged seeds should be removed carefully. The seeds are highly impermeable to water and may be stored for many years with no loss of viability. Seeds stored in gunny bags for 13 years gave 30 % germination (Dent, 1948) while seeds kept in stoppered bottle for 31 years gave 30% germination. Seeds are best stored in gunny bags in a cool dry place. Stored seeds germinate quickly than fresh seeds. Seeds are prone to insect attack. About 6000 to 7090 seeds weigh a kilogram (FRI, 1983). Seed storage behaviour is orthodox (CABI, 1998).

Untreated seeds are difficult to germinate. Therfore, pre-sowing treatment is necessary. Soaking the seeds in boiling water for 5 minutes is reported to give 75% germination, but some workers report that untrteated seeds give better germination than those treated with cold, hot or boiling water. Soaking of seed in concentrated sulphuric acid gave 35% germination as against 14% for untreated seeds (FRI, 1983).

2.2.8. *WRIGHTIA TINCTORIA*

Description of the tree:

Wrightia tinctoria is a small to medium-sized, deciduous tree with a short, irregularly shaped trunk. It may attain up to 18 m height (CABI, 1998) and rarely more than one metre in girth. It is found in the deciduous forests through out the Peninsular India (FRI, 1985). In the Western Ghats, it occurs in the moist and dry deciduous forests up to 1200 m elevation (Balasubramanyan *et al.*, 1985). The leaves fall during the cold

season and the new leaves appear in March and early April. The tree is affected by many fungal diseases and pests (FRI, 1985). It is suitable for arid, semi-arid and moist regions with a wide range of soil types, and especially dry sandy sites or hillsides. It is valued for its indigo-like dye, which is extracted from the leaves, flowers, fruits and roots. The timber is high in quality; used for carving, turnery and toy making. The bark and leaves have medicinal properties, and used to treat psoriasis, stomach pains, toothache and dysentery. The flowers, leaves, fruits and seeds may be eaten as vegetables (CABI, 1998).

Flowering and fruiting:

The flowers also appear during March-April and continue until June. The fruits ripen in January-February (FRI, 1985).

Seed technological aspects

The fruit consists of pair of slender follicles cohering at the tips only. They remain viable up to about six months. Soaking in cold water before sowing is apparently beneficial. The seeds weigh 28,700 per kg. The germinative capacity is 42 per cent and plant percent 26 (FRI, 1985).

2.2.9. *HOLOPTELEA INTEGRIFOLIA*

Description of the tree:

Holoptelea integrifolia is a large deciduous tree attaining 30 m height (Balasubramanyan *et al.*, 1985) and 1.4 m girth. It is found in semi-arid and semi-moist areas of the Indian Subcontinent (CABI, 1998). In the Western Ghats, it occurs

in the moist deciduous and semi-evergreen forests at low elevations (Balasubramanyan *et al.*, 1985). It is an important fodder tree and is a good species for afforestation of brackish or rocky areas, gullies and ravines. Wood is used for agricultural implements, handles, interior carpentry and furniture. Seeds yield edible oil, which is also used for illumination. It also supplies medicinal products and fish poisons (obtained from bark) (CABI, 1998).

Flowering and fruiting:

The tree flowers during January to February (Kumar and Bhanja, 1992) and mature seeds are available during April-May (Sen Gupta, 1937).

Seed technological aspects

Seeds are winged. Seeds are pucked off the felled branches, cleaned and dried in the sun. Seeds do not retain viability more than 7 to 8 months (Kumar and Bhanja, 1992). Seed storage behaviour is intermediate (CABI, 1998). Pre-sowing treatment is not necessary (Kumar and Bhanja, 1992).

3. MATERIALS AND METHODS

Seed trees of the six species viz., *Hopea parviflora, Melia dubia. Terminalia crenulata. T. paniculata*, *Swietenia macrophylla* and *S. mahagoni* were identified in three seed zones of Kerala, following the zonal classification mentioned in Ram Prasad and Kandya (1992). Phenological observations were recorded periodically on a specially designed proforma. Seeds were collected and transported to the laboratory where trials were conducted on processing, storage and pre-sowing treatments with the objective of improving seed handling practices for better seed quality. Seed pathological studies were conducted for 15 species including the six species, which were taken up for detailed studies. Seedlings were raised in root trainers of three capacities and polythene bag, and their growth was compared in the nursery. Trials were also conducted on vegetative propagation of branch cuttings of the six species using root hormones Indole Acetic Acid (IAA) and Indole Butyric Acid (IBA). Details of methodology for each species are provided under.

Location of seed bearing trees and seed collection

Seed bearing trees were identified for all the six species (Table 1) in the three zones suggested in Ram Prasad and Kandya (1992).

Table 1. Seed trees selected for phenological observations and seed collection of *Hopea parviflora, Melia dubia, Terminalia crenulata, T. paniculata, Swietenia macrophylla* and *S. mahagoni* in Kerala

Species	Seed zone	Locality	Type of stands
Hopea parviflora	KL-I	Thiruvananthapuram museum campus	Avenue tree
	KL-I	Arippa	Plantation
	KL-I	Between Kulathupuzha and Thiruvananthapuram	Natural along river side
	KL-I	Kallely	Natural along river side
	KL-I	Kalaketty and Erumely	Natural forest
	KL-I	Aryenkavu	Natural along river side and road side tree
	KL-II	Champakkad in Chinnar	Natural along river side
	KL-II	Vazhachal and Sholayar	Natural forest
	KL-II	Iringole sacred grove	Natural forest
	KL-II	Thrissur museum campus	Planted avenue tree
	KL-II	Vellanipacha (Pattikkad Range)	Natural forest
	KL-III	KFRI Sub-centre campus, Karimpuzha	Plantation
	KL-III	Karulai and Nedungayam, in Nilambur	Natural along river side
	KL-III	Between Mannarkkad and Mukkali	Natural along river side
	KL-III	Dhoni	Natural forest
	KL-III	Parappa (Kasaragod)	Natural forest as well as plantation
Melia dubia	KL-I	Vallampetty, in Aryankavu	Road side trees
	KL-I	Between Kallada Dam and Kulathupuzha	Natural forest
	KL-I	Edappalayam	Road side tree
	KL-I	Naduvathumuzhy	Natural forest
	KL-II	Chinnar	Natural forest
	KL-II	Churulipetty, Alampetty and Karimutty in Chinnar	Natural forest
	KL-II	KFRI main campus, Peechi	Natural forest
	KL-II	Peechi	Natural forest
	KL-III	Sholayoor in Palakkad District	Natural forest
	KL-III	Dhoni	Natural forest
	KL-III	Thunakadavu in Parambikulam	Natural forest
	KL-III	Karmanthody in Kasaragod	Road side tree
	KL-III	Kozhichena in Kozhikode	Road side tree

	KL-III	Between Mananthavady and Panamaram	Road side and avenue trees
	KL-III	KFRI Sub-centre campus, Chandakkunnu	Planted in natural forest
Terminalia crenulata	KL-I	Punalur	Road side tree
	KL-I	Erumely and Kalaketty	Natural forest
	KL-I	Thenmala	Natural forest
	KL-II	Between Angamaly and Perumbavoor	Road side tree
	KL-II	Peechi	Natural forest
	KL-II	KFRI main campus	Natural forest
	KL-II	Vellanipacha (Pattikkad Range)	Natural forest
	KL-III	Dhoni	Natural forest
	KL-III	Thunakadavu, in Parambikulam	Natural forest
	KL-III	Walayar	Natural forest and road side tree
	KL-III	Nilambur; KFRI Subcentre	Natural forest; plantation and road side tree
	KL-III	Between Mananthavady and Panamaram	Natural forest; road side tree
	KL-III	Nellithattu (Kasaragod)	Natural forest
	KL-III	Kuruva island (Wayanad)	Natural forest; road side tree
	KL-III	Parappa (Kasaragod)	Natural forest; road side tree
Terminalia paniculata	KL-I	Punalur	Road side tree and natural forest
	KL-I	The rehabilitation plantations, Kulathupuzha estate	Natural forest (mixed with rubber trees)
	KL-I	Thenmala	Natural forest
	KL-I	Erumely; Kalaketty	Natural forest
	KL-II	Between Muvattupuzha and Koothattukulam	Road side tree
	KL-II	Peechi	Natural forest
	KL-II	KFRI main campus	Natural forest
	KL-II	Vellanipacha (Pattikkad Range)	Natural forest
	KL-III	Nelliampathy	Natural forest
	KL-III	Between Kuzhalmantham and Meenakshipuram	Road side tree
	KL-III	Nemmara	Road side tree
	KL-III	Thunakadavu, in Parambikulam	Natural forest
	KL-III	Dhoni	Natural forest
	KL-III	Nilambur	Natural forest

	KL-III	KFRI Sub-centre, Chandakkunnu	Natural forest
	KL-III	Kalpetta (Wayanad)	Natural forest and road side tree
	KL-III	Nellithattu (Kasaragod)	Natural forest
	KL-III	Kuruva (Wayanad)	Natural forest
Swietenia macrophylla	KL-I	Punalur	Road side trees
	KL-I	Thenmala	Road side trees
	KL-I	Edappalayam	Road side as well as plantation
	KL-I	Aryenkavu	Plantations
	KL-I	Arippa	Plantation
	KL-I	Naduvathumuzhy	Plantation (1943)
	KL-I	Ambalapuzha and Alappuzha	Road side tree
	KL-I	Pattom, in Thiruvananthapuram	Avenue trees
	KL-I	Thiruvananthapuram, University Campus, Kariavattom	Avenue trees
	KL-I	Attingal	Avenue road side trees
	KL-II	Between Angamaly and Perumbavoor	Road side trees
	KL-II	Muvattupuzha	Avenue trees
	KL-II	Vazhoor	Avenue road side trees
	KL-II	Kozha	Avenue trees
	KL-II	Kuruvilankadu	Plantation
	KL-II	Between Neriamangalam and Adimaly	Plantation
	KL-II	Kodanad	Avenue, road side and plantation
	KL-II	Perunthode	Plantation
	KL-II	Changanacherry	Avenue trees
	KL-II	Ayyanthole in Thrissur	Avenue trees
	KL-II	Kannara	Road side trees
	KL-II	KFRI main campus Peechi	Road side avenue trees
	KL-III	Dhoni	Plantation
	KL-III	Nilambur	Road side avenue trees
	KL-III	Chaliyarmukku, Nellikuthu and Nedungayam in Nilambur	Road side trees and plantations
	KL-III	Bovikanam (Kasaragod)	Road side trees as well as plantation
	KL-III	Kozhikode	Road side trees
	KL-III	Nidumpoil in Kannore	Road side as well as plantation
	KL-III	Kalpetta; Manathavady	Avenue trees
	KL-III	Olavakkod, Forest Office campus	Avenue trees

Swietenia mahagoni	KL-I	Thiruvananthapuram	Avenue trees
	KL-II	Thrissur Medical College Hospital	Road side tree
	KL-III	Between Vaniyampara and Palakkad	Road side trees
	KL-III	Olavakkod Forest Office campus outside	Avenue trees
	KL-III	Chaliyarmukku in Nilambur	Plantation
	KL-III	Karulai in Nilambur	Planted tree but mixed with natural forest

Phenological observations of trees marked in different localities were recorded periodically through out Kerala for about two years in a proforma.

Mature fruits were collected from the trees either by lopping the branches or by manual shaking and also from the ground, and transported to the laboratory for further studies.

Seed characteristics

Seed characteristics such as seed dimensions, seed moisture and seed weight were recorded following standard methods.

Seed processing and pre-sowing treatments

Seed processing for different species was done by different methods. For *Hopea parviflora*, wings were removed for easy handling as suggested by Tompsett and Kemp (1996). In *Melia dubia*, the pulpy mesocarp was removed by beating the fruits with wooden piece and the germination was compared with mechanically extracted true seeds and longitudinally split seeds. Extraction of seeds of *S. macrophylla* was tried by three methods viz., drying under direct sunlight, in laboratory, and also in hot air oven at 50°C. After extraction, sound seeds were selected and the insect attacked unsound empty and decayed seeds were discarded. Both *S. macrophylla* and *S. mahagoni* were de-winged by

hand before germination and storage trials. Table 2 shows various pre-sowing treatments done for seeds of different species.

Table 2. Various pre-sowing treatments for different species are as under

Species	Pre-sowing treatments
Hopea parviflora	T1 Seeds with wings intact (Control) T2 Removal of wings
Melia dubia	T1 Control T2 Longitudinal splitting of the hard endocarp T3 True seeds extracted from the hard endocarp
Terminalia crenulata	T1 Seeds with wings intact (Control) T2 Removing the wings using scissors, followed by cold water soaking for 24 hrs
Swietenia macrophylla	T1 Seeds with wings intact (Control) T2 Removal of wings
S. mahagoni	T1 Seeds with wings intact (Control) T2 Removal of wings

Seed storage

Hopea parviflora: Initial moisture content of de-winged seeds was determined by drying samples in an oven for 17 hours at 105°C, using two replications of 20 seeds each, and moisture content was calculated on fresh weight basis. Sub-samples of 260 seeds each were kept in perforated plastic bags of 700 gauge, and stored under room temperature

(T1) and also at 18°C after treating with Bavistin (fungicide) (T2). Germination at weekly interval was recorded using seed samples under storage.

Melia dubia

After cleaning and drying, the seeds were stored in containers such as polythene bags (700 gauge), plastic woven bags, and gunny bags under room temperature (29 ± 2°C) and humidity (70% to 100%). The seeds were also stored in open trays.

Terminalia crenulata

After cleaning and drying, the seeds were stored in plastic woven bags under room temperature (29 ± 2°C) and humidity (70% to 100%). The seeds were also stored in open trays, and also over silica gel in a desiccator. The desired moisture content (DMC) was monitored by using the formula

$$\text{Weight of seed (g) at DMC\%} = \frac{(100 - \text{initial moisture content \%})}{(100 - \text{DMC\%})} * \text{Initial seed weight}$$

Swietenia macrophylla

Seeds collected from different trees were de-winged and bulked together, and used for the study. The initial moisture content was determined by drying them in an oven for 17 hours at 105°C, using two replications of 10 seeds each and expressed on fresh weight basis. Seeds were then air-dried in a ventilated room for 8 days. The seeds were divided in to 18 samples of 250 seeds each. They were sealed in 700 gauge plastic bags, and stored under two storage conditions. Nine bags were kept in each storage conditions, viz.,

T_1 Control (at 29 ± 2°C)

T_2 Refrigerator (at 0°C)

S. mahagoni

After cleaning and drying, the seeds were stored in polythene bags (700 gauge), under room temperature (29±2°C) and humidity (70% to 100%).

Seed testing

Germination test: Germination test was carried out using 200 seeds of *Hopea parviflora*, *Melia dubia*, and *Terminalia crenulata*; 400 seeds of *Swietenia macrophylla* and *S. mahagoni*; 1600 seeds of *T. paniculata*, distributed equally in four replicates in plastic trays containing vermiculite as germination medium, following simple random design.

Cutting test: Random samples of four replicates of 25 seeds each were taken from the same seed lot used for germination test and the test was carried out by cross cutting the seeds using a seed cutter. Colour of the cotyledon was taken as indicator of viability, and this was compared with germination percent to arrive a relation between cutting test and germination percent.

Tetrazolium test: The tetrazolium test was carried out only for *S. macrophylla*. Two samples of 50 seeds each were drawn, completely decoated and soaked in water for 24 hrs. The imbibed seeds were picked up and longitudinally split. They were then immersed in 0.1% tetrazolium salt solution and kept at room temperature in a dark room for 24 hrs. The seeds were then washed thoroughly in running tap water and examined for staining.

Hydrogen peroxide test: This test was done for *S. macrophylla* and *S. mahagoni*. Two samples of 50 seeds each were drawn and decoated partially at the radicle end. *S. macrophylla* seeds were then immersed in 0.35%, and *S. mahagoni* seeds in 1% hydrogen

peroxide solutions and kept at 25°C and 70% relative humidity in a seed germinator. Radicle emergence was recorded daily for 33 days.

Seed pests

Random samples were drawn from the seeds collected from various locations for observations on the nature and extent of damage by seed pests. The intensity of attack was determined based on the percentage of seeds affected in each lot. For this, the number of infested seeds in the sample as well as the number of insects per affected seed was recorded. Infestation above 50% was rated as heavy, 25-50% as moderate and up to 25% as mild.

Seed health test

Seeds of different forestry species were collected during 1997, 1998 and 1999 seeding seasons from different forest areas in Wayanad, Kannur, Kozhikkode, Nilambur, Thrissur, Olavakkode, Vazhachal, Chalakkudy and Malayattoor Forest Divisions. Seeds collected from individual trees were mixed together to make composite samples. Seeds collected from trees and forest floor were separately stored and transported to the laboratory. Moisture content (MC) of the seeds was determined by oven drying method. The seeds were air/sun-dried to reduce the moisture content at the level of 10 to 15%. Cleaned and de-winged (to reduce storage volume) seeds were stored in cloth bags at room temperature 25 $\pm$ 2°C.

Dry seed examination and seed characteristics

Seed sample (working sample) drawn from the composite sample of each species was examined under stereoscopic microscope (50x) to ascertain any discolouration and indications of fungal or insect infestation. The seeds were categorized into apparently

healthy, discoloured and deformed. The percentage of seeds belonging to each category was determined. Seed weight, seed length, width, number of seeds per pod or fruit, number of locules, emptiness, etc., were recorded. Extraction of seeds from fruits was also done for many species and observations on seed and fruit characteristics were recorded separately.

Standard Blotter test

The Standard Blotter method of seed health testing (ISTA 1976, 1985) was employed to determine the association of spermoplane microflora with the seeds. A working sample of 400 seeds of each species drawn from the composite sample was tested. Seeds were de-winged and placed at equal distance in sterile Plastic Petri plates (90 to 140 mm dia) lined with three moistened filter /germination paper discs (blotter). The number of seeds incubated per plate varied with the size of the seeds. The set ups were incubated 25 $\pm$ 2° C in a seed germinator adjusted with alternating cycles of fluorescent light and darkness (12 h each) for 14 days. Observations on the presence of microorganisms, germination of seeds and infection, if any, on young seedlings etc., were recorded using a stereobinocular microscope. Identification of microorganisms was attempted up to generic level or species level in certain cases. Percent incidence of each microorganism was calculated using the following formula

$$\% \text{ incidence} = \frac{\text{No. of seeds recorded with an organism}}{\text{Total number of seeds examined}} \times 100$$

Agar plate method

Seeds surface sterilized in 0.01% mercuric chloride were plated in potato dextrose agar medium in Petri-dish (90 or 120 mm dia) and incubated for 7 to 12 days. Observations on percent incidence of spermoplane microorganisms were made. Microorganisms developing from the seeds were isolated, purified and identified.

Growing- on test

To assess the effect of spermoplane microorganisms, some of which may also be seed-borne, on the germinability of seeds, a procedure of growing- on test was carried out. Steam sterilized perlite (at 1.0 kg cm^2 for two hours) was used as the sowing medium. Plastic trays (60 x 30 x 20) were filled with sterilized perlite and the seeds of respective tree species were sown, watered and maintained. Observations on germination, incidence of disease on emerging seedlings, etc., were recorded up to 30 to 45 days of emergence. The diseased parts from the seedlings were plated aseptically on potato dextrose agar medium and causal agent isolated and identified.

Seed pre-treatment

Pre-treatment of seeds using cold water, hot water, concentrated sulphuric acid, etc., were carried out for certain species to enhance the seed germinability. Pre-treated seeds were further tested by blotter and agar plate method.

Fungicidal seed dressing

Fungicides viz. Thiride (Hexathir), Captan (Hexacup) were evaluated for their efficacy as seed dressing chemicals. Cleaned, de-winged (in the case of winged seeds), seeds of each species were treated with fungicides @ 4 or 5 g/ 1kg of seeds in polythene bags (18 x 12

cm) and stored for 3 weeks. The treated seeds were tested employing blotter technique and percent seed infestation, seed germination, etc. were assessed.

Plant production

Using seeds: The seedlings were potted in root trainers of three capacities (90 cc, 145 cc and 310 cc), and polybags of 22.5 x 17.5 cm (1400 cc) using the potting mixture of soil: sand: compost in the volume ratio 3:1:1. The growth of seedlings was measured for 6 months. Parameters such as shoot height, shoot fresh weight, shoot dry weight, number of leaves, collar diameter, root length, root fresh weight, root dry weight, etc., were recorded.

Observations were also made on the nursery on seedlings on infestation by insect pests. The nature of damage, mode of feeding and the life history of insects damaging the seedlings were recorded. The damage intensity was established based on visual scoring as severe, moderate, and minor. Pests observed on the seedlings were collected for establishing their identity and bred in the laboratory.

Vegetative propagation: Vegetative propagation with mature branch cuttings and juvenile cuttings was attempted using the rooting hormones such as IAA and IBA at various concentrations ranging from 1000 ppm to 4000 ppm. For *T. paniculata* and *T. crenulata* juvenile cuttings (coppice shoots) of thickness ranging from 0.26 to 0.53 cm and length 9 to 10 cm were collected from fallen trees as well as coppice shoots. Mature cuttings of thickness 0.74 to 1 cm and 0.22 to 0.32 cm were used for *M. dubia* and *H. parviflora* respectively. Both the mature and juvenile cuttings were collected from one-year-old seedlings of thickness ranging from 0.45 to 0.73 cm. For *S. macrophylla.* cuttings of thickness 0.35 to 0.43 cm were used.

Pathological studies on miscellaneous tree species

Seeds of *Lagerstromia microcarpa*, *Pongamia pinnata*, *Grewia tiliifolia*, *Terminalia bellerica*, *Xylia xylocarpa*, *Pterocarpus marsupium*, *Cassia fistula*, *Wrightia tinctoria* and *Holoptelia integrifolia* were collected during 1997, 1998 and 1999 seeding seasons from different forest areas in Wayanad, Kannur, Kozhikode, Nilambur, Thrissur, Olavakkode, Vazhachal, Chalakkudy and Malayattoor Forest Divisions. Seeds collected from individual trees of a particular species were mixed together and composite samples made. Seeds collected from trees and forest floor were separately stored and transported to the laboratory. Moisture content (MC) of the seeds was determined by oven drying method. The seeds were sun or air-dried to reduce the moisture content at the level of 10 to 15%. Cleaned, de-winged (to reduce storage volume) seeds were stored in cloth bags at room temperature $25 \pm 2^{\circ}C$.

Seed health test was carried out as done for the six species chosen for detailed study. Pre-treatment of seeds using cold water, hot water, concentrated sulphuric acid, etc. were carried out for certain species to enhance the seed germinability. Pre-treated seeds were further tested by blotter and agar plate method.

Details of seed handling and nursery practices for 30 species were compiled in a user-friendly format using information generated through the study and also those gathered from literature.

4. RESULTS AND DISCUSSION

4.1. *Hopea parviflora*

Phenological observations

Flowering and fruit maturity seasons are summarised in Table 3.

Table 3. Season of flowering and fruit maturity in different localities

Seed Zone	Locality	Year	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
KL-I	Arippa	2000			*	*	* ✦	✦						
KL-I	Thiruvanantha puram	1999								*	*	✦	✦	
KL-I	Kallely (Konni)	1998			*	*	* ✦	✦						
KL-II	Chinnar	1999				*	*	* ✦	✦					
		2000	No flowering and fruiting											
KL-II	Vellanipacha	2000	*	*	* ✦	✦	✦							
KL-II	Iringole	2000	*	*	*	✦	✦	✦						
KL-II	Thrissur	2000	*	*	✦	✦								*
KL-III	Nilambur	1998		*	*	* ✦	✦	✦						
		1999	No flowering and fruiting											
		2000			*	*	* ✦	✦	✦					
KL-III	Parappa	1999	*	*	*	✦	✦							
		2000	*	*	*	✦	✦							

Note: * Flowering; ✦ Mature fruits

There is wide variation in flowering and fruiting of *H. parviflora* in Kerala. Mature fruits are generally available during April-June. On the other hand, in trees standing along stream banks of Chinnar, which is a semi arid region, flowering starts in April-May and fruit matures in June-July. Another variation was observed on a single tree in the compound of Thiruvananthapuram Museum, which flowered in August-September 1999 and had mature fruits during October-November. Flowering was totally absent in Nilambur during 1999 and in Chinnar during 2000. In Iringole kavu, in 2000, no mature seed was available due to immature seed fall.

Seed collection and processing: The seed fall is during rainy season and the seed collection from the tree is difficult. Wings of the immature seeds are light green and the seeds are bright green. On maturity the wing colour changes from green to yellow and finally to brown. Tamari (1976) also suggested the colour change of wings as an indication for seed collection of many dipterocarps.

Seed storage: The seeds with 40.24% moisture content and 90% germination, when stored under room temperature (29±2°C) for four weeks recorded 29.78% moisture content and 34 % germination, whereas seeds of the same seed lot when stored at 18°C recorded 41.9% mosture content and 56% germination during the same period. The seeds stored under room temperature started germinating within 7 days.

When seeds with an initial germination of 79.5% were stored in desiccator, the germination percentage initially increased to 89%, and then drastically dropped to 0% within three days.

Seed pre-treatment: De-winged seeds gave 89% germination as against 93% for seeds with wings, the difference being negligible.

Seed testing: As the seeds germinate quickly, seed testing can be easily done through germination test. However, the cutting test may also be performed for fresh seeds to evaluate the seed quality soon after collection. Viable seeds have dark green cotyledons whereas non-viable seeds are straw coloured and insect attacked. When cutting test revealed 69% viability, the same seed lot gave 67% germination, suggesting cutting test as reliable alternative to germination test.

Seed health test: *Hopea parviflora* seeds (Fig.1a) are harboured by a rich spermoplane microflora consisting of 19 fungi including Mycelia sterilia, bacteria and actinomycetes (Fig. 1b). *Penicillium* spp., and *Aspergillus* spp., were the important storage fungi and of the 67.25% seed infestation, *Penicillium* spp., recorded 54% incidence. Among the 10 species of field fungi recorded, *Fusarium* sp., occurred in high frequency (11%) followed by *Botryodiplodia theobromae* (8.50%). Surface sterilization reduced the percent incidence of the spermoplane fungi in general. However, *Cylindrocladium quinqueseptatum* was encountered in high frequency (14% incidence). By surface sterilization, incidence of *Fusarium* sp., could be reduced from 11% to 1.25%. However, incidence of bacteria was found slightly higher (3.25%) than in non-surface sterilized seeds (2.25%). Similar results were obtained in agar plate test also. *B. theobromae* occurred in high frequency (25.5%). Bacteria were found associated mostly with discoloured and rotten seeds (4.50%). Storage fungi including *Aspergillus* sp., and *Penicillium* spp., encountered in most of the seeds with severe incidence (92.5%) (Table 4). Percent seed germination in blotter test was 49.25% for non-surface sterilized seeds and 53% in surface sterilized seeds.

Fig. 1a. *Hopea parviflora* seeds with and without wings

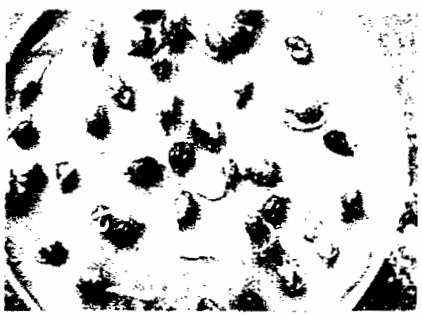


Fig. 1b. De-winged seeds in blotter test. Note the severe infestation with different fungi

Table 4. Spermoplane microflora detected on seeds of *Hopea parviflora* by blotter and agar methods and their per cent incidence

Sl. No.	Microorganisms	Blotter method % incidence		Agar method % incidence
		NSS	SS	
1	*Aspergillus* spp.	4.50	28.50	46.00
2	*A. niger*	0.75	12.25	24.50
3	*Beltrania rhombica*	-	1.75	-
4	*Beltraniella odinae*	3.75	1.75	9.00
5	*Botryodiplodia theobromae*	8.50	2.75	25.50
6	*Chaetomium* sp.	1.00	2.25	4.00
7	*Cladosporium* sp.	2.25	-	-
8	*Colletotrichum gloeosporioides*	0.75	-	5.00
9	*Cylindrocladium quinqueseptatum*	2.25	14.00	4.00
10	*Curvularia lunata.*	-	2.00	3.00
11	*Fusarium* sp.	11.00	1.25	3.50
12	*Myrothecium* sp.	-	0.25	-
13	*Paecilomyces sp.*	0.75	1.75	4.50
14	*Penicillium* spp.	54.00	28.50	22.00
15	*Pestalotiopsis* sp.	0.25	-	-
16	*Phoma* sp.	-	0.50	2.00
17	*Trichoderma* sp.	6.25	-	6.00
18	*T. viride*	-	2.25	-
19	Mycelia sterilia (black)	0.75	1	1.00
20	Bacteria	2.25	3.25	4.50
21	Actinomycetes	-	-	1.50

*NSS: non-surface sterilized; SS: surface sterilized

Plant production

Using seeds: Seedling growth in root trainers of 90, 145 and 310 cc as well as polythene containers of 1400 cc are presented in figures 2a, b c and 3.

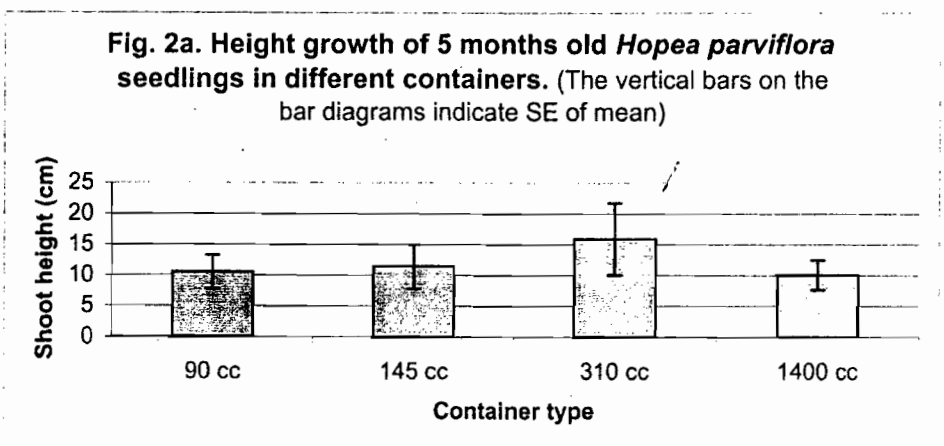


Fig. 2a. Height growth of 5 months old *Hopea parviflora* seedlings in different containers. (The vertical bars on the bar diagrams indicate SE of mean)

Fig. 2b. Shoot biomass of 5 months old *Hopea parviflora* seedlings in different containers (The vertical bars on the bar diagrams indicate SE of mean)

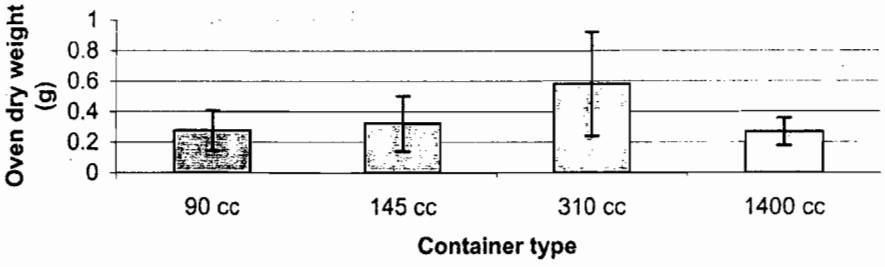
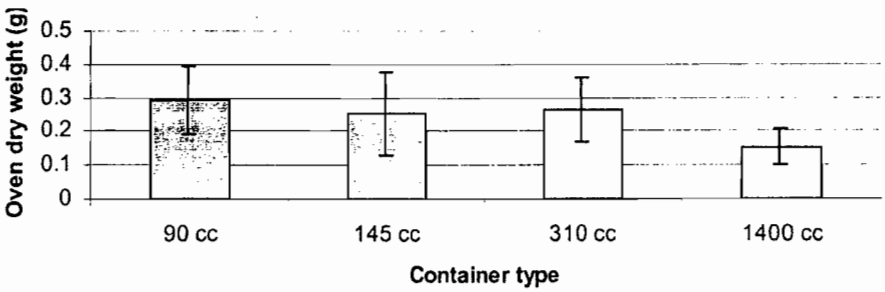


Fig. 2c. Root biomass of 5 months old *Hopea parviflora* seedlings in different containers



The potential of producing seedlings in root trainers is evident from the study. As compared to polybag seedlings the root trainer seedlings were much better. No insect pest has been recorded in the nursery. Leaf spot and foliage blight caused by *Colletotrichum gloeosporioides* and *Cylindrocladium quinqueseptatum* respectively in 1 to 3 months old seedlings were recorded.

Seedlings raised in sterilized perlite medium showed foliage infection caused by *Colletotrichum gloeosporioides* and *Cylindrocladium quinqueseptatum.*

Vegetative propagation: Of the two rooting hormones (IAA and IBA) used, the rooting and sprouting was best with IBA 1000 ppm (42.9%), followed by 2000 ppm

(28.6%) and 4000 ppm (14%) (Fig.4). Branch cuttings of 0.2-0.3 cm diameter (at thick end) and 9-10 cm length were used for propagation.

Fig. 3. Five months old seedlings of *H. parviflora* in 1400 cc (22.5 x 17.5 cm) polybag, 310 cc, 145 cc and 90 cc root trainers

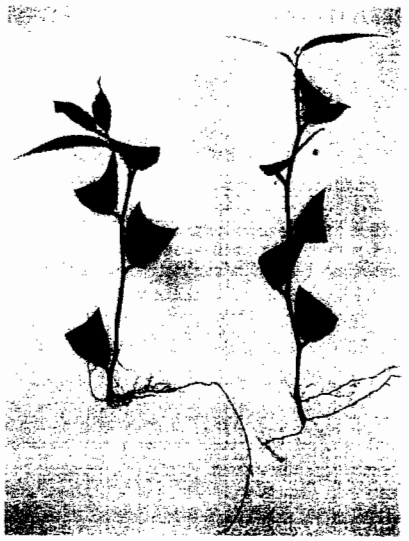


Fig. 4. Rooted branch cuttings of *H. parviflora*

4.2. *Melia dubia*

Phenological observations

Flowering and fruit maturity seasons are summarized in Table 5.

Table 5. Season of flowering and fruit maturity in different localities

Seed Zone	Locality	Year	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
KL-I	Kulathupuzha	1998	* ✦	*										✦
KL-II	Chinnar	1998					✦	✦						
		1999		✦	* ✦	* ✦								
KL-II	Peechi	1997											✦	✦
		1998	*	*									✦	✦
		1999	*	*									✦	✦
		2000	*	*									✦	✦
KL-III	Sholayoor	1999	✦	✦										
KL-III	Nilambur	2000	*	*									✦	✦

Note: * Flowering; ✦ Mature fruits availability

There is considerable variation in flowering and fruiting between moister (Kulathupuzha, Peechi, Sholayoor and Nilambur) and drier localities (Chinnar). The flowering period is for 2 months and it takes 9-10 months for flower to become mature fruits. Mature fruits are available in Chinnar during February-June and during November-January in other localities.

Seed characteristics

Seed measurements and mean number of sound seeds in a fruit is given in Table 6.

Table 6. Seed characteristics of *Melia dubia*

Sl. No.	Locality	Seed zone	Date of collection	No. of fruits observed	Mean fruit measurements		Mean no. of locules per fruit	Mean no. of sound seeds per fruit
					Diameter (cm)	Length (cm)		
1	Koorkapara	KL-II	31/12/97	80	2.9 (±0.114)	2.33 (±0.135)	0.53 (±0.75)	0.50 (±0.679)
2	Peechi	KL-II	20/01/98	40	3.28 (±0.082)	2.29 (±0.020)	1.7 (±0.94)	1.5 (±0.84)
3	Edappalayam	KL-I	20/01/98	40	2.30 (±0.078)	3.16 (±0.178)	2.6 (±1.42)	2.4 (±1.50)

Figures in parenthesis indicate SD

Diameters of fruit vary between 2.3 cm and 3.3 cm and the length varies between 2.3 cm to 3.2 cm. A fruit has normally five locules. Mean number of developed locules varies betwen 0.5 and 2.6 and the mean number of seeds per fruit varies between 0.5 and 2.4.

Seed pre-treatment

True seeds extracted from the fruits gave maximum germination (12%) as compared to splitting the hard endocarp longitudinally into two halves (1%). Sowing seeds with endocarp intact did not give any germination. However, extraction of true seeds is laborious and lot of seeds is wasted during the process. However, reports indicate that soaking the seeds in cold water for a week is very effective in accelerating and improving germination up to 50 % with in a period of 48 days (FRI, 1981).

Seed testing

Only 36% of the sound seeds germinate even after splitting open hard endocarp (Table 7).

Table 7. Seed quality of *Melia dubia* as revealed through cutting and germination tests.

Test	Test results (%)
Cutting test (n=80)	33.75
Germination test (n=80)	12.00
Ratio of Germination % and cutting test	36.00

Seed storage

Germination percentage of seeds dried to low moisture content are given in Table 8.

Table 8. Effect of moisture content on germination of *Melia dubia*

Moisture content (%)	Storage period (days)	Germination percentage
11.19	54	8
7.59	60	12

The results show that 8-12% seeds germinate even at low moisture content of 11.19 to 7.59 % (Table 8) which is comparable to germination percentage (12%) obtained for fresh seeds with 52.5% moisture content suggesting the orthodox behaviour of seeds. However this aspect need detailed investigation following method suggested by Hong and Ellis (1996).

Seed pests

Heavy incidence of a beetle *Carpophilus* sp. (Coleoptera: Nitidulidae) was recorded in seed samples stored at peechi. The dull coloured, oblong beetles measured about 1.5 mm in length and were found feeding on the fleshy fruits collected and heaped. In most of the attacked fruits, the fleshy parts were completely eaten. On an average, 112 beetles and 24 larvae were found per affected seed. Both immature and adult stages feed on the fruits.

Members of the genus *Carpophilus* Stephens are known to attack various stored products including dried fruits stored grains, nuts, beans etc. They generally attack stored products that are not properly dried or having high moisture content (Booth *et al.*, 1990).

Seed health test

Seeds of *M. dubia* were found harboured by a rich microflora consisting of 19 fungi, a bacterium and actinomycetes. Storage fungi recorded on seeds included *Aspergillus* spp., (3 species), *Chaetomium globosum, Penicillium* spp., *Trichoderma* spp., etc. Of these *A. flavus* and *Trichoderma* sp., were the most frequently occurred fungi with percent incidence of 19.50 and 16 respectively. Among the field fungi, *Bipolaris maydis, Botryodiplodia theobromae, Colletotrichum* sp., *Fusarium oxysporum* and *Myrothecium* sp., were the important fungi encountered (Fig. 5). Among the spermoplane microbes recorded, highest percent incidence of 27 was observed for *F. oxysporum* (Table 9).

Surface sterilization of seeds reduced the number of spermoplane microbes as well as their percent incidence and severity. Only seven fungi were recorded on surface sterilized seeds. Seedlots from Nilambur and Thrissur tested using agar plate method gave almost similar results. *B. theobromae* was recorded in all the three seed samples and its per cent incidence ranged from 9 to 41. *Colletotrichum* spp., were recorded in all the three samples and highest incidence of 29% was recorded on seeds from Thrissur seedlot. *Fusarium* sp., was also recorded in high frequency (16%) on seeds from Thrissur. *Colletotrichum* sp., *Fusarium* sp., and *Phoma* sp., occurred in high

frequency and seem to be seed-borne. Percent seed infestation by different microbes in seed samples from different seedlots varied from 63 to 93% (Table 10). While germination of seeds ranged from 11% to 19%.

Seedlings raised in sterilized perlite medium showed foliage infection caused by *Colletotrichum gloeosporioides* as well as collar rot caused by *Fusarium oxysporum*.

Table 9. Spermoplane microorganisms detected on extracted seeds of *Melia dubia* by blotter and agar methods and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence			Agar method %incidence	
		NBR 1999 seed lot 1			NBR 1999 seed lot 2	TCR 1999 seed lot
		NSS	SS	A	A	A
1	*Aspergillus* spp.			9.33		
2	*A. flavus*	19.50	6.50	6.66	7.00	4.00
3	*A. niger*	6.00		28.00	14.00	3.00
4	*Bipolaris maydis*	1.50				
5	*Botryodiplodia theobromae*	4.50	1.00	41.33	24.00	9.00
6	*Cephalosporium acremonium*	4.00				
7	*Chaetomium globosum*	7.50				
8	*Colletotrichum* sp.					29.00
9	*C. gloeosporioides*	3.00	1.50	6.66	6.00	
10	*Fusarium* sp.					16.00
11	*F. oxysporum*	27.00	2.00	2.66		
12	*Myrothecium* sp.					1.00
13	*Paecilomyces* sp.				5.00	3.00
14	*Penicillium* spp.	7.00	9.00	8.00	3.00	
15	*Pestalotia* sp.	2.00	1.50	8.00		
16	*Periconia* sp.	1.00				
17	*Phoma* sp.				3.00	8.00
18	*Trichoderma* sp.	16.00				
19	*T. viride*		32.00	16.00	20.00	40.00
20	Bacteria	2.00				
21	Actinomycetes			8.00		

*NSS: non-surface sterilized; SS: surface sterilized; A: Sulphuric acid treated

Table 10. Percent seed germination and percent infestation of *Melia dubia* seeds with different pre-treatments

Locality and seedlot	% seed germination			% seed infestation		
	NSS	SS	A	NSS	SS	A
Nilambur 1999 seedlot	12.00	19.00	18.66	88.00	63.00	93.33
Nilambur 1998 seedlot2			16			72
Thrissur 1999 seedlot			11.00			88.00

*NSS: non-surface sterilized; SS: surface sterilized; A: conc.sulphuric acid treated

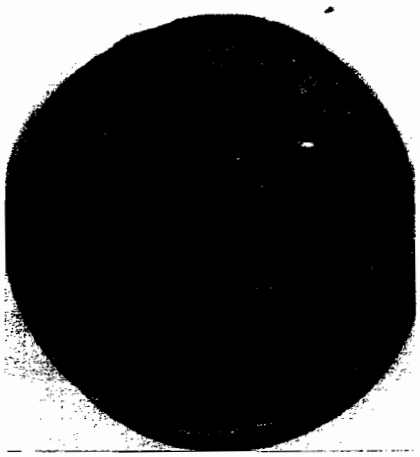


Fig. 5. Extracted seeds of *Melia dubia* in blotters. Note the severe infestation with spermoplane microbes

Plant production

Using seeds: Results of growth performance of 3, 4 and 5 months old seedlings raised in different containers are presented in figures 6, 7 and 8 respectively.

Studies suggest that polypotted container produces seedlings of superior quality in terms of shoot height, number of leaves, shoot biomass, root biomass, etc., and plantable at three months. Seedlings in 310 cc root trainers also produce plantable seedlings of about 25 cm in five months.

Fig. 6. Height growth of *Melia dubia* seedlings in different containers

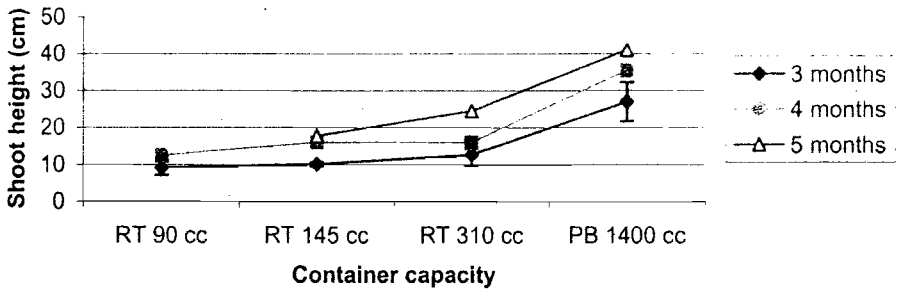


Fig. 7. Shoot biomass of *Melia dubia* seedlings in different containers

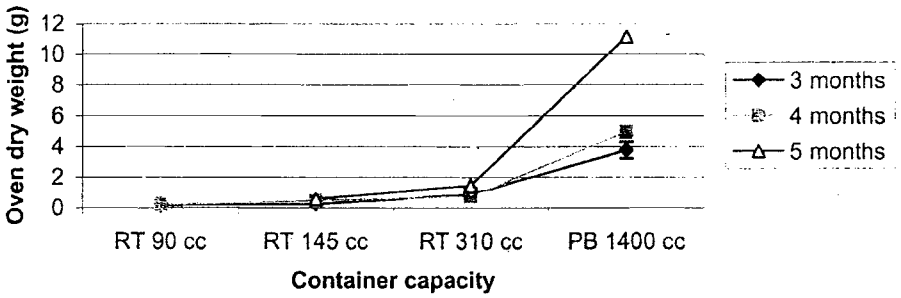


Fig. 8. Root biomass of *Melia dubia* seedlings in different containers

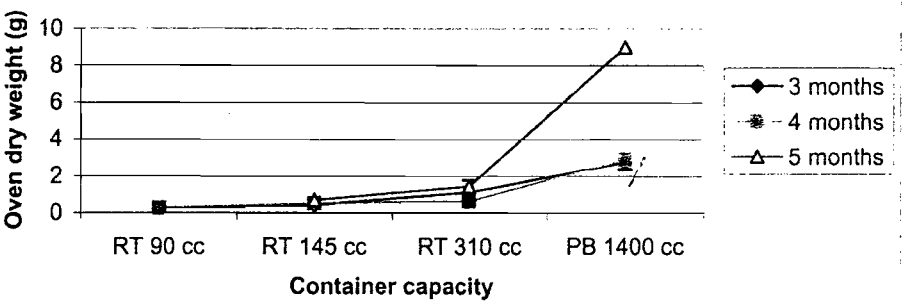


Fig. 9. Three months old *Melia dubia* seedlings
(A) in 1400 cc Polybag (22.5 x 17.5 cm)
(B) in 310 cc root trainer
(C) in 140 cc root trainer

Growth of the seedlings was very fast (Fig. 9). Within a period of four months seedlings grew to 35.5 cm in polybags, whereas in root trainers of 90 cc, 145 cc and 310 cc capacity seedlings grew to 12.5 cm, 16 cm and 16 cm, respectively. Seedlings in polybags were superior in terms of height and biomass production and were ready for planting after three months in polybags.

No instance of pest incidence was noticed in the nursery during the period of study.

Vegetative propagation: Vegetative propagation of the species using mature branch cuttings from the tree with the rooting hormones such as IAA and IBA did not yield any positive result. The trials need to be carried out with juvenile cuttings.

4.3. *Terminalia crenulata*

Phenological observations

Phenological observations are summarized in Table 11.

Table 11. Season of flowering and fruit maturity in different localities

Seed Zone	Locality	Year	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
KL-I	Erumely	1998		✦	✦									
KL-II	Vazhachal	1998			✦	✦								
		1999		✦	✦									
KL-II	Peechi	1997					* ✦	*	*					
		1998												
		1999			✦	✦								
		2000			✦	✦	*	*	*					
KL-III	Walayar	1999		✦	✦									
KL-III	Nilambur	1998		✦	✦									
		1999			✦	✦	✦							
KL-III	Dhoni	1998		✦	✦									
		1999			✦	✦								
KL-III	Agali	1999		✦	✦									
KL-III	Wayanad	1999			✦	✦								

Note: * Flowering; ✦ Mature fruits

There is not much variation in flowering and fruiting in different zones. Usually, flowering starts during May-June and the fruit takes 8 months to mature. Seed matures during February and continues up to April. Three trees standing in KFRI campus at Peechi, which flowered during 1997, did not flower during 1998. Conclusions on flowering and fruiting cannot be drawn based on limited years data.

Seed characteristics

Fruit/seed characteristics are given in Table 12.

Table 12. Fruit size, fruit weight and germination capacity of *Terminalia crenulata* seeds collected from different localities

Sl.No.	Locality	Mean fruit measurements (with wings)				Remarks
		Diameter (cm)	Length (cm)	No. of wings	Seeds per kg	
1	Nilambur	3.28 (±0.35)	4.12 (±0.43)	5 (±0.14)	752 (±16.33)	The seeds were first de-winged and then soaked in tap water for 24 hrs prior to sowing
2	Dhoni	4.63 (±0.52)	4.52 (±0.70)	4.93 (±0.26)	490 (±2.31)	
3	Peechi	3.48 (±0.49)	3.79 (±0.47)	4.92 (±0.27)	724 (±3.83)	
4	Agali	4.03 (±0.64)	4.88 (±0.75)	5 (±0.14)	397 (±19.87)	
5	Walayar	4 (±0.35)	4.33 (±0.39)	4.95 (±0.22)	511 (±6.56)	
6	Vazhachal	3.80 (±0.25)	4.20 (±0.50)	-	800	
7	Erumely	2.42 (±0.18)	3.56 (±0.34)	-	1370	

Figures in paranthesis indicate SD

The fruits generally have five wings, but those with four and six wings have also been rarely observed. For fruit with wings, diameter varies between 2.4 and 4.6 cm and, the length between 3.56 and 4.88 cm.

Seed storage

For seeds when stored in desiccator over silica gel under ambient conditions, viability is lost rapidly after 3 weeks (Table 13). The experiment needs to be repeated with short time intervals and more number of samples.

Table 13.Germination of *T. crenulata* stored in desiccator at ambient conditions

Seed storage period (days)	Germination percentage	Seed moisture content % just before germination test
23	54.5 (± 4.35)	13.8
52	17 (± 2.89)	10

Seed pre-treatment

Soaking of seeds in cold water for 24 hrs after clipping of the wings enhanced cumulative germination from 54% to 57% and advanced germination period by 10 days (Table 14).

Table 14. Effect of pre-sowing treatments on seed germination of *T. crenulata*

Treatments	Germination percentage at 31 days after sowing	Germination period (days after sowing)	
		Date of commencement	Date of completion
Control	54	17	31
De-winging followed by 24 hrs cold water soaking	57	7	17

Seed testing

The ratio of the percentages obtained through cutting test and germination test (Table 15) does not lead to conclusions with the number of samples tested. More studies are needed in this regard. Nonetheless, cutting test results can be used as an indication of the seed quality as in most cases the ratio of germination percent to soundness as revealed through cutting test ranges from 0.54 to 0.9.

Table 15. Seed quality of *Terminalia crenulata* as revealed through cutting and germination tests

Locality	Date of collection	No. of seeds examined	Percentage of sound seeds as revealed through cutting test	Germination percentage at 28 days after sowing	Ratio of germination percent to cutting test
Nilambur	21/02/1998	25	68	57	0.84
Dhoni	16/02/1998	25	44	26	0.59
Erumely	04/03/1998	25	84	34	0.40
Vazhachal	21/03/1998	25	56	30	0.57
Peechi	15/04/1999	100	40	6	0.15
Agali	20/02/1999	100	57	8	0.14
Walayar	25/02/1999	100	74	52	0.70
Nilambur	14/04/1999	100	60	54	0.90
Dhoni	17/04/1999	100	5	-	-

Seed pests

A caterpillar (yet to be identified) was found to feed on the seeds causing moderate damage to mature seeds.

Seed health test

In blotter test, spermoplane microflora comprising of 27 fungi belonging to 21 genera, mycelia sterilia, bacteria and actinomycetes were detected. Though, percent infestation ranged from 32 to 86.25 (Table 16), severe infestation was recorded only on few seeds. In seedlots from Nilambur (1999), among many storage fungi recorded, *Aspergillus niger* (32.25%) and *Chaetomium* sp., (25.25%) were the predominant species. While *Aspergillus clavatus*, *A. niger and Chaetomium* sp., were the dominant storage fungi in seedlots of Nilambur 1999. Comparatively a large number of fungi, both field and storage fungi were recorded on non-surface sterilized seeds from Nilambur (1999), while only a few fungi (5 storage fungi) were recorded on seeds from Walayar. Among the field fungi recorded, *Drechslera* sp., *Alternaria* sp., *Cylindrocladium* sp., *Myrothecium* sp., are the important ones. In surface sterilized seeds, though the number of fungi associated and their percent infestation were lower than that obtained from non-surface sterilized seed samples, a very high per cent (16.50%) infestation by *Fusarium* sp., was recorded (Table 16). In agar plate method. only 11 fungi were recorded and their percent infestation was also low. *Cylindrocladium quinqueseptatum* and *Drechslera* sp., were recorded and the affected seeds were found covered with the fungal mycelium and such seeds fail to germinate. Both of these fungi seem to be seed-borne. Bacterial infestation was detected only in Nilambur (1998) seedlots and shrunken and discoloured seeds showed the bacterial ooze and such seeds became rotten. Seed germination in different treatment ranged from 29 to 50% (Table 17). Germination of seed was affected by the severe infestation by the storage fungi, especially *Aspergillus* spp., and *Penicillium* sp.

Seedlings raised in sterilized perlite medium showed cotyledon rot caused by bacterium and leaf infection caused by *Colletotrichum gloeosporioides*.

Seed dressing with fungicides, Captan (@5g / kg seeds) and Thiride (@ 4 g/kg seeds) reduced the spermoplane microflora considerably. Captan was more effective in reducing the microbes. Only 12% seed infestation was recorded on Captan treated and stored seeds.

Table 16. Spermoplane microflora detected on seeds of *Terminalia crenulata* by blotter and agar plate methods and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence				Agar method % incidence
		NBR 1999		NBR1998	WL1999	NBR 1999
		NSS	SS	NSS	NSS	
1	*Acroconidiella* sp.	0.75				
2	*Alternaria* sp.	3.25	1.00			
3	*Aspergillus* spp.	1.75	1.50	19.00		34.00
4	*A. clavatus*	0.25				
5	*A. flavus*		1.50		5.00	
6	*A. niger*	35.25	13.00	17.00	12.00	
7	*Beltrania rhombica*	2.75	2.50			3.00
8	*Botryodiplodia theobromae*	3.00				10.00
9	*Chaetomium* sp.		16.50	13.00	3.00	12.00
10	*Chlamydomyces palmarum*	0.75				
11	*Cladosporium* sp.	13.75	1.50		2.00	
12	*Curvularia pallescens*	4.5				
13	*Cylindrocladium quinqueseptatum*	0.50	2.50			2.00
14	*Drechslera* sp.	5.75	2.50	2.00		2.00
15	*D. hawaiensis*				6.00	
16	*Fusarium* sp.		16.50			12.00
17	*Graphium* sp.					3.00
18	*Myrothecium* sp.	3.50	2.00			
19	*Paecilomyces* sp.			10.00		
20	*Penicillium* spp.	7.00	6.50	14.00	9.00	
21	*Phoma* sp.	0.50				0.50
22	*Pithomyces* sp.	1.25				
23	*Scolecobasidium* sp.	1.00				
24	*Trichoderma* sp.	2.25	11.00	22.00		9.00
25	*Verticillium* sp.			2.00		
26	Sterile mycelium (white)	0.75		2.00		
27	Sterile mycelium (black)		1.50			
28	Bacteria			4.00		
29	Actinomycetes	2.00	6.00		8.00	

*NSS: non-surface sterilized; SS: surface sterilized; NBR: Nilambur, WL: Walayar

Table 17. Percent seed germination and infestation with spermoplane microorganisms of *Terminalia crenulata* seeds

Locality	% seed germination		% seed infestation	
	NSS	SS	NSS	SS
Nilambur 1998 seedlot	50		72	
Walayar 1999 seedlot	38		32	
Nilambur 1999 seedlot	29.25	40.50	86.25	59

*NSS: non-surface sterilized; SS: surface sterilized

Plant production

Using seeds

The growth of seedlings at 2, 3 and 4 months old are measured and given in figures 10, 11 and 12.

Fig. 10. Height growth of *Terminalia crenulata* seedlings in different containers

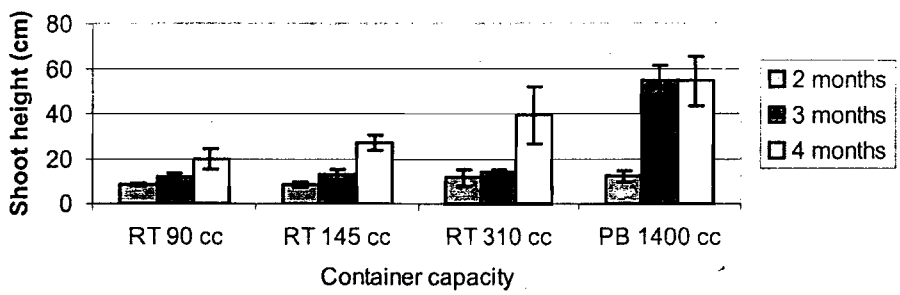


Fig. 11. Shoot biomass of *Terminalia crenulata* seedlings in different containers

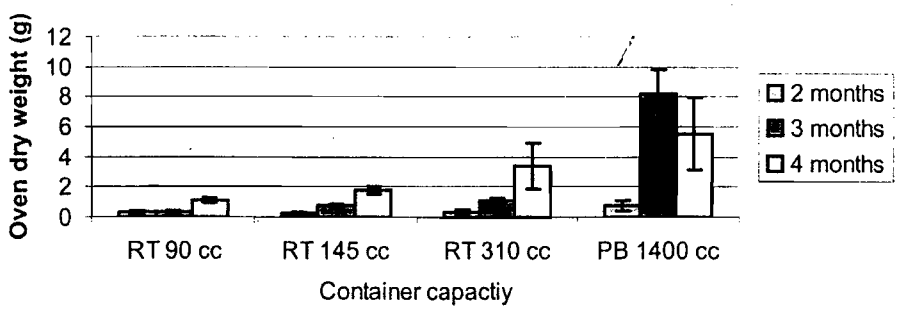
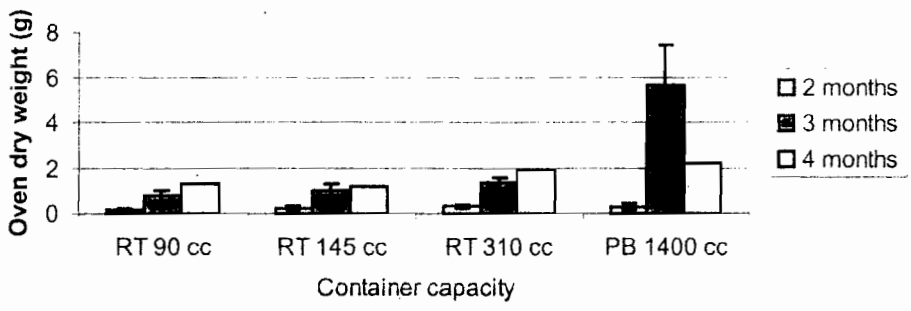


Fig. 12. Root biomass of *Termindia crenulata* seedlings in different containers



The height growth of two months old seedlings in 90 cc, 145 cc, 310 cc root trainers and polybags (1400 cc) were 8.5 cm, 8.4 cm, 11.6 cm and 12.2 cm respectively. Although shoot growth was maximum in polybags, large sized root trainer seedlings were the best in terms of shoot height, shoot biomass and root biomass. Plantable seedlings can be obtained within three months in root trainers.

Mild infestation by caterpillars and grasshoppers was recorded from the nursery. The caterpillars included 3 species of hairy caterpillars and a bagworm. Brief accounts of the nature and extent of damage by the pests are given below:

i). *Dasychira mendosa* Hb. (Lepidoptera: Lymantriidae)

Incidence of this insect was observed in September to November 1998 and from February to March 1999. The eggs were laid in masses on the foliage. The larvae that hatched out were yellowish to greyish and spotted with red and with red stripes on prothorax and paired lateral tufts of greyish-white hairs on each of the body segments. They fed vigorously on the foliage causing defoliation. Larval period lasted for about 15-25 days. Pupation occurred in a loose cocoon of silk hairs. Pupal period lasted for 10-15 days. The adult moth measured about 4-5 cm in expanse with the forewings patterned in various shades of brown and pale hind wings.

ii). *Euproctis fraterna* Moore (Lepidoptera: Lymantriidae)

Incidence of this insect was observed in May 1998. Eggs were laid on the lower surface of leaves in a mass covered with hairs from the anal tuft of the female. The newly hatched larvae, which measured about 2.5 mm in length, were slender, hairy and yellowish in colour. The full-grown larvae were stout, dark reddish brown, paler along the lower surface, having a bright orange-red head and with a prothoracic shield. The body was covered with tufts of whitish hairs, with a pair of large tufts of darker hairs directed forward on either side of the head and with a similar tuft directed backwards from the anal segment. Larval period lasted for 25-30 days. The larvae, which were hairy caused defoliation of seedlings. The damage intensity was rated as 'severe'and the defoliation occurred in patches within the nursery bed. Pupa was red-brown, enclosed in a small cocoon interwoven with larval hairs. Pupal period lasted for 7-10 days. The adult moth was yellowish in colour with black spots. This pest can be controlled by the application of a contact insecticide like Ekalux (quinalphos).

iii). *Redoa* sp. (Lepidoptera: Lymantriidae)

Incidence of this insect was observed during September and November 1998. The larvae, which were hairy, fed on the foliage causing mild defoliation of seedlings and hence not considered as potential pest.

iv). *Metisa* sp. (Lepidoptera: Psychidae)

Mild attack of the bagworm, *Metisa* sp. was noticed during November 1999. Feeding by this insect caused irregular holes on the leaf surface. As only a few insects were present, no major damage was caused to the seedlings. Bagworms usually have wide host range and are already known to be potential pests of various forest trees in Kerala.

v). Unidentified leaf webber

Mild incidence of an unidentified leaf webber (Lepidoptera: Pysalidae), which feed from within rolled tender leaves (Fig. 13) was observed on some occasions.

Fig. 13. *Terminalia crenulata* seedling showing signs of attack by a pyralid leaf webber

vi). Grasshoppers

Two species of grasshoppers belonging to Acrididae (short-horned grasshopper) and Tettigonidae (long-horned grasshopper) were noticed to feed on the foliage of seedlings. However, their population was not high and hence did not cause much damage.

Vegetative propagation

Vegetative propagation using juvenile cuttings of thickness ranging from 0.26 cm to 0.53 cm, and length 9 cm to 10 cm using the rooting hormones IAA and IBA has been unsuccessful.

4.4. *Terminalia paniculata*

Phenological observations

Phenological observations are summarized in Table 18.

Table 18. Season of flowering and fruit maturity in different localities

Seed Zone	Locality	Year	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
KL-I	Thenmala	1998	*	*										
		1999		✦	✦						*	*	*	
KL-II	Peechi	1997			✦	✦	✦					*	*	*
		1998			✦	✦	✦				*	*	*	
		1999		✦	✦	✦					*	*	*	*
		2000		✦	✦	✦			*	*	*			
KL-III	Walayar	1998		✦	✦	✦			*	*	*			
		1999	✦	✦										
KL-III	Nilambur	1999			✦	✦								
KL-III	Dhoni	1998									*	*	*	
		1999		✦	✦	✦								
KL-III	Nelliampathy	1997									*	*	*	

Note: * Flowering; ✦ Mature fruits

There is considerable variation in flowering and fruiting between moister (Peechi, Nelliampathy and Nilambur) and drier localities (Walayar). In moister localities, the flowering starts during September-October whereas in drier localities, flowering starts earlier during July-August. The fruits take 5 months to ripen and the mature fruits are available from February to April.

Seed testing

The results of the cutting tests which showed 0.5 to 3.0% seeds as sound (Table 19) compares reasonably well with germination tests (0.5 to 0.7%), suggesting the use of cutting test as a reliable means of testing viablity of *T.paniculata.*

Table 19. Seed quality of *Terminalia paniculata* as revealed through cutting and germination tests

Locality	Date of collection	Percentage of sound seeds by cutting test n= 400	Germination % *n= 400
KFRI campus near Type I Quarter, Peechi	29/03/1997	1.5	-
KFRI campus near main gate, Peechi	21/04/1997	1	0.5
KFRI campus near Mist Chamber, Peechi	05/03/1997	0	0.5
KFRI campus backside to Quarter 1/15, Peechi	29/03/1997	1.5	1
KFRI Sub-centre campus, Nilambur	31/01/1997	0.5	-
KFRI Sub-centre campus, Nilambur	04/04/1997	1.25	1
KFRI main campus, Peechi	05/04/1998	0.75	0.5
Vazhachal	03/05/1998	3	-
Walayar	22/01/1999	2.5	0.688
Thenmala	11/03/1999	3.75	-
Marady	12/03/1999	2	-
Dhoni	17/04/1999	0.125	-
Nilambur	14/04/1997	1	0.5
KFRI campus, Peechi	03/04/1999	3	0.25

* Since different samples are used for cutting test and germination, test, variation in percentages between both will be seen

Seed pests

The infertility of the seed is suspected to be due to the attack of the weevil, *Nanophyes terminaliae*. Feeding by the noctuid, *Garella rotundipennis* was also noticed. It is believed that they lay their eggs very soon after the fruit formation.

Seed health test

Terminalia paniculata seeds were harboured by a rich microflora (Fig. 14a) consisting of 37 fungi belonging to 34 genera, one bacterium and actinomycetes (Table 20). Among the fungi recorded on seeds, 14 are field fungi and other represents storage moulds (Figs. 14b-i). A very high percent infestation (82.5%) was recorded in non-surface sterilized seeds. Among the storage fungi, *Aspergillus niger* (14.50%) was the

most predominant fungus encountered on seeds. Interestingly a large number of field fungi were recorded on seeds and among these *Alternaria* sp., *Ascochyta* sp., *Curvularia lunata*, *Pestalotia* sp., *Beltraniella odinae*, etc., occurred in high frequency (Table 20). *Drechslera australensis*, *Graphium* sp., *Myrothecium* sp., *Cercospora* sp., are the other important fungi encountered. Surface sterilization of seeds reduced the number of fungal flora as well as their percent frequency of occurrence. Only 15 fungi were recorded on surface sterilized seeds and their percent incidence was comparatively lower than that obtained from non-surface sterilized seeds (Table 21). Agar plate technique also revealed the same trend. In all the three treatments, *Beltrania odinae* was occurred in high frequency and seems to be seed-borne. In agar plates, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *Fusarium* sp., *Cylindrocladium* sp., *Myrothecium* sp., *Phoma* sp., *Phomopsis* sp., etc., also occurred in high frequency. The highest percent incidence was recorded for *Phomopsis* sp., (32.50%), which was encountered in all the three treatments. This field fungus also seems to be seed-borne. Most of the field fungi were found associated with the discoloured and shrunken seeds. The results indicate that both storage and field fungi play a major role in lowering the seed germination. Percent seed germination was found slightly increased by surface sterilization of seeds (Table 21). Seedlings raised in sterilized perlite medium showed foliage infection caused by *Colletotrichum gloeosporioides* and *Alternaria* sp.

Seed dressing with Captan and Thiride showed that Captan (@ 5 g/kg seeds) was effective in reducing the seed microflora. Only 10% seed infestation was recorded in Captan treated seeds, while 18% seed infestation was recorded in Thiride (@ 4 g/kg seeds) treated seeds.

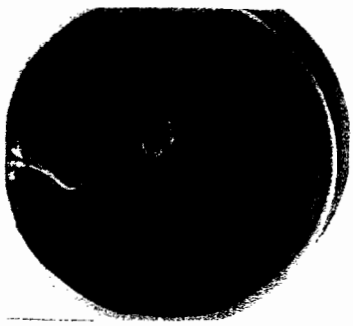


Fig.14a *Terminalia paniculata* seeds in blotters

Fig.14b. *Beltrania odiniae* on *T. paniculata* seeds

Fig. 14c. *Beltraniopsis* sp. on *T. paniculata* seeds

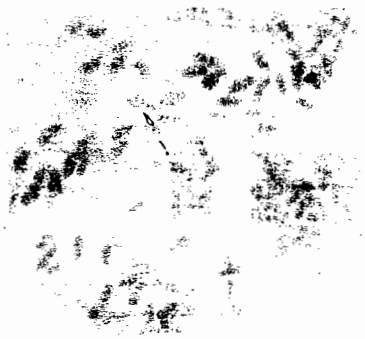


Fig.14d. *Ascochyta* sp. on *T. paniculata* seeds

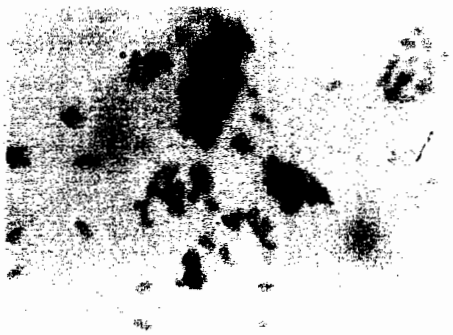


Fig.14 e. *Ascochyta* sp. on *T. paniculata* seeds

Fig.14f. *Dwaiyabeeja* sp. on *T. paniculata* seeds

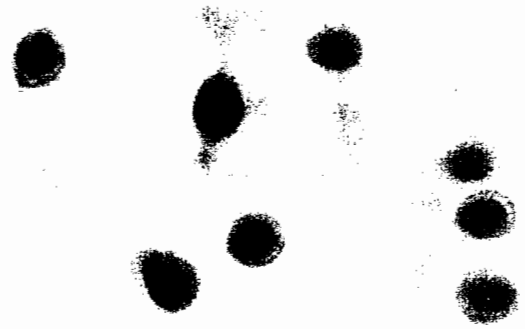


Fig. 14g. *Chlamydomyces palmarum* on *T. paniculata* seeds

Fig.14h.*Chaetomium* sp. on *T. paniculata* seeds

Fig. 14i. *Botryodiplodia theobromae* on *T.paniculata* seeds

Table 20. Spermoplane microorganisms detected on seeds of *Terminalia paniculata* by blotter and agar methods and their per cent incidence

Sl. No.	Microorganisms	Per cent incidene			
		Vazhachal 1999 seedlot			NBR 1998
		NSS	SS	A	NSS
1	*Alternaria* sp.	11.75	6.50		
2	*Arthrobotrys* sp.	9.25	2.25		
3	*Ascochyta* sp.	2.75	0.50		
4	*Aspergillus* spp.	8.75	4.00	13.33	83
5	*A. niger*	14.50	9.00	5.00	72
6	*A. restrictus*				2.00
7	*Beltraniella* sp.				0.25
8	*B. odinae*	10.00	6.00	18.33	
9	*Bipolaris* sp.	1.00			
10	*Botryodiplodia theobromae*	2.25	0.75		
11	*Cercospora* sp.	1.50			
12	*Chaetomium* sp.	5.50			
13	*Chlamydomyces palmarum*	2.25			
14	*Cladosporium cladosporioides*	3.50	3.00		
15	*Colletotrichum gloeosporioides*			3.33	
16	*Curvularia lunata*	7.50	0.75	3.33	
17	*Cylindrocladium* sp.			1.66	
18	*Drechslera australensis*	3.75			
19	*Fusarium* sp.			6.66	1.00
20	*Graphium* sp.	3.25			
21	*Helminthosporium* sp.	1.25			
22	*Heterosporium* sp.	1.25			
23	*Memnoniella* sp.	0.75			
24	*Mucor* sp.	1.50			
25	*Myrothecium* sp.	2.25		13.33	
26	*Nigrospora* sp.	1.25			
27	*Paecilomyces* sp.	1.25			
28	*Penicillium* sp.		2.00	5.80	3.75
29	*Periconia* sp.	1.50			
30	*Pestalotia sp.*	9.00	4.75	3.33	
31	*Pithomyces* sp.	1.75			
32	*Phoma* sp.	1.50	4.25	2.50	
33	*Phomopsis* sp.	1.75	4.75	32.50	
34	*Trichothecium roseum*	4.75	2.25		
35	*Trichoderma* sp.		5.75	0.80	2.00
36	*Torula* sp.			0.80	
37	*Ulocladium* sp.	1.00			
38	Bacteria	2.25			7.50
39	Actinomycetes	13.00	4.50		

* NSS: non-surface sterilized; SS: surface sterilized; A: agar plate test.

Table 21. Percent germination of *Terminalia paniculata* seeds under different pre-treatments and percent seed infestation with microorganisms

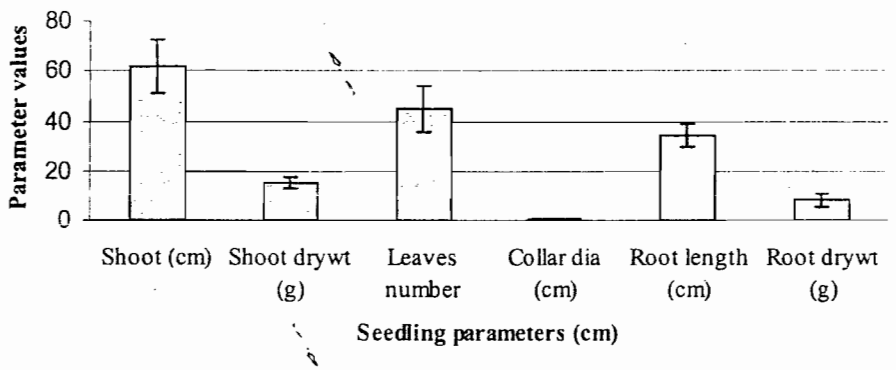
Locality and seedlot	% seed germination		% seed infestation	
	NSS	SS	NSS	SS
Vazhachal 1999 seedlot	11.75	16.75	82.5	40.75

*NSS: non-surface sterilized; SS: surface sterilized

Plant production

Using seeds: The growth of 6 months old seedlings grown in polythene bags of 22.5 x 17.5 cm are measured given in figure 15.

Fig. 15. Growth peformance of 6 months old *Terminalia paniculata* seedlings in polybag (1400 cc)



Growth of the seedlings was generally slow as compared to *T. crenulata*. After six months the seedlings attained 62 cm height in polybags.

Gall formation due to Psyllid, *Triosa* sp., was the major damage to nursery seedlings (Fig. 16). The immature stages which develops in the stem and petiole cause swelling and distortion. Growth is affected as the infestation occurs at the growing tip. Also, infestation cause formation of epicormic shoots which also get affected. Two species of Psyllids viz., *T. hirsuta* Crawf and *T. fletcheri minor* Crawf., have been reported on

T. paniculata (Mathur, 1975). Infestation usually progresses and persists in the nursery and application of a systemic insecticide might be effective. Application of Nuvacron (monocrotophos) at 0.05% concentration has been found to be effective. Other than the Psyllid, incidence of an unidentified weevil and a grasshopper feeding on the foliage has been noticed. The damage was negligible.

Fig. 16. *Terminalia paniculata* seedling showing heavy infestation by Psyllid, *Triosa* sp.

Vegetative propagation: Vegetative propagation of the species using branch cuttings has been unsuccessful.

4.5. *Swietenia macrophylla*

Phenological observations

Phenological observations are summarized in Table 22.

Table 22. Season of flowering and fruit maturity of *Swietenia macrophylla* in different localities

Seed Zone	Locality	Year	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
KL-I	Thiruvananthapuram	1998	✦	*	*									✦
KL-I	Arippa	1998	✦											✦
KL-I	Alappuzha	1998			✦	✦								
		1999		✦	✦	✦								
		2000		✦	✦	✦								
KL-I	Vazhoor	1998		✦	✦									
KL-II	Peechi	1997											✦	✦
		1998	✦	✦										
		1999	✦	✦	✦	*	*							
		2000	✦	*	*									✦
				✦										
KL-II	Thrissur	1997	✦											✦
		1998	✦											✦
		1999									✦	✦	✦	
		2000										✦	✦	✦
KL-III	Nilambur	1998			✦	✦								
		1999	✦										✦	✦
		2000				✦	✦	*	*					

Note: * Flowering; ✦ Mature fruits

Flowering occurs generally during February-July and capsules mature during September-May, but flowering and fruiting seasons vary with localities. The flowering period is 45 days and the capsules take 10 months to ripen. The tree is deciduous only for a very short period.

A tree was leafless for about 2 days in Peechi (during February) and it was full of leaves within 9 days.

Seed collection and processing

Capsules are collected from the tree by lopping off the fruiting twig when capsule changes its colour from grey-green to brown. However, it is difficult to decide seed maturity based on colour and hence commencement of dehiscence of a few capsules is regarded as appropriate time for collection. In case where the seed trees are not accessible, the seeds are collected from the ground immediately after dispersal, but this is a laborious process as the seeds are dispersed by wind to far away places. Seeds are extracted from the capsules as soon as possible, since rot occurs within 2-3 days. Capsules dried under direct sun opened within two days, under diffused light opened within six days and those dried in oven opened within 24 hours (Table 23). The drying period varies between 1 to 6 days, depending on the ripeness of the capsule, ambient temperature and humidity.

Table 23. Effect of different methods of seed extraction on moisture content and germination of *S. macrophylla*

Sl. No.	Method	Duration	MC%	Germination capacity (%)
1	Oven dry (50°C)	One day	30	85.8
2	Sun drying	Two days	16	85.8
3	Shade	Six days	29	59.2

Fruit and seed characteristics

The fruit and seed characteristics were studied and the results are given in Table 24.

Table 24. Fruit and seed characteristics of *Swietenia macrophylla*

Sl. No.	Locality	Mean capsule measurements			Mean no. of seeds per capsule		
		Width (cm)	Length (cm)	Fresh weight per capsule (g) at 52.09% MC	Sound	Unsound	Total
1	Vazhoor	8.99 (±0.36)	13.08 (±0.65)	389.8 (± 56.33)	47.7 (±3.23)	12.9 (± 2.60)	61 (± 3.37)
2	Thrissur	9.77 (±0.54)	14.32 (±0.92)	465(± 55.99)	38 (±3.36)	30.5 (± 3.87)	69 (± 4.73)

Seed storage

Seeds with moisture content of 4% gave 74% germination at the commencement of storage (Table 25). Seeds stored well for 12 months in refrigerator, which suggests orthodox storage physiology, which is contrary to the report of Hong and Ellis (1998) that seeds of *S. macrophylla* are intermediate.

Table 25. Effect of different storage conditions and period on viability of *Swietenia macrophylla*

Storage conditions	% viability at different months after storage					
	0	1	3	6	9	12
Control 29±2oC)	74	81	72	0	0	0
Refrigerator 0°C)	74	74	70	67	69	87

Seed pre-treatment

No pre-treatment, other than de-winging, is required before sowing, as 85% seeds germinate even without any pre-sowing treatment.

Seed testing

Tetrazolium test: The results of tetrazolium test are given in Table 26 and figure 17.

Table 26. Viability percentage of *Swietenia macrophylla* determined by tetrazolium test

Percentage staining in each class				Test duration (after incubation)
Class I	Class II	Class III	Class IV	
55	20	20	5	One day

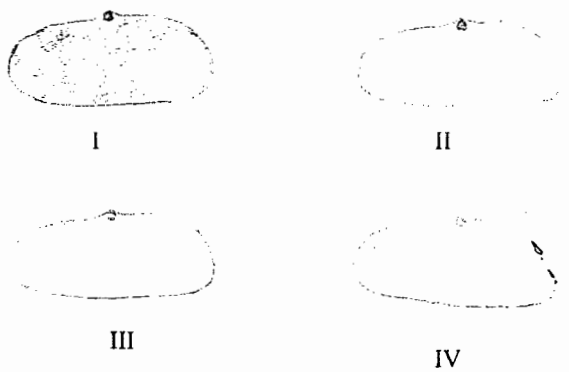


Fig. 17. Seed viability evaluation by tetrazolium test of *S. macrophylla*

Class I: Seed with both embryo and cotyledons completely stained uniformly

Class II: Seed with embryo dark stained and cotyledons moderately stained

Class III: Seed with both embryo and cotyledons unstained

Class IV: Seed with embryo unstained and cotyledons stained

Hydrogen peroxide test: The results of H_2O_2 test are given in Table 27 and figure 18. Seed is considered as viable when the radicle length exceeds 0.3mm after 27 days.

Table 27. Viability percentage of *Swietenia macrophylla* determined by hydrogen peroxide test

Radicle length (percentage)				Test duration (after incubation)
< 0.3 mm	< 0.4 mm	< 0.5 mm	< 0.7 mm	
45	22	2	7	27 days

Viable Non-viable

Fig. 18. Seed viability evaluation in *S. macrophylla* by hydrogen peroxide test

Germination test: The results of germination test for the seed lot from which samples were drawn for tetrazoliun and hydrogen peroxide tests are given in Table 28.

Table 28. Germination percentage of *Swietenia macrophylla* at 64 days after sowing

Viability percentage				Germination period (Days after sowing)
Germination %	Ungerminated seeds			
	Sound	Dead	Abnormal seedlings	
74	0	23	3	19- 64

The results of various viability tests such as tetrazolium (Tz) test, hydrogen peroxide (H_2O_2) test, and cutting test are compared with germination tests in Table 29. The total of classes I and II stained in Tz test compares well with germination test and H_2O_2 test and nearly tallies with the cutting test. However, the H_2O_2 test cannot be employed as rapid viability test for mahogany as the test period is 15 days.

Table 29. Comparison of percentage viability between germination, tetrazolium, hydrogen peroxide and cutting tests

% germination	Tz test (Class I and II taken together)	H_2O_2 test (all seeds with radicle emergence)	Cutting test
74	75	75	80

Seed pests

There was no incidence of seed pests. However, *Hypsipyla robusta* Moore (Lepidoptera: Phycitidae) is known to be a serious pest affecting the flowers, seeds and shoots of *S. macrophylla*. Eggs of the first generation (flower generation) are laid on the flowering shoots early in March. One female lays 400-600 eggs. The larvae feed gregariously on all parts of the inflorescence. Life cycle lasts 24-29 days and the insects pass to the second generation (fruit generation). The larvae from the first generation feed on the fruits selecting the youngest and softest. The subsequent generations are essentially 'shoot generation' boring in the soft shoots which might pose threat to seedlings.

Seed health test

Seeds of *Swietenia macrophylla* (Fig. 19) were found harboured by a rich microflora consisting of 32 fungi belonging to 24 genera and an unidentified fungus, a bacterium and actinomycetes. Storage fungi, *Aspergillus* spp., were the most predominant spermoplane microorganisms encountered on all the seed samples. Among the four species of *Aspergillus* recorded, *Aspergillus niger* and an unidentified *Aspergillus* spp., were recorded in high frequency (94.5%). Severity of infestation by these fungi was also very high in seed sample from Nilambur (1998). Interestingly, other storage

moulds like *Penicillium* sp., and *Trichoderma* sp., occurred in low frequency. *Fusarium* sp., *Drechslera* sp., *Helminthosporium* sp., *Alternaria* sp., *Curvularia* sp., etc., were the field fungi recorded on seed samples from different localities. However, their percent incidence was very low. *Botryodiplodia theobromae* (44.5%) and *Fusarium moniliforme* (4.25%) were the important fungi recorded on seed lot from Thrissur (1999) and these fungi were found mostly associated with discoloured and deformed seeds and caused seed rot (Figures 19 b-d). Infection of emerging seedlings (radicle rot) caused by *Fusarium moniliforme* was observed. Surface sterilization of the seeds reduced the number of spermoplane microflora as well as their percent incidence. In surface sterilized seeds, total number of fungi ranged from 6 to 9 in seedlots from Nilambur (Table 30) and their percent incidence was low which ranged from 0.25 to 3.25%. In agar plate method, only 5 microorgnaisms including bacteria were detected and their percent incidence ranged from 2% to 8%. *Drechslera* sp. recorded in all the seedlots and suspected to be seed-borne. Percent seed infestation by different microbes in seed samples from different seedlots varied from 6.50 to 99.50% (Table 31). While seed germination in different treatments ranged from 18.25% to 76%.

Fig. 19a. Winged seeds of *Swietenia macrophylla*

Fig. 19b. De-winged seeds in blotter test showing severe infestation with fungi

Seedlings raised in sterilized perlite medium showed foliage infection caused by *Colletotrichum gloeosporioides.*

Seed dressing with Thiride (@4 g/ kg seeds) was effective in reducing the fungal infestation to 16%. In Captan (@ 5 g/ kg seeds) treated seeds, a slightly higher percent infestation (23%) by the spermoplane organisms was recorded.

Fig. 19c. ***Trichothecium roseum*** **on** ***S. macrophylla*** **seeds**

Fig. 19d. ***Bipolaris*** **sp. on** ***S. macrophylla*** **seeds**

Fig. 19e. ***Bipolaris*** **sp. on** ***S. macrophylla*** **seeds**

Fig. 19f. ***Alternaria alternata*** **on** ***S. macrophylla*** **seeds**

Table 30. Spermoplane microflora detected on seeds of *Swietenia macrophylla* by blotter method and their percent incidence

Sl. No.	Microorganisms	Per cent incidence						
		NBR '98	NBR 1999seedlot1			NBR '99sl2	Trichur 1999	
		NSS*	NSS	SS	A	SS	NSS	SS
1	*Alternaria* sp.		2.00			0.5		
2	*Aspergillus* sp.	63.75	0.25	0.25		1.5	0.75	
3	*A. clavatus*		0.25					
4	*A. flavus*		0.25					2.00
5	*A. niger*	30.75		1.0			3.50	
6	*Beltrania rhombica*						0.75	
7	*Bipolaris* sp.						2.0	
8	*Botryodiplodia theobromae*					1.25	44.5	20.0
9	*Chaetomium* sp.	1.5	3.75			0.75	0.75	2.00
10	*Chlamydomyces palmarum*						0.75	3.00
11	*Cladosporium* sp.		1.00		8.00	0.75	0.75	
12	*Colletotrichum* sp.						0.5	
13	*Curvularia* sp.						1.25	1.25
14	*Curvularia lunata*	1.75	6.0	1.25	6.00		2.5	
15	*Drechslera* sp.	0.25	5.50		6.00	2.00	1.00	
16	*Ellisiopsis* sp.	0.25						
17	*Fusarium* sp.	12		1.25		0.75		1.00
18	*Fusarium moniliforme*		1.25	1.25			4.25	
19	*Gliocladium* sp.						7.75	7.00
20	*Helminthosporium* sp.						1.25	
21	*Heterosporium* sp.						0.25	
22	*Memnoniella* sp.		2.25					
23	*Paecilomyces sp.*	4.25						
24	*Penicillium* spp.	1.25	2.00	0.50	4.00	0.75	2.75	2.00
25	*Pestalotia* sp.		0.50					
26	*Phytophthora* sp.		0.50					
27	*Trichoderma* sp.	7.50				1.00	1.75	
28	*T. viride*		1.00					3.00
29	*Trichothecium roseum*	0.75					6.50	
30	Unidentified fungus						0.25	
31	Mycelia sterilia (black)							3.00
32	Mycelia sterilia (white)						0.50	3.00
33	Bacteria	5.75			2.00			
34	Actinomycetes		1.25					

*NSS: non-surface sterilized; SS: surface sterilized; SL: seedlot; NBR: Nilambur;
A: agar plate test

Table 31. Percent seed germination and seed infestation with spermoplane microorganisms of *Swietenia macrophylla* collected from different localities during 1998 and 1999 seeding seasons

Sl. No.	Localities and seedlots	% seed germination		%seed infestation	
		NSS	SS	NSS	SS
1	Nilambur 1998 seedlot	18.25		6.50	
2	Nilambur 1999 seedlot1	71.25	76.00	46.50	37.00
3	Nilambur 1999 seedlot2		56.00		38.00
4	Trichur 1999 seedlot	36.75	51.00	99.50	60.00

*NSS: non-surface sterilized; SS: surface sterilized

Plant production

Using seeds: The growth of seedlings at different ages is given in figures 20, 21, and 22. Although seedlings in polythene bags were superior in terms of height and biomass production than in root trainer, root trainer seedlings also attained plantable standards in three months.

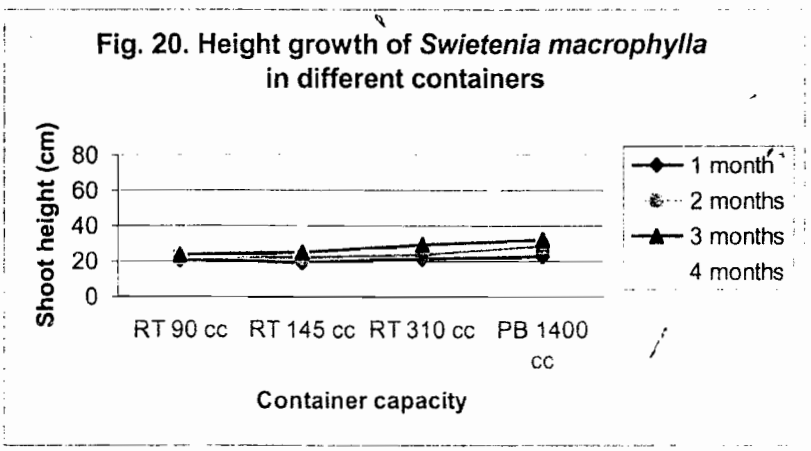


Fig. 21. Shoot biomass of *Swietenia macrophylla* seedlings in different containers

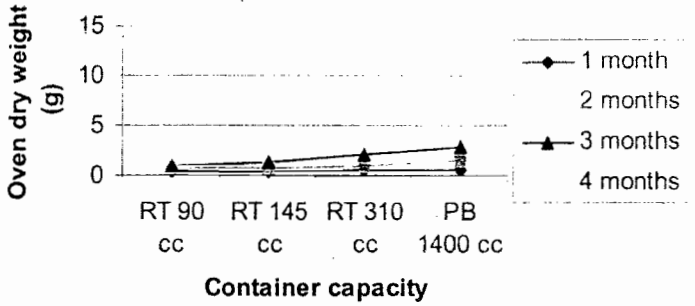
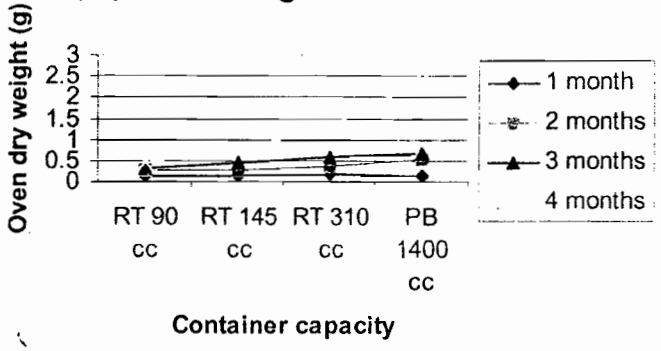


Fig. 22. Root biomass of *Swietenia macrophylla* seedlings in different containers



No pest incidence was noticed in the nursery, although the Phycitid, *Hypsipyla robusta* Moore is known to be a serious pest boring in the shoots causing die back.

Vegetative propagation: Leafy cuttings of sizes between 6.5 cm and 7.5 cm showed the highest survival rates with IAA at 1000 ppm. With doubling of IAA concentration, rooting percentage decreased to 7%, and no rooting occurred for 4000 ppm. The cuttings took 11 weeks to root (Table 32 and Fig.24). IBA had no effect on rooting and sprouting.

Table 32. Percentage rooting and sprouting of *Swietenia macrophylla* branch cuttings three months after treatment

IAA concentration (ppm)	Percentage rooting and sprouting
1000	23
2000	7
4000	0

Fig. 23. Three months old seedlings of *Swietenia macrophylla* in 1400 cc (22.5 x 17.5 cm) polybag, 310 cc, 145 cc and 90 cc root trainers

Fig. 24. Rooted branch cuttings of *Swietenia macrophylla*

4.6. *Swietenia mahagoni*

Phenological observations

Phenological observations are summarized in Table 33.

Table 33. Season of flowering and fruit maturity of *Swietenia macrophylla* in different localities

Seed Zone	Locality	Year	Months											
			J	F	M	A	M	J	J	A	S	O	N	D
KL-I	Thiruvanathapuram	1998	*	*										
KL-III	Nilambur	1997	✦	✦	✦									
		1998	✦	✦										
		1999			✦	✦								
		2000		✦	✦									
KL-III	Nellappara (Palakkad)	2000		✦	✦									
		2001	✦	✦										

Note: * Flowering; ✦ Mature fruits

Mature fruits are generally available during January-April with variations between localities and years.

Seed technology

Seed characteristics

Seed characteristics are given in Table 34.

Table 34. Seed size, seed weight and germination percentage in *Swietenia mahagoni*

Sl. No.	Locality	Mean seed measurements (with wings)		Mean seed weight (with wings) (g/seed)	Germination % (Fresh seeds)
		Length (cm)	Width (cm)		
1	Nilambur	5.24 (±0.310)	1.59 (±0.043)	0.25	86.6

Seed storage

The results of storage of dewinged seeds in a tray in the laboratory are presented in Table 35.

Table 35. Effect of storage period and moisture content on viability of *Swietenia mahagoni*

Days after storage	Moisture content (%)	Germination percentage	Remarks
0		93.0 (± 4.76)	The seeds were dewinged and stored under room temperature in an open tray. Initial viability was 93% (± 4.761).
16	8.39	91.75 (± 1.5)	
50	7.85	87 (± 2.582)	
80	3.78	81.5 (± 5)	

For long-term conservation, lower moisture contents (down to 2%) and very low temperatures (-13°C or less) are desirable (Tompsett and Kemp, 1996). Under Indian conditions, the seeds keep well in a sealed tin up to 8 or even 12 months (FRI, 1981).

Seed testing

Hydrogen peroxide test: The results of H_2O_2 test are given in Table 36. A seed was considered as viable if the radicle length exceeded 0.10 mm length.

Table 36. Viability percentage of *Swietenia mahagoni* determined by hydrogen peroxide test

Radicle emergence (percentage)				Test duration (after incubation in days)
< 0.15 mm	< 0.2 mm	< 0.25 mm	Total	
72	25	3	98.5	13 – 18

Table 37. Germination percentage of *Swietenia mahagoni*

The results of germination test of seeds of the same lot used for cutting test and H_2O_2 test are given in Table 37.

Viability percentage				Germination period (Days after sowing)
Germination	Ungerminated seeds			
%	Sound	Dead	Abnormal seedlings	
98.5	0	1.5	0	13 - 25

A comparison of hydrogen peroxide test, cutting test and germination test shows (Table 38) that there is strong agreement between cutting test and germination test (99%), and between H_2O_2 test and germination test (100%). However, as in the case of *S. mahagoni*, H_2O_2 test takes 13 days and hence not useful as a rapid viability testing method.

Table 38. Comparison of percentage viability between germination, hydrogen peroxide and cutting tests

Viability percentage		
Germination test	H_2O_2 test	Cutting test
98.5	100	100

Seed health test

A total of 23 microorganisms including a bacterium were encountered on seeds of *Switenia mahagoni*. *Aspergillus* spp., *Chaetomium* sp., *Cladosporium* sp., *Mucor* sp., *Penicillium* spp., *Paecilomyces* sp., *Trichoderma* sp., were the important storage fungi recorded on seeds. *Botryodiplodia theobromae*, *Colletotrichum gloeosporioides*, *Drechslera* sp., *Fusarium* sp., *Rhizoctonia* sp., etc. were the important field fungi encountered on seeds. Seeds from 1998 seedlot were found affected with a large number of microbes than that of 1999 seed lot (Table 39). In blotter test, non-surface sterilized seeds exhibited more microbes than on surface sterilized seeds. Radicle rot

caused by *Botryodiplodia theobromae* and *Drechslera* sp. was observed (Fig. 25). Severe microbial infestation affected the germinability of seeds. Surface sterilization of the seeds not only reduced the infestation percentage but also increased the percent seed germination. Of the different technique employed, seeds from 1999 seedlot exhibited highest percent germination of 84.75% in surface sterilized seeds. Seeds from 1998 seedlot showed 100% infestation with a severity scale of 4 in most cases and also showed very low percent germination (16.50%). In agar plate method *Botryodiplodia theobromae* was found associated with 12% of seeds tested and suspected to be seed borne. *Fusarium solani, Fusarium moniliforme, Phoma* sp. are the other important fungi encountered on seeds in agar plate method. Total percent infestation with microbes was 50 and seed germination was 42% (Table 39).

Seedlings raised in sterilized perlite medium showed seedling foliage infection and stem infection caused by *Colletotrichum gloeosporioides*. Leaf tip blight caused by *Alternaria* sp. was also noticed.

Seed dressing with Captan (@ 5g/kg seeds) was found very effective in reducing the spermoplane microflora as well as increasing the percent seed germinability. Total percent seed infestation was reduced to 17%.

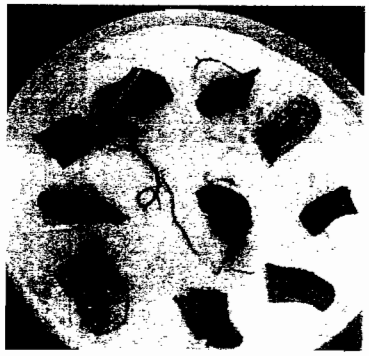


Fig. 25. De-winged seeds of *S. mahagoni* in blotter test. Note the radicle infection (discoloured) and fungal infestation

Table 39. Spermoplane microorganisms detected on seeds of *Swietenia mahogoni* by blotter and agar methods and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence			%incidence NBR'99
		NBR'98	NBR'99 SL		
		NSS	NSS	SS	A
1	*Alternaria alternata.*			1.50	
2	*Aspergillus* spp.	79.50	0.75		5.00
3	*A. niger*	20.50	3.50	1.75	3.00
4	*Botryodiplodia theobromae*		0.25		12.00
5	*Chaetomium* sp.	0.25	4.50	1.75	
6	*Cladosporium* sp.				3.00
7	*Colletotrichum gloeosporioides*		0.75		
8	*Curvularia* sp.	0.50			
9	*Drechslera* sp.	1.25	2.75		
10	*Fusarium* sp.	8.00	9.25	3.25	
11	*F. solani*		1.00		3.00
12	*F. moniliforme.*				5.00
13	*Mucor* sp.	0.50			
14	*Paecilomyces* sp.	3.25			
15	*Penicillium* spp.	7.75	4.75		5.00
16	*Periconia* sp.				2.00
17	*Phoma* sp.				4.00
18	*Rhizoctonia* sp.	3.75			
19	*Trichoderma* sp.	10.75			
20	*T. viride*		2.50	4.50	4.00
21	*Verticillium* sp.		2.25		
22	Mycelia sterilia	3.25			3.00
23	Bacteria	4.25			2.00
	% seed germination	16.50	79.75	84.75	42.00
	% seed infestation	100	22.25	12.75	50.00

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method

Plant production

Using seeds

The growth of 1, 2, 3, and 4 months old seedlings grown in root trainers and polypots are presented in figures 26, 27, and 28.

Fig. 26. Height growth of *Swietenia mahagoni* seedlings in different containers

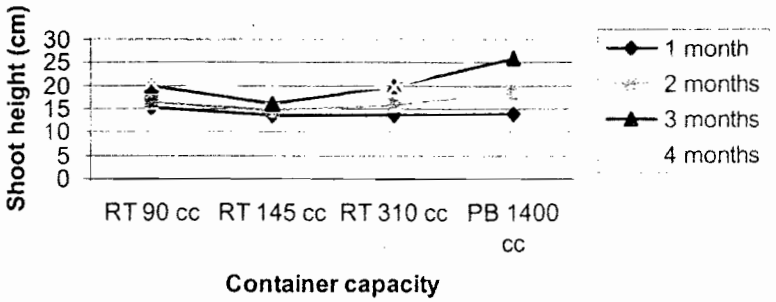


Fig. 27. Shoot biomass of *Swietenia mahagoni* seedlings in different containers

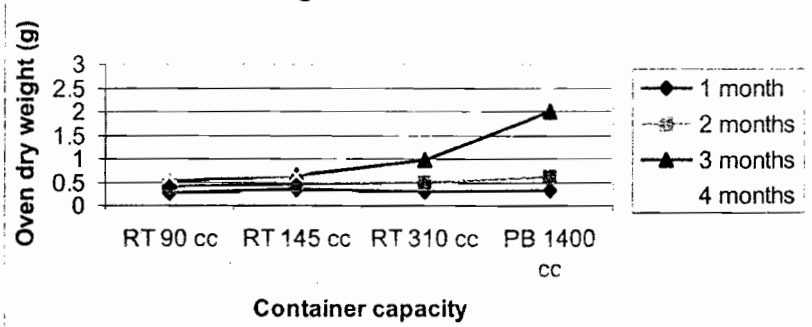
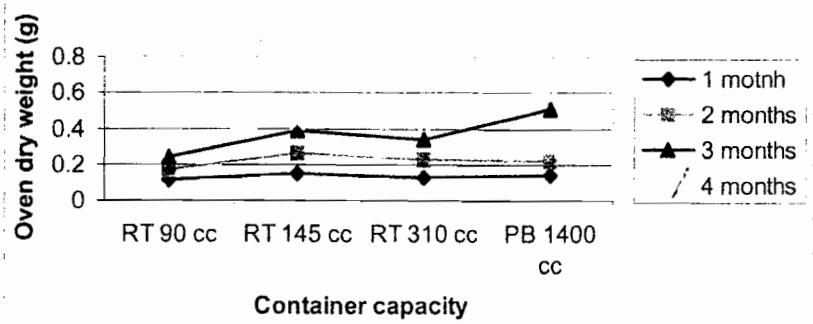


Fig. 28. Root biomass of *Swietenia mahagoni* seedlings in different containers



As compared to *S. macrophylla,* seedling growth was comparatively slower for *S. mahagoni.* Of the three types of root trainers used (90 cc, 145 cc and 310 cc), large sized root trainer (310 cc) gave maximum growth (Fig. 29). Although, seedlings in polythene bags were superior in terms of height and biomass than root trainers, seedlings of plantable quality can be produced in root trainers also.

The phycitid, *Hybsipyla robusta* Moore that attacks the flowers, seeds and seedlings is considered as a potential pest of seeds and seedlings.

Fig. 29a Six months old *Swietenia mahagoni* in polybag

Fig. 29b. Six months old *Swietenia mahagoni* in 310 cc root trainer

Fig. 29c Root system of polybag seedling

Fig.29d. Root system of root trainer seedling

4.7. *Lagerstroemia microcarpa* Wt.

Seed characteristics and dry seed examination: *Lagerstroemia microcarpa* seeds collected from Nilambur and Walayar during 1998 and 1999 seeding seasons were utilized for the study. Categorization of seeds based on their external appearance revealed that the percentages of discoloured seeds in seedlots from Walayar (1999), Nilambur (1998), Nilambur (1999) were 26.15%, 7.75% and 14.4% respectively. The percentages of deformed seeds in those seedlots were 6.15%, 1.6% and 15% respectively. Insect infestation on seeds was noticed only in seedlot from Walayar 95%. The percent moisture content in seeds varied from 8.11-11.17%. Dry seed examination showed fungal fructifications as well as fungal mycelial mats on seeds. Severe actinomycetes infestation was recorded on seeds from Walayar.

Seed microflora: In blotter test, spermoplane microflora comprising of 23 fungi belonging to 19 genera and actinomycetes was detected (Table 40). Though, percent seed infestation ranged from 56.80 to 93.85 in different seedlots from different localities, severe infestation was recorded only on a few seeds. In seedlot from Walayar, severe infestation with *Fusarium semitetum, Colletotrichum* sp., and Actinomycetes was recorded (Fig. 30). Actinomycetes were recorded in very high frequency (90%). In seedlots from Nilambur (1998) severe infestation with *Aspergillus niger* was recorded. *Alternaria* sp., *Fusarium oxysporum* and *Curvularia* sp., caused severe infestation in seedlots from Nilambur (1999). The total percent seed infestation was 86.50%. *Alternaria* sp., *Ascochyta* sp.. *Colletotrichum gloeosporioides, Curvularia* sp., *Drechslera* sp., *Fusarium* spp., *Helminthosporium* sp., and *Phoma* sp., were the important field fungi recorded on seeds from different localities (Table 41). Agar plate method yielded only a few fungi and of these *Phoma*

sp., *Colletotrichum* and *Curvularia* sp., are the important ones and seem to be seed borne. Percent seed infestation was 24. In all the treatments comparatively low percent seed germination was obtained (0-11%). Earlier, Mohamed Ali and Sharma (1989) recorded *Aspergillus niger* and bacteria on seeds of *L. microcarpa*.

Seed dressing with fungicides: Seed dressing with Captan (@ 5 g/kg seeds) and Thiride (@ 4 g/kg seeds) were carried out and the effect on spermoplane microflora studied. Seeds dressed with Captan showed low percent seed infestation (11%) than that with Thiride (17%).

Table 40. Spermoplane microorganisms detected on seeds of *Lagerstroemia microcarpa* by blotter method and their percent incidence

Sl.No.	Microorganisms	Blotter method % incidence			Agar plate
		WR1999	NBR1999	NBR 1998	NBR 1999
		NSS	NSS	NSS	A
1	*Alternaria* sp.	0.75	6.00		
2	*Ascochyta* sp.		2.25		
3	*Aspergillus* spp.	1.50	1.75	21.60	
4	*A. flavus*				1.00
5	*A. niger*			9.70	
6	*Bipolaris* sp.		1.00		
7	*Botryodiplodia theobromae*	1.90	0.75		
8	*Cephalosporium* sp.	0.75	0.75		
9	*Chaetomium* sp.	1.50	0.75	11.20	
10	*Chlamydomyces palmarum*	1.90			
11	*Cladosporium* sp.	0.40	0.50		
12	*Colletotrichum gloeosporioides*	11.90	1.75	1.60	3.00
13	*Curvularia* sp.	3.00	8.00	0.80	4.00
14	*Drechslera* sp.		15.50	6.40	
15	*Fusarium oxysporum*		12.50		
16	*F. semitectum.*	5.00			
17	*Helminthosporium* sp.	0.40	0.75	11.20	
18	*Penicillium* spp.	4.20		11.20	
19	*Pestalotia* sp.			2.40	4.00
20	*Phoma* sp.	3.00	1.50	2.40	
21	*Trichoderma viride*		13.00	0.80	9.00
22	*T.* sp.	16.50			
23	Mycelia sterilia			0.80	56.80
24	Actinomycetes	90.00	1.50		4.00
	% seed germination	11.00	9.50		7.00
	% seed infestation	93.84	86.50		24.00

*NSS: non-surface sterilized;WR: Walayar; NBR: Nilambur; A: agar plate method

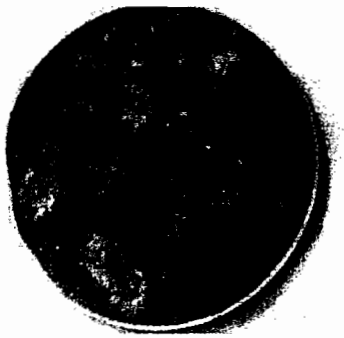


Fig. 30. Seeds of *Lagerstroemia microcarpa* in blotters

4.8. *Pongamia pinnata* (L.) Pierre

Seed characteristics and dry seed examination: *Pongamia pinnata* seeds collected from Perinthalmanna (Nilambur Forest Division) during 1999 seeding season were utilized for the study. Seeds were categorized into apparently healthy, discoloured and deformed (Fig. 31a). The percentage of discoloured and deformed seeds in the seedlot was 6.9% and 2.69% respectively. Insect infestation was observed on 6.5% seeds. Seed moisture content determined by oven dry method was 16.32%. Dry seed examination revealed bacterial ooze, mostly from the shrunken and discoloured seeds. Conidial masses of *Aspergillus* spp. were also recorded.

Seed microflora: *Pongamia pinnata* seeds in blotter test, were found to be harboured by 14 fungi belonging to 11 genera (Table 41). Total seed infestation was found 36.50%. Storage fungi belonging to the genera *Aspergillus* and *Trichoderma* were the most predominant spermoplane fungi with about 68.5% incidence. *Botryodiplodia theobromae, Colletotrichum gloeosporioides, Curvularia lunata, Drechslera* sp., *Fusarium* sp., *Helminthosporium* sp., etc. are the important field fungi detected on seeds. Among these, *Fusarium* sp., occurred in high frequency and the severely affected seeds failed to germinate and became rotten. Severe seed infestation with

Aspergillus sp., also caused seed rot (Fig. 31b). Percent seed germination was low (36.50%) and severe infestation with storage fungi was found responsible for the low germinability and seed rot. Earlier, Thapar (1989) has recorded a few spermoplane microbes on *P. pinnata*.

Growing-on test: Emerging seedlings in sterilized perlite medium showed infection on radicle and plumule. *Aspergillus* spp., were found associated with the seed rot and emerging radicle rot.

Table 41. Spermoplane microorganisms detected on seeds of *Pongamia pinnata* by blotter method and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence	
		No. of seeds infected	NSS
1	*Aspergillus* spp.	11	5.50
2	*A. flavus*	25	12.50
3	*A. versicolor*	26	13.00
4	*A. niger*	50	25.00
5	*Botryodiplodia theobromae*	20	10.00
6	*Colletotrichum gloeosporioides.*	4	2.00
7	*Curvularia lunata*	9	4.50
8	*Diplodia* sp.	1	0.50
9	*Drechslera* sp.	5	2.50
10	*Fusarium* sp.	27	13.50
11	*Memnoniella* sp.	5	2.50
12	*Helminthosporium* sp.	2	1.00
13	*Sporothrix* sp.	2	1.00
14	*Trichothecium* sp.	25	12.50
15	Actinomycetes	9	4.50
	% seed germination	36.50	
	% seed infestation	84.50	

*NSS: non-surface sterilized

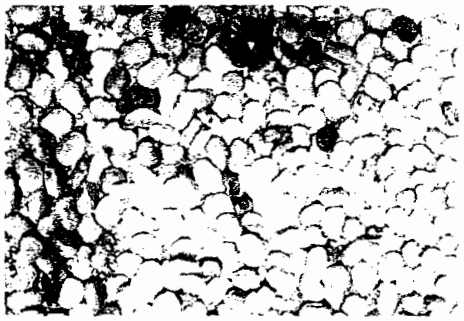


Fig. 31a. *Pongamia pinnata* seeds

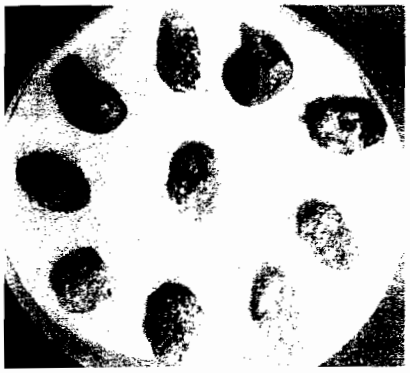


Fig. 31b. Seeds in blotter test. Note the severe infestation with the spermoplane microbes

4.9. *Grewia tiliifolia* Vahl

Seed characteristics and dry seed examination: *Grewia tiliifolia* seeds collected from Thrissur (Thrissur Forest Division) during 1999 seeding season were used for the study. Categorization of seeds showed 15% discoloured seeds, 11.78% deformed and shrunken seeds, and 0.7% insect infested seeds. Seed moisture content determined by oven dry method was 14.63%. Fungal mycelial mat was observed on discoloured and shrunken seeds.

Seed microflora: *Grewia tiliifolia* seeds were harboured by a rich spermoplane microflora consisting of 23 fungi, a bacterium and actinomycetes. Total percent seed infestation was 60.71%. Percent incidence of storage fungi and their severity of infestation were comparatively lower than that of field fungi (Table 42). *Graphium* sp., *Fusarium* sp., and *Torula herbarum* occurred in high frequency. Incidence of bacterial infestation was also found to be very high (12.5%). Hot water treatment of seeds effectively reduced the percent incidence of storage fungi. However, a large number of field fungi like *Corynospora* sp., *Curvularia lunata, Cylidnrocladium* sp., *Fusarium* sp., *Myrothecium* sp., *Phoma* sp., *Phomopsis* sp., *Verticillium* sp., were

encountered on the treated seeds. *Fusarium* sp., *Phoma* sp., and bacteria were found to be associated with the seed rot. Earlier, spermoplane microflora of the species was studied in detailed and recorded a few fungi (Mohanan and Sharma, 1991; Mohamed Ali and Sharma, 1989).

Table 42. Spermoplane microorganisms detected on seeds of *Grewia tiliifolia* by blotter method and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence	
		No. of seeds infected	NSS HW
1	*Arthrobotrys* sp.	7	2.5
2	*Aspergillus* spp.	6	2.14
3	*A. niger*	1	0.35
4	*Balanium* sp.	2	0.71
5	*Cephalosporium* sp.	2	0.71
6	*Chaetomium sp.*	4	1.42
7	*Chalara* sp.	2	0.71
8	*Corynespora* sp.	2	0.71
9	*Curvularia lunata*	8	2.85
10	*Cylindrocladium* sp.	4	1.42
11	*Fusarium* sp.	21	7.50
12	*Graphium* sp.	33	11.78
13	*Myrothecium* sp.	5	1.78
14	*Paecilomyces* sp.	7	2.5
15	*Penicillium* spp.	27	9.64
16	*Phoma* sp.	8	2.85
17	*Phomopsis* sp.	3	1.07
18	*Stachybotrys* sp.	9	3.21
19	*Torula herbarum*	19	6.78
20	*Trichoderma* sp.	5	1.78
21	*Verticillium* sp.	3	1.07
22	Mycelia sterilia	24	8.57
23	Unidentified fungi	3	1.05
24	Actinomycetes	9	3.21
25	Bacteria	35	12.5
	% seed germination	6.07	
	% seed infestation	60.71	

*NSS: non-surface sterilized: HW: hot water treatment

4.10. *Terminalia bellirica* Roxb.

Seed characteristics and dry seed examination: *Terminalia bellirica* seeds collected from Nilambur (Nilambur Forest Division) and Peechi (Thrissur Forest Division) during 1998 and 1999 seeding seasons were utilized for the study. Fruit characteristics were studied and seeds were extracted. Based on the seed characteristics, seeds were categorized. Discoloured and deformed seeds were found 4% and 9% respectively in Nilambur 1999 seedlot, and 6% and 11.5% respectively in Thrissur 1999 seedlot. Insect infestation was high in both the seedlots from Nilambur and Thrissur, which ranged from 11 to 13.5%. Moisture content (MC) in seeds ranged from 8.45 to 10.5%. Dry seed examination revealed fungal fructification, hyphal mats and insect's faecal matters.

Seed microflora: *Terminalia bellirica* seeds were found harboured by 17 spermoplane microorganisms. Fungi belonging to 10 genera, a bacterium and actinomycetes were the microbes encountered on seeds under different treatments (Fig. 32). In blotter test, only eight fungi were recorded, of which *Aspergillus niger* occurred in high frequency (63.25%). *Colletotrichum gloeosporioides*, *Fusarium* sp., *Phoma* sp., and *Periconia* sp., were the important spermoplane organisms recorded. In surface sterilized seeds only five fungal species and a bacterium were recorded. Bacteria were found associated mostly with shrunken and discoloured seeds and also caused rot. *Aspergillus niger* was found associated with most of the seeds in all the treatments and its percent incidence ranged from 25 to 100 (Table 43). In non-surface sterilized seeds its percent incidence ranged from 63.75 to 100. The intensity of infestation was also very high and in most cases it caused seed rot. In agar plate technique, *Fusarium* sp., was encountered in high frequency (13%) in 1999 seedlot

from Nilambur. Percent seed infestation by different microbes in various seed samples ranged from 58 to 100% (Table 44) and also affected the seed germination. The highest percent (65.50%) of seed germination was obtained in surface sterilized seeds from Nilambur 1999 seedlot.

Growing-on test: Seedlings raised in sterilized perlite medium showed radicle rot caused by *Aspergillus* sp., and *Fusarium* sp.

Table 43. Spermoplane microorganisms detected on extracted seeds of *Terminalia bellirica* by blotter and agar methods and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence			Agar method %incidence	
		NBR 1999 seedlot		NBR 1998 seedlot	NBR 1999 seedlot	TCR 1999 seedlot
		NSS	SS	NSS	A	A
1	*Aspergillus* spp.	11.25	3.50		9.00	
2	*A. flavus*			4.00		
3	*A. niger*	63.25	64.50	100	52.00	25.00
4	*A. restrictus*					5.00
5	*Colletotrichum gloeosporioides*	2.25	4.50		1.00	1.00
6	*Fusarium* sp.	4.25	3.50		13.00	
7	*F. moniliforme*					6.00
8	*Mucor* sp.	1.25				
9	*Penicillium* spp.					21.00
10	*Periconia* sp.	3.00				2.00
11	*Phoma* sp.	1.50			2.00	
12	*Phomopsis sp.*					1.00
13	*Trichoderma* sp.		6.00			
14	*T. viride*					
15	Mycelia sterilia	1.00		12.00		
16	Bacteria		4.00	6.00	2.00	4.00
17	Actinomycetes		1.50	12.00	2.00	4.00

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method

Table 44. Percent seed germination and percent infestation of *Terminalia bellirica* seeds with different pre-treatments

Locality and seedlot	% seed germination			% seed infestation		
	NSS	SS	A	NSS	SS	A
Nilambur 1998 seedlot	20.00			100		
Nilambur 1999 seedlot	41.00	65.50	58.00	88.25	77.00	74.00
Thrissur 1999 seedlot			37.00			58.00

*NSS:non-surface sterilized; SS:surface sterilized; A: agar plate method

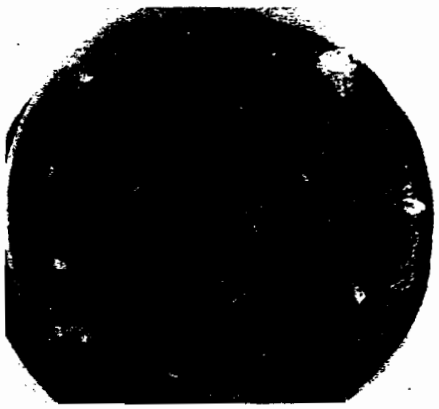


Fig. 32. Extracted seeds of *Terminalia bellirica* plated on blotters

4.11. *Xylia xylocarpa* Taub.

Seed characteristics and dry seed examination: *Xylia xylocarpa* seeds collected from Nilambur Division during 1998 and 1999 seeding seasons were utilized for the study. Characterization of seeds based on external appearance revealed a high percentage of discoloured and deformed seeds in 1998 seed lots, 31.5% and 26% respectively. Discoloured and deformed seeds in 1999 seedlot were 27.66% and 36% respectively. Percentage of insect infested seeds was 3.66%. Dry seed examination revealed fructifications of fungi and mycelial mats mostly associated with discoloured and deformed seeds.

Seed microflora: *Xylia xylocarpa* seeds collected during 1998 and 1999 seeding seasons tested by blotter method were found harboured by a rich microflora. A total of 27 fungi belonging to 20 genera were found associated with the seeds, besides bacteria and actinomycetes. Storage fungi like *Aspergillus* spp., *Penicillium* sp.,

Chaetomium globosum, Rhizopus sp., *Trichoderma* sp., are the predominant microbes. A total of 8 *Aspergillus* spp., were found associated with the seeds. Among the field fungi, *Botryodiplodia theobromae, Colletotrichum gloeosporioides, Cylindrocladium quinqueseptatum, Fusarium* sp., etc., are the important ones (Table 45). Seeds from 1999 seed lot harboured more number of microbes than that of 1998 seedlot. Surface sterilization considerably reduced the number as well as percent incidence of microbes on seeds. Besides fungi, bacteria and actinomycetes were the other frequently encountered microbes on *Xylia* seeds. Actinomycetes occurred on non-surface sterilized and surface sterilized seeds and their percent incidence was 22.33 and 19 respectively. In agar plate technique only six fungi belonging to five genera were recorded. *Colletotrichum gloeosporioides* and *Fusarium* sp., detected on seeds were suspected to be seed borne and their percent incidence was 8 and 12 respectively. Spermoplane microflora severely affected the germinability of seeds. In 1998 seedlot about 48% seed germination was recorded while in 1999 seedlot 3.33% seed germination was obtained (Table 46). Among the spermoplane microbes, storage fungi and bacteria are the important ones, which adversely affected the seed germination and seedling growth.

Growing-on test: Seedlings raised in sterilized perlite medium showed foliage infection caused by *Colletotrichum gloeosporioides* and collar rot caused by *Fusarium* sp.

Seed dressing: Seed dressing with fungicide (Captan @ 5 g/kg seeds and Thiride @ 4 g/kg seeds) was effective in reducing the spermoplane fungal flora. Captan treatment was more effective than the Thiride treatment.

Table 45. Spermoplane microorganisms detected on extracted seeds of *Xylia xylocarpa* by blotter and agar methods and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence			Agar method %incidence
		NBR '98 SL	NBR '99 SL		NBR'98 SL
		NSS	NSS	SS	A
1	*Aspergillus* spp.	15.75		3.00	
2	*A. candidus*		4.00	3.00	
3	*A. clavatus*			4.50	
4	*A. flavus*		2.33		13.00
5	*A. fumigatus*		2.33	1.00	
6	*A. niger*	46.00	5.66	5.00	11.00
7	*A. ochraceus*		3.00	3.00	
8	*A. restrictus*		3.00	0.50	
9	*Botryodiplodia theobromae*		4.33	3.00	
10	*Cephalosporium* sp.		1.33		
11	*Chaetomium globosum*	8.00	1.66	2,50	8.00
12	*Colletotrichum gloeosporioides*		1.00	0.50	4.00
13	*Cylindrocladium quinqueseptatum*	4.50	2.00	2.50	
14	*Curvularia* sp.		1.00	0.50	
15	*Fusarium* sp.		4.33	1.00	12.00
16	*Fusariella* sp.		2.00		
17	*Mucor* sp.	2.25			
18	*Paecilomyces* sp.		0.66	0.50	
19	*Penicillium* spp.		8.00	10.50	2.00
20	*Periconia* sp.		4.33	1.50	
21	*Pestalotia* sp.	4.00			
22	*Pestalotiopsis* sp.		1.00		
23	*Rhizopus* sp.	2.00		2.00	
24	*Sclerotium* sp.		0.66	0.50	
25	*Trichoderma viride*	3.00	3.30	4.50	
26	*Trichothecium* sp.		1.00		
27	Mycelia sterilia		0.66	1.00	
28	Bacteria	2.50	8.00	6.00	
29	Actinomycetes		22.33	19.00	

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method

Table 46. Percent seed germination and percent infestation of *Xylia xylocarpa* seeds with different pre-treatments

Locality and seedlot	% seed germination			% seed infestation		
	NSS	SS	A	NSS	SS	A
Nilambur 1998 seedlot	48.00		41.00	81.00		50.00
Nilambur 1999 seedlot	3.33	8.00		71.00	70.00	

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method

4.12. *Pterocarpus marsupium* Roxb.

Seed characteristics and dry seed examination: *Pterocarpus marsupium* seeds collected from Nilambur and Vazhachal Forest Divisions during 1999 seeding season were utilized for the study. Seed categorization based one external appearance revealed deformed and shrunken seeds (15.25%) and insect infested seeds (9.75%) in the Vazhachal seedlot. In seedlot from Nilambur discoloured seeds were 10% and deformed seeds were 21%. No insect infestation was noticed in this seedlot. Moisture content of the seeds from the two areas ranged from 20 to 21.07%. Dry seed examination showed presence of fungal mycelium and fructifications, especially of *Chaetomium* sp., and *Phoma* sp.

Seed microflora: Seeds of *Pterocaprus marsupium* harboured a rich microflora comprising of 36 fungi, a bacterium and actinomycete (Fig. 33a-h). Among the fungi, most of them were recorded on non- surface sterilized seeds. Seeds from Nilambur recorded more number of microbes than that from Vazhachal. Typical storage organisms like *Aspegillus* sp., and *Penicillium* spp., were less in both the seed lots. Interestingly, a large number of field fungi like *Alternaria* sp., *Bipolaris* sp., *Corynospora* sp., *Colletotrichum gloeosporioides*, *Cylindrocladium* spp., *Curvularia lunata*, *Dactylaria, Drechslera, Fusarium* sp., *Myrothecium* sp., *Phoma* sp., etc., were recorded on seeds in blotter test. Species of *Cylindrocladium*, viz., *C. quinqueseptatum. C. parvum, Cylihndrocladium* sp., and an unidentified species, were recorded on non-sterilized and sterilized seeds. *Phaeoisaria* sp., *Torula herbarum* and *Cylindrocladium parvum* were the most frequently encountered fungi and their percent incidence in non-surface sterilized seeds (blotter) was 18.50. 15.75 and 8% respectively (Table 47). Surface sterilization reduced the incidence of total number of

spermoplane microflora to 13 fungi and also reduced the percent frequency of the fungi. In agar plates, *Cylindrocladium quinqueseptatum, Fusarium moniliforme* and *F. oxysporum, Phoma* sp., and *Torula herbarum* were the important fungi encountered. Hot water treatment given for enhancing the seed germination, also affected the spermoplane microfloral number as well as their percent incidence.

Growing-on test: Growing on test carried out employing the seeds from Nilambur showed infection on emerging cotyledons and radicle. *Fusarium* sp., and *Alternaria* sp., were isolated from the affected tissues. Seedling blight of 20-35-day-old seedlings caused by *Colletotrichum gloeosporioides* and bacteria was recorded in perlite-raised seedlings.

Seed pre-treatment: Seed germination percent ranged from 15.5 to 41% in different treatments. Highest germination was recorded in seedlot from Nilambur. Surface sterilizaiton and then washing the seeds with cold water enhanced the germination (Table 48). Hot water treatment of the seed lot from Vazhachal gave only 23% germination.

Seed dressing: Seed dressing with the fungicides, Captan and Thiride was effective in reducing the spermoplane microflora. Captan @ 4g /kg seeds treatment was more effective and reduced the total seed infestation to 18%.

Table 47. Spermoplane microorganisms detected on seeds of *Pterocarpus marsupium* by blotter and agar methods and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence			
		NBR '99 seedlot			Vazhachal '99SL
		NSS	SS	A	HW
1	*Alternaria* sp.	1.75			
2	*Arthrobotrys* sp.	2.50			
3	*Aspergillus* spp.		2.50	8.50	8.00
4	*A. clavatus*		0.50		
5	*A. flavus*		2.00		
6	*A. niger*				10.50
7	*Bipolaris* sp.	1.00			
8	*Cephalosporium* sp.	0.50	4.00		
9	*Chaetomium* sp.	1.00			13.50
10	*Cladosporium* sp.	0.75			1.50
11	*Corynespora* sp.	0.50			
12	*Colletotrichum gloeosporioides*	1.25			3.50
13	*Cylindrocladium quinqueseptatum*			1.75	
14	*C. parvum*	8.00	2.00		
15	*Cylindrocarpon* sp.	2.50			
16	*Curvularia lunata*	4.75	2.00	6.00	1.00
17	*Dactylaria* sp.	0.75			
18	*Drechslera* sp.				2.00
19	*Fusarium oxysporum*	4.75	7.50	7.75	
20	*F. moniliforme.*			1.75	5.50
21	*Graphium* sp.	0.75	4.00		4.00
22	*Gyrothrix* sp.	0.50			
23	*Myrothecium* sp.				2.50
24	*Memnoniella* sp.				1.50
25	*Mucor* sp.	0.25		20.65	
26	*Penicillium* spp.		4.00	18.95	
27	*Periconia* sp.			1.75	
28	*Phaeoisaria* sp.	18.50	2.50		
29	*Phoma* sp.	2.50	2.00	0.85	4.50
30	*Pithomyces* sp.	1.25			
31	*Rhizoctonia* sp.		1.00		
32	Unidentified fungus	0.50			
33	*Torula herbarum*	15.75	8.00	5.00	
34	*Trichoderma viride*			3.40	3.50
35	*Verticillium* sp.			1.70	
36	Mycelia sterilia	2.75			
37	Bacteria			6.00	4.00
38	Actinomycetes	1.50		0.85	1.50

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method; HW: hot water treatment

Table 48. Percent seed germination and percent infestation of *Pterocarpus marsupium* seeds with different pre-treatments

Locality and seedlot	% seed germination				% seed infestation			
	NSS	SS	A	HW	NSS	SS	A	HW
Nilambur 1999 seedlot	32.75	41.00	15.50		74.50	37.50	67.25	
Vazhachal 1999 seedlot	23.00			23.00				58

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method; HW: hot water treatment

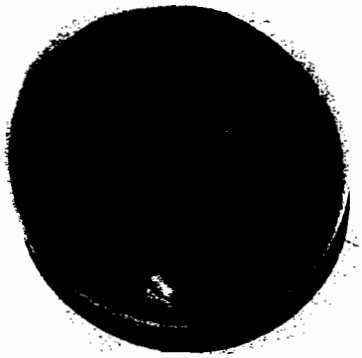


Fig. 33a. Seeds of *Pterocarpus marsupium* in blotters

Fig. 33b. *Curvularia tuberculata* on *P. marsupium* seeds

Fig. 33c. *Curvularia lunata* on *P. marsupium* seeds

Fig. 33d. *Phaeoisaria* sp. on *P. marsupium* seeds

Fig. 33e. *Abgleophragma* sp. on *P. marsupium* seeds

Fig. 33f. *Torula* sp. on *P. marsupium* seeds

Fig. 33g. *Cylindrocladium quinqueseptatum* on *P. marsupium* seeds

4.13. *Cassia fistula* L.

Dry seed examination: *Cassia fistula* seeds collected from Nilambur (Nilambur Forest Division) and Wadakkancherry (Olavakkod Forest Division) during 1998 and 1999 seeding seasons were utilized for the study. Seedlot from Nilambur showed discoloured and deformed seeds 9% and 12% respectively. While in seedlot from Wadakkancherry discoloured and deformed seeds were found 1.5% and 6% respectively. Seed moisture content in both the seedlots was 14.72%. One kilogram weighs about 831 seeds and the seed length ranged from 5-7 mm and seed width 5-7 mm. Dry seed examination revealed fungal mycelium and fungal fructifications on the seed surface, especially on discoloured and shrivelled seeds.

Seed microflora: A total of 10 fungal genera and a bacterium were detected on seeds of *Cassia fistula* tested by blotter method. Non-surface sterilized seeds yielded 8 fungi while seed pre-treated with concentrated sulphuric acid showed incidence of five fungi. Percent incidence of microorganisms in both the treatments was low and ranged from 1.00 to 17.00. *Aspergillus* spp., *Chaetomium* sp., *Mucor* sp., *Penicillium* spp., *Trichoderma* sp., etc., were the storage fungi encountered. Field fungi like *Dactylaria* sp., *Fusarium* sp., *Periconia* sp., etc were detected on non-surface sterilized seeds. In acid treated seeds, only *Fusarium* sp., was detected with 5.00% incidence and may possibly be seed-borne. *Fusarium* sp., was found associated mostly with shrunken seeds and all such infected seeds became rotten. *Aspergillus niger* was found associated mostly with the discoloured seeds (Table 49). Earlier spermoplane microflora of *C. fistula* was studied by many workers (Randhawa *et al.*, 1981. Mittal and Sharma, 1981, Tiwari and Sharma. 1981) and recorded a large number of fungi.

Growing-on test: Though, fungus like *Fusarium* sp. was suspected to be seed-borne, no seedling infection was noticed in emerged seedlings in growing-on test.

Seed pre-treatment: Concentrated sulphuric acid pre-treatment for 20 min gave 58% seed germination, while seeds without any pre-treatment showed only 13.5% germination. Seed pre-treatment also reduced the number and intensity of infestation by spermoplane microorganisms, especially by field fungi.

Table 49. Spermoplane microorganisms detected on seeds of *Cassia fistula* by blotter method and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence	
		Wadakkencherry '99	Nilambur '98
		NSS	A
1	*Aspergillus* spp.		17.00
2	*A. nidulens*	2.00	
3	*A. niger*	5.00	15.00
4	*Chaetomium* sp.		6.00
5	*Dactylaria* sp.	2.50	
6	*Fusarium* sp.	5.50	5.00
7	*Mucor* sp.		4.00
8	*Nigrospora* sp.	1.00	
9	*Penicillium* spp.	3.50	
10	*Periconia* sp.	5.50	
11	*Trichoderma* sp.	4.00	
12	Mycelia sterilia		4.00
13	Bacteria		8.00
	% seed germination	13.50	58
	% seed infestation	35.50	53

*NSS: non-surface sterilized; A: conc. sulphuric acid treatment

4.14. *Wrightia tinctoria* (Roxb.) R. Br.

Seed characteristics and dry seed examination: Seeds of *Wrightia tinctoria* collected from Karulai (Nilambur Forest Division) during 1998 and 1999 seeding seasons were utilized for the study. In 1999 seedlot, the discoloured seeds were 4% and shrunken and deformed seeds were 8%. Moisture content ranged from 14.9 to 28.13%. Fungal fructifications and mycelial mats were not detected in dry seed examination.

Seed microflora: A total of 9 spermoplane microorganisms were detected on seeds of *Wrightia tinctoria* in blotter test (Figures 34a & b). Non-surface sterilized seeds from 1998 seedlot recorded more number of microbes as well as their higher frequency of occurrence. Storage fungi belonging to the genera *Aspergillus*, *Penicillium* and *Chaetomium* were the predominant ones and recorded a high frequency of occurrence (79%) in seeds from 1998 seedlot. However, their frequency of occurrence was low 13.50%) in seeds from 1999 seedlot (Table 50). *Fusarium* sp. was the only field fungi recorded on seeds in 1998 seedlot and the corresponding percent incidence was 40. Most seeds severely infested with *Fusarium* spp., became rotten. Severe infestation with the storage fungi was the other possible reason for the failure of germination on most of the seeds tested. *Curvularia eragrostidis* was the important fungus associated with the seeds of 1999 seedlot. Seedling cotyledon rot caused by *Curvularia* sp., was noticed in blotter test. Surface sterilization reduced the microflora considerably and the percent seed infestation was reduced from 100 to 3%. Seed germination also slightly enhanced in surface sterilized seeds (99.5%).

Growing-on test: Emerged seedlings in growing-on test exhibited no infection. All the seedlings were healthy and well developed.

Table 50. Spermoplane microorganisms detected on seeds of *Wrightia tinctoria* by blotter method and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence		
		NBR1998	NBR1999	
		NSS	NSS	SS
1	*Aspergillus* spp.	29.00		
2	*A. niger*	28.00	9.50	1.00
3	*Chaetomium* sp.	4.00		
4	*Curvularia eragrostidis.*		4.50	1.50
5	*Fusarium* sp.	40.00	1.75	
6	*Penicillium* sp.	20.00	4.00	
7	*Trichoderma* sp.	4.00		0.50
8	*Mycelia sterilia*	2.00	1.75	
9	Bacteria	5.00		
	% seed germination		97.00	99.50
	% seed infestation	100.00	21.00	3.00

*NSS: non-surface sterilized; NBR: Nilambur

Fig. 34a. *Wrightia tinctoria* fruits and seeds

Fig. 34b. *W. tinctoria* seeds in blotter test

Table 50. Spermoplane microorganisms detected on seeds of *Wrightia tinctoria* by blotter method and their percent incidence

Sl. No.	Microorganisms	Blotter method % incidence		
		NBR1998	NBR1999	
		NSS	NSS	SS
1	*Aspergillus* spp.	29.00		
2	*A. niger*	28.00	9.50	1.00
3	*Chaetomium* sp.	4.00		
4	*Curvularia eragrostidis*.		4.50	1.50
5	*Fusarium* sp.	40.00	1.75	
6	*Penicillium* sp.	20.00	4.00	
7	*Trichoderma* sp.	4.00		0.50
8	*Mycelia sterilia*	2.00	1.75	
9	Bacteria	5.00		
	% seed germination		97.00	99.50
	% seed infestation	100.00	21.00	3.00

*NSS: non-surface sterilized; NBR: Nilambur

Fig. 34a. *Wrightia tinctoria* fruits and seeds

Fig. 34b. *W. tinctoria* seeds in blotter test

4.15. *Holoptelia integrifolia* (Roxb.) Planch.

Seed characteristics and dry seed examination: *Holoptelia integrifolia* seeds collected from Nilambur (Nilambur Forest Division), Thaliparamba (Kannur Forest Division), and Dhoni (Olavakkod Forest Division) during 1998 and 1999 seeding seasons were used for the study. The categorization of seeds in various seedlots showed that discoloured seeds ranged from 10% to 17% and the deformed seeds ranged from 9.3% to 16%. Insect infested seeds in various seedlots ranged from 1.25% to 21%. Percent moisture content of seeds in different seed sample also varied from 16.35 to 20.01%. Discolouration of seeds was associated with fungal mycelial mat and fructifications.

Seed microflora: A rich spermoplane microflora comprising of 33 fungi, a bacterium and actinomycetes was detected on seeds of *Holoptelia integrifolia* belonging to different seedlots (Figures 35a-c). A fairly large number of storage and field fungi were detected on non-surface sterilized seeds of Kannur 99 seedlot. *Alternaria* spp., *Cercospora* sp., *Colletotrichum* sp., *Curvularia* spp., *Fusarium oxysporum*. *Myrothecium* sp., *Phoma* sp., *Phomopsis* sp., etc., are the important field fungi detected on both surface sterilized and non-surface sterilized seeds. Interestingly, a high percent (25%) incidence of actinomycetes was recorded on non-surface sterilized seeds of 1999 seedlot from Kannur. Severe infestation with actinomycetes reduced the invasion by other microorganisms (Table 51). Even though, seed germination was not found affected with the actinomycete infestation, heavily infested seeds became rotten. *Drechslera australiensis*, was recorded on surface sterilized seeds (3.24%) and in agar plate (8%). Seedling cotyledon infection caused by *Drechslera australiensis* and radicle rot caused by *Alternaria* sp., were recorded. In agar plate, mostly field

fungi belonging to 9 genera were recorded. *Alternaria alternata* was recorded in high frequency (40%) followed by *Fusarium oxysporum* (33%) and *Curvularia* spp.. (17%). Seed germination in different seedlots ranged from 38.12% to 68% (Table 52). Percent seed infestation in different treatments ranged from 67.29 to 100.

Table 51. Spermoplane microorganisms detected on seeds of *Holoptelia integrifolia* by blotter and agar methods and their percent incidence

Sl No.	Microorganisms	per cent incidence				
		NBR98	KR'99 SL1	Dhoni 1999	KR'99 SL2	KR'99 SL1
		NSS	NSS	NSS	SS	A
1	*Alternaria alternata.*		7.50		9.43	40.00
2	*A.* sp.		4.37	8.00	1.88	
3	*Aspergillus* spp.	19.00	3.12	1.00		
4	*A. clavatus*			1.00		
5	*A. niger*	19.00	9.37	16.00		14.00
6	*Bispora* sp.				1.25	
7	*Cercospora* sp.		4.37			
8	*Chaetomella* sp.		1.25			
9	*Chaetomium* sp.	11.00	2.50	4.00		6.00
10	*Colletotrichum* sp.		4.00			3.00
11	*Cladosporium* sp.		3.75		0.62	8.00
12	*Curvularia* spp.	2.00		10.50	8.17	
13	*Curvularia spp.*		9.37		3.14	17.00
14	*Cylindrocladium* sp.				1.88	
15	*Drechslera australiensis*				3.14	8.00
16	*Drechslera* sp.	3.00				
17	*Fusarium* sp.			4.00	1.88	
18	*F. moniliforme*				10.69	
19	*F. oxysporum*		8.12			33.00
20	*Graphium* sp.		4.37		3.77	
21	*Helminthosporium* sp.					1.00
22	*Myrothecium* sp.		0.62			
23	*Nigrspora sphaerica*		6.25			
24	*N. oryzae*					4.00
25	*Paecilomyces* sp.	8.00			4.40	
26	*Penicillium* spp.		1.25	4.00	9.43	5.00
27	*Phomopsis* sp.		2.50		2.51	2.00
28	*Phoma* sp.		1.87			7.00
29	*Stachybotrys atra*		1.25			
30	*Torula* sp.				3.14	
31	*Trichoderma viride*			12.50		2.00
32	*Verticillium* sp.	2.00	0.62		1.25	
33	Mycelia sterilia	4.00				3.00
34	Bacteria	12.00	0.62			
35	Actinomycetes		25.00	85.50		6.00

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method; NBR: Nilambur; KR: Kannur; SL: seedlot

Table 52. Percent seed germination and percent infestation of *Holoptelia integrifolia* seeds under different treatments

Locality and seedlot	% seed germination			% seed infestation		
	NSS	SS	A	NSS	SS	A
Nilambur 1998 seedlot	0			69.00		
Dhoni 1999seedlot	65.00			100.00		
Kannur 1999 seedlot1	38.12			89.37		
Kannur 1999 seedlot2		37.10			67.29	
Kannur 1999 seedlot1			68.00			97.00

*NSS: non-surface sterilized; SS: surface sterilized; A: agar plate method

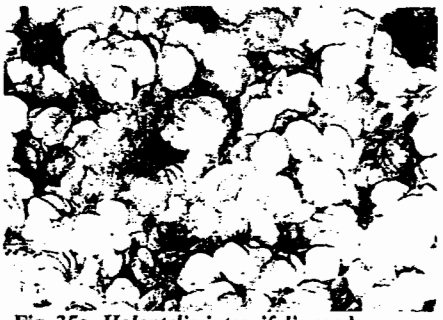


Fig. 35a. *Holoptelia integrifolia* seeds

Fig. 35b. Winged seeds in blotter test

Fig. 35c. De-winged seeds in blotter test; note the severe infestation with spermoplane microbes

5. CONCLUSIONS

5.1. *Hopea parviflora*

Flowering and fruiting season in *H.Parviflora* vary considerably between localities. In high rainfall localities such as, Iringole sacred grove (Seed zone KL-II), Nilambur. Dhoni and Parappa (KL-III) flowering starts in the month of January and the fruits mature and fall with the onset of South-west monsoon rains during May-June. On the other hand, in dry localities (Chinnar, KL-II) flowering occurs during April and the mature fruits fall in the month of August. Nearly 90% of the freshly collected seeds germinate. Nineteen fungi infest seeds falling on ground and no serious damage by insects recorded. For raising seedlings, seeds are de-winged before sowing. Seeds treated with fungicide (Bavistin @ 1 g/500 g) dusting can be stored at 18°C and 70% relative humidity for about two weeks with approximately with 70% viability. For production of seedlings, seeds are sown in plastic trays containing vermiculite. seedlings are potted in polybags of size 20 x 10 cm filled with the potting mixture of soil and sand at the ratio of 1:1. The growth of the seedlings is very slow. Seedlings are ready for planting after six months, by which time they attain a height of 13 cm. Seedlings can also be maintained in root trainers of 15 cm length and 310 cc capacity filled with the potting mixture soil: sand: compost (3:1:1) for more than one year. Seedlings raised in sterilized perlite medium showed foliar infection caused by *Collectotrichum gloeosporioides* and *Cylindrocladium quiqueseptatum*.

Vegetative propagation trials with branch cuttings of 0.2 to 0.3 cm diameter and 9 to 10 cm length after dipping basal end of 2 cm in IBA at 1000 ppm solution for one minute yielded up to 43% sprouting and rooting; this is a notable outcome of the

project. The sprouted cuttings are transferred to polybags of size 20 x 10 cm containing the potting mixture of soil and sand and maintained in the nursery for further growth.

5.2. *Melia dubia*

In *Melia dubia*, considerable variation has been observed in flowering and fruiting seasons between localities. In moist localities such as, Kulathupuzha (Seed zone KL-I), Peechi (KL-II) and Nilambur (KL-III), flowering starts in the month of January-February and the mature fruits fall during October-January. On the contrary, in dry areas (Chinnar, KL-II and Sholayoor, KL-III) flowering occurs during May-June and fruit matures in May. Generally, the trees shed their leaves when the fruits mature, and remain leafless for about two weeks. Soon after, young leaves appear along with the flowers.

Untreated seeds do not germinate easily due to hard endocarp. For raising seedlings, true seeds are extracted from the fruits or the fruits are split open and sown in vermiculite. The seedlings in two to three leaves are potted in polybags of size 22.5 cm x 17.5 cm or root trainers of 15 cm length and 310 cc capacity containing the potting mixture of soil: sand: compost (3:1:1). The growth of the seedlings is fast. The root growth is also fast; in three months the taproot grows up to 28 cm in polypots. The seedlings are ready for planting after three months in polybags when they attain 50 cm height. Root trainer seedlings can be kept upto six months in the nursery. Seed infestation by insects is high; about 112 beetles of a single species are found feeding on a single fruit. Nineteen fungi also infest seeds. Seeds surface sterilization with 0.01% mercuric chloride reduce disease incidence. Further, seedlings in the nursery

showed foliar infection caused by *Collectotrichum gloeosporioides* and collar rot by *Fusarium oxysporum*.

5.3.*Terminalia crenulata*

Generally, flowering of *T. crenulata* starts during May-June and the fruits take 8 months to mature. Seed collection commences during February and continues up to April. Three trees standing in KFRI campus at Peechi, which flowered during 1997, did not flower during in1998 but good seed crop occurred in the year 1999. Seed size and germination capacity also varies considerably between localities. About 400 (Agali) to 1370 (Erumely) seeds with wings intact weigh one kg. Further, seed germination varies from 3% (Dhoni) to 56% (Erumely). Pre-treatment of seeds by cold water soaking prior to sowing improves germination. Seeds can be stored up to two months under ambient room temperatures (29±2°C) and humidity (70%), with retention of 17% (54% initial viability) viability. A caterpillar causes moderate damage to seeds. Seeds are infested with fungi also. Seed dressing with fungicide (Captan @ 5 g/kg) was effective in reducing the microbes. Seedlings raised in sterilized perlite medium showed cotyledon rot caused by bacterium and leaf infection caused by *Colletotrichum gloeosporioides*. For seedling production, water soaked seeds are sown in vermiculite. Seedlings are potted in polybags of size 22.5 cm x 17.5 cm containing the potting mixture soil: sand: compost (3:1:1). The root growth is remarkably high; in three months the taproot grows up to 31 cm. The polybag-raised seedlings are ready for planting after three months when they are about 50 cm height.

5.4. *Terminalia paniculata*

The time of flowering and fruiting of *Terminalia paniculata* varies between localities. In moist localities such as Peechi (Seed zone KL-II), Vazhachal (KL-II) and Nilambur (KL-III), flowering starts during September-October where as in drier areas like Walayar (KL-III) flowering was during July-August. The fruits ripen in dry weather and available mostly during March-May. An important observation is the extremely low percentage of fertile seeds; more than 97% seeds are infertile. The flowers and young fruits are attacked by weevil, which probably causes ovule abortion. Seeds can be stored in a dry place at room temperature in cotton bags for about a year. Seed pre-treatment is not necessary. For raising seedlings, seeds are sown thickly in nursery bed to include maximum number of fertile seeds. The seedlings are potted in polybags of size 22.5 cm x 17.5 cm or root trainer of 15 cm length and 310 cc capacity containing the potting mixture soil: sand: compost (3:1:1). The seedlings are ready for planting after five months when they attain 50 cm height. The seedlings can be kept in polybag up to five months after which root coiling occurs. Root trainer raised seedlings can be kept in nursery for about six months.

5.5. *Swietenia macrophylla*

Considerable variations have been observed in the time of flowering and fruiting of *Swietenia macrophylla* between localities. In high rainfall localities, Thrissur (Seed zone KL-II) and Nilambur (KL-III), flowering and fruiting occur in October–May. Mature fruits are available for collection for about six months in different places all over Kerala, usually from October-April. The capsules are collected before they dehisce and processed without delay, as they are liable to be infested with fungi within 2-3 days after collection. The capsules are collected in cotton bags and loosely

packed during transport. Seeds are de-winged, dried thoroughly to low moisture content of about 4% and can be stored in air tight containers, preferably in sealed polybags under cold conditions (at 0°C) for one year with 87% viability. To assess the viability quickly, tetrazolium test (0.1%) may be employed. Embryos of viable seeds turn dark and light red whereas embryos of dead seeds do not stain. Damaged seeds show irregular and intensive red colour in embryo, cotyledon and endosperm.

A borer, *Hypsipyla robusta*, damages seeds. About 32 fungi are found on seeds. Seed dressing with Thiride (@ 4 g/kg seeds) and Captan (@ 5 g/kg seeds) reduced the fungal infestation.

For raising seedlings, the de-winged seeds are sown in vermiculite. Seedlings are potted in containers such as polybags (22.5 cm x 17.5 cm) and root trainers of 15 cm length and 310 cc capacity containing the potting mixture soil: sand: compost (3:1:1) within 45 days of germination. The seedlings are ready for planting after three months of potting. Root trainer seedlings can be kept up to one year in the nursery. Seedlings raised in nursery showed foliage infection caused by *Colletotrichum gloeosporioides*.

Vegetative propagation trials with branch cuttings of 0.4 to 0.7 cm diameters and 9 to 10 cm length after dipping in IAA at 1000 ppm solution for one minute produced 23% sprouting and rooting. The sprouted cuttings are transferred to polybags of size 22.5 x 17.5 cm containing the potting mixture soil and sand (1:1) for further growth.

5.6. *Swietenia mahagoni*

Flowering of *Swietenia mahagoni* occurs during March-April. The capsules ripen during February-March. The capsules are collected before they dehisce and processed immediately since they are infested with fungi within 2-3 days after collection. The

packed during transport. Seeds are de-winged, dried thoroughly to low moisture content of about 4% and can be stored in air tight containers, preferably in sealed polybags under cold conditions (at 0°C) for one year with 87% viability. To assess the viability quickly, tetrazolium test (0.1%) may be employed. Embryos of viable seeds turn dark and light red whereas embryos of dead seeds do not stain. Damaged seeds show irregular and intensive red colour in embryo, cotyledon and endosperm.

A borer, *Hypsipyla robusta*, damages seeds. About 32 fungi are found on seeds. Seed dressing with Thiride (@ 4 g/kg seeds) and Captan (@ 5 g/kg seeds) reduced the fungal infestation.

For raising seedlings, the de-winged seeds are sown in vermiculite. Seedlings are potted in containers such as polybags (22.5 cm x 17.5 cm) and root trainers of 15 cm length and 310 cc capacity containing the potting mixture soil: sand: compost (3:1:1) within 45 days of germination. The seedlings are ready for planting after three months of potting. Root trainer seedlings can be kept up to one year in the nursery. Seedlings raised in nursery showed foliage infection caused by *Colletotrichum gloeosporioides*.

Vegetative propagation trials with branch cuttings of 0.4 to 0.7 cm diameters and 9 to 10 cm length after dipping in IAA at 1000 ppm solution for one minute produced 23% sprouting and rooting. The sprouted cuttings are transferred to polybags of size 22.5 x 17.5 cm containing the potting mixture soil and sand (1:1) for further growth.

5.6. *Swietenia mahagoni*

Flowering of *Swietenia mahagoni* occurs during March-April. The capsules ripen during February-March. The capsules are collected before they dehisce and processed immediately since they are infested with fungi within 2-3 days after collection. The

capsules are preferably collected in cotton bags and should not be tightly packed during transport. Seeds are de-winged while extracting from the capsule. Seeds are dried thoroughly to low moisture content of about 3% and can be stored in airtight containers, preferably in sealed polybags under cold conditions (at 0°C) for more than one year. Stored seeds germinate quicker than the fresh seeds, indicating the after ripening process. To assess the viability quickly, tetrazolium test may be conducted. Seeds are attacked by *Hypsipyla robusta*. About 23 microbes were found on seeds. Seed dressing with Captan (@ 5 g/kg seeds) reduced the fungal infestation. For raising seedlings, the de-winged seeds are sown in vermiculite. Seedlings are potted in containers such as polybags (22.5 cm x 17.5 cm) and root trainer of 15 cm length and 310 cc capacity containing the potting mixture soil: sand: compost (3:1:1) after 45 days of germination. Growth of the seedlings is comparatively slower than *S. macrophylla*. The seedlings are ready for planting after three months of potting, raised in polybags by the time they attains 26 cm height. Root trainer seedlings can be kept up to one year in the nursery. Seedlings raised in nursery showed foliar and stem infection caused by *Colletotrichum gloeosporioides*. Leaf tip blight caused by *Alternaria* sp., was also noticed.

5.7. *Lagerstroemia microcarpa*

About 23 fungi belonging to 19 genera including *Alternaria* sp., *Colletotrichum* sp., *Curvularia*, etc., and actinomycetes were recorded on seeds. Among these, actinomycetes cause severe infestation. Seed dressing with Captan @ 5 g/kg of seeds reduces fungal infestation.

5.8. *Pongamia pinnata*

About 14 fungi belonging to 11 genera including *Aspergillus*, *Trichoderma*, *Fusarium* sp., etc., were recorded on seeds. *Aspergillus* sp., causes severe infestation on seeds and *Fusarium* sp., causes emerging radicle rot on seedlings.

5.9. *Grewia tiliifolia*

About 23 fungi, a bacterium and actinomycetes were recorded on seeds. *Graphium* sp., *Fusarium* sp., and *Torula* sp., occur in high frequency and the hot-water treatment reduces the incidence of microbial infestation.

5.10. *Terminalia bellirica*

At least 17 spermoplane microorganisms belonging to 10 fungal genera, a bacterium and actinomycetes were recorded on seeds. Among these, *Aspergillus niger*, *Fusarium*, *Colletotrichum gloeosporioides*, etc., are important. *Aspergillus* sp., and *Fusarium* sp., causes seedling radicle rot.

5.11. *Xylia xylocarpa*

About 27 fungi belonging to 20 genera, bacteria and actinomycetes were recorded on seeds. Among the field fungi recorded, *Botriodiplodia theobromae*, *Colletotrichum gloeosporioides*, *Cylindrocladium* and *Fusarium* are the important ones. Seed dressing with Captan @ 5 g/kg seeds reduce the incidence of spermoplane fungi. Foliar infection and collar rot caused by *Colletotrichum gloeosporioides* and *Fusarium* sp., were found on seedlings, respectively.

5.12. *Pterocarpus marsupium*

About 36 fungi, a bacterium and actinomycetes were recorded on seeds. Seed dressing with Captan @ 4 g/kg seeds reduces the microbial infestation. Surface sterilisation with 0.01% mercuric chloride solution and hot-water treatment also reduces the infestation. *Colletotrichum gloeosporioides* and bacteria cause seedling blight.

2.5.13. *Cassia fistula*

A total of 10 fungi and a bacterium were recorded on seeds. Among *Aspergillus* sp., *Mucor* sp., *Penicillium* sp., and *Trichoderma* are important. Concentrated sulphuric acid pre-treatment for 20 minutes not only reduces disease incidence but also improves germination.

5.14. *Wrightia tinctoria*

Nine spermoplane microorganisms including the genera *Aspergillus*, *Penicillium* and *Chaetomium* were recorded on seeds. Surface sterilization with 0.01% mercuric chloride reduces the spermoplane microorganisms. *Curvularia* sp., causes seedling cotyledon rot.

5.15. *Holoptelia integrifolia*

About 33 fungi, a bacterium and actinomycetes were detected on seeds. Among theses, *Alternaria* sp., *Cercospora* sp., *Colletotrichum* sp., *Curvularia* sp.. *Fusarium oxysporum* sp., and *Phoma* sp., are the important fungi. Seedling cotyledon infection caused by *Drechslera australiensi* and radicle rot caused by *Alternaria* sp.. were recorded on seedlings.

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Appendix 1

Phenological Observations
(To be recorded weekly once)

Form: KFRI 255/96

Species	:	Tree Number	:
Locality	:	Tree height	: (m)
Plantation name	:	Tree GBH	: (cm)
(or Reserve)	:	Crown width	: x (m)
		Crown height	: (m)
		Crown length	: (Tree height – crown height) = m

Year		January				February				March				April				May				June			
	Month																								
	Date	8	15	22	29	5	12	19	26	5	12	19	26	2	9	16	23	1	8	15	22	1	8	15	22
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Leaf																									
1.1. Leaf fall (Nil/few/moderate/high)	(0/ 1/ 2/ 3)																								
1.2. Leaf on tree (Nil/few/partial/full)	(0/ 1/ 2/ 3)																								
1.3. New flushing (Nil/few/partial/full)	(0/ 1/ 2/ 3)																								
2. Twig																									
2.1. Twig fall (Nil/few/moderate/high)	(0/ 1/ 2/ 3)																								
3. Flower																									
3.1. Flowering (Nil/started/mostly/all	(0/ 1/ 2/ 3)																								
3.2. Flower crop (Nil/poor/moderate/good)	(0/ 1/ 2/ 3)																								
3.3. Flower bud fall (Nil/few/moderate/good)	(0/ 1/ 2/ 3)																								
3.4. Flower fall (Nil/few/moderate/heavy	(0/ 1/ 2/ 3)																								
4. Bark exfoliating (Nil/low/moderate/high)	(0/ 1/ 2/ 3)																								
5. Fruit																									
5.1. Fruiting (Nil/poor/moderate/good)	(0/ 1/ 2/ 3)																								
5.2. Immature fruit fall (Nil/few/moderate/high)	(0/ 1/ 2/ 3)																								
5.3. Proportion of mature fruits on tree (Nil/low/moderate/high)	(0/ 1/ 2/ 3)																								
5.4. Fruit crop (Nil/poor/average/good)	(0/ 1/ 2/ 3)																								
5.5. Mature fruit fall (Nil/few/moderate/high)	(0/ 1/ 2/ 3)																								
5.6. Mature fruits lying on ground (Nil/few/moderate/high)	(0/ 1/ 2/ 3)																								

Name and dated signature of the recorder :

Remarks :

Phenological Observations

(To be recorded weekly once)

Form: KFRI 255/96

Species	:	Tree Number	:
Locality	:	Tree height	: (m)
Plantation name	:	Tree GBH	: (cm)
(or Reserve)	:	Crown width	: (m)
		Crown height	: (m)
		Crown length	: (Tree height – crown height) = m

Year	Month	July				August				September				October				November				December			
	Date	7	14	21	28	5	12	19	26	4	11	18	25	2	9	16	23	1	8	15	22	1	8	15	22
	Week	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
1. Leaf																									
1.1. Leaf fall (Nil/few/moderate/high) (0/ 1/ 2/ 3)																									
1.2. Leaf on tree (Nil/few/partial/full) (0/ 1/ 2/ 3)																									
1.3. New flushing (Nil/few/partial/full) (0/ 1/ 2/ 3)																									
2. Twig																									
2.2. Twig fall (Nil/few/moderate/high) (0/ 1/ 2/ 3)																									
3. Flower																									
4.1. Flowering (Nil/started/mostly/all (0/ 1/ 2/ 3)																									
4.2. Flower crop (Nil/poor/moderate/good) (0/ 1/ 2/ 3)																									
4.3. Flower bud fall (Nil/few/moderate/good) (0/ 1/ 2/ 3)																									
4.4. Flower fall (Nil/few/moderate/heavy (0/ 1/ 2/ 3)																									
5. Bark exfoliating (Nil/low/moderate/high) (0/ 1/ 2/ 3)																									
5. Fruit																									
5.7. Fruiting (Nil/poor/moderate/good) (0/ 1/ 2/ 3)																									
5.8. Immature fruit fall (Nil/few/moderate/high) (0/ 1/ 2/ 3)																									
5.9. Proportion of mature fruits on tree (Nil/low/moderate/high) (0/ 1/ 2/ 3)																									
5.10. Fruit crop (Nil/poor/average/good) (0/ 1/ 2/ 3)																									
5.11. Mature fruit fall (Nil/few/moderate/high) (0/ 1/ 2/ 3)																									
5.12. Mature fruits lying on ground (Nil/few/moderate/high) (0/ 1/ 2/ 3)																									

Name and dated signature of the recorder

Remarks

APPENDIX 2

FIELD MANUAL OF THIRTY FOREST TREES OF KERALA

HOW TO USE THE MANUAL?

The manual contains data sheets, which provide, seed characteristics and various information needed for handling of seeds from seed collection to seedling production for 30 tree species.

The information provided in the data sheet are mostly from published work, the references of which are given in bracket; wherever references are not given, the data is either based on unpublished work at KFRI or field experience of authors.

The users are requested to note down any information that they find useful, based on their field experience with the species. This may be transmitted to KFRI so that the information can be included at the time of revision of the manual, which is planned after five years. The most important information which the field officers can provide is about the availability of seeds in different localities and information on their experience in germinating seeds using novel methods, although any other relevant information are also equally important.

Brief description of various information included in the data sheet are explained on the following page.

[**Recent name** with author's name]

Synonyms: [These are other scientific names which were in use].

Family: [Family to which the species belongs].

Trade name: [Name used in commerce].

Common names: [Names used in Kerala and nearby States along with Hindi and English names are provided].

Species description

Habit: [Rate of growth as well as size attained deciduous/evergreen].

Distribution: [Natural range of distribution in India, status of the species distribution within Kerala, etc].

Uses: [Wood and non-wood uses].

Seed maturity: [Refers to the seed collection time in general as well as specific months in the event of a variation in time between localities].

Collection: [Method of fruit/seed collection].

Transportation: [Containers used, and the special care to be taken during transport].

Processing: [Seed drying, extraction of seeds from fruits, separation of chaff and other impurities, etc].

Seed characteristics

Description: [The fruit/seed is described].

Dimensions: [Length, width, diameter, thickness, etc].

Weight: [Number of seeds per kg in the case of larger seeds and number of seeds per g for smaller seeds].

Seed emptiness: [Refers to seed filling. Some seeds such as *Terminalia paniculata* are mostly empty. Terms such as Negligible (<10%)/Low (10-30%)/Moderate (30-70%)/High (70-90%)/Very high (>90%) are used to denote the levels of emptiness].

Insect infestation: [This gives the level of insect infestation in freshly collected seeds. Negligible (<10%)/Low (10-30%)/Moderate (30-70%)/High (70-90%)/Very high (>90%)].

Fungal infestation: [This gives the level of fungal infestation in freshly collected seeds. Negligible (<10%)/Low (10-30%)/Moderate (30-70%)/High (70-90%)/Very high (>90%)].

Storage physiology: [Orthodox/Recalcitrant].

Viability period: [The period (days/months/years) up to which seeds can be stored under normal laboratory (ambient) conditions without any special facilities such as cold storage].

Germination type: [Epigeal/Hypogeal].

Germination: [Per cent germination of the seeds reported; range of values is given].

Germination period: [Minimum period taken to initiate germination and minimum period within which most of the seeds germinate].

Storage: [Type of containers, storage environment (temperature), etc].

Viability testing: [Refers to quick testing methods such as Tetrazolium, Hydrogen peroxide and cutting tests. For seeds with short (less than about 5 days) germination period, germination test is also mentioned as a method of viability testing. For details of the procedure. see appendix].

Pre-sowing treatments: [Treatments to enhance germination include hot-water/cold water soaking, Acid scarification, Termite treatment, etc. For details of the procedures, see appendix].

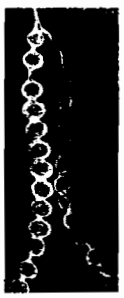
Seedling production: [Nursery practices for production using seeds (seedling plant production) and other vegetative measures are mentioned. Procedure for preparation of hormonal collections used for rooting of stem cuttings, see appendix].

Acacia nilotica (L.) Willd. *ex* Del.

Synonyms: *Acacia arabica auct. non* Willd.
Mimosa nilotica L.
Family: Leguminosae
Subfamily: Mimosoideae
Trade name: Babul
Local names:
Malayalam: Karuvelam
Tamil: Karuvai, Karuvelam
Kannada: Jali, gobli
Hindi: Kikar, Babul, Babur
Common name: Indian gum arabic tree


Branch bearing flowers


Pods


Dehiscing pod


Seeds

Species description

Habit: A small to moderate-sized, moderately fast-growing, thorny evergreen indigenous tree attaining a height of 18 m and a girth of 3 m.

Distribution: *Acacia nilotica* occurs in many parts of the plains of India in the Deccan Peninsular, Maharashtra, Rajasthan and Gujarat. It is grown along railway embankments, grazing lands, waste lands, spoil banks, fields, etc. It is widely planted and self-sown throughout dry, hot regions of India. It is also found in Myanmar, Sri Lanka, Saudi Arabia, Egypt and tropical Africa and is a very common tree throughout West and East Sudan (FRI, 1983). In Kerala, it is found in drier parts of Palakkad and Idukki Districts.

Uses: Wood is used for carts, buildings, agricultural implements, etc. The bark is used for tanning. The pods are rich in tannin. Leaves are used as fodder.

Seed maturity: Mature fruits are available in India during Feb-May (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala				*	*							
Chinnar (Idukki)				*	*							
Walayar (Palakkad)				*	*							
Meenakshipuram (Palakkad)				*	*							

Collection: The ripe pods blown off from the trees by winds may be collected from the ground. These may also be beaten off the trees with a stick on to the ground previously swept clear (FRI, 1983).

Transportation: Dry or almost dry pods can be loosely packed in fairly closely woven hessian sacks, well tied and arranged in the vehicle to allow adequate air

circulation between them. In dry weather the regular rotation of sacks on the roof carrier of the collection vehicle often promotes the drying process. Care must be taken that the sacks do not develop holes that allows seed to spill out This is most likely in lighter cotton or linen sacks when a significant amount of sharp living material remains attached to the pods (Doran *et al.*, 1983).

Processing: Sundry the pods and extract seeds by beating them with thick sticks. Seeds can be separated from the husk and other impurities by winnowing (FRI, 1983).

Seed characteristics

Description: Fruit is a pod, moniliform, deeply constricted between seeds, 7.6-15.2 cm x 1.2-1.8 cm, contains 8-12 dark brown ovate to oblong compressed seeds (FRI, 1983).

Dimensions: 7-9 mm long, 6-8 mm wide, and 2-5 mm thick.

Weight: 5,329-11,600 seeds/kg (FRI, 1983)

Seed emptiness: Sometimes high, due to damage by bruchid beetles (NAS, 1990).

Insect infestation: Moderate. *Argyroploce illepida* Butl. and *Cryptophelbia* sp., which feed on developing fruits/pods as well as *Caryedon gonagra* Fb. which attack the seeds are the potential seed pests in India.

Fungal infestation: High (40-96%). Seeds harbour a rich microflora comprising of 18 fungal genera, bacteria and actinomycetes. Most of them are storage microbes. *Fusarium* spp., *Coniella* spp., *Beltrania* sp., *Phoma* sp. are the field fungi.

Storage physiology: Orthodox (Kindt *et al.*, 1997)

Viability period: Seeds retain viability for three years without any fall in germination percentage, under proper storage (FRI, 1983). Seeds with an initial germination capacity of 75% when stored in gunny bags gave a 50% germination after two years, 30% after five years and 20% after 10 years (Dent, 1948), suggesting retention of 67%, 40% and 27% of initial germination capacity at the end of 2, 5 and 10 years respectively.

Germination type: Epigeal (FRI, 1983)

Germination: Up to 89% (FRI, 1983)

Germination period: 6-199 days (FRI, 1983)

Storage: Seed can be stored in gunny bags or tins or baskets in a cool and dry place with good air circulation. Seeds to be stored for a longer time particularly in the rainy season should be kept in air-tight sealed containers in cool place after complete drying (FRI, 1983).

Seed characteristics

Description: Fruit is a pod, oblong in shape, 12 cm x 2 cm size contains 10 obovate seeds.

Dimensions: 8 mm long

Weight: 28,000-46,000 seeds/kg (FRI, 1983)

Seed emptiness: Low

Insect infestation: No information.

Fungal infestation: Storage moulds like *Aspergillus* sp., *Penicillium* sp. and field fungi *Botryodiplodia theobromae* and *Phoma* sp. are causing infestation.

Storage physiology: Orthodox (Napier and Robbins, 1989)
Intermediate (Kindt *et al.*, 1997)

Viability period: Seeds with an initial germination capacity of 12% when stored in gunny bags or sealed tins, have given 6% germination after two years and 2% after three years (Dent, 1948) suggesting a retention of 50% viability at the end of two years and 17% viability at the end of three years.

Germination type: Epigeal

Germination: Up to 90% for conc. sulphuric acid treated seeds (FRI, 1983).

Germination period: 3-14 days, for scarified seeds (Napier and Robbins, 1989)

Storage: Seeds store well in gunny bags and airtight tins for 19 months. However, seeds stored for long are said to be liable to insect attack (FRI, 1983).

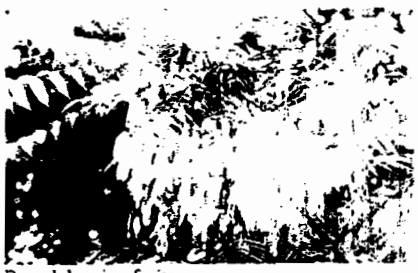
Viability testing: Cutting test

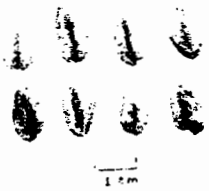
Pre-sowing treatments: Conc. sulphuric acid scarification for 10 minutes followed by cold water soaking for 18 hours (Rai, 1999).

Seedling production: Sow pre-treated seeds in plastic trays filled with moist vermiculite. Seedlings are potted in polybags of size 22.5 x 17.5 cm when they have 3-4 leaves and kept under shade (FRI, 1983).

Ailanthus triphysa (Dennst.) Alston

Synonyms: *Adenanthera triphysa* Dennst.
Ailanthus malabarica DC.
Family: Simaroubaceae
Trade name: White palle
Local names:
Malayalam: Perumaram, Matti, Pongilyam
Tamil: Mattipal
Kannada: Dhupa, Hal-maddi
Hindi:
Common name:


Branch bearing fruits


Extracted seeds

Species description

Habit: A large fast-growing deciduous tree attaining a height of 30 m and a girth of 3 m.

Distribution: *Ailanthus triphysa* occurs in the Western Ghats, from Konkan, southwards to Kerala up to 1500 m m.s.l. It also occurs in Myanmar (FRI, 1981). It is indigenous to Kerala, and widely cultivated.

Uses: Wood is used for the manufacture of match splints and boxes. The bark and gum that exudes from the trunk, leaves and roots are used in medicine. The tree is used as a standard for growing black pepper wines.

Seed maturity: Mature fruits are generally available in India during March-April (Rai, 1999). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala	*	*	*									
Peechi (Thrissur)	*	*										
Palakkad		*	*									

Collection: Mature fruits are collected from the tree by lopping off the fruiting branches, since they are wind dispersed (Luna, 1996).

Transportation: Fruits collected in cotton/plastic/polythene/gunny bags are packed and transported.

Processing: The fruits should be dried in the sun and the insect attacked ones are removed by hand picking.

Seed characteristics

Description: Fruit winged (samara), reddish-brown, membranous, flat, oblong, obtuse at the ends, one seed in the entire, compressed and circular (Luna, 1996).

Dimensions: 8.5 cm length and 2 cm width

Weight: 24,000-25,000? (Kindt *et al.*, 1997); 7,620-10,000 fruits/kg (with wings)

Seed emptiness: Moderate

Insect infestation: Moderate. Most damage is caused by the leaf and shoot webber, *Atteva fabriciella* Swed. (Lepidoptera: Yponomeutidae) which webs the tender shoots and developing fruits and feeds on it.

Fungal infestation: High (30-91%). More than 23 fungi and bacterium were recorded on seeds. *Aspergillus* sp. and *Penicillium* sp. are the important storage moulds. *Drechslera* sp., *Colletotrichum gloeosporioides*, *Curvularia* sp., *Fusarium moniliforme*, *Helminthosporium* sp., *Phoma* sp. are the important, field fungi recorded on seeds.

Storage physiology: Orthodox (Kindt *et al.*, 1997)

Viability period: Seed is viable up to two months, under ambient conditions.

Germination type: Epigeal

Germination: 70% (Luna, 1996)

Germination period: 10-20 days (Luna, 1996)

Storage: Fruits can be stored in gunny bags for about 3 months (Luna, 1996; Nair, 2000).

Viability testing: Cutting test and germination test.

Pre-sowing treatments: Remove the wings before sowing.

Seedling production: The de-winged seeds are sown horizontally in plastic trays in vermiculite and watered regularly. Heavy watering causes rotting of the seeds, hence should be avoided. Seedlings are potted in polybag of size 22.5 x 17.5 cm. Seedlings in the nursery are susceptible to defoliator attacks, which can be controlled by spraying insecticide (Rai, 1999). Seedlings are also affected with damping off, collar rot and seedling blight diseases, which can be controlled by fungicidal application.

Albizia lebbeck (L.) Willd.

Synonyms: *Mimosa lebbeck* L.
Mimosa sirissa Roxb.
Family: Leguminosae
Subfamily: Mimosoideae
Trade name: Kokko
Local names:
Malayalam: Vaka, Nenmenivaka
Tamil: Karuvagei
Kannada: Bage, Banghe
Hindi: Kalshish, Siris
Common name: East Indian Walnut Tree, Siris


Branch bearing mature pods

Species description

Habit: A fast growing, moderate-sized to large deciduous tree attaining a height of more than 30 m and a girth of 4.50 m (FRI, 1983).

A: Pod B: Seeds

Distribution: *Albizia lebbeck* is one of the most common Indian trees found in dry and moist deciduous forests all over the country and extensively grown in avenues and gardens (FRI, 1983). It is also indigenous to Myanmar, Sri Lanka, Malaysia, China, North Australia, tropical Africa, Egypt and Afghanistan. It is indigenous to Kerala and occurs in the moist and dry deciduous forests.

Uses: Wood is moderately strong and durable, used for buildings and furniture.

Seed maturity: Mature fruits are generally available in India during November-February (FRI, 1983). Variations have also been noted. Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala			*									
Peechi (Thrissur)												
Agali (Palakkad)	*	*	*	*								
Chirulipetty (Chinnar)	*	*	*	*								
Kuzhalmandam (Palakkad)						*	*	*				
Neleswaram (Kasaragod)		*										
Tamil Nadu												
Pollachi	*	*									*	*

Collection: Mature fruits (pods), yellow in colour, may be collected from the tree by knocking off the pods using long stick (FRI, 1983). Mature pods remain on trees for about 4 months.

Transportation: Pods are packed in cotton/jute bags and transported.

Processing: The pods are dried in the sun till they dehisce and release seeds. Seeds are also extracted by beating them with a stick if necessary (FRI, 1983).

Seed characteristics

Description: Fruit is a pod, 14-18 cm x 4-5 cm, flat, contains ovate or oblong, compressed, pale brown smooth seeds, smooth with a hard testa (FRI, 1983).

Dimensions: 7-13 mm (length) x 6-9 mm (width) x 1-3 mm (thickness)

Weight: 3,700-16,000 seeds/kg (Kindt *et al.*, 1997; Carlowitz, 1991)
6,700-12,320 (Luna, 1996)

Seed emptiness: Low (up to 3%)

Insect infestation: Low to medium (8-53%). Beetles are the major pests. The bruchids, *Bruchus pisorum* L., *B. saundersi* Jekel., *Bruchidius uberatus* Fb., *B. sparsimaculatus* Pic. and *Caryedon gonagra* Fb., cause most damage (Browne, 1968).

Fungal infestation: High (53-73%). Species of *Aspergillus*, *Chaetomium*, *Rhizopus*, *Penicillium* are the important storage moulds. *Colletotrichum gloeosporioides*, *Fusarium* sp. and *Phoma* sp. are the important field fungi affecting the seeds.

Storage physiology: Orthodox (Napier and Robbins, 1989; Kindt *et al.*, 1997).

Viability period: Seeds with initial germination of 20% have been stored in sealed tins for six years without substantial loss of viability (Dent, 1948).

Germination type: Epigeal (FRI, 1983)

Germination: Up to 94% (Sen Gupta, 1937)

Germination period: 7-30 days (Kumar and Bhanja, 1992)

Storage: Seeds after drying under sun can be stored in sealed plastic or aluminium containers for one year (FRI, 1983) and even up to five years if properly stored (Dent, 1948).

Viability testing: Cutting test

Pre-sowing treatments: Soak the seeds for 24 hours in boiled water and allow to cool (Kumar and Bhanja, 1992); or scarify the seeds using conc. sulphuric acid for 25 minutes, wash thoroughly with running water and soak for 24 hours in water before sowing.

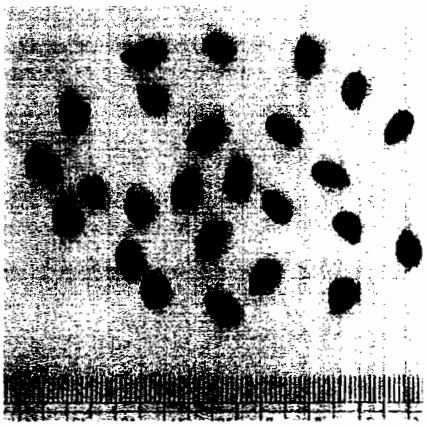
Seedling production: Seed is sown in drills 15 cm apart in the middle of March after being scarified with con. H_2SO_4. Germination commences in 4 days and is over in about 17 days (FRI, 1983). Seed can also be sown in 20 x 10 cm bags during December to January or October to November. The potting mixture containing soil, sand and compost (3:1:1). Jassids, fungi and leaf cutters attack the seedlings. For jassids an appropriate systemic insecticide (Nuvacron) (monocrotophos) can be used at 0.2-0.5% by volume (Rai, 1999). Seedling blight caused by *Rhizoctonia solani* can be controlled by application of carboxim (0.1%).

Stumps made from 15 months old seedlings give up to 80% establishment (FRI, 1983).

Albizia odoratissima (L.f.) Benth.

Synonyms: *Mimosa odoratissima* L.f.
Acacia odoratissima (L.f.) Willd.
Albizia micrantha Bovin
Family: Leguminosae
Subfamily: Mimosoideae
Trade name: Black siris
Local names:
Malayalam: Pulivaga, Nellivaga, Kunnivaka
Tamil: Karu vagai, Chittalei vagai
Kannada: Godhunchi, Chelavagai
Hindi: Siris, Kalasiris
Common name: Ceylon Rosewood


Branch bearing pods


Seeds

Species description

Habit: A fast growing, moderate sized to large deciduous tree attaining a height of more than 24 m and a girth of 2 m (FRI, 1983).

Distribution: *Albizia odoratissima* is widely distributed throughout India, ascending to 1500 m m.s.l in the sub-Himalayan tract. It is common, especially along hill slopes in the dry deciduous forests of the Siwaliks, Ajmer-Mervara, Khandesh, etc. and in the moist deciduous forests of North Kanara and Konkan. It is indigenous to Kerala and frequently found in open forests up to 915 m m.s.l. It also occurs in Bangladesh, Myanmar and Sri Lanka (FRI, 1983). It is indigenous to Kerala and found in the moist deciduous, dry deciduous and semi-evergreen forests.

Uses: Wood is used for constructional and cabinet works. The leaf is used as fodder (FRI, 1983).

Seed maturity: Mature fruits are generally available in India during January-March (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)	*	*	*	*								
Nilambur (Malappuram)	*	*	*									
Mukkali (Palakkad)	*	*										*
Walayar (Palakkad)	*	*	*									*

Collection: Pods are collected from the tree by lopping the branches. Freshly fallen pods can also be collected from the ground (FRI, 1983).

Transportation: The pods collected in cotton or gunny bags are packed and transported.

Processing: The pods are spread out in the sun until dry. If the pods not split open, beat with a stick to release the seeds, which are cleaned by winnowing (FRI, 1983).

Seed characteristics

Description: Fruit is a pod, 12-15 cm x 2.5-2.8 cm, contains 8-12 flat, compressed brownish-black seeds.

Dimensions: 7-9 mm (length) x 5-6 mm (width)

Weight: 7,400-22,900 seeds/kg (Sen Gupta, 1937)

Seed emptiness: Medium

Insect infestation: Moderate. Seeds prone to infestation in storage mainly by the bruchids, *Bruchus chinensis*, *Bruchidius andrewesi* Pic., *B. bilineatopygus* Pic. and *Caryedon serratus* Oliv.

Fungal infestation: Medium (63-66%). 19 fungi, actinomycetes and a bacterium were recorded on seeds. *Penicillium* spp. and *Cladosporium* sp. are the important storage moulds. *Drechslera* sp., *Fusarium* sp., *Myrothecium* sp., *Phoma* sp., *Colletotrichum gloeosporioides* are the important field fungi.

Storage physiology: Orthodox (CABI, 1998)

Viability period: Seeds retain viability for long period. Seeds stored in stoppered bottle have given 1% germination even after 27 years (FRI, 1983).

Germination type: Epigeal

Germination: 47% (FRI, 1983)

Germination period: 10-17 days

Storage: After processing, the seeds can be stored in gunny bags in a dry place for long.

Viability testing: Cutting test

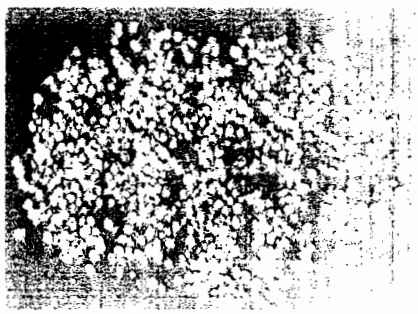
Pre-sowing treatments: Soak the seeds in cold water for 24 hours (Kindt *et al.*, 1997).

Seedling production: Pre-treated seeds are sown in plastic trays containing vermiculite. Seedlings are potted in polybags of size 20 x 10 cm filled with soil when they have a pair of leaves and kept under shade.

Anogeissus latifolia (Roxb. *ex* DC.). Wall. *ex* Guill. & Perr.

Synonyms: *Conocarpus latifolia* Roxb. *ex* DC.
Family: Combretaceae
Trade name: Axlewood
Local names:
Malayalam: Vellanava, Mazhukanjiram, Korattikanjiram
Tamil: Namai, Namme vekkali
Kannada: Bejjal, Dindal, Dindalu
Hindi: Bakla, Bakli
Common name: Bakli


Fruiting branch


Seeds

Species description

Habit: A slow growing, moderate to large sized deciduous tree attaining a height of up to 30 m and a girth of 3 m.

Distribution: *Anogeissus latifolia* is distributed throughout India except in West Bengal, Assam, West Rajasthan and the Andamans. It is also found in the drier regions of Sri Lanka and Nepal (FRI, 1984). It is indigenous to Kerala, and occurs in dry and moist deciduous forests.

Uses: Wood is preferred for cart-axles, shafts, frames of carts, wheels, agricultural implements, tool handles, etc. (FRI, 1984).

Seed maturity: Mature fruits are generally available in India during December-May (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)	*	*										
Chinnar (Idukki)			*	*	*							
Walayar (Palakkad)			*	*	*							
Attappady (Palakkad)		*	*	*								

Collection: Fruits are collected from the trees using a long pole attached with a sharp hook, on tarpaulins or plastic sheet spread on ground (FRI, 1984).

Transportation: Pack the seeds in polythene/cotton bags for transporting.

Processing: Sundry the seeds for storing.

Seed characteristics

Description: The yellowish-brown compressed narrowly 2-winged drupe subtended by a stiff beak is the seed for our purpose.

Dimensions: 7-8 mm length x 4-5 mm width

Weight: 1,08,000-1,35,000 seeds/kg (Kumar and Bhanja, 1992)

Seed emptiness: High (99%). Poor seed filling results in very poor germination.

Insect infestation: Negligible.

Fungal infestation: Medium (43-67%). Spermoplane microflora detected includes 10 fungi and actinomycetes. *Aspergillus niger*, *Penicillium* spp., *Pithomyces* sp., are the important storage moulds. *Alternaria alternata*, *Drechslera* sp., *Fusarium* sp., *Pestalotria* sp., *Stemphylium* sp., etc., are associated with discoloured seeds.

Storage physiology: Orthodox (?)

Viability period:

Germination type: Epigeal (Kumar and Bhanja, 1992)

Germination: Very low 0.05 to 4.62% of the total seeds sown (FRI, 1984); 35-40% (?) (Rai, 1999).

Germination period: 2-14 days (FRI, 1984; Rai, 1999)

Storage: Store the sun-dried seeds in gunny bags (Kumar and Bhanja, 1992).

Viability testing: Cutting test and germination test.

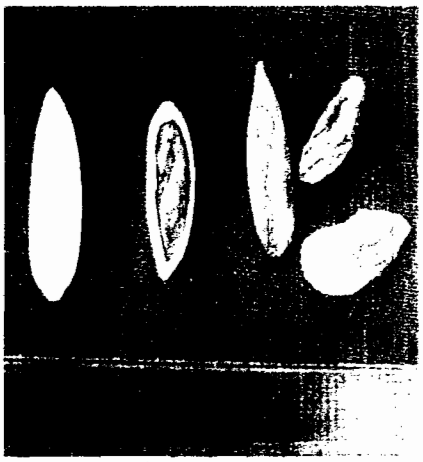
Pre-sowing treatments: Soak the seeds in cold water for 48 hours before sowing (Kumar and Bhanja, 1992).

Seedling production: The seeds are hard and many are infertile. Therefore, they are sown densely on raised beds, the soil being mixed with large quantity of coarse sand. The bed is well shaded at 45 cm above the ground. Germination is fairly quick. The seedlings are extremely liable to insect damage. Growth of the seedling is very slow (Kumar and Bhanja, 1992). The seedlings are pricked out after 40-45 days of germination and planted in 22.5 x 17.5 cm polybags, preferably in the afternoons on cloudy days.

Azadirachta indica A. Juss.

Synonyms: *Melia azadirachta* L.
Melia indica Br.
Family: Meliaceae
Trade name: Neem
Local names:
Malayalam: Vepu, Aryaveppu
Tamil: Vembu, Veppam
Kannada: Bevu, Kirri Bevu
Hindi: Neem, Nim, Balnimb
Common name: Margosa tree, Neem


Branch bearing fruits


A: Depulped fruit, B: L.S. of seed.
C: Extracted seeds

Species description

Habit: A moderate to large sized, evergreen (deciduous in drier areas) tree attaining a height of 12-15 m (rarely up to 25 m) and a girth of 1.5-2.5 m.

Distribution: *Azadirachta indica* occurs throughout the drier parts of the country and is widely cultivated. It is indigenous to Kerala and occurs in dry deciduous forests. It is often planted as avenue tree along roadsides, and community lands.

Uses: The wood is used for building, furniture, carts, etc. The oil (margosa oil) extracted from the seed is medicinal. Neem oil cake is an effective insecticide. The bark yields a fibre, which is used for making ropes. The tree yields a gum used in medicine. The foliage is used as fodder.

Seed maturity: Fruits generally mature during March-June (Sen Gupta, 1937). Location-specific information on seed maturity/availability is given below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Thrissur						*	*					
Chinnar (Idukki District)					*	*						
Tamil Nadu					*	*	*					
Karnataka							/					

Collection: Collect fruits, turning yellow from the tree by shaking the branches. Ripe fruits falling on ground may be collected at the earliest as crows often eat ripe fruits.

Transportation: Fruits collected in ventilated containers (cotton bags, gunny bags woven plastic bags, etc.) should be taken to the processing unit as quick as possible.

Processing: If green fruits are collected heap them for a day or two to make depulping easier. Ripe fruits are immediately de-pulped by squeezing in water and drying under shade.

Seed characteristics

Description: The fruit is a drupe (1.2-2 cm), one celled, and one or two seeded. The true testa of the seed is a brown papery covering inside the cartilaginous putamen of the drupe.

Dimension: 1cm (length) x 0.63cm (diameter).

Weight: 5,700-6,350 seeds/kg (Sen Gupta, 1937)

Insect infestation: Low. Rarely by *Araecerus suturalis* Boh. (Coleoptera: Anthribidae) (Browne, 1968).

Fungal infestation: Low (20-26%). *Aspergillus* spp., and *Trichoderma* spp., are the important storage fungi and *Colletotrichum gloeosporioides* is the important field fungi recorded on seeds.

Storage physiology: Recalcitrant (Kindt *et al.*, 1997).

Viability period: Short; seeds with an initial germination capacity of 75% when stored in gunny bags have given 30% in the third week and 2% in the fifth week. Viability was prolonged when the seeds were stored in sealed tin (i.e., up to 10^{th} week with 2% germination) (Dent, 1948). Under ambient conditions viable up to 30 days (Rai, 1999).

Germination type: Epigeal

Germination: Up to 90% (Kumar and Bhanja, 1992; Rai, 1999).

Germination period: 10-30 days

Storage: The seed has short viability. Seeds extracted from greenish yellow fruits (not fully turned yellow) give around 70% germination even after three months. Seeds extracted from the fallen fruits can be stored in earthen pots buried in sand. The earthen pots may be filled with seeds up to neck leaving its mouth open. These pots are buried in sand up to neck and sand around the pot is kept moist by sprinkling water. These seeds retain viability for 3 months (Rai, 1999).

Viability testing: Cutting test; seeds are viable if cotyledons are green and not viable if they are brown or yellow (Luna, 1996).

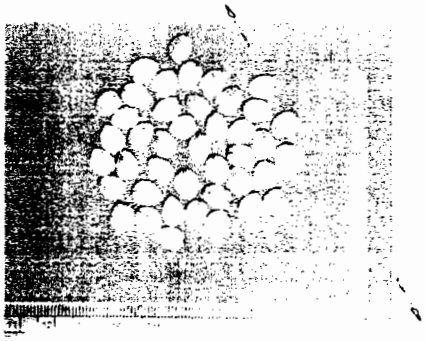
Pre-sowing treatments: De-pulped and air-dried seeds do not require any pre-sowing treatment. However, soaking in lukewarm/cold water for 48 hours (Kindt *et al.*, 1997) is also recommended.

Seedling production: Seeds are sown in plastic trays containing vermiculite and watered twice a day. Seedlings are potted in polybags of 20 x 10 cm size when they have a pair of leaves. Under too moist conditions fungal attack in form of leaf spot and shoot hole formation occurs on the seedlings, which can be controlled by application of fungicide (Bavistin, 0.1%).

Cassia fistula L.

Synonyms: *Cassia rhombifolia* Roxb.
Family: Leguminosae
Subfamily: Caesalpinioideae
Trade name: Rajbrikh
Local names:
Malayalam: Kanikkonna
Tamil: Sarakonnai
Kannada: Konne
Hindi: Amaltas, Kirwara, Warga
Common name: Indian laburnum

Branch bearing flowers and mature pods



Seeds

Species description

Habit: A slow-growing medium-sized deciduous tree attaining a height of more than 15 m and a girth of 1.5 m.

Distribution: *Cassia fistula* is one of the most widespread forest trees in India, usually occurring in deciduous forests throughout and ascending to 1220 m m.s.l. in the sub-Himalayan tract and outer Himalayas, from the Indus eastwards, up to Assam. It is common throughout the Gangetic valley, Central India, Deccan and South India. It also occurs in Myanmar and Sri Lanka. It is often grown as an ornamental in gardens (FRI, 1983). It is indigenous to Kerala, and occurs in dry and moist deciduous forests.

Uses: The timber is largely used for house posts, bridge posts, rice pounders, agricultural implements, etc.

Seed maturity: Mature fruits are available generally during January-May (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Kuzhalmantham (Palakkad)	*	*	*									
Mukkali (Palakkad)	*	*	*									
Peechi (Thrissur)	*	*	*	*								
Kulathuphuzha (Kollam)	*	*										

Collection: Collect brownish-black fruits from the tree.

Transportation: Collect fruits in cotton/gunny bags and transport; no special care is needed.

Processing: The fruits are dried in the sun and broken to extract the seeds. The seeds are separated from the soft pulp and washed with cold water before drying (FRI, 1983).

Seed characteristics

Description: Fruit is a pod, woody, oblong, brown coloured, 40 cm x 2 cm size contains many, orbicular seeds embedded in the pulp.

Dimensions: 1cm diameter

Weight: 5,640-7,055 seeds/kg (Sen Gupta, 1937)

NB: A low figure of 2600 seeds/kg is reported by Carlowitz (1991).

Seed emptiness: Low

Insect infestation: Mild damage due to *Bruchus pisorum* L. and *Caryedon gonagra* Fb. Incidence of *Corcyra cephalonica* Stainton to ripe pods was observed. In addition to these, a caterpillar, *Nephopteryx rhodobasalis* Hamp., was reported to bore in young pods (Beeson, 1941).

Fungal infestation: Medium (35.5-53%). Spermoplane microbes recorded include 10 fungi and a bacterium. *Aspergillus*, *Chaetomium*, *Mucor*, *Penicillium*, *Trichoderma* are the important storage fungi and *Fusarium* and *Periconia* are the field fungi recorded. *Fusarium* and *Aspergillus* were found associated with shrunken and discoloured seeds.

Storage physiology: Orthodox (Kindt *et al.*, 1997).

Viability period: Seeds are viable for long period; even up to 13 years without loss of viability (Dent, 1948).

Germination type: Epigeal (FRI, 1983)

Germination: Up to 65% (Kumar and Bhanja, 1992)

Germination period: 9-97 days (Sen Gupta, 1937)

Storage: The seeds can be stored for long time. They may be kept either in sealed tin or in gunny bags for many years with no loss of viability (Dent, 1948).

Viability testing: Cutting test.

Pre-sowing treatments: Soak the seed in boiling water for 5 minutes and then in cold water for 24 hours, or scarify the seeds using concentrated sulphuric acid for about 6 minutes. Wash thoroughly with water before sowing (FRI, 1983).

Seedling production: The pre-treated seeds are sown in seedbeds in drills about 25 cm part in March or April and regularly watered. The seedlings are pricked out and planted in polybags of 22.5 x 17.5 cm size.

Dalbergia sissoides Grah. *ex* Wt.&Arn.

Synonyms: *Dalbergia latifolia* Roxb. var. *sissoides* Grah. *ex* (Wt. & Arn.) Baker
Family: Leguminosae
Subfamily: Faboideae
Trade name: Malabar black wood
Local names:
Malayalam: Eetti, Veetti, Karitti
Tamil: Thothagatti
Kannada: Chelabetti
Hindi:
Common name: Rose wood


Branch bearing fruits

Species description

Habit: A slow-growing, large deciduous, tree attaining a height of 30 m and a girth of 3.24 m.

Distribution: *Dalbergia sissoides* is indigenous to Kerala and occurs in moist deciduous and semi-evergreen forests up to 1500m m.s.l.

Uses: The wood is used for constructions, furniture cabinet, etc.


Pods


Seeds

Seed maturity: Mature fruits are generally available in India during February (Thothathri, 1987).

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)		*										
Silent Valley (Palakkad)		*										

Collection: Seeds are collected from the trees by lopping the branches and pods are allowed to fall on a tarpaulin sheet, which is spread around the tree. Collection may be done in the early morning, otherwise chances to fly away the pods to distant places being light in weight, making collection miserable.

Transportation: Pods can be packed in jute/cloth/polythene bags and transported.

Processing: The pods can be processed by any one of the methods described below.
(1) Pods are dried in the sun and extracted manually. If crushed by hand the seed containing part will be separated distinctly making the extraction easier.
(2) Pods are dried in an oven keeping at 50°C for 3.5 hours and crushed by hand as well as keeping in the metal grater (0.5 cm) and rubbing so that seeds and chaff will go through the pores and unhusked will remain in the grater. Seeds can be separated from the chaff by winnowing. About 75% of seeds can be separated from the pods by this method.

(3) Seed can also be extracted with the help of a mechanical scarifier. Dried pods are kept in a mechanical scarifier and switching it on for 3 minutes after which the seeds can be separated from the chaff with the aid of a metal grater.

Seed characteristics

Description: Fruit is a pod, contains 2-4 compressed, reniform, deep brown to black coloured seed.

Dimensions: 5-7 mm x 3-5 mm x 1-2 mm

Weight: 26,000-46,000 seeds/kg

Seed emptiness: 26-38%

Insect infestation: 5-18%. The bruchids, *Bruchus pisorum* L., *B. maculatithorax* Pic., and *Bruchidius uberatus* Fb. are reported to cause damage to stored seeds (Sensarma *et al.*, 1994).

Fungal infestation: High (45-81%). More than 24 fungi were recorded. Species of *Aspergillus*, *Chaetomium*, *Cladosporium*, etc., are the important storage moulds *Alternaria* sp., *Drechslera* sp., *Bipolaris* sp., *Fusarium* sp. are the important field pathogens associated with the seeds.

Storage physiology: Orthodox (?)

Viability period: The seeds keep well in gunny bags for six months, thereafter the seed rapidly deteriorates (Dent, 1948).

Germination type: Epigeal (FRI, 1983)

Germination: Up to 89%

Germination period: 2-11 days

Storage: Seeds are stored in gunny bags or sealed containers for six months.

Viability testing: Cutting test and germination test.

Pre-sowing treatments: Not necessary.

Seedling production: Seeds are sown in plastic trays in vermiculite and watered. The seedlings are pricked out in to polybags of size 22.5 x 17.5 cm, when they are about 5-6 cm height. Seedling collar rot caused by *Rhizoctonia solani* occurs in nursery, which can be controlled by application of fungicide, carboxin (0.1%).

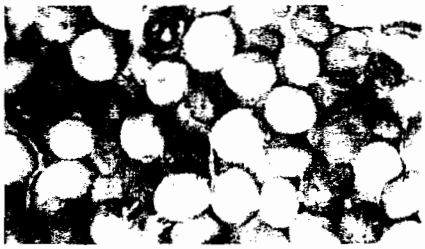
Gmelina arborea Roxb.

Synonyms: Nil
Family: Verbenaceae
Trade name: White teak, Gamari
Local names:
Malayalam: Kumbil, Kumizhu
Tamil: Gumadi
Kannada: Shivani
Hindi: Gamhar, Sewan
Common name: Kashmir tree


Branch bearing fruits

Species description

Habit: A fast-growing, moderate-sized to large deciduous tree attaining a height of 20 m and a girth of 1.5 m.


Fruits

Distribution: *Gmelina arborea* occurs generally throughout the greater part of the India and Myanmar, but usually scattered. It is also found in the moist region of Sri Lanka. Usually found in mixed deciduous forests, but occasionally in evergreen forests (Troup, 1921). It is indigenous to Kerala, and occurs in moist deciduous and secondary forests up to 1500 m m.s.l.

Uses: Wood is used for planking, panelling, carriages, furniture, boxes and carpentry of all kinds (Troup, 1921).


Seeds

Seed maturity: Mature fruits are generally available in India during April-July (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Nilambur, Malappuram							•	•	•			
Peechi, Thrissur					•	•	•					

Collection: Seeds can be collected by plucking the ripe brown fruits from the tree or from the ground, duly rejecting the green and black ones (Kumar and Bhanja, 1992).

Transportation: Fruits collected in cotton or plastic bags should be kept open and transported.

Processing: Fruits are heaped under or buried in a pit for 4-5 days and then washed to remove the pulp (Kumar and Bhanja, 1992). Dry the seeds in sun for 2-3 days (Rai, 1999).

Seed characteristics

Description: Fruit is a drupe, ovoid, greenish yellow, 2.5 -3.5 cm x 1.8 -2 cm contains 2-4 seeds.

Dimensions: 1.5-1.8 cm long (Kumar and Bhanja, 1992).

Weight: 1,129-2,500 de-pulped fruits/kg (Sen Gupta, 1937; Kumar and Bhanja, 1992).

Seed emptiness: Negligible

Insect infestation: No attack.

Fungal infestation: Medium (10-49%). Spermoplane microbes recorded include 11 fungi and actinomycetes. *Trichoderma viride* occurred in high frequency. *Cylindrocladium parvum* and *Colletotrichum gloeosporioides* are the important field fungi recorded on seeds.

Storage physiology: Probably intermediate (?)

Viability period: Seeds retain 50% of initial germination per cent after one year and 25% of initial germination after two years when if stored in gunny bags (Dent, 1948).

Germination type: Epigeal (Troup, 1921)

Germination: Up to 85% (Sen Gupta, 1937)

Germination period: 10-35 days (Sen Gupta, 1937)

Storage: Seeds can be stored in sealed tins and gunny bags (Brandis, 1971). It loses viability in storage especially after one year and hence advised to use when fresh (Kumar and Bhanja, 1992).

Viability testing: Cutting test

Pre-sowing treatments: Not necessary (Kumar and Bhanja, 1992). However, weathering of seeds enhances (alternate wetting and drying) germination (Rai, 1999).

Seedling production: Seeds are sown in plastic trays to a depth of 2 cm in vermiculite and watered. The seedlings begin to appear in about 2-3 weeks and potted in polybags of size 22.5 x 17.5 cm. Seedlings grow fairly fast under proper nursery conditions, reaching a height of up to 1 m in 3-4 months. It can also be propagated vegetatively using branch cuttings. Seedlings raised in seedbeds are found affected with fungal diseases like collar rot, southern blight, foliage blight, etc. which can be controlled by fungicidal (Bavistin 0.1% or Dithane M45 (Indofil) 0.2%) application.

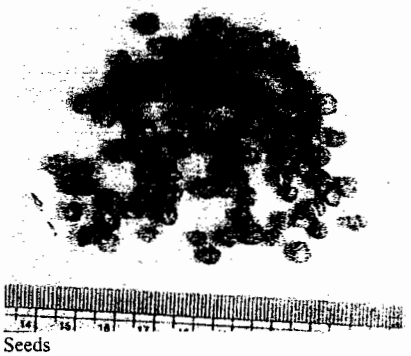
Grewia tiliaefolia Vahl

Synonyms: Nil
Family: Tiliaceae
Trade name: Dhaman
Local names:
Malayalam: Chadachi, Unnam
Tamil: Chadachi, Unam
Kannada: Batala, Thadsal
Hindi: Dhaman, Pharsa
Common name:


Branch bearing fruits

Species description

Habit: A moderately fast-growing, moderate-sized to large deciduous tree attaining a height of more than 25 m and a girth of 2.5 m.


Seeds

Distribution: *Grewia tiliaefolia* occurs in sub-Himalayan tract from the Yamuna to Nepal and throughout Central and Southern India, ascending up to 1200 m m.s.l. It is quite common in the Western Ghats. It is indigenous to Kerala, and occurs in moist deciduous forests.

Uses: Wood is used for shafts, furniture, poles, frames, panels, tool candles, agricultural implements, etc. The bark and wood are used in indigenous medicine.

Seed maturity: Mature fruits are generally available in India during June-August, but vary with locality. Location-specific information is provided below. Seeds fall with pre-monsoon showers.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)				*	*	*						

Collection: Collect ripe fruits from the ground by manual shaking. Ripe fruits fall abundantly during the pre-monsoon showers.

Transportation: Fruits collected in cotton or plastic bags can be packed and transported.

Processing: Fruits should be de-pulped, washed and dried properly. A fruit will normally have two seeds (Nair *et al.*, 1991).

Seed characteristics

Description: Fruit is a drupe, globose or 2-lobed, reddish purple coloured, 5 mm across contains 2 seeds.

Dimensions: 0.51 cm long x 0.49 cm diameter

Weight: 5,290 (with pulp)-19,400 de-pulped seeds/kg (Sen Gupta, 1937)

Seed emptiness: Low

Insect infestation: Low

Fungal infestation: Medium (61%). More than 23 fungi, bacteria and actinomycetes were recorded on seeds. *Corynespora* sp., *Curvularia lunata*, *Cylindrocladium* sp., *Fusarium* sp., *Myrothecium* sp., *Phomopsis* sp. are the important fungi.

Storage physiology: Intermediate (?)

Viability period: Keeps well for four months (possibly for much longer) in gunny bags or sealed tins (Dent, 1948).

Germination type: Epigeal

Germination: Up to 10% (Nair *et al.*, 1991)

Germination period: 5-60 days (Nair *et al.*, 1991)

Storage: Seeds are stored in gunny bags, mixed with BHC to avoid insect attack (Rai, 1999).

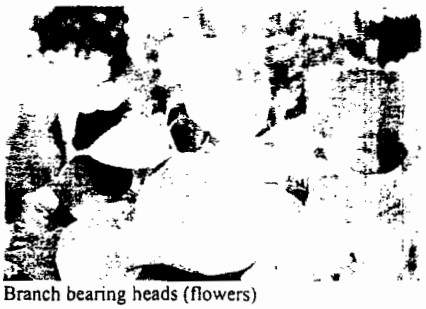
Viability testing: Cutting test.

Pre-sowing treatments: Not required.

Seedling production: The seeds are sown in plastic trays containing vermiculite and watered. The seedlings should be pricked out at 2-leaf stage and planted in 22.5 x 17.5 cm polybags.

Haldina cordifolia (Roxb.) Ridsd.

Synonyms: *Nauclea cordifolia* Roxb.
Adina cordifolia (Roxb.) Hk. f. *ex* Brand.
Family: Rubiaceae
Trade name: Haldu
Local names:
Malayalam: Manjakadambu
Tamil: Bandaru, Manjakadambi
Kannada: Rudraganapu, Ahnan, Anavu, Arasintega
Hindi: Haldu, Hardu, Kaim
Common name:


Branch bearing heads (flowers)


Seeds

Species description

Habit: A slow-growing, large deciduous tree attaining a height of more than 40 m and a girth of 7.5 m.

Distribution: *Haldina cordifolia* is found scattered in deciduous forests throughout the greater part of India and Myanmar; also in the dry regions of Sri Lanka (FRI, 1985). It is indigenous to Kerala, and occurs in moist deciduous forests up to 450 m m.s.l.

Uses: The wood is mainly used for structural works and turnery.

Seed maturity: Mature fruits are generally available in India during October-June (Sen Gupta, 1937). There is considerable variation between localities. Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)	*	*	*	*								*
Nilambur (Malapuram)		*										

Collection: The ripe fruits (heads), which are yellowish black, are collected from the trees by lopping off branches.

Transportation: The heads are packed in polythene/jute/cotton bags and transported.

Processing: After collection the heads are dried in the sun and when dry, are broken up and immersed in water to separate the seeds from the husk. The heavier seeds settle to the bottom and the husk floating on water is removed by decantation. The seeds should then be dried. The seeds can also be cleaned by winnowing (FRI, 1985).

Seed characteristics

Description: Seeds are oblong, minute, brown, shortly winged; contained in globose heads of 2.5-3 cm across.

Dimensions: 0.15-0.3 cm long (FRI, 1985).

Weight: 90,00,000-1,30,00,000 seeds/kg.

Seed emptiness: ?

Insect infestation: Negligible

Fungal infestation: Low (10-16%). *Aspergillus* spp., *Chaetomium* sp., *Penicillium* spp. are the storage moulds recorded on seeds. *Fusarium* sp. is the important field fungi associated with the discoloured seeds.

Storage physiology: Orthodox (?)

Viability period: Seeds are viable up to one year in sealed tins (FRI, 1985).

Germination type: Epigeal

Germination: Up to 90% (Sen Gupta, 1937)

Germination period: 10-15 days (Kumar and Bhanja, 1992)

Storage: The cleaned seeds can be stored in sealed plastic or aluminium tins for one year (FRI, 1985).

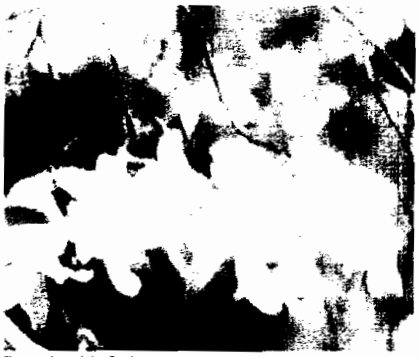
Viability testing: Germination test.

Pre-sowing treatments: Not required.

Seedling production: Seeds are sown in plastic trays filled with vermiculite and water regularly. Seeds can also be sown in germination paper, which is rolled and kept in a beaker containing water. When seedlings are in 4-leaf stage they are pricked out into 22.5 x 17.5 cm polybags.

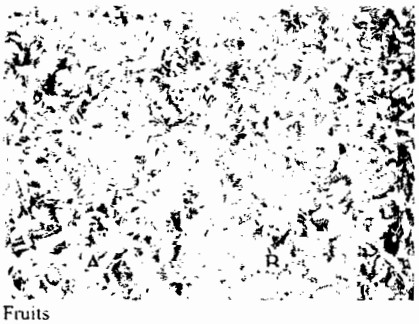
Hopea parviflora Bedd.

Synonyms: Nil
Family: Dipterocarpaceae
Trade name: Hopea
Local names:
Malayalam: Thambakam, Kambakam, Irumbakam, Urippu
Tamil: Irumbugam, Vellai Kongu, Pongu
Kannada: Bogimara, Kiralbogi
Hindi: Bovige
Common name:


Branch with fruits

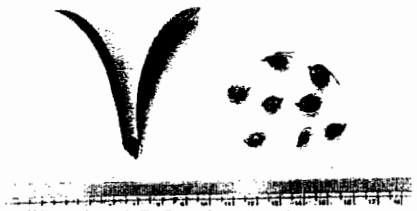
Species description

Habit: A slow-growing, very large evergreen tree attaining a height above 35 m and a girth of 4.5 m.


Fruits

Distribution: *Hopea parviflora* grows in the forests of Karnataka and Kerala and extends to Tirunelveli District of Tamil Nadu. It is endemic to the Western Ghats of Kerala and indigenous (FRI, 1980), particularly in evergreen and semi-evergreen forests along riverbanks.

Uses: The timber had high preference for construction purposes in the past. Though, slow growing, the tree is ideal for avenue planting.


A: Winged seed, B: De-winged seeds

Seed maturity: Mature fruits are generally available during April-July (Sen Gupta, 1937). Location-specific information for southern States is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Nilambur (Malappuram)				*	*	*						
Vazhachal (Thrissur)				*	*							
Chinnar (Idukki)					*	*						
Kulathupuzha (Kollam)					*	*	*					
Thiruvananthapuram								*	*			
Arippa (Thiruvananthapuram)					*	*						
Pattikkad (Thrissur)			*	*	*							
Iringol (Ernakulam)				*	*	*						
Tamil Nadu			*	*	*	*						
Karnataka			*	*	*	*						

Collection: Fruits may be collected from the tree when the wing colour changes from green to brown (Tompsett and Kemp, 1996). Seed collection from tree is laborious. Mature seeds falling during the pre-monsoon showers, can be conveniently collected from the ground. As the fallen seeds germinate soon, seed collection may be done without time lapse. Always check a small sample of seeds before collecting, since insect infestation may be excessive in some localities.

Transportation: Transport fruits in moist and ventilated containers under low temperature, but above 18°C. If the wings are left intact, a reservoir of air is created which provides support for respiration; this method will limit both the imbibition of moisture and the accumulation of heat produced by respiration, thereby reducing the chance of germination during transport. Polythene bags with small ventilation holes, and open-weave sacks are some types of containers used for transport. Where greater rigidity is required, these containers should in turn be closed in cardboard or wooden boxes provided with ventilation holes (Tompsett and Kemp, 1996).

Processing: Wings may be removed for ease of handling and reduction of bulk (Tompsett and Kemp, 1996).

Seed characteristics

Description: Nut-like fruit is enclosed in a 5-lobed calyx of which two lobes are enlarged into wings; the wings measures 4-6 x 1 cm.

Dimensions: 0.7 cm x 0.6 cm (without wings) (Tompsett and Kemp, 1996).

Weight: 2,470 fruits/kg (with wings) (FRI, 1980); 4,100-4,586 seeds/kg (without wings) (Tompsett and Kemp, 1996).

Seed emptiness: Low

Insect infestation: High infestation due to an unidentified beetle borer.

Fungal infestation: High (67%). Seeds were found harboured by a rich microflora. Nineteen fungi, actinomycetes and bacteria were recorded on seeds. *Fusarium* sp., *Botryodiplodia theobromae*, *Cylindrocladium quinqueseptatum* are the important field fungi associated with seed discolouration and rot.

Storage physiology: Recalcitrant (Tompsett and Kemp, 1996).

Viability period: Seed is viable up to 10 days under normal conditions.

Germination type: Epigeal

Germination: 68-84% (Tompsett and Kemp, 1996).

Germination period: 11-37 days (Dent, 1948).

Storage: Seeds can be stored for about a week without loss of viability under normal conditions (Dent, 1948). For larger quantities of seed, storage at or near harvest moisture content in media such as softwood sawdust (16% moisture content) and perlite (0-4% moisture content) is recommended (Tompsett and Kemp, 1996).

Smaller quantities of seed can be stored in inflated polythene bags at 99% relative humidity and 18°C. Ventilation, at least once in a week is essential; use of air at a high relative humidity would be desirable for this purpose (Tompsett and Kemp, 1996).

Seeds with 41% moisture content have been successfully stored with retention of 84% viability in sealed and inflated polythene bags regularly ventilated for 104 days (Tompsett and Kemp, 1996).

Viability testing: Cutting test and germination test.

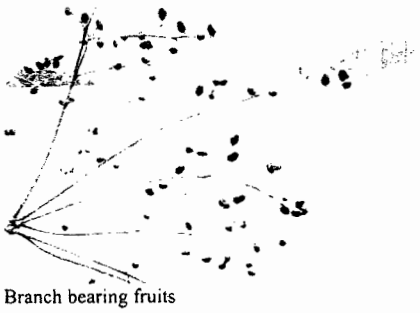
Pre-sowing treatments: De-winging prior to sowing is recommended. Ideal germination temperature is 31°C (Tompsett and Kemp, 1996).

Seedling production: Seeds may be dibbled in vermiculite or river sand medium (in trays) with or without wings, horizontally or with wings downwards. Sowing with wings upwards will result in abnormality to the radicle and produce abnormal seedlings. Germinated seedlings can be pricked out to polythene bags or root-trainers filled with appropriate potting mixture.

Branch cuttings of 2 mm to 3 mm thickness and 7 cm length when dipped for one minute in IBA 2000 ppm solution has produced a 30% rooting and sprouting.

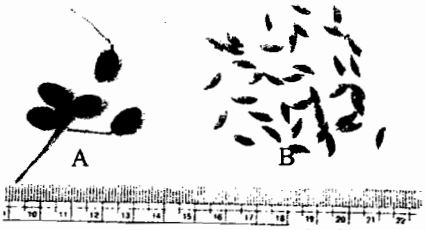
Lagerstroemia microcarpa Wt.

Synonyms: *Lagerstroemia lanceolata* Wall. *ex* Cl.
L. thomsonii Koehne
Family: Lythraceae
Trade name: Venteak, Nava
Local names:
Malayalam: Venthekku, Vellilavu
Tamil: Venteak, Chennanji, Benteak
Kannada: Billinandi, Benteak
Hindi: Benteak
Common name:


Branch bearing fruits

Species description

Habit: A moderately fast-growing, medium-sized to large deciduous tree attaining a height of up to 30 m and a girth of 3 m.



A: Mature capsules, B: Seeds

Distribution: *Lagerstroemia microcarpa* is one of the most important trees of the west coast of the Indian Peninsula, in moist mixed deciduous forests (FRI, 1984). It is indigenous to Kerala, and occurs in moist deciduous and semi-evergreen forests.

Uses: Wood is used for house building, furniture, ships, boats, etc. The leaves are used as green manure (FRI, 1984).

Seed maturity: Mature fruits are generally available in India during March (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala	*	*	*	*	*							*
Peechi (Thrissur)			*	*	*							
Vazhchal	*	*										*

Collection: Ripe capsules, which are brown in colour should be collected from the tree before dehiscence, since the seeds are winged and wind dispersed (FRI, 1984).

Transportation: The capsules collected in cotton/gunny/plastic/polythene bags can be transported.

Processing: The capsules are dried in the sun with a cover to prevent the tiny, winged seeds being blown away by wind. The seeds are separated and cleaned and mixed with BHC before storing (FRI, 1984; Rai, 1999).

Seed characteristics

Description: Fruit is a capsule, ellipsoid, smooth, 4-valved, 1.2-2 cm long contains many winged cultriform seeds.

Dimensions: 0.8 cm long (FRI, 1984)

Weight: 8,416(?)- 2,68,082 seeds/kg (Sen Gupta, 1937).

Seed emptiness: High

Insect infestation: Nil

Fungal infestation: Medium to high (24-94%). Twenty-three fungi belonging to 19 genera and actinomycetes were recorded. *Fusarium semitectum*, *Alternaria* sp., *Curvularia* sp., *Drechslera* sp., *Colletotrichum gloeosporioides*, *Helminthosporium* sp., *Phoma* sp., etc., are the important spermoplane fungi.

Storage physiology: Orthodox (?)

Viability period: Seeds store well in gunny bags for six months (Dent, 1948).

Germination type: Epigeal

Germination: Up to 20% (FRI, 1984)

Germination period: 8-66 days (FRI, 1984)

Storage: Seeds can be stored in gunny bags in ventilated sheds up to 6 months. Seeds smeared with wood-ash can be stored up to 3 months. Seeds can also be stored in sealed tins, but it is better to keep in gunny bags (Dent, 1948; FRI, 1984).

Viability testing: cutting test and germination test.

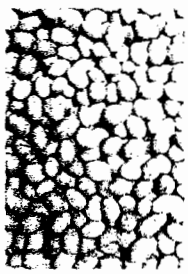
Pre-sowing treatments: Not necessary (FRI, 1984).

Seedling production: Seeds are sown in plastic trays filled with vermiculite and watered regularly. After one month the seedlings are pricked out in to 22.5 x 17.5 cm polybags. Seedlings are ready for planting in the next planting season (Rai,1999). It can be propagated by using stumps of 1-2 years old nursery raised seedlings.

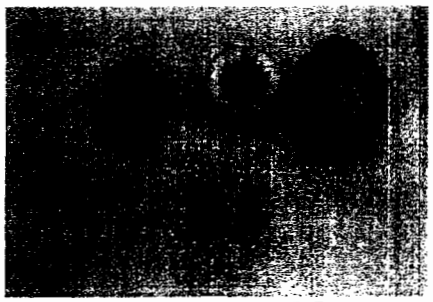
Melia dubia Cav.

Synonyms: *Melia composita* Willd.
M. robusta Roxb.
M. superba Roxb.
Family: Meliaceae
Trade name: Malabar neem wood
Local names:
Malayalam: Malavepu
Tamil: Malai-vembu
Kannada: Heb-bevu
Hindi: Mahanim
Common name:


Branch bearing flowers and mature fruits


Mature fruits


Depulped fruits


A: Depulped fruit, B: C.S. of fruit, C: Fruit, D: Seeds

Species description

Habit: A fast-growing, large deciduous tree attaining a height of more than 30 m and a girth of 4.5m.

Distribution: *Melia dubia* occurs in deciduous hill forests in the Peninsular India. It is also a tree of the Eastern Himalayas, ascending up to 1800 m m.s.l in North Bengal and in the Khasi and Cachar hill tracts. It also occurs in Sikkim and Bhutan (FRI, 1981). It is indigenous to Kerala, occurs in moist deciduous forests up to 600 m m.s.l.

Uses: The timber is used for making wallboard, door panel, and furniture, farm implements, flooring, boxes and crates.

Seed maturity: Mature fruits are generally available in India during October-February (FRI, 1981). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)	*										*	*
Chinnar (Idukki)				*	*							
Kulathupuzha (Kollam)	*	*										
Nilambur	*											*

Collection: Mature fallen fruits are collected from the ground, as plenty of mature ripe fruits are available on the ground during fruiting season.

Transportation: Fruits collected in cotton/polythene/plastic bags can be transported to processing centre.

Processing: The fruits collected in gunny bags are beaten with a wooden billet or pounded in a wooden mortar to remove the pulp (FRI, 1981).

Seed characteristics

Description: Fruit is a drupe, ovoid, 4-5-celled, 2.5-3.5 cm contains 1-5 black coloured seeds.

Dimensions: 1 cm long

Weight: 250-320 fruits/kg (FRI, 1981)

Seed emptiness: Low

Insect infestation: Low

Fungal infestation: High (63-93%). Spermoplane microflora includes 19 fungi, bacteria and actinomycetes. *Aspergillus* spp., *Penicillium* spp., *Chaetomium globosum* and *Trichoderma* spp., are the important storage moulds. *Bipolaris maydis*, *Botryodiplodia theobromae*, *Fusarium* sp., *Colletotrichum* sp., *Myrothecium* sp., etc., are the important field fungi associated with seed discolouration and seed rot.

Storage physiology: Intermediate (?)

Viability period: Seeds are viable for about 6 months.

Germination type: Epigeal

Germination: 1.5 to 50% (?) (FRI, 1981)

Germination period: 48 days (FRI, 1981)

Storage: Depulped and dried seeds dressed with insecticide can be stored for about 6 months.

Viability testing: Viability can be assessed through cutting test as germination does not provide any indication of seed viability due to dormancy of seeds.

Pre-sowing treatments: 1. Splitting the hard endocarp longitudinally into two halves with a sharp nut cutter. 2. Burying the seeds in a pit for about a year. 3. Soaking the seeds in cold water for a week.

Seedling production: The seeds after de-pulping are spread out in the seedbed, covered with a 7.5 cm layer of leaf litter and burnt. Immediately after the burn, the seeds are covered with a 7.5-10 cm layer of earth and watered frequently. Seedlings that are 20-30 cm in height are suitable for planting out at the commencement of the southwest or northeast monsoon (FRI. 1981).

Mimusops elengi L.

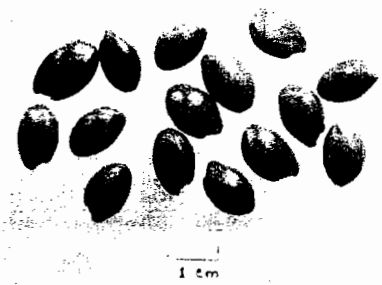
Synonyms: *Mimusops parvifolia* R. Br.
Family: Sapotaceae
Trade name: Bullet wood
Local names:
Malayalam: Elengi, Ilanji
Tamil: Elengi, Mahizhampoo maram
Kannada: Bogalamara, Bakula
Hindi: Bakul, Bolsari
Common name: Indian medlar


Branch bearing immature fruits

Species description

Habit: A slow growing, medium-sized to large evergreen tree attaining a height of more than 25 m and a girth of 2.5 m (FRI, 1985).

Distribution: *Mimusops elengi* occurs in moist evergreen forests of the Western Ghats, and in the dry evergreen forests of the Eastern Ghats. It also occurs in Andamans, Myanmar and Sri Lanka (FRI, 1985). It is indigenous to Kerala in the evergreen and semi-evergreen forests up to 1200 m.



Seeds

Uses: The wood is used for general constructional works and house building and also for piles, bridges, carts, boats, etc (FRI, 1985).

Seed maturity: Mature fruits are generally available in India during June-July (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)						*	*					

Collection: Fruits are collected from the ground after fall (Rai, 1999).

Transportation: The fruits collected in cotton/polythene bags are packed and transported.

Processing: The fruits are squeezed in water to depulp and to separate the seeds, which should be dried under shade (FRI, 1985; Rai, 1999).

Seed characteristics

Description: Fruit is a berry, ovoid, yellowish, 2.5-3 x 1.8-2 cm contains single blackish or greyish brown, ovoid, compressed, shining, seed.

Dimensions: 1.5-2.3cm x 1-1.3 cm (FRI, 1985)

Weight: 1,940-2,152 seeds/kg (Sen Gupta, 1937).

Seed emptiness: Negligible

Insect infestation: Nil

Fungal infestation: Low (11.5–18%). *Rhizopus* sp., *Mucor* sp., *Torula* sp., *Aspergillus* spp. are the important spermoplane fungi recorded.

Storage physiology category: Recalcitrant (?)

Viability period: Seed do not retain viability for long.

Germination type: Epigeal (FRI, 1985)

Germination: 30-40% (Kumar and Bhanja, 1992); 60% (Rai, 1999); 90% (fresh seeds)

Germination period: 30-45 days (Rai, 1999); 87 days (FRI, 1985).

Storage: Viability of seeds is about 2 months. Seeds are susceptible to damage by ants, hence treat with insecticide before storage (Rai, 1999). Store seeds in dry condition in closed aluminium or plastic containers.

Viability testing: Cutting test and germination test.

Pre-sowing treatments: Cold water treatment may be given because of the hard testa.

Seedling production: Freshly collected seeds are sown in plastic trays in vermiculite and watered under shade. In about 60 days, the seedlings attain 5 cm height and are pricked out in to polybags of size 22.5 cm x 17.5 cm. Keep the polybags under shade for about 60 days. Seedlings have to be maintained in the nursery for about 8 months. Adequate watering twice a day should be given (Rai, 1999).

Neolamarckia cadamba (Roxb.) Bosser

Synonyms: *Anthocephalus chinensis* (Lamk.) Rich. *ex* Walp.
Anthocephalus cadamba (Roxb.) Miq.
Anthocephalus indicus Rich.
Nauclea cadamba Roxb.
Sarcocephalus cadamba Kurz

Family: Rubiaceae

Trade name: Kadam

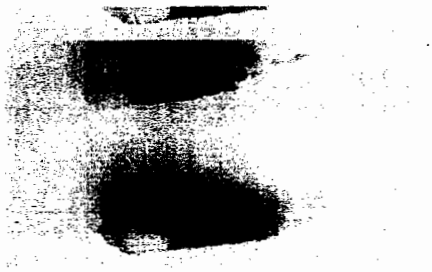
Local names:

Malayalam: Kadambu, Aatuthekku
Tamil: Vellacadamba, Kola-aiyila
Kannada: Bale, Kada, Kadwal
Hindi: Kadamb, Kadam

Common name: Kadam

Branch bearing heads

L.S. of mature fruit



Capsule showing seeds

Seeds

Species description

Habit: A fast-growing, large deciduous tree attaining a height of more than 25 m and a girth of 2.5 m (FRI, 1985).

Distribution: *Neolamarckia cadamba* occurs in moist warm regions, frequenting in moist deciduous and evergreen forests, and often occurring on alluvial soil along rivers and also on swampy areas. It is distributed in the sub-Himalayan tract from Nepal eastwards, Bengal, Assam, Bihar, Myanmar, Andhra Pradesh, and the west coast from North Kanara southwards to Southern Kerala. It also occurs in Sri Lanka. It is cultivated in many parts of India (FRI, 1985). It is indigenous to Kerala, in the semi-evergreen forests up to 800 m m.s.l.

Uses: The wood is used for ceiling boards, packing cases, light furniture, etc. Bark and leaves are used for medicinal purposes (FRI, 1985).

Seed maturity: Mature fruits are generally available October (FRI, 1985; Luna, 1996). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Konni (Pathanamthitta)								*	*	*	*	
Kottayam								*	*	*	*	
Kaniamangalam (Ernakulam)								*	*	*	*	
Dhoni (Palakkad)								*	*	*	*	
Nilambur (Malappuram)								*	*	*	*	

Collection: Fruits are collected from the ground and heaped under shade. Mature fruits can also be collected from the trees using long poles with billhooks.

Transportation: Fruits collected in polythene or cotton bags should not be packed and transported.

Processing: The fruits are allowed to rot for 3 or 4 days and the pulp is washed off by hand in a bucket of water leaving the seeds at the bottom. Seeds are then thoroughly dried and stored in a dry place (FRI, 1985). Another method is to dry the fruits well and rub on a hand-made metal grater to release the seeds. Seeds can be separated using a sieve (0.05 mm mesh) (Chacko, 1981), which allows passage only of seeds and some finer articles (Brandis, 1971). Seeds can be cleaned by winnowing.

Seed characteristics

Description: The globose, fleshy, orange-yellow coloured pyrenes contains many angular seeds.

Dimensions: 0.59-0.68 mm x 0.41-0.48 mm

Weight: 9,20,651 (Sen Gupta, 1937)- 23, 000, 000-31,200,000 seeds/kg.

Seed emptiness: Negligible

Insect infestation: Moderate damage due to an unidentified caterpillar.

Fungal infestation: Low (18-29%). *Colletotrichum gloeosporioides*, *Drechslera* sp., *Fusarium* sp., and *Phoma* sp. are the important field fungi on seeds. Storage moulds include: *Aspergillus* spp., *Chaetomium* sp., and *Mucor* sp.

Storage physiology: Orthodox (?)

Viability period: Seed is viable up to one year (Dent, 1948).

Germination type: Epigeal

Germination: 67-75%

Germination period: 7-21 days (Sen Gupta, 1937); 15-30 days (Rai, 1999); 11-50 days (FRI, 1985).

Storage: Seeds can be stored in dry place for one year (Dent, 1948).

Viability testing: Germination test.

Pre-sowing treatments: Nil

Seedling production: The seeds, being very minute are mixed with fine sand before sowing at the rate of about 130 g of seeds per square meter of bed (FRI, 1985).

The bed should be made with more sand. Cover the bed with straw. The entire bed should be sprayed with fungicide and dusted with insecticide like BHC to prevent fungal and insect damage. Water the bed with a fine rose can twice a day. In each bed of one square meter about 2000 seedlings are expected. When the seedlings are about 1-2 cm in height, pricked out along with the ball of earth and transplanted in polybags of size 22.5 x 17.5 cm. Keep these young seedlings under shade for about 60 days.

Pterocarpus marsupium Roxb.

Synonym: *Lingoum marsupium* (Roxb.) Kuntze
Family: Leguminosae
Subfamily: Faboideae
Trade name: Kino tree
Local names:
Malayalam: Venga
Tamil: Vengai
Kannada: Benga, Honne
Hindi: Bijasal, Murgasal
Common name: Malabar kino tree


Branch bearing immature pods

Species description


A: Mature pods, B: Seeds

Habit: A slow growing, large deciduous tree attaining a height of 30 m and a girth of 3 m.

Distribution: *Pterocarpus marsupium* occurs throughout the greater parts of the Indian Peninsula extending from Gujarat up to Bihar and Orissa. It is common in Madhya Pradesh, Maharashtra, Andhra Pradesh, Orissa, Karnataka, Kerala and Tamil Nadu. It is also common in West Bengal (FRI, 1983). It is indigenous to Kerala, and occurs in moist, dry deciduous and semi-evergreen forests up to 1,300 m m.s.l.

Uses: Wood is extensively used for construction and furniture purposes. After teak and rose wood, it is the most preferred timber for construction work. The bark, wood and flowers have various medicinal uses. Leaves are used as fodder.

Seed maturity: Mature fruits are generally available in India during February-May (FRI, 1983; Luna, 1996). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala		*	*	*								
Peechi (Thrissur)		*	*	*								
Chinnar (Idukki)										*	*	*
Karnataka	*	*										

Collection: The pods are collected by lopping off the branches or from the ground.

Transportation: Fruits collected in cotton or gunny bags can be transported. No special care is needed.

Processing: The pods must be dried properly as inadequately dried pods are susceptible to insect and fungal attack (Rai, 1999).

Seed characteristics

Description: Fruit is a pod, orbicular, compressed, winged, indehiscent, 5-6 cm across contains 1 or 2 seeds.

Dimensions: 10-12 mm length x 5-6 mm width

Weight: 1,587-1,940 fruits/kg (Sen Gupta, 1937; Luna, 1996).

Seed emptiness: Low

Insect infestation: High infestation due to *Eucosma* sp., (Lepidoptera: Eucosmidae), the caterpillars of which bore in to the developing fruits and feed on the seed.

Fungal infestation: Medium (37-74%). Seeds were harboured by a rich microflora comprising 36 fungi, a bacterium and actinomycetes. Storage moulds like *Aspergillus* sp., and *Penicillium* sp., occurred in low frequency. Field fungi like *Alternaria* sp., *Bipolaris* sp., *Corynespora* sp., *Cylindrocladium* sp., *Myrothecium* sp., *Phomopsis* sp., and *Fusarium* sp., were found associated with discolouration and seed rot. *Phaeoisaria* sp., *Torula herbarum*, *Cylindrocladium parvum* were the most frequently encountered ones.

Storage physiology: Orthodox (?)

Viability period: Seeds keep well for about one year (Dent, 1948).

Germination type: Epigeal (FRI, 1983)

Germination: Up to 97% (Sen Gupta, 1937).

Germination period: 7 (FRI, 1983) - 60 days (Sen Gupta, 1937).

Storage: The seeds can be stored up to 9 months, sometimes to a year in gunny bags (Dent, 1948).

Viability testing: Cutting test.

Pre-sowing treatments: The following pre-treatments are usually given. (1) cutting across and soaking the ends of pods in water for a few days. (2) By placing alternate layers of pods and dried leaves in a pit flooding it with water till germination starts. (3) The seeds are tied up in a cloth or gunny bag and soaked in water for 24 hrs and the excess water is allowed to drain off. After 2-3 days the germinating seeds are taken out and used for sowing (FRI, 1983).

Seedling production: The fruits are dibbled in plastic trays using vermiculite and watered regularly. The young seedlings can be pricked out and planted in polybags of size 22.5 x 17.5 cm. Seedlings reach a height of about 15-20 cm in 4-5 months. One-year-old seedlings can be transplanted with a ball of earth or can be made in to stumps.

Schelichera oleosa (Lour.) Oken.

Synonyms: *Pistacia oleosa* Lour.
Schelichera trijuga Willd.
Family: Sapindaceae
Trade name: The Lac tree
Local names:
Malayalam: Poovam, Dhoothalam
Tamil: Puvam, Pumaratha
Kannada: Sagdi, Chakota
Hindi: Kosum, Gosum
Common name: Ceylon oak


Branch bearing fruits


Seeds

Species description

Habit: A slow to moderately fast growing, medium-sized to large deciduous tree attaining a height of 20 m and 2 m in girth (FRI, 1981).

Distribution: *Schelichera oleosa* is widely distributed almost throughout the Indian sub-continent, with only a few breaks in continuation. It also found in Myanmar, Sri Lanka and Java. In India, it occurs sporadically on the low hills of the Himalaya up to 900m m.s.l. from the Sutlej eastwards up to Bihar, West Bengal, Central and Southern India (FRI, 1981). It is indigenous to Kerala, and occurs in semi-evergreen and moist deciduous forests up to 900m m.s.l.

Uses: Wood is used for rice-pounders, tool handles, building construction, etc. The kernel yields an oil which is used in cooking. Also it is a source of lac (FRI, 1981).

Seed maturity: Mature fruits are generally available in India during August-November (FRI, 1981). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Chinnar (Idukki)							*	*				
Pariyaram (Thrissur)									*	*		

Collection: The ripe fruits are collected from the ground as soon as they fall. The fruits may also be collected from the tree using long pole attached with billhook.

Transportation: Fruits collected in cotton or plastic bags are packed and transported as early as possible.

Processing: The ripe fruits are thrashed to separate the seeds.

Seed characteristics

Description: Fruit is a drupe, globose, 1-1.5 cm across contains 1 to 2 seeds enclosed by a pulpy aril.

Dimensions: 1.5 cm long (FRI, 1981)

Weight: 1,517 (Sen Gupta, 1937) - 2,200 seeds/kg (FRI, 1981; Kumar and Bhanja, 1992; Luna, 1996).

Seed emptiness: Medium

Insect infestation: Low infestation due to an unidentified beetle.

Fungal infestation: High (64%). More than 23 fungi, actinomycetes and bacteria were recorded on seeds. *Chlamydomyces palmarum* and *Botryodiplodia theobromae* were the most frequently encountered fungi. *Cylindrocladium* sp., and *Phoma* sp., were found associated with seed rot.

Storage physiology: Orthodox-intermediate (?)

Viability period: Loss of viability is minimal during the first year of storage in both gunny bags and sealed tins (Dent, 1948).

Germination type: Epigeal (Kumar and Bhanja, 1992)

Germination: 6-58% (Sen Gupta, 1937); 50-80 (FRI, 1981; Luna, 1996)

Germination period: 8-94 days (Sen Gupta, 1937; FRI, 1981; Luna, 1996)

Storage: Seeds can be stored in gunny bags or in airtight tins for about 6 months without any deterioration preferably after smearing them with wood ash (FRI, 1981). Seeds remain viable after one year in gunny bags and after 2 years in sealed tin.

Viability testing: Cutting test and germination test.

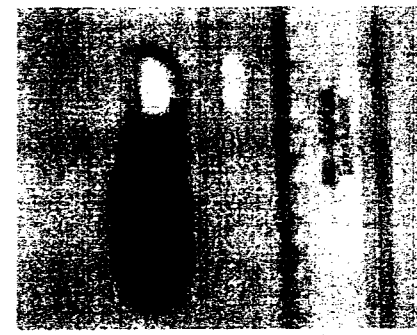
Pre-sowing treatments: Not necessary (Kumar and Bhanja, 1992). Soaking in hot water is also recommended (Kindt *et al.*, 1997).

Seedling production: Seed is sown in polybags of size 22.5 x 17.5 cm in July to August directly since seeds do not withstand the transplanting because of the very fast growth of the taproot (Kumar and Bhanja, 1992). *Cylindrocladium* sp., and *Phoma* sp., cause seedling rot in nursery, which can be controlled by application of Bavistin (0.1%). The planting in the field can be taken up after the second rains.

Swietenia macrophylla King

Synonyms: *Swietenia belizensis* Lundell
S. candollei Pittier
S. krukovii Gleason
S. tessmanii Harms
Family: Meliaceae
Trade name: Honduras mahogany
Local names:
Malayalam: Valia Mahogany, Mahogany
Tamil: Mahogany
Kannada: Mahogani
Hindi:
Common name: Bastard mahogany, Large-leaved mahogany


Branch bearing capsule


A: Winged seed showing the true seed
B: Extracted seed

Species description

Habit: A moderately fast-growing, very large deciduous tree attaining a height of 40 m and a girth of 4 m.

Distribution: *Swietenia macrophylla* is widely distributed in tropical America. It was introduced into India in 1872 and has been planted in West Bengal, Bihar, Orissa, Maharashtra and Uttar Pradesh. It was planted as an ornamental tree and a plantation species in South India (FRI, 1981). It is not indigenous to Kerala.

Uses: Wood is favoured for high-value furniture and interior fittings (Mayhew and Newton, 1998).

Seed maturity: Mature fruits are generally available in India during February-April (FRI, 1981). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Thrissur	*								*	*	*	*
Dhoni (Palakkad)	*	*										
Nilambur (Malappuram)	*	*	*	*	*							
Ambalapuzha (Alappuzha)	*	*	*									
Aryankavu (Kollam)	*	*										
Thiruvananthapuram	*	*	*									

Collection: Mature fruits turning grey green to brown are collected from the trees before they dehisce (Tompsett and Kemp, 1996; Mayhew and Newton, 1998). It will be difficult to collect the seeds from ground as the fruits dehisce and disperse.

Transportation: Capsules or dehisced seeds can be transported in closed containers as cool as possible but not below 2°C or –20°C. Moist material should be ventilated (Tompsett and Kemp, 1996).

Processing: The fruits are dried in the sun until they open and seeds are extracted by hand (FRI, 1981). Break open the capsules by spreading them on a slatted tray, using sufficient air circulation to allow for quick drying (Tompsett and Kemp, 1996).

Seed characteristics

Description: The flat winged brown seeds are arranged on the central axis of the bulbous capsule.

Dimensions: Length 8.3 x 2.5cm

Weight: 1,905-2,293 seeds/kg (with wings intact) (Sen Gupta, 1937); 1600-2300 seeds/kg (with wings intact) (Mayhew and Newton, 1998).

Seed emptiness: Low

Insect infestation: Low infestation by an unidentified caterpillar in fallen fruits. Incidence of the shoot and fruit borer, *Hypsipyla robusta* Moore has been reported to be a serious pest of fruits throughout the range (Beeson, 1941).

Fungal infestation: Low to high (6.5-99.5%). Thirty-two fungi belonging to 24 genera, bacteria and actinomycetes were recorded on seeds. *Aspergillus* spp. are the important storage moulds. Species of *Helminthosporium*, *Alternaria*, *Drechslera* and *Curvularia* are the important field fungi recorded on seeds.

Storage physiology: Orthodox (Tompsett and Kemp, 1996); Intermediate (Kindt *et al.*, 1997; Hong and Ellis, 1998).

Viability period: Under normal conditions, it is viable up to three months (Mayhew and Newton, 1998).

Germination type: Hypogeal (FRI, 1981)

Germination: 90% (Luna, 1996) - 95% (Mayhew and Newton, 1998)

Germination period: 10-97 days (Sen Gupta, 1937; FRI, 1981); 14-112 days (Mayhew and Newton, 1998)

Storage: Seeds may be stored for six months in sealed tin. Seeds stored in gunny bags for one year failed to germinate. Therefore, it is advisable to keep the seeds in sealed tin than in any bags or open baskets (Dent, 1948). Dried seeds (4% MC or lower) should be retained in hermetic storage and at 2°C. For long-term storage, lower moisture contents (down to 2%), and very low temperatures (-13°C or less) are desirable (Tompsett and Kemp, 1996).

Viability testing: Cutting test (for fresh seeds only), hydrogen peroxide (0.35% solution) test and tetrazolium test (0.1%).

Pre-sowing treatments: No pre-treatment other than de-winging is required.

Seedling production: Seeds are sown horizontally to a depth of 2 cm in plastic trays containing vermiculite. Germination commences within 17 to 20 days of sowing and continues for about 50 days. The seedlings are transferred to polybags of 22.5 x 17.5 cm size filled with soil or root trainers when they attains 15 cm height. The seedlings are ready for planting after 3 months of potting.

It can also be propagated vegetatively by leafy cuttings and by tissue culture. Cuttings of sizes between 6.5 cm and 7.5 cm showed the highest survival rates when IBA was applied. The cuttings took 11 weeks to root (Mayhew and Newton, 1998).

Swietenia mahagoni (L.) Jacq.

Synonyms: *Cedrus mahagoni* L.
Family: Meliaceae
Trade name: Cuban Mahogany
Local names:
Malayalam: Cheriamahogany
Tamil: Mahogany
Kannada: Mahogani
Hindi:
Common name: Spanish mahogany, Small-leaved mahogany


Branch bearing capsule


A: Winged seeds, B: Extracted seed

Species description

Habit: A moderately fast-growing, medium-sized to large evergreen tree attaining a height of 30 m and a girth of 4.5 m.

Distribution: *Swietenia mahagoni* was introduced into India in 1795, from West Indies and established in many parts of India including West Bengal, Bihar, Orissa, Gujarat, Uttar Pradesh, Andamans, Maharashtra, Tamil Nadu, Karnataka and Kerala (FRI, 1981).

Uses: Wood is used extensively for furniture.

Seed maturity: Mature fruits are generally available in India during October-December (FRI, 1981). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Nilambur	*	*	*									
Erumayoor	*	*										

Collection: The capsules are collected from trees just before they start to dehisce. It is also possible to collect the fruits from the ground after they have fallen (FRI, 1981).

Transportation: Transport the capsules or seeds in closed containers as cool as possible but not below 2°C or -20°C. Moist material should be ventilated. Remove the wings to facilitate subsequent handling (Tompsett and Kemp, 1996).

Processing: Capsules are dried in the sun and when they open, the seeds are taken out and stored (FRI, 1981).

Seed characteristics

Description: Fruit is a capsule, seeds flat, winged arranged on the central axis.

Dimensions: Length 5.4 cm x 1.5 cm width (FRI, 1981).

Weight: 3527 seeds/kg (with wings) (Sen Gupta, 1937); 9100 seeds/kg (?) (Tompsett and Kemp, 1996).

Seed emptiness: Low

Insect infestation: Low infestation by an unidentified caterpillar in fallen fruits. Incidence of the shoot and fruit borer, *Hypsipyla robusta* Moore has been reported to be a serious pest of fruits (Beeson, 1941).

Fungal infestation: Low to high (12-100%). Spermoplane microorganisms recorded include 23 fungi and a bacterium. Species of *Aspergillus*, *Penicillium*, *Chaetomium*, *Cladosporium* are the important storage moulds. *Botryodiplodia theobromae*, *Rhizoctonia* sp., *Drechslera* sp., *Fusarium* sp., are the important field fungi.

Storage physiology: Orthodox (Tompsett and Kemp, 1996)

Viability period: Under normal conditions, viable up to 6 months (FRI, 1981).

Germination type: Hypogeal

Germination: 86% at 6.5% moisture content.

Germination period: 14-28 days

Storage: Seeds dried in the sun and stored in an air-tight tin will remain fairly viable for over six months (Brandis, 1971). Dried seeds (4% MC or lower) should be retained in hermetic storage and at 2°C. For long-term storage, lower moisture contents (down to 2%) and very low temperatures (-13°C or less) desirable (Tompsett and Kemp, 1996). When stored in open baskets, the viability loses rapidly after 6 months (Dent, 1948).

Viability testing: The viability can be tested by cutting test, germination test and by hydrogen peroxide (1% solution) test.

Pre-sowing treatments: No pre-treatment other than de-winging is required.

Seedling production: The de-winged seeds are sown either vertically or horizontally to a depth of 3 cm in vermiculite/soil.

Syzygium cumini (L.) Skeels

Synonyms: *Eugenia jambolana* Lam.
Syzygium jambolanum DC
Myrtus cumini L.
Family: Myrtaceae
Trade name: Jaman
Local names:
Malayalam: Njaval, Njara
Tamil: Naval, Naga
Kannada: Narala, Neeram
Hindi: Jam, Jaman
Common name: Black plum

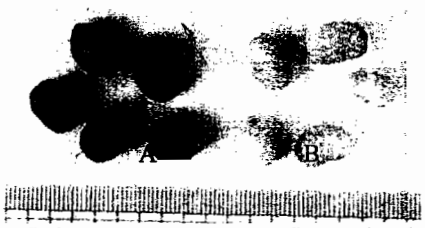
Branch bearing fruits

Species description

Habit: A moderately slow growing, large evergreen tree attaining a height to 30 m and a girth of 6 m.

Distribution: *Syzygium cumini* is found throughout India, including the Andamans and Union Territories, except in the most arid regions. It also occurs in Sri Lanka, Myanmar, Malaysia and Australia (FRI, 1984). It is indigenous to Kerala and occurs in evergreen and semi-evergreen forests up to 1800 m m.s.l.

Use: It is extensively used for posts, beams, door-frames and panels. The fruits are edible. The bark and fruits have medicinal uses.



A: Fruits, B: Depulped seeds

Seed maturity: Mature fruits are available in India during May-August (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Thrissur		*	*	*								
Karnataka			*	*	*							
Tamil Nadu			*	*	*	*						

Collection: The fruits are collected from the ground immediately after they have fallen (FRI, 1984). However, it is best to collect the ripe fruits, which are black in colour from the tree by shaking the branches.

Transportation: Fruits collected in cotton or polybags should be transported as quick as possible since the seeds not only susceptible to fungal attack but also lose viability quickly. No packing is needed while transporting.

Processing: Immediately after collection and transportation, remove the pulp by rubbing with hand and washing and dry the seeds under shade before sowing.

Seed characteristics

Description: The oblong purple coloured berry of 1.5-2.5 x 1-1.5 cm contains single seed.

Dimensions: 1.2 cm x 0.8 cm

Weight: 1,129-1210 seeds/kg; 3,880 fruits/kg (Sen Gupta, 1937); 1,100-1,300 seeds/kg (Kumar and Bhanja, 1992); 1,800 seeds/kg (FRI, 1984).

Seed emptiness: Negligible.

Insect infestation: Low infestation due to an unidentified caterpillar, which feeds on the fleshy pericarp often boring into the seed. A weevil, *Sitophilus rugicollis* Casey has been reported to bore in seeds (Beeson, 1941).

Fungal infestation: Low (18.2-21%). Spermoplane microflora reported includes 11 fungi and actinomycetes. Species of *Trichoderma*, *Aspergillus*, *Mucor*, *Cladosporium* are the storage moulds and *Drechslera* sp. and *Botryodiplodia theobromae* are the field fungi recorded on seeds.

Storage physiology: Recalcitrant (Hong and Ellis, 1996)

Viability period: Under natural conditions seed loses viability soon ie., within 15 days (Rai, 1999).

Germination type: Hypogeal (FRI, 1984)

Germination: Up to 90% (Sen Gupta, 1937; Kumar and Bhanja, 1992).

Germination period: 12-98 days (Sen Gupta, 1937).

Storage: The seeds lose their viability on storage and should be sown soon after collection as possible. Therefore, the seeds can't be stored for long (Dent, 1948). However, the seeds stored for 3 weeks with little loss of viability have been recorded (FRI, 1984).

Viability testing: Cutting test and germination test.

Pre-sowing treatments: Except de-pulping no other treatment is needed.

Seedling production: Fresh seeds are sown in plastic trays containing vermiculite and watered regularly. Pricked out seedlings within 50 days and plant in polybags of size 22.5 x 17.5 cm. Keep them under shade till the seedlings are established (Rai, 1999). The seedlings can be retain in polybags for about two years (FRI, 1984).

Tectona grandis Linn. f.

Synonyms: *Jatus grandis* (L.f.) Kuntze
Tectona theka Lour.
Theka grandis (L.f.) Lam.
Family: Verbenaceae
Trade name: Teak, Thekku
Local names:
Malayalam: Thekku
Tamil: Thekku
Kannada: Tegu, Tegina
Hindi: Sagum
Common name: Teak


Branch bearing fruits

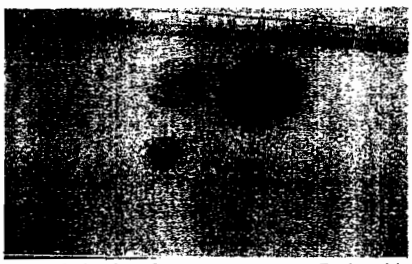
Species description

Habit: A moderately fast growing, large deciduous tree attaining a height of more than 50 m and a girth of 6.50 m.

Distribution: *Tectona grandis* occurs in India, Myanmar, Indo-China, Indonesia and Thailand. It has been planted in Pakistan, Bangladesh, East and West Africa, Central and South America, and on many islands of the Atlantic, Pacific and Indian Oceans. In India, it occurs both in moist and dry deciduous forests. It is indigenous to Kerala, and occurs in moist deciduous forests up to 900 m m.s.l.

Uses: The timber is versatile and suitable for almost all end uses.


Termite treated seeds


A: Fruit having felty mesocarp, B: Fruit with calyx, C: Mesocarp removed seed, D: Extracted seed

Seed maturity: Mature seeds are generally available in India during November-March (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala (in most places)	*	*								*	*	*
Chinnar (Idukki)					*	*						
Churulipetty (Idukki)					*	*						
Champakkad (Idukki)		*	*	*	*							
Karimutti (Idukki)		*	*	*	*							
Tamil Nadu		*	*									
Karnataka		*	*									

Collection: Mature fruits are beaten off with sticks and collected on sinpolin sheet spread around the tree before collection. They may also be collected from the tree by manual shaking using a long pole and hook.

Transportation: Fruits are packed in cotton or jute bags. The seed bags can be stacked in vehicles and transported.

Processing: Remove the bladder like calyx by vigorously rubbing the seeds in a cloth/gunny bag. Winnow the fruits to separate calyx parts (Tewari, 1992). Grade the seeds using a sieve of 9 mm square mesh size and discard fruits below 9 mm.

Seed characteristics

Description: Fruit is a drupe, enclosed within a persistent calyx.

Dimensions: 1-2 cm x 1 cm

Weight: 1,433-3,527 fruits/kg (Sen Gupta, 1937)

Seed emptiness: Medium

Insect infestation: Negligible. *Lasioderma serricorne* Fb. (Coleoptera: Anobiidae) is reported to attack teak seeds under storage (Beeson, 1941).

Fungal infestation: Medium to high (38-86%). Twenty three fungi, a bacterium, and actinomycetes were recorded on seeds. *Alternaria alternata*, *Colletotrichum glaeosporioides*, *Fusarium* sp., *Botryodiplodia theobromae* are the important field fungi associated with the seeds.

Storage physiology: Orthodox (Kindt *et al.*, 1997)

Viability period: Under natural conditions, viable for more than a year (Dent, 1948).

Germination type: Epigeal (Luna, 1996)

Germination: Up to 77% (Sen Gupta, 1937)

NB: For calculation of germination percentage, fruit is taken as unit. Therefore, even if more than one seedlings emerge from a seed it will be counted as one. However, this fact is not taken care of in most germination studies, creating complication in comparison of germination percentages.

Germination period: 8-530 days (Sen Gupta, 1937)

Storage: Seeds can be dry-stored in gunny bags, airtight sealed plastic or aluminium tins for 2 to 3 years (Dent, 1948).

Pre-sowing treatments: Soaking the seeds in water during nighttime and drying them under sun during day, repeating the process for 7 to 21 days. Another very effective method is feeding the mesocarp of the seeds by termites leaving behind seeds with stony endocarp (Chacko, 1998). Soaking the seeds in cow-dung solution for 24 hrs before sowing (Kumar and Bhanja, 1992). Other methods such as acid pre-treatment and charring might improve germination, although, these treatments are not reliable owing to difficulty in proper control of the treatments.

Seedling production: Conventionally, seeds are sown in raised nursery beds between summer and rainy season. The seedlings are ready for planting during next year. Stumps prepared from such seedlings are planted in the field. Root trainer seedlings of 60 to 90 days old are also equally good for planting especially under high input management. Damping-off and collar rot caused by *Rhizoctomia solani* are the important diseases of seedlings in nursery. Timely application of fungicide (Carboxin 0.1%) can control the disease (Sharma *et al.*, 1985).

Terminalia arjuna (Roxb. *ex* DC.) Wt. & Arn.

Synonyms: *Pentaptera arjuna* Roxb. *ex* DC.
Terminalia berryi Wt. & Arn.
Family: Combretaceae
Trade name: Arjun
Local names:
Malayalam: Neermaruthu, Attu-maruthu
Tamil: Vella marda ,Kulamaruthu
Kannada: Bilimoddi-nirmathi
Hindi: Arjuna
Common name: Malabar almond


Branch bearing mature fruits

Species description

Habit: A fast-growing, large evergreen tree attaining a height of 40 m and a girth of 9.5 m (FRI, 1984).

A: Fruit, B: C.S. of seed, C: Extracted seeds

Distribution: *Terminalia arjuna* is common throughout the greater part of the Indian Peninsula, from Avadh southwards, and in Southern, Western and Central India. It is also found in Sri Lanka (FRI, 1984). It is indigenous to Kerala, and is a rare tree along river banks in the dry deciduous forests.

Uses: The timber is used for carts, agricultural implements, water troughs, boat building and other domestic purposes. The bark is used in medicinal preparations (FRI, 1984).

Seed maturity: Mature fruits are generally available in India during December-May (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Chinnar (Idukki)	*	*										*

Collection: Seeds can be collected from the trees or from the ground previously kept clean.

Transportation: Fruits collected in gunny bags or cotton bags are transported as early as possible.

Processing: Fruits are dried under shade for about three days before storage.

Seed characteristics

Description: Fruit is a drupe, ovoid-obovoid, winged, wings five, reddish brown, glabrous, 4-5 cm x 2.5-3 cm.

Dimensions: Length 2.5 cm to 5 cm x width 1.3 cm.

Weight: 176-375 fruits/kg (Sen Gupta, 1937); 1450 (Kumar and Bhanja, 1992)

Seed emptiness: Low

Insect infestation: Negligible; not reported.

Fungal infestation: High (79.5%). Spermoplane microbes recorded include 16 fungi, a bacterium and actinomycetes. Species of *Aspergillus*, *Nigrospora*, *Mucor*, *Penicillium*, *Colletotrichum* and *Botryodiplodia theobromae* are the important field fungi recorded on seeds.

Storage physiology: Orthodox (?)

Viability period: Keeps fairly well for a year (Dent, 1948)

Germination type: Epigeal

Germination: 61% (Sen Gupta, 1937)-90% (Kumar and Bhanja, 1992)

Germination period: 14-48 days (Sen Gupta, 1937)

Storage: Seeds are stored in sealed tins and gunny bags for a year without any loss of viability (Dent, 1948).

Viability testing: Cutting test

Pre-sowing treatments: Not necessary. However, soaking in cold water for 24 hrs is beneficial.

Seedling production: The fruits are sown vertically with the stalk downwards in plastic trays containing vermiculite and watered regularly. The germinated fruits are pricked out into polybags of 22.5 x 17.5 cm. No serious disease has been noticed. Damping-off and collar rot caused by *Rhizotonia solani* are the important diseases. No serious insect infestation was recorded, although, some larvae were found to feed on the leaves affecting growth, which can be controlled by spraying appropriate insecticide (Rai, 1999).

Terminalia bellirica Roxb.

Synonyms: *Myrobalanus bellirica* Gaertn.
Family: Combretaceae
Trade name: Belleric myrobalan
Local names:
Malayalam: Thani
Tamil: Kattuelupay, Thani, Thandi
Kannada: Santi, Thani, Thare
Hindi: Behera, Buhura, Bulla
Common name: Bedda nut tree

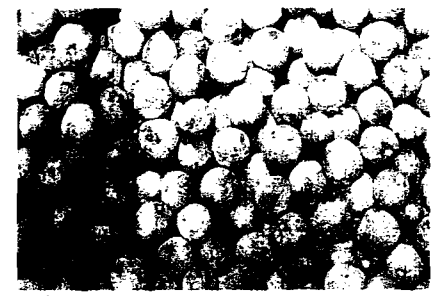

Branch bearing fruits

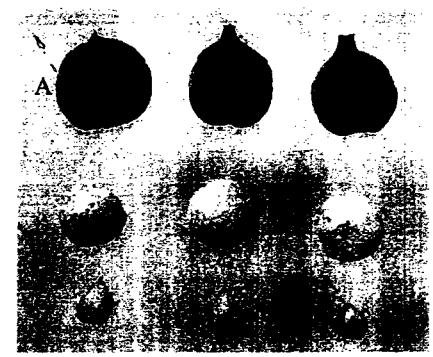
Species description

Habit: A moderately fast-growing, large deciduous tree attaining a height of up to 40 m and a girth of more than 4 m.

Distribution: *Terminalia bellirica* is widely distributed throughout India except in the arid regions of Rajasthan. It is also found in Pakistan, Myanmar, Sri Lanka, Indo-China and Malaysia (FRI, 1984). It is indigenous to Kerala, and occurs in moist deciduous and semi-evergreen forests up to 900 m m.s.l.

Uses: The timber is in considerable demand in places where superior timbers are not available. Fruit is medicinal and is an important constituent of triphla.


Fruits


A: Fruits, B: Depulped fruits, C: Extracted seeds

Seed maturity: Mature fruits are generally available in India during February-April (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)	*	*										*
Agali (Palakkad)	*	*										
Thekkady (Idukki))	*	*										*

Collection: Freshly fallen fruits can be collected from the ground, swept clean in advance.

Transportation: Fruits collected in polythene, cotton or gunny bags can be transported with out much care.

Processing: Remove the pulp immediately after collection and dry the seeds in the sun before storing (Luna, 1996).

Seed characteristics

Description: Fruit is a drupe, obovoid or subglobose, 1.5-2.7 cm contains oval-shaped, light-yellow coloured seed.

Dimensions: 1.5-2.7 x 2-2.5 cm

Weight: 97-176 fruits/kg (Sen Gupta, 1937)

Seed emptiness: Low

Insect infestation: Moderate damage by *Euproctis scintillans* Wlk. (Lepidoptera: Lymantridae), larvae of which feed gregariously on leaves, flowers and young fruits. Mature fruits falling on the ground, porcupines eat particularly the kernals.

Fungal infestation: High (63-100%). More than 17 spermoplane microorganisms including 15 fungi, a bacterium and actinomycetes were recorded on seeds. *Colletotrichum gloeosporioides*,. *Fusarium* spp., and *Phoma* spp. are the important fungal pathogens. Bacterial infestation also causes discolouration and seed rot.

Storage physiology: Orthodox (?)

Viability period: The seed is viable up to one year under normal conditions (Dent, 1948).

Germination type: Hypogeal

Germination: Up to 69% (Sen Gupta, 1937); 85% (Rai, 1999)

Germination period: 16-110 days (Sen Gupta, 1937)

Storage: The seeds retain viability for about a year, in sealed tin and gunny bags (Dent, 1948).

Viability testing: Cutting test

Pre-sowing treatments: Soaking seeds in cold water for a week have been reported to be beneficial (Rai, 1999).

Seedling production: The pretreated seeds are sown in plastic trays filled with vermiculite and watered regularly. The seedlings are pricked out when they have 3-4 leaves into polybags of 22.5 x 17.5 cm. No serious pests are noticed (Rai, 1999). Seedling collar rot caused by *Rhizoctonia solani* is an important disease in nursery.

Terminalia chebula (Gaertn.) Retz.

Synonyms: *Myrobalanus chebula* Gaertn.
Family: Combretaceae
Tradename: Black myrobalan, Chebulic myrobalan
Local names:
Malayalam: Kadukka
Tamil: Kadukhai
Kannada: Aralaikai, Alalai
Hindi: Harara, Haritaki
Common name: Gall nut


Branch bearing fruits

Species description

Habit: A slow-growing, medium to large deciduous tree attaining a height of 24 m and a girth of more than 2.5 m (FRI, 1984).

Distribution: *Terminalia chebula* occurs throughout India in mixed deciduous forests, extending to forests of comparatively dry types. It is found in the sub-Himalayan tracts from the Ravi, eastwards, to West Bengal and Assam up to 1500 m. It also occurs in Sri Lanka and Myanmar (FRI, 1984). It is indigenous to Kerala, and occurs in dry and moist deciduous forests up to 600m m.s.l.


A: Fruits, B: Seeds

Uses: The most important product from the tree is the fruit, the chebulic myrobalan, used in Indian system of medicine (FRI, 1984).

Seed maturity: Mature fruits are generally available in India during November-May (FRI, 1984). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Chinnar (Idukki)	*	*	*	*								
Kumarikulam (Idukki)						*	*	*				

Collection: The seeds can be collected from the ground as soon as they fall or from the tree by shaking the branches manually, when the fruits are yellow (Kumar and Bhanja, 1992).

Transportation: Fruits can be transported in polythene/plastic/cotton bags.

Processing: The seeds are dried under shade immediately after collection.

Seed characteristics

Description: Fruit is a drupe, obovoid, woody, obscurely angled, 2.5-4 x 1.5-2 cm contains the seed.

Dimensions: 2.99 cm (length) x 1.90 cm (diameter).

Weight: 141-220 fruits/kg (Sen Gupta, 1937)

Seed emptiness: Low

Insect infestation: Medium infestation due to an unidentified coleopteran borer. Fallen fruits are often damaged due to feeding by monkeys.

Fungal infestation: Low (16.5%). Species of *Aspergillus*, *Cephalosporium*, *Mucor* and *Botryodiplodia theobromae* are the important spermoplane organisms recorded.

Storage physiology: Orthodox (?)

Viability period: Seeds are viable for more than a year under natural conditions.

Germination type: Epigeal (FRI, 1984)

Germination: Up to 60% (Sen Gupta, 1937)

Germination period: 15-30 days (Kumar and Bhanja, 1992)

Storage: Seeds stored well in sealed tin and gunny bags for about 3 years have been recorded. Seeds stored for one or two years often germinate better than the fresh seeds (Dent, 1948).

Viability testing: Cutting test and germination test.

Pre-sowing treatments: The seeds should be either treated by fermentation process for a period of 15 to 20 days (FRI, 1984) or the seeds may be clipped at its broad end and then soaked in water for about 36 hours (Kumar and Bhanja, 1992).

Seedling production: The pre-treated seeds are sown in vermiculite, sand, or soil. The germinated seeds are pricked out into polybags of size 22.5 x 17.5 cm and kept under shade.

Terminalia crenulata Roth

Synonyms: *Terminalia tomentosa* var. *crenulata* (Roth) Cl
Family: Combretaceae
Trade name: Laurel
Local names:
Malayalam: Karimaruthu, Thembavu
Tamil: Karimarudu, Karumaruthu
Kannada: Banappu sajad, Karimatti
Hindi: Asan
Common name: Indian laurel


Branch bearing flowers

Species description

Habit: A moderately fast-growing, large deciduous tree attaining a height of more than 40 m and a girth of 5.5 m.


Winged fruits

Distribution: *Terminalia crenulata* is widely distributed in South-west India and is common all along the Western Ghats (FRI, 1984). It is indigenous to Kerala, and occurs in moist and dry deciduous forests up to 600 m m.s.l.


A: Fruit, B: C.S. of fruit, C: Extracted seed

Uses: The wood is useful for building, agricultural implements, fuel and charcoal (FRI, 1984).

Seed maturity: Mature fruits are available in India during March-April (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												

Collection: The best time to collect seeds is just after leaf shedding (FRI, 1984) and when the wings turn into black colour. The seeds may also be collected from the ground.

Transportation: Fruits collected either in cotton or plastic or gunny bags do not require special care during transportation.

Processing: The fruits are dried in sun for 3 or 4 days before storage (FRI, 1984).

Seed characteristics

Description: Fruit is a drupe, winged, wings four to five, 3-4 x 3.5 cm, contains the pale yellow coloured seed.

Dimensions: Length 3.56-4.20 cm, width 2.42-3.80 cm.

Weight: 441-551 (Sen Gupta, 1937); 1370 fruits/kg

Seed emptiness: Low

Insect infestation: Medium damage due to an unidentified caterpillar causing premature falling of fruits. The damage can be recognised from the typical oozing of fluid on fallen fruits.

Fungal infestation: Twenty seven fungi belonging to the groups of storage moulds and field fungi, a bacterium and actinomycetes were detected on seeds. Species of *Drechslera*, *Alternaria*, *Cylindrocladium* and *Myrothecium* are the important field fungi detected on seeds.

Storage physiology: Intermediate (CABI, 1998).

Viability period: Seeds stored in sealed container keep viability well for one year (Dent, 1948).

Germination type: Epigeal (FRI, 1984)

Germination: Up to 72% (Sen Gupta, 1937)

Germination period: 10-35 days (Sen Gupta, 1937)

Storage: The sun dried fruits can be stored in sealed tin or gunny bags in a dry well ventilated shed well up to one year (Dent, 1948).

Viability testing: Cutting test

Seed dressing: Seed dressing with fungicide, Captan @ 4g/1 kg seed was effective in reducing the seed infestation by fungi.

Pre-sowing treatments: Remove the wings using scissors or crush the fruits and then soak in water for 24 hours.

Seedling production: The seeds are sown with the fruits stalk end downwards in plastic trays containing vermiculite and watered daily. Seedlings at 3 or 4 leaf stage, are planted in to polybags of 22.5 x 17.5 cm size. Stumps made from nursery raised seedlings are used for stand establishment (CABI, 1998).

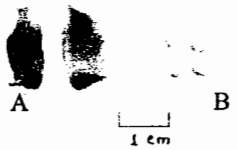
Terminalia paniculata Roth

Synonyms: *Pentaptera paniculata* Roxb.
Family: Combretaceae
Trade name: Kindal
Local names:
Malayalam: Maruthu, Pullamaruthu
Tamil: Admarudu, Pillamarudu, Poomarudu, Pulvai, Pullamarathu, Vellimarathu
Kannada: Bill-mathi, Hongal, Ulvi
Hindi:
Common name:


Branch bearing fruits

Species description

Habit: A slow growing, large deciduous tree attaining a height of more than 35 m and a girth of 3.5 m.



A. Seeds with wing ; B. Extracted Seeds

Distribution: *Terminalia paniculata* occurs in the Western Ghats from Maharashtra extending southwards through North and South Kanara to Malabar, Coorg and Travancore. It is one of the commonest trees in the Western Ghats. It also occurs along the Eastern Ghats (FRI, 1984). It is indigenous to Kerala, and occurs in dry, moist deciduous and semi-evergreen forests up to 600m m.s.l.

Uses: The wood is useful for building purposes.

Seed maturity: Mature fruits are generally available in India during Dec-May (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Nelliampathy (Palakkad)											*	*
Dhoni (Palakkad)			*	*								
Nilambur (Malappuram)			*	*								
Thenmala (Kollam)		*	*	*								
Erumely (Kottayam)		*	*	*								
Vazhachal (Thrissur)			*	*								
Peechi (Thrissur)			*	*								
Walayar (Palakkad)			*	*								

Collection: Mature fruits, which are brick red in colour are collected by lopping the branches. The seeds can also be collected from the ground.

Transportation: Fruits collected in cotton or plastic bags can be transported with out much care.

Processing: The fruits are sun-dried. Insecticide application should be done to prevent insect attack (Rai, 1999).

Seed characteristics

Description: Fruit is a drupe, reddish yellow, winged, wings 3, unequal, the longer wing to 15 x 8 mm small ones to 5 mm.

Dimensions: 1.3 cm length x 0.6 cm width.

Weight: 26,103-59,966 seeds/kg; 3,880 fruits/kg (Sen Gupta, 1937).

Seed emptiness: Very high. Only about 3% seeds are usually well filled and hence nurseries producing *T. paniculata* seedlings will need very high quantity of seeds for sowing.

Insect infestation: Medium infestation due to an unidentified beetle. A weevil, *Nanophyes terminaliae* is reported affecting fruits. Among other insects reported on this species, the larvae of the noctuid, *Garella rotundipennis*, feed on the flowers and developing fruits (FRI, 1984).

Fungal infestation: Thirty-seven fungi belonging to 34 genera, a bacterium, and actinomycetes were detected on seeds. *Drechslera australensis*, *Myrothecium* sp., *Graphium* sp., *Ascochyta* sp., *Cercospora* sp. are the important spermoplane fungi. *Phomopsis* sp. was found to be seed-borne.

Storage physiology: Orthodox (?)

Viability period: Seeds retain viability for five months in sealed tin and gunny bags (Dent, 1948).

Germination type: Epigeal

Germination: 2 (Sen Gupta, 1937)-3.75%

Germination period: 16-30 days (Rai, 1999)

Storage: Seed keeps well up to five months in sealed tin, gunny bags and in stoppered bottle (Dent, 1948).

Viability testing: Cutting test.

Seed dressing: Seed dressing with fungicide Captan @ 5 g/1 kg seed was effective in reducing seed infestation by fungi.

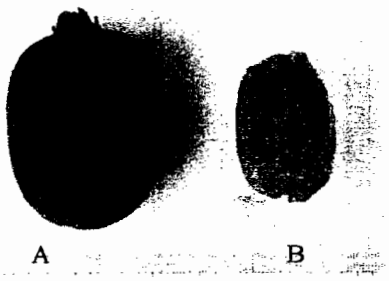
Pre-sowing treatments: No pre-sowing treatment is necessary.

Seedling production: The seeds are sown in vermiculite, sand or soil. When the seedlings have two pair of leaves, they are pricked out and planted in to polybags of 22.5 x 17.5 cm size.

Vateria indica L.

Synonyms: *Vateria malabarica* DC.
Family: Dipterocarpaceae
Trade name: White Damar
Local names:
Malayalam: Vellappayin, Kunthrikkappayin
Tamil: Dhup maram, Kondricam
Kannada 'ni, Bilidupa
Hindi: Dı
Common name: Indian copal tree


Branch bearing fruits


A B
A: Fruit, B: Germinating decoated seed

Species description

Habit: A slow to moderately fast-growing, large evergreen tree attaining a height of more than 30 m and a girth more than 5 m (FRI, 1980).

Distribution: *Vateria indica* occurs in the West coast tropical evergreen and semi-evergreen forests and is endemic to the Western Ghats of India. It is indigenous to Kerala, and occurs in evergreen and semi-evergreen forests up to 1000 m m.s.l. (FRI, 1980).

Uses: Wood is used for tea-chests, packing cases, planking, commercial plywood and for the manufacture of match splints. The tree yields resin called Indian Copal or White damar (FRI, 1980).

Seed maturity: Mature fruits are generally available in India during May-August (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Amala Nagar (Thrissur)						*	*	*				
Vazhachal (Thrissur)					*	*	*					
Thiruvananthapuram					*	*	*					
Kothamangalam (Ernakulam)						*	*					
Silent Valley (Palakkad)						*	*	*				
Karnataka						*	*					

Collection: The ripe fruits are collected as soon as they fall on the ground, otherwise they are attacked by weevil (FRI, 1980).

Transportation: The fruits may be transported as quickly as possible since they loses viability very rapidly.

Processing: Discard insect attacked fruits by hand picking.

Seed characteristics

Description: Fruit is a capsule, oblong, 3-valved, 4.5-5.5 x 3-3.5 cm.

Dimensions: 5.5 cm length x 3.69 cm diameter.

Weight: 28-57 fruits/kg (FRI, 1980); 60 fruits/kg (Luna, 1996).

Seed emptiness: Nil

Insect infestation: Moderate to heavy infestation by the weevil, *Sitophilus vateriae*. The infestation, which initiates in the developing seeds proceeds, with the mature beetles emerging out of the ripe fruits, virtually damaging the entire fruit. *Alcidodes crassus*, *Sitophilus rugicollis*, *Nanophes dipterocarpi* and *Coccotrypes borasi* (Coleoptera: Scolytidae) are already reported as seed pests in India (Sensarma and Thakur, 1994).

Fungal infestation: High (39-91%). More than 16 fungi were recorded on seeds. *Aspergillus flavus*, *Penicillium* spp., *Rhizopus* sp., are the important storage moulds. *Botryodiplodia theobromae*, *Colletotrichum gloeosporioides*, *Cylindrocladium quinqueseptatum*, *Fusarium* sp., and *Phoma* sp., are the important field fungi recorded on seeds. *C. quinqueseptatum* and *B. theobromae* were found associated with discoloured and rotten seeds.

Storage physiology: Recalcitrant (?)

Viability period: In gunny bag seeds remain viable up to 10 days (Dent, 1948).

Germination type: Hypogeal

Germination: Up to 98% (FRI, 1980).

Germination period: 25-35 days (FRI, 1980); 2-21 days (Rai, 1999).

Storage: Seeds can be stored in gunny bags for about a month (Dent, 1948).

Viability testing: Cutting test

Pre-sowing treatments: Not necessary

Seedling production: Freshly collected fruits are sown in polybags of size 22.5 x 17.5 cm. Seedlings are maintained in the nursery till the next planting season; at times it reaches a height of 70-80 cm. Regular watering is needed (Rai, 1999).

Xylia xylocarpa Taub.

Synonyms: *Mimosa xylocarpa* Roxb.
Family: Leguminosae
Sub-family: Mimosoideae
Trade name: Irul
Local names:
Malayalam: Irul, Irumullu, Kadamaram
Tamil: Irul, Aruyapalam
Kannada: Jambe
Hindi: Jambu, Soriva
Common name: Irul


Branch bearing fruits

Species description

Habit: A moderately fast-growing, medium-sized to large deciduous tree usually attaining a height of up to 30 m and a girth of 2.7 m (FRI, 1983).


Dehiscing pod showing seeds

Distribution: *Xylia xylocarpa* occurs in the Indian Peninsula extending to Maharashtra in the West, Orissa and Southern West Bengal in the East and Balaghat and Raipur Divisions of Madhya Pradesh in the Centre. It is plentiful throughout the deciduous forests of the Western Ghats, in the Belgaum and Kanara in Karnataka and Malabar and south to Thiruvananthapuram in Kerala (FRI, 1983). It is indigenous to Kerala, and occurs in moist deciduous and semi-evergreen forests up to 600 m m.s.l.

A: Pod; B: Seeds

Uses: Wood is used for heavy constructional works, house building.

Seed maturity: Mature fruits are available in India during January-July (Sen Gupta, 1937). Location-specific information is provided below.

LOCALITY	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Kerala												
Peechi (Thrissur)		*	*	*								
Nilambur (Malappuram)		*	*	*								

Collection: It is important that the ripe pods are collected from the trees before they dehisce. Dehiscence of a few pods on a tree can be considered as an indication of seed collection time.

Transportation: Pods are collected in cotton/jute bags, packed and transported.

Processing: Pods are spread out in cotton bags in the sun to open and the seeds are collected (FRI, 1983).

Seed characteristics

Description: Fruit is a pod, woody, oblong, falcate, compressed, dehiscent, 18 cm x 5 cm contain 8-10 brown coloured oblong smooth surfaced seeds.

Dimensions: 1.3-1.6 cm x 0.6-0.9 cm (FRI, 1983).

Weight: 3,175-3,850 seeds/kg (Sen Gupta, 1937); 4000 seeds/kg (Luna, 1996)

Seed emptiness: Low

Insect infestation: Low infestation due to unidentified bruchid borer.

Fungal infestation: High (50-81%). Seeds were found harboured by a rich microflora. Twenty seven fungi belonging to 20 genera, bacteria and actinomycetes were recorded. Storage fungi like *Aspergillus* sp., *Penicillium* sp., *Chaetomium globosum*, *Trichoderma* sp., etc., are the predominant ones. *Colletotrichum gloeosporioides*, *Cylindrocladium quinqueseptatum*, *Botryodiplodia theobromae* are the field fungi recorded on seeds.

Storage physiology: Orthodox (Kindt *et al.*, 1997)

Viability period: Under natural conditions seeds are viable for about a year (Dent, 1948).

Germination type: Epigeal (FRI, 1983)

Germination: 70-90% (Sen Gupta, 1937)

Germination period: 4-11 days (Sen Gupta, 1937)

Storage: Seeds are dried and stored in gunny bags or air-tight bins in dry places (Dent, 1948).

Viability testing: Cutting test

Pre-sowing treatments: Not required (Kumar and Bhanja, 1992).

Seedling production: Nursery raised seedlings do not stand planting out well owing to injury to root. Direct sowing in well-loosened patches at 2 m intervals in rows 3 m apart is advocated. Plantations of this species are not common as its natural regeneration is very good (Kumar and Bhanja, 1992). The species is well regenerated from root suckers and coppices.