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STUDIES ON SELECTED INDIGENOUS SPECIES FOR FUTURE PLANTATION PROGRAMMES IN KERALA

K.K.N. Nair
K.C. Chacko
A.R.R. Menon
George Mathew
M.I. Mohamed Ali
R.C. Pandalai

KERALA FOREST RESEARCH INSTITUTE
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ABSTRACT

This report contains data gathered while evaluating the plantation potentials of six moist deciduous species indigenous to the State of Kerala. The species investigated are *A. odoratissims* (L.f.) Benth., *Grewia tiliifolia* Vahl, *Haldina cordifolia* (Roxb.) Taub. , *Lagerstroemia microcarps* Wt., *Pterocsrpus mar-supium* Roxb. and *Xylia xylocarpa.* (Roxb.) Taub. Apart from the silvicultural and plantation trial aspects of the six species delt with, the report also includes details on the pest and disease incidences in the natural stands, nurseries and trail plantations of a11 the six species and control measures for those potential pests and pathogens observed either in the nursery or in the plantation trial experiment. Supplementing the data on the above mentioned aspects of the investigation, information gathered on the botanical, ecological, and wood anatomical and utilization aspects of the six species based on studies in their natural populations in Kerala are also provided.

1. INTRODUCTION

Traditionally, production forestry is focussed on the monoculture of a few species aimed at producing wood for industrial uses. Becuase of this, at present, almost 85% of the total forest plantations in the tropics are of eucalypts, teak and pines (Evans, 1982). India is also not an exception to this. There are mainly two reasons for the preference of exotic species in earlier forest plantation programmes. The main reason is that, in the past, forest plantations were mostly raised as industrial plantations to meet the raw material demand of paper and pulp industries, for which exotics like ecualypts were preferred. The other reason for establishing large scale plantations of exotics was the ready availability of sufficient information on their plantation aspects. Coupled with these two reasons, in the past, there was also adequate supply of timber of most of the indigenous species and hence, there was no need to consider the local species in a plantation perspective, and at the same time area under plantations of exotics went on increasing to reach the present level.

Of late, there is a growing awareness with regard to the need for raising indigenous trees on a plantation scale. This is mainly due to the dwindling supply of timber of such species to meet the increasing local demand. Therefore, it is imperative that adequate research and experimental background has to be generated in countries where such indigenous timber trees grow naturally, which are the proven eco-climatic zones of such species. The project 'Studies on selected indigenous species

for future plantations programmes in Kerala is a step in this direction.

Indigenous species are those which grow naturally in a country though not necessarily in all parts and certainly not suited for all areas. With such species, there are no political or quarantine restrictions to hinder their use in any plantation programme in their native countries, and added to this, there are certain important biological advantages, like:

i. Growth of such species in natural areas can provide sufficient indication of their possible performance in plantation.
ii. Such species are well suited to the environment and are falling within an ecological niche of the country which will render them less susceptible to serious damages from pests and diseases, since controlling agents (predators, viruses, climatic factors, etc.) are already present.
iii. Indigenous species, even in monoculture, are generally considered ecologically more suited than exotics for the conservation of native flora and fauna.
iv. Timber of indigenous species is more familiar and comnonly used by the local people and also industrial wood consumers of the reglon.

For such reasons, if the plantation potential of Indigenous species is worked out and demonstrated by establishing experimental plantations, such species will certainly be used in the future plantation programmes in their home countries. There are also a number of examples to support this view, like *Pinus merkusii* in Indonesia, *Araucaria hunstinii* in Papua New Guinea,

Tectona grandis in India and Burma, *Terminalia ivorensis* in West Africa, *Cordia alliodora* in Central America, and so on.

In this multi-disciplinary project, it is envisaged to investigate the plantation potential and related aspects of six species of well known timber value, indigenous to the moist deciduous forests of Kerala, and to assess their feasibility as plantation species in the State, either as monoculture or as mixtures among them. Evolving suitable silvicultural methods for large scale raising of seedlings and to assess the performance of each of the species In plantation are the two main thrust areas of this investigation. Establishment of an experimental plantation containing all the six species in pure and different combinations among them, to serve as a demonstration plot was also envisaged in this study. Other related aspects which received attention include gathering details on the botany and ecology of the species, wood anatomical studies and assessment of log quality in three different parts of Kerala where the species grow naturally and also evolving suitable control measures against serious pests or pathogens identified either in the nursery or in the plantation trial experiment. The species selected for the investigation are:

I. *Albizia odoratissima* (L.f.) Benth. (Mimosaceae) - Kunni-vaka

ii. *Grewia tiliifolia* Vahl (Tiliaceae) - Chadachi

iii. *Haldina cordifolia* (Roxb.) Rldsd. (Rubiaceae) - Manja-kadambu

iv. *Lagerstroemia microcarpa* Wt. (Lythraceae) - Venthekku

v. *Pterocarpus marsupium* Roxb. (Papilionaceae) - Venga

vi. *Xylia xylocarpa* (Roxb.) Taub. (Mimosaceae) - Irul

Among the six species mentioned above, *A. odoratissima* yeilds hard and heavy timber used mainly In construction and as furniture and panelling wood. Timber from *G. tiliifolia* is also heavy, but more elastic, often used to make shafts, frames, agricultural implements and as furniture wood. 'Haldu', the timber of *H. cordifolia,* is moderately strong and hard, very commonly employed for structural works, flooring and turnery. Very hard and strong tlmber of *X. xylocarpa* iswell known for railway sleepers and in construction work. Wood of *L. microcarpa* is much valued as construction timber as well as in boat and ship building. In southern India, the very hard and heavy timber of *P. marsupium* isquite popular for building construction and as a substitute for teak in making a variety of items like beams, shafts, posts, etc. and in the manufacture of railway carriages.

In this report, apart from the general introductory part, chapters like project proposal, details on the objectives of the study and methodology adopted for various aspects of the investigation are given. Data gathered on different aspects of each of the species are arranged species–wise. For each of the species, details on its botany and natural distribution in Kerala and ecological aspects like species association in natural stands and regeneration status in natural areas are given first. This is followed by details on wood anatomy and log quality parameters of each of the species. Data gathered on the silvicultural and plantation aspects follow, and information on pests and diseases associated with all the six species in their natural stands, nursery and in the plantation trial experiment and control strategies for potential ones among them form the last part of the account on each of the species. General observations,

conclusions and recommendations emerged from the study are given towards the end of the report followed by an alphabetical list of references cited in the text. Scientists who did different aspects of the investigation are, i. Dr. K.K.N. Nair (Botanical aspects), ii. Shrl K.C. Chacko (Silviculture and plantation trials), iii. Dr. A.R.R. Menon (Ecological aspects), iv. Dr. K.V. Bhat (Wood anatomy and utilization), v. Dr. George Mathew (Pest problems and control) and vi. Shri M.I. Mohamed All (Disease problems and control).

OBJECTIVES OF THE STUDY

Following are the decipline-wise objectives of the investigation.

2.1. Botanical studies

In order to provide basic information on the distribution and taxonomy of each of the species and to facilitate their easy identification and correct naming, the component of botanical study envlsages the following objectives.

- to map the natural distribution of each of the species in the State,
- to record the natural variatlons within each species and to prepare taxonomic descriptions and illustrations of it, authenticated by voucher specimens, and
- to establish an arboretum containing all the species under study.

2.2. Silvicultural studies and plantation trials

Choice of suitable species is a very important aspect in any plantation programme and species selected will influence silvicultural and management practises and utilization of the crop. The purpose of plantation, availability of planting material and site characteristics are the three basic aspects to be considered in species selection.

Kerala has a forest area of 9,400 km^2 of which 48% is covered by evergreen and semievergreen and 30.5% by moist deciduous forests. Most of the moist deciduous areas are either degraded or devoid of sufficient regeneration. This provides opportunity for planting Important indigenous species in such areas. At present, teak contributes to about 50% of the forest plantations in Kerala, whereas, all other indigenous species together constitute only 20% (Kerala Forest Department, 1989).

The present study was aimed at generating information on artificial regeneration of *A. odoratissima, G. tiliifolia, H. cordifolia, L. microcarpa, P. marsupium* and *X. xylocarpa,* on a plantation scale, which are well known moist deciduous timber species of Kerala. Raising plantations of these species has not been seriously attempted in the past and therefore, the silvicutlure and plantation trial aspect the investigation is based on the following objectives.

- to evolve suitable methods for seed collecticn and storage,
- to standardize pre-sowing treatments for seeds and to work out the suitable container size for the seedlings of each of the species, and

- to assess the performance of each species in plantation, bcth pure and in mixtures.

2.3. Ecological studies

The study was intended to generate information regarding ecological associations and regeneration status of the six species in Kerala, based on field observations from different ecoclimatic zones. The objectives of this component of the study are:

- to analyse the ecological associations of the species selected for the study in their natural stands,
- to assess their regeneration status in natural conditions, and
- to identify broad eco-climatic zones suited for raising plantations of the species in the State.

With these objectives, extensive field surveys were conducted throughout Kerala and permanent **study** plots were established for continuous monitoring, to evaluate the current status of regeneration and factors affecting the same. Even though similar studies were conducted in various parts of the country (Lall, 1990; Rai, 1989; Meher-Homji, 1979; Rai and Proctor, 1986) and also outside India (Unesco, 1986; Tubbs,1977), only very little work has been done in Kerala with regard to the six species, and hence this aspect was included in the investigation.

2.4. Utilization aspects

Scientifically based utilization of any timber demands a complete knowledge regarding its properties and behaviour. The

is particularly important in the case of a heterogeneous material like wood. Further, the biological origin of this material adds another dimension to its complexity, namely, the variability in quality. It is very often noticed that the same timber growing in different geographical regions shows drastically different quality; the colour, texture, weight, strength, etc. may vary considerably. Unless the full range of this variation is understood, it is rather difficult to assign appropriate uses for a timber or to use it efficiently. Thus, the study of variation has got vital importance in Wood Science and Technology.

Wood quality variation is of great concern to foresters as well. If the expected quality of timber is to be realized from a forest plantation, several silvicultural manipulations may have to be adopted in accordance with the species raised. For this, not only the inherent tree characteristics affecting the timber quality will have to be identified but also the set of conditions that favour the desired type of growth and quality. In addition, it should be clearly known if faster or slower growth has any effect on wood characteristics. Nevertheless, the problem with majority of native timbers is that they do not possess distinct growth rings (Pearson and Brown, 1932) as common to many tropical hardwood species (Jacoby, 1989). Therefore, no such studies have been carried out so far except for a few selected species (Rao *et al.*, 1966; Purkayastha *et al.*, 1972, Purkayastha *et al.*, 1974). Some of these aspects which are considered important from the point of thrust of the present study are included in the following objectives.

- to up–date informatlon of the anatomical characteristics of each of the species,

- to estimate the variation in wood structure, proporties and log quality in relatlon to locality and sites, and
- to correlate wood structure and properties with growh rate wherever growth rings are distinguishable.

2.5. Pest problems and control

Pest incidence is a major practical problem for the successful establishment of any plantation. Information on insect pests and the severity of their attack is very essential in developing strategies for the management of forest plantations. Since there are very few studies on the pest incidence patterns in natural stands and in monocultures of indigenous species, careful evaluation of the pest incidence pattern as well as their impact is very essential before venturing into large scale plantation activities. Information on the insect pests of the species selected for the study were collected from three situations, viz. natural stands, trial plantation and nurseries. The objectives of the study are:

- to gather information on various economically important insects associated with each of the species in different stages of their growth and to evaluate the extent of damage caused, and
- to evolve suitable pest control Strategies against the potential pests.

2.6. Disease problems and control

Availability of germinsble seeds is an important factor in raising planting stock for establishing large scale

Germinabllity of seeds greatly depends upon seed health and storage conditions. Like seeds of agricultural and horticultural crops, seeds of trees are also liable to be affected by microorganisms during storage (Mital, 1983; Mital and Sharma, 1981; Sharma and Mohanan, 1980). The various ways by which the seed borne fungi affect the quality of seeds reducing germination, introduction of diseases into newly sown crops/areas and reduction in viability of stored seeds, etc. are aspects included in the study. Availability of healthy stock of seedlings is of intrinsic value for raising plantations and to meet this, elimination of nursery diseases by appropriate chemical control methods is of prime importance. However, information on microbial deterioration of seeds, disease of seedlings and trees and their control measures is meagre. The investigation will encompass pathological studies on seeds, seedlings and mature trees, as it envisages:

- to investigate seed disorders, especially those affecting seed viability, caused by microorganisms and to develop suitable control measures,
- to identify disease causing organisms in nurseries, trial plantations and natural stands and to assess the level of infection and to evolve control measures for serious ones, and
- to explore the feasibility of enhancing the growth of seedlings of leguminous species *(A. odoratissima, P. marsupium* and *X. xylocarpa)* by the application of suitable *Rhizobium* species.

3. MATERIALS AND METHODS

Materials used and methodologies followed for different aspects of the investigation are given discipline-wise.

3.1. BOTANY

Initially, to facilitate field work, literature and herbarium specimens in the neighbouring libraries and herbaria were scrutinised to gather information on the distribution and flowering and fruiting periods of all the six species in Kerala. Based on these data, forest range-wise field surveys were undertaken throughout the State to collect specimens, either in the flowering or in the fruiting stage, for conducting botanical studies, and also to gather field data to map the natural distribution of each of the species. The collected materials were processed and made into herbarium specimens (4 each per collection), which were labelled with up-to-date name, distribution data, phenological details and other field notes relevant to the study.

Side by side with this, earlier collections of the species from Kerala available in the herbaria of the Southern Circle, Botanical Survey of India, Coimbatore and Institute of Forest Genetics and Tree Breeding, Coimbatore were studied to gather information on their taxonomy, variations, phenology and distribution. Their identities were confirmed and are enumeratec! under the head 'specimens examined' to authenticate the data presented in the report.

Based on studies of samples collected during field surveys

and also specimens consulted from the herbaria mentioned above, revised descriptions were prepared for each of the species with details on both qualitative and quantitative variations. Data on flowering and fruiting periods of each of the species were also gathered from herbarium specimens and this was supplemented by data collected by field observations.

To prepare distribution maps of each of the species for Kerala, data were gathered both by field studies and also herbarium scrutiny. Such data were plotted on a skeleton map of the State, keeping in view area within each forest division and range in the State.

Flower samples were collected from the field and preserved in suitable preservatives after recording those characters which may not be available with specimens after preservation (eg. flower colour, smell, texture of flower parts, etc.). Several such samples of each of the species were dissected and critically examined and illustrations of floral parts prepared . To facilitate easy identification, a representative habit sketch for each of the species is also provided along with the floral illustration. Morphological variations, mainly observed in leaf characters are also illustrated based on scrutiny of a large number of herbarium specimens showing such variations.

In order to evaluate the observed qualitative and quantitative variations of leaf characters, actual measurements of the length of compound leaves and length, breadth and petiole or petiolule of leaves or leaflets and qualitative characters like nature of margin, apex, base, etc. were recorded based on IAPT (1962) specification from collections from trees distributed in different parts of the State. Each such specimen formed an Operational Taxonomic Unit (OTU) in the statistical analysis.

Incidence of different characteristics in dichotomous states were recorded from 38 specimens for *Grewia,* 20 specimens of *AIbizia,* 22 specimens of *Haldina,* 18 specimens of *Lagerstroemia,* 4 specimens of *Pterocarpus* and 15 specimens of *Xylia.* . For characters showing continuous variation, the total range was divided into three dichotomous variables. Similarity measure used was the coefficient of Jaccard (Sneath and Sokal, 1983). Both specimens and characters recorded from them were clustered based on complete linkage algorithm. The least value for resemblence measure within a clustesr was set to 0.5 of the coefficient of Jaccard to distinguish the groups.

By exhaustive scrutiny of literature, nomenclature of the species were updated in accordance with the *International Code of Botancial Nomenclature (1988).* Up–to–date name, basionym if any, and synonyms are given for each species, and wherever known, types are also specified. Citations to monographs, taxonomic revisions, floras of the State and adjoining regions and other reference relevant to the taxonomy of the species are also made in the nomenclature part to facilitate further reference.

In order to establish an arboretum containing all the six species under investigation, seeds were collected from South, Central and Northern parts of Kerala. They were germinated and are initially grown In polythene container for transplanting in the arboretum plot. As mentioned, herbarium specimens consulted during the study are those available in the following three herabria with their acronyms given in parenthesis.

Herbarium, Kerala Forest Research Institute, Peechi (KFRI).

Herbarium, Southern Circle, Botanical Survey of India, Coimbatore (MH).

Herbarium, Institute of Forest Genetics and Tree Breeding, Forest Research Institute, Coimbatore (FRI).

In the botanical ccmpcnent of the study, the data gathered are presented in the order nomenclature, type, local name(s), revised taxonomic description, field notes, phenology (supported by graph), world distribution, forest division–wise distribution in Kerala (with distribution map), general notes and details on within species variations with cluster dendrograms. Authenticating the data presented, a list of the specimens examined is also given for each of the species.

3.2. ECOLOGICAL STUDIES

3.2.1. Stand selection

Extensive field surveys were conducted throughout Kerala and based on the species richness and diversity, sample stands were selected. The stands were located in Northern Kerala, viz. Bavali and Peruvannamuzhi area in Wynad region and Central Kerala at Thellikkal and Kuriyarkutty in Parambikulam Wildlife Sanctuary of Palghat District, and Vazhani Sanctuary area in Trichur District (Fig.1). In the case of plots where all the six species were not present, subplots were taken in nearby localities for the missing species. The Kuriyarkutty plot in Parambikulsm Forest Division is one such plot selected for regeneration studies of

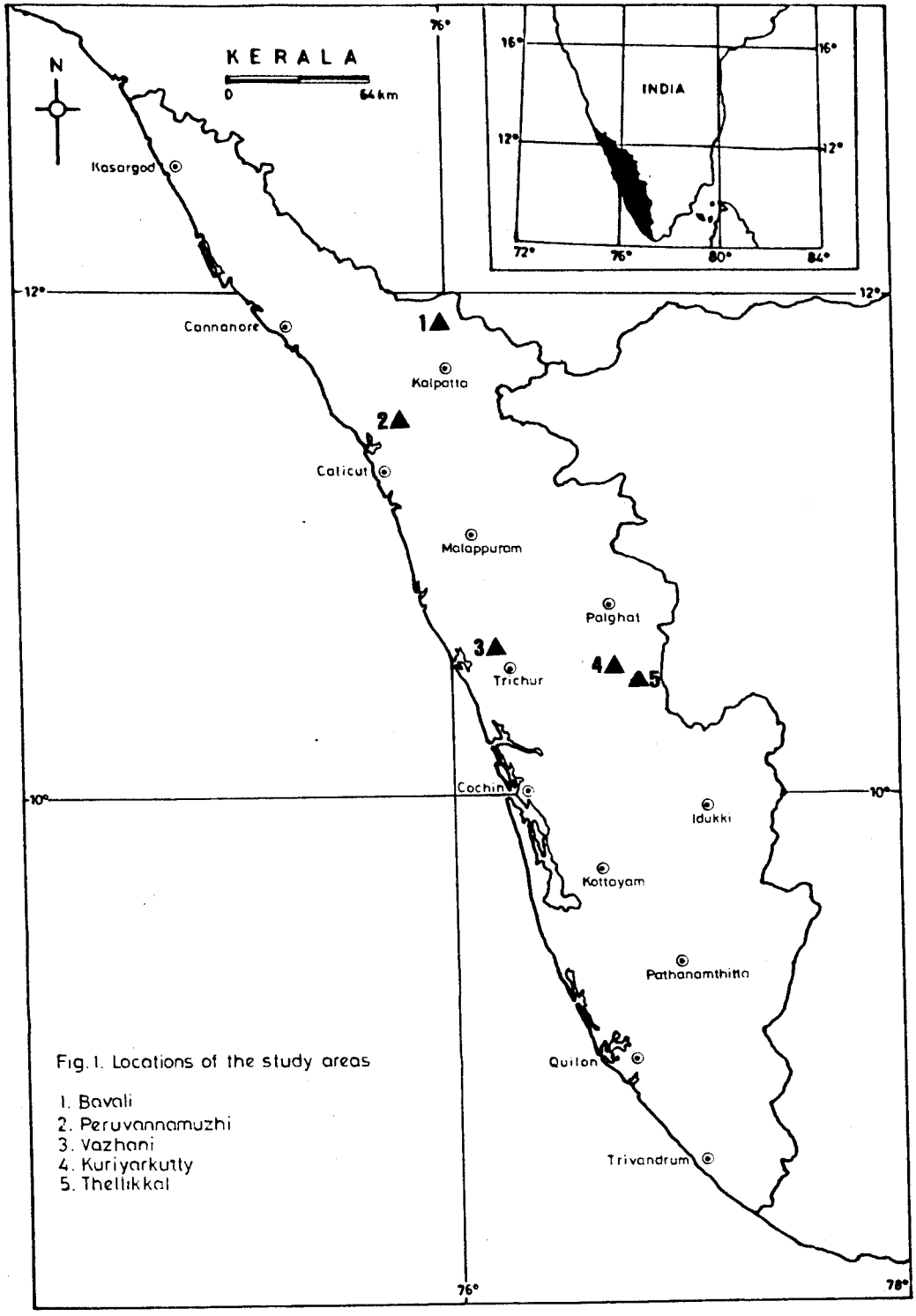


Fig. 1. Locations of the study areas

1. Bavali
2. Peruvannamuzhi
3. Vazhani
4. Kuriyarkutty
5. Thellikkal

3.2.2. Size of releve

The minimum size of the plots were worked out by species–area curve method (Braun–Blanquet, 1932; Sharma *et al.*, 1983; Muller-Doubois and Ellenberg, 1974). The minimum size of the quadrat was later enhanced to the convenient higher size (10 m x 10 m) for analysis and calculation efficiency. The overall plot size of 2,000 m^2 area, ie. 20 m x 100 m size or twenty numbers of 10 m x 10 m subplots. The structural status of the vegetation of the localities were then studied by monitoring permanent observation plots using quadrat method (Phillips, 1959).

3.2.3. Regeneration status

The regeneration status of the selected species were assessed by periodical observations from the permanent plots established. During field trips, the germination and growth status of seedlings, micro and macro–climatic features, etc. were noted. The height of each tagged seedlings was recorded. The data thus obtained were further classified Into 11 subclasses of 10 cm interval, viz. 0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, 91-100 and above 100 cm. The average height of each class was worked out for further evaluation (Table 1). The seedlings of more than 1 m height were grouped into a single class, on the assumption that at this stage they have crossed the mortality range and are established so as to obtain the prerequisite information on regeneration. Phenalogical observations were made by repeated field visits at regular intervals. Distributional data of parent trees were plotted on grid sheets during the field visits.

3.2.4. Phytosociology

The stands selected in each locality were further divided into 20 subgrids of 10 m x 10 m size for gathering phytosociological data. The census quadrat method was adopted for field data acquisition. Very rarely, on slopes of varying

Table 1. Details of the parameters used in the ecological descriptions given for each species

Parent tree source	Good (more than 50%)	Medium (30% - 50%)	Poor (less than 30)
Parent tree distribution	Frequent	Occasional	Rare
Biotic interference	Undistribed	Partially disturbed	Highly disturbed
Regeneration status	One (more than 50%)	Two (30%-50%)	Three (Less than 30%)
Young seedlings	Sufficient Nos. (more than 10 Nos./ 100 m^2)		Insufficient Nos. (less than 10 Nos./ 100 m^2)
Older seedlings	Unlimited (more than 5 Nos./ 100 m^2)		Limited (less than 5 Nos./ 100 m^2)
Saplings	Frequent (more than 50% occurrences)	Occasional (30%–50% occurrences)	Rare (Less than 30% occurrences)
Mortality	Low	Medium	High

physical features, belt transect method was also adopted for data collection. Trees of more than 30 cm GBH were considered as the lowest level of trees and those between 15 cm - 30 cm as saplings. The height of all trees falling within the quadrat limit were noted using Ravi-multimeter. The girth at breast height or 1.3 m above ground level was measured for all trees. The position of each parent tree was also charted. The structural data thus collected were further analysed for various vegetation features like density, frequency, abundance, important value index, etc. using conventional formulae (Muller-Dombois and Ellenberg, 1974).

3.3. UTILIZATION ASPECTS

Wood samples for the study were collected from three parts of Kerala representing northern, central and southern regions of the State. For Cental Kerala samples were collected separetly from three localities namely, Pothundi, Parambikulam and Palappilly-Vazhachal for the study of variation within the region. However, for rest of the regions locallty–specific collection was not made. Wynad was selected for the northern region and samples from Ranni and Konni representesd southern region of the State. Thus, in total five localities were selected for comparison and from each locality five mature trees were sampled for each species. Wood samples were collected from breast height level of standing trees using an increment borer of 4 mm diameter. GBH of sampled trees was also recorded for further calculations along with field notes on tree characteristics. Based on the radius computed from GBH, samples for density measurements were prepared

from appropriate parts of the increment cores so as to represent outer, inner and intermediate positions of the trunkwood radius. This was done in order to determine the mean basic density at BH for each tree. The length of the core samples measured accurately was used to calculate the green volume using the formula $V = \pi r^2 l$. Basic density was calculated by dividing the ovendry weight by the green volume thus obtained.

The heartwood percentage was calculated from the width of the sapwood measured from the increment cores. For calculating the cross sectional area of the trunkwood, its radius was computed first from the GBH value and was corrected for bark thickness. The cross sectional area of the heartwood was estimated by deducting the sapwood width from the trunkwood radius thus calculated. The area was calculated using the formula $a = \pi r^2$. For *H. cordifolia* the heartwood was not distinct from sapwood and hence the heartwood percentage could not be determined.

For anatomical study, 15 to 20 micron thick sections of the increment core were cut on a Reichert Sliding Microtome. Tangential sections were directly cut from the core samples after boiling them in water. On the other hand, radial and transverse sections were cut after affixing the core pieces on small cubes of wood of suitable size using a water-resistant adhesive; Araldite. The blocks thus mounted were boiled in water before sectioning. Sections were stalned with 0.5% Safranln prepared in 50% alcohol and were mounted in DPX mountant after dehydration.

For the study of relationship between ring width and anatomical characteristics only two species namely, *L. microcarpa* and *G. tiliifolia* were slected as the rings were distinct only in these two among the six species. Transverse sections were cut from the wood samples of these species as detslled above. Only

the outer portion of the trunkwood was compared so as to eliminate the interference of age related structural changes in the comparison. Measurement of the ring width and other anatomical parameters were done with the help of Reichert Projection Microscope. The sectional views were traced on tracing film and the estimation of vessels, parenchayma, fibres and rays was done gravimetrically as proposed by Ghouse and Yunus (1974) for ray tissue estimation of cambium.

3.4. SILVICULTURAL STUDIES AND PLANTATION TRIALS

3.4.1. Seed collection and germination trials

Seeds of the selected trees were collected during different months to obtain them in different levels of maturity. Seed collection was carried out by the conventional methods with certain modifications to suit smaller seeds especially that of *H. cordifolia.* The seed samples were sundried and cleaned of debris to determine the number of seeds/kg. Germination trials were conducted to assess the percentage germination of different seeds. The tests were conducted in different months to determine the season for maximum percentage germination. The germination capacity of stored seeds was also determined at periodic intervals.

3.4.2. Nursery technique

The nursery beds were sown with various quantities of seeds. Optimum seed rate was determined on the basis of seedling density on the seed beds. Seed beds were provided with shade and were maintained under irrigated condition till potting , . Optimum

container size was arrived at based on the root growth of the seedlings as well as the length of the period the potted seedlings had to be retained in the nursery . Growth details of the seedlings were recorded prior to outplanting.

3.4.3. Plantation trials

During 1988, pilot plantations of only *A. odoratissima, H. cordifolia* and *X. xylocarpa* were raised at Nilambur while all the six species were raised individually and as mixed plantations (except *L. microcarpa)* during 1989. Outplanting was done at the onset of monsoon. Planting was done at an espacement of 2m X 2m in pits (30 X 30 X 30 cm) which were prepared during May-June.

Randomised block design was followed for the trials. The 1989 trial had 14 treatments replicated thrice with 100 plants in each replicate. The outermost planting row of each treatment plot, consisting of 36 plants was regarded as surround and was excluded from regular observations for survival and height growth In mixed plantations, different species occupied different diagonals in the planting design. Thus, a 50% mixed plantation had two species and a 25% mixture had four species as combination (Table 1).

The plots were protected against grazing and fire and maintained free from weeds by knife weeding. Observations were taken at monthly intervals for a period of 24 and 13 months respectively for 1988 and 1989 plantations. The 13th month data on survival and height and mean annual height increment (MAHI)

Table 1. Species combinations in pure and mixed plantations (1989 trial).

Pure plantations	Mixed plantations	
100%	50%	25%
Albizia odoratissima (A)	A H A P A X	AG HP
Grewia tiliifolia (G)	-	GH PX
Haldina cordifolia (H)	A H H P H X	AG HP GH PX
Lagerstroemia microcarps (L)	-	-
Pterocarpus marsupium (P)	H P P X A X	AG HP GH PX
Xylia xylocarpa (X)	H X P X	GH PX

during this period of the 1989 trial were subjected to analysis of variance. Analysis of variance for survival percentage was done after angular transformation of the data. Height and MAHI values were subjected to logarithmic transformations to the base E. The significance of differences between treatment means was tested using cluster analysis.

3.5. PEST PROBLEMS AND CONTROL

3.5.1. Pest incidence in natural stands

Data were gathered by making regular observations in the natural forests as well as regeneration areas. As quantitative data on the distribution of each of the species in various Forest Divisions was not available, only qualitative sampling could be carried out. For this, information on the occurrence of each of the species in various Forest Ranges of the State was gathered from the Forest Working Plans or by consulting the Forest Department staff. The areas thus identified were visited and attempts were made to cover as many trees as possible. Observations were made on the insects present and the degree of the damage. For recording damage to the foliage, the trees were scored into one of the following intensity classes based on visual assessment of the damage.

0 = Healthy tree, no attack.
1 = Low level attack, with upto 15% of foliage affected.
2 = Medium level attack with upto 50% of foliage affected.
3 = High infestation where about 75% of foliage affected.
4 = Very heavy infestation with over 75% of foliage affected.

Other types of damages like sap sucking, wood boring, etc. were recorded separately.

3.5.2. Pest infestation in trial plantations

Trial plantations of the 6 species raised both as pure and in mixtures at Nilambur were used for recording data. Altogether 13

blocks representing the two categories (ie. 6 blocks as pure plantations having either *H. cordifolia, P. marsupium, L. microcarpa, X. xylocarps, G. tiliifolia* or *A. odoratissima* and the remaining blocks having the above species in different combinations were selected for recording observations. Monthly observations were made successively for 5 months, from March 1990 to July 1990 and the occurrence of various insect pests, their intensity as well as impact on the host were recorded. The proportions of infestation in pure plantations and mixtures were compared by standard normal deviate test.

3.5.3. Studies on nursery pests

Observations on the nursery pests were made on seedlings raised on standard nursery beds at Peechi. For each species, 2 such beds were laid out for recording observations. Five rectangular grids of size 30 cm x 30 cm, selected along diagonal transects within each bed formed the sampling units. The number of healthy and affected seedlings within each grid and the nature of damage caused to them were recorded and the pooled average value for both beds was recorded as the percent infestation. Observations were repeated every fortnight.

3.5.4. Control of insect pests

Two species of psyllids, viz. an unidentified species attacking *A. odoratissima* and *Spanioneura* sp. attacking *P. marsupium;* an unidentified species of mite (attacking *L. microcarpa)* and a weevil *Indomias hispidulus,* feeding on leaf tissues of *X. xylocarpa* were identified as the most important nursery pests.

Standardisation of chemicals to control the above mentioned

pests was done on the nursery beds. For this purpose, two beds belonging to the three affected species were selected, each of which was divided into 12 blocks of 1 m x 1 m. Alternate compartments were left blank as buffers between treatments in order to avoid any possibility of insecticidal drift while spraying. The treatments were done in a completely randomised design. Three insecticides Endosulphan, Phosphsmidon and Monocrotophos - at uniform concentrations of 0.05% a.i. were tried against the psyllids. Dicofol, Phosphamidon (at 0.05% a.i.) and Sulphur (at 0.25% a.i.) were used against the mite.

3.6. DISEASE PROBLEMS AND CONTROL

3.6.1. Collection and storage of seeds

Seed samples were collected from different forest ranges during 1989. The pooled samples, soon after their collection were labelled, sun-dried to reduce the moisture content to about 10-15% and stored separately in cotton bags at room temperature (25-35oC). For chemical control studies, seeds were treated with appropriate chemicals and stored in wide mouthed sir-tight polyester containers at room temperature (25-35 ^{o}C).

3.6.2. Incubation tests

The standard blotter test recommended for seed testing was employed (ISTA, 1966). A random sample of 200 seeds was used for each species. But for *P. marsupium* and *X. xylocarpa* where the seed size is large, only 50 and 100 seeds respectively were used. Wet sterllised blotters of 9 or 11 cm size were used in the study. The plates were incubated at 25^{o} $\pm$ 2 C under 12 hours of

alternating cycles of light and darkness for 6 days and were examined on the 7th day with the help of a stereomicroscope for microbial growth. Relative percent incidence (RPI) of each micro-organism was calculated from the following formula.

$$RPI = \frac{\text{No. of seeds with organism}}{\text{Total number of seeds tested}} \times 100$$

3.6.3. Effect of fungicides on seed-borne fungi

Common seed dressers like MEMC, mancozeb, carbendazim and carboxin were used in the study. Treated seeds, stored in plastic containers, were examined one day and 90 days after the treatment, employing standard blotter method. Observations were recorded on the 7th day of incubation. RPI of various microorganisms was calculated as mentioned under item 3.6.2.

3.6.4. Diseases of seedlings

Seedlings of different species were raised in seed beds (12 m x 1.2m) at Peechi during April, 1989. For the first 45 to 60 days a shade pandal of coir mat was provided to protect seedlings from sun scorch. The seed beds were watered at regular intervals. Seedlings were maintained till the next planting season, ie. May, either in the mother beds or in polythene containers (18 cm x 12 cm size).

Occurrence of disease(s), if any, their symptoms and nature of damage caused to seedlings were recorded. The incidence of a disease was estimated either by counting the number of disease patches and approximate area covered by them or percent seedlings affected for a given density of seedlings in a seed bed (Sharma

et al., 1985). Appropriate part of diseased seedlings were collected for isolation and identlfication of the causal organism.

3.6.5. Incidence of diseases in natural stands

Natural stands in various areas of the State were surveyed for the occurrence of diseases on standing trees. As far as possible the same areas were visited during dry (December-April) and wet season (June–September) and observations recorded. Diseased specimens were collected for isolation and identification of the causal organism.

3.6.6. Isolation and identification of causal organism

Diseased specimens were taken in separate polythene bags to the laboratory. Isolations were made usually within one week. Generally, potato dextrose agar for lsolatlon of fungi, and nutrient agar for isolation of bacteria were used. Causal organisms in pure culture were provisionally identified and identity confirmed through CAB International Mycological Institute, Kew, UK. The cultures were periodically subcultured and stored in cold room at 25 $\pm$ 2^{o}C.

3.6.7. Pathogeneclty studies

For pathogenicity studies, a specially designed humidity chamber, fabricated locally was used. For inoculation of leaves, detached leaf culture technique was employed (Sharna *et al.,* 1985).

In the case of root, stem or shoot diseases of seedlings, pathogenicity was tested on seedlings inaluminium trays (30cm x 30cm x 5cm). Initially seedlings raised in normal soil

transplanted to aluminium trays with sterile soil. The seedlings were first allowed to establish for a few days in the humidity chamber and then appropriately inoculated. In the case of soil-borne diseases, soil was infested with appropriate quantity of inoculum of the test organism, usually raised on corn meal medium, dried and powdered (Sharma *et al.,* 1985). The trays were maintained in the humidity chamber throughout, to observe the development of disease.

3.6.8. Evaluation of fungicides for disease control

Poison food technique and modified soil fungicide technique (Zentmeper, 1955; Sharma *et al.,* 1935) were used to evaluate various fungicides *in vitro* against the most important seedling disease causing pathogens. The efficacy of most effective fungicides Identified in *in vitro* studies was evaluated in pilot scale field trials.

3.6.9. Root nodulation studies

Collection of nodules and isolation of *Rhizobium* were done based on the standard procedure of Vincent (1970). Nodules were collected from the nursery beds maintained at Peechi. Evaluation of isolates of *X. xylocarpa, P. marsupium* and *A. odoratissima* was done in polythene bags. The *Rhizobium* pelleted seeds were dibbled in polythene bags filled with gravel - free garden soil. The experiment had 25 replications, but the effective replications were between 10 to 15 because of non-viability of seeds. Seedlings were carefully removed and nodules collected after removing the soil and floating the seedlings in water. The effectiveness was evaluated based on the number of nodules and biomass production after 6 and 15 weeks.

Results of seed pathological studies are dealt as incubation tests and effect of fungicides on seed borne fungi. The diseases listed for each of the tree species are divided into nursery diseases and diseases in natural stands. Control measures for serious seedling diseases were worked out and recommendation made. Each disease has Seen discussed separately and a general discussion on diseases is given at the end, host-wise. Observations on root nodulation studies pertaining to the three leguminous species, viz. *A. odoratissima, P. marsupium* and *X. xylocarpa* are included host-wise.

4. ALBIZIA ODORATISSIMA

(Kunni–vaka)

4.1. BOTANY

4.1.1. Nomenclature

Albizia odoratissima **(L.f.)** Benth. in Hook. J. Bot. Kew Gard. Misc. 3:88. 1844; Bedd. Fl. Sylvat. t.54. 1870; Baker in Hook. **f.** Fl. Brit. India 2: 298. 1878; Prain, J. Asiat. **Soc.** Bengal **66(2):259.1897;** Brandis, Indian Trees **371. 1906;** Rama Rao, Fl. Pl. Travancore **153. 1914;** Bourd. **For.** Trees Travancore **141. 1908;** Gamble, Fl. Presid. Madras **1:431. 1918;** Bhattacharya *et* Maheswari, J. Indian bot. Soc. 52: **283.** fig. **6c. 1973;** Nair et Henry (eds.), Fl. Tamilnadu 1: **137. 1983;** Kosterm. in Dassanapake *et* Fosberg (eds.), Revis. Handb. **Fl.** Ceylon **1: 499. 1980;** Matthew, Fl. Tamilnadu Carnatic **3(1): 539. 1983;** Ramach. et Flair, Fl. Cannanore **170. 1988.**

Mimosa odoratissima L.f. Suppl. P1. 437. 1781; Roxb. Corm. Pl. **t.** 120. 1799 & Fl. Indica 2: 546. 1832; Wt. et Arn. Prodr. Fl. Penin. Indiae Orient. 1: 275. 1834 (as *odoratissima).*

Acacia odoratissims (L.f.) Willd. **Sp. Pl. 4:1063. 1805; DC.** Prodr. 2:466. 1825.

Mimosa marginata Lamk. Encyl. **1: 12.1783.**

Acacia ***lomatocarpa*** **DC.** Prodr. **2: 467.1825.**

Albizia micrantha Biov. in Miq. **Fl.** Ind. Bat. **1:24. 1834.**

Albizia lebekkoides Benth. in Hook. J. Kew Gard. Misc. 3:88. 1844.

Waga van Rheede, Hort. Malab. 6:9.t.5. 1686.

Type : Koenig, s.n.

4.1.2. Local names

Kunni-vaka, Nelli-vaka, Chittilei-vaka, Puli-vaka, Karu-vaka, Chela-vaka.

4.1.3. Botanical description

Deciduous trees, 13 - 30 m high; bark black, flaking or cracking; young shoots drark-coloured, appressed-pubescent. Leaves bipinnate, 3.5 - 15.5 cm long with a sessile gland on the rachis a little above its base and also at the base of 1 or 2 pinnae towards apex; stipules cauducous; pinnae usualy 3 - 5 pairs, paripinnate, rather distant, 4.5 - 13.5 cm long, with pubescent rachis. Leaflets 8 to 15 pairs, sessile, 0.9 - 2.6 x 0.3 - 0.9 cm, narrowly oblong, narrowly elliptic, narrowly ovate, narrcwly obovate or rarely linear, narrowly oblique, obovate or very rarely elliptic, entire, acute, apiculate, obtuse, retuse, oblique or cuneate at base, dark green and slightly pubescent above, glaucous and pubescent beneath, often broadest at the base. Inflorescence axillary or terminal in umbellate or corymbose panicles of 8 to 12 flowered subglobose heads, ± 2 cm in diameter; bracts 2 or none, upto 0.1 cm long, pubescent. Flowers sessile, cream-coloured, white, yellowish-greenish white or pale greenish, grey and ashy-tomentose when young, ± 1 cm long, upto 0.4 cm across, fragrant; calyx 0.1 - 0.2 cm long, pubescent, campanulate, teeth obselete; corolla with 5 petals, connate, funnel or tublular-shaped, 5 teethed, grey-silky pubescent outside; corolla teeth ovate-lanceolate, acute at apex; stamens indefinite, twice as long as the corolla or more; filaments upto 1 cm long, pale or yellowish white, connate at base, upto 0.3 cm in length, long exserted; pistil upto 1.2 cm

long; ovary stipitate. Pods subsessile, 12 - 22 x 1.8 - 3 cm, thin, flat, straight, strongly veined, continuous within, or subdehiscent, obtuse at apex, drying black; seeds 5 to 15 per pod, upto 0.8 x 0.5 cm, broadly ovate or orbicular, compressed, much flattened, brown or yellowish in colour, exalbuminous, with filiform funicle (Figs. 1 & 2).

4.1.4. Field notes

Trees with spreading crown, commn in the moist deciduous forests and grasslands of the State upto an altitude of about 1200 m above msl, often growing in valleys and along the sides of ravines. When in flowers, the trees attract a lot of insects. Branching is less towards the base of the trunk, but profuse towards apex.

4.1.5. Phenology

Flowers from March to June, often profuse during April and May; fruits from July to January, maturing mostly during November and December (Fig. 3).

4.1.6. World distribution

Throughout India, Sri Lanka, Burma and Malays.

4.1.7. Distribution in Kerala

Trivandrum, Thenmala, Konni, Rsnni, Kottayam, Thekkedy, Munnar, Idukki, Kothamangalam, Mankulam, Malayattoor, Vazhachal, Chalakudy, Trichur, Nemmara, Palghat, Parambikulam, Cslicut, Nilambur and Wynad Forest Divisions. Almost throughout the State (Fig. 4).

4.1.8. Notes

Attributing the authorship to Bentham, Baker (*l. c.*) recognized the variety *A. odorstissima* (L. f.) Benth. var. *mollis* Benth. characterized by leaflets and rachis densely grey-dawny, the former less rigid than the type (ie. *A. odorstissima* (L.f.) Benth. var. *odoratissima)* and referred to specimens of Thomson from Rohilkund and that of Edgeworth from Siwaliks, both in North India, to authenticate the identity and distribution of the variety. Subsequently, Gamble (l.c.) and Nair and Henry (l,c,) confirmed the occurrence of var. *mollis* in Peninsular India from Coimbatore and North Arcot districts of Tamilnadu State, wherein, grey on dawny–velvetty leaflets were noted as characteristic to the variety. Studies on the natural populations of the species in Kerala revealed that var. *mollis* does not occur in the State, eventhough its occurrence in the Walayar forests of Palghat Division in Kerala is possible, as forests of this region form a continuous stretch with that of Coimbatore wherefrom the variety has been reported in South India. There is also no record of the existence of var. *mollis* in Sri Lanka or in any other country falling within the range of distribution of the species.

4.1.9. Within species variation

Data on leaf variation were gathered from 20 specimens collected from different locations in the State. Characters recorded as measurements like length of compound leaves and length and breadth of individual leaflets (petiolule being very shcrt was not accounted) were transformed to dichotomous variables by dividing their ranges into classes. The class are 3.5 to 7.5 cm (short), 7.5 to 11.5 cm(medium long) and 11.5 tc 15.5 cm (very long) for the length of coumpound leaves, 0.8 to

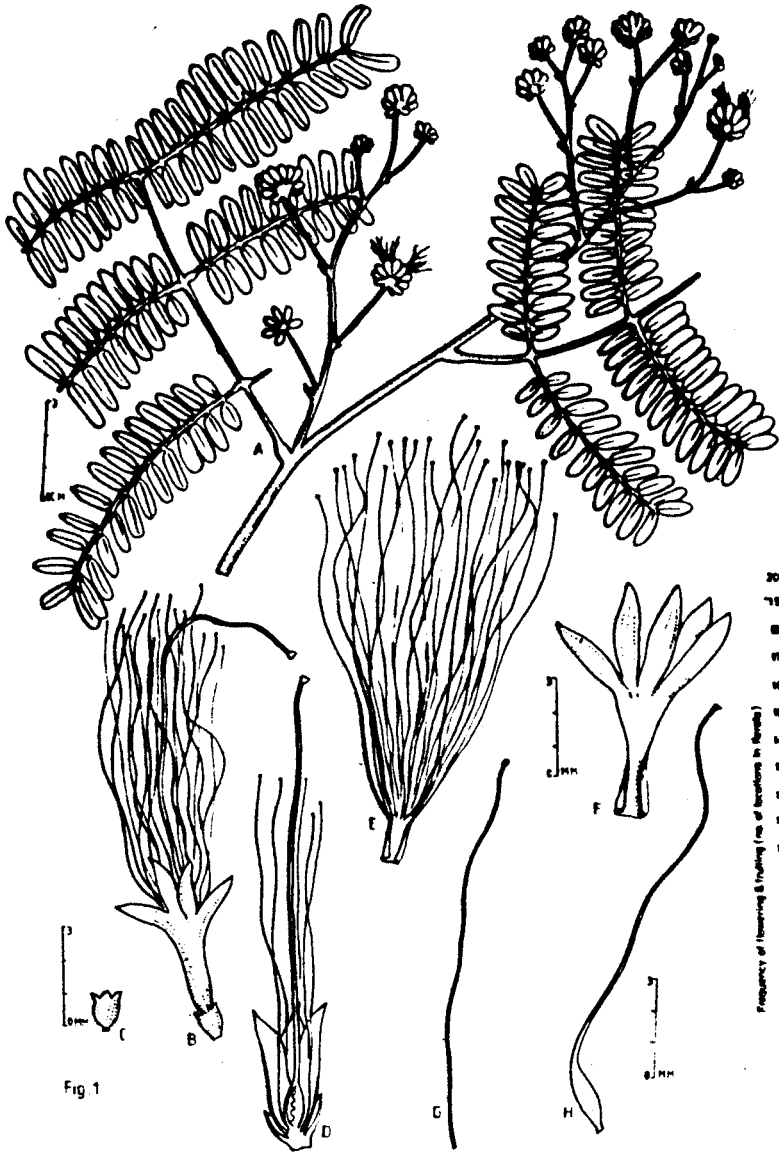


Fig.1

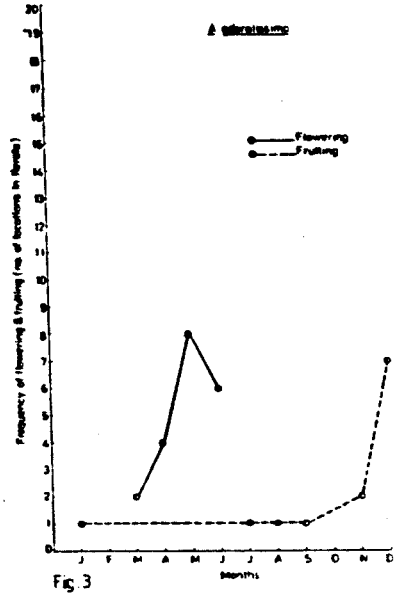


Fig.3

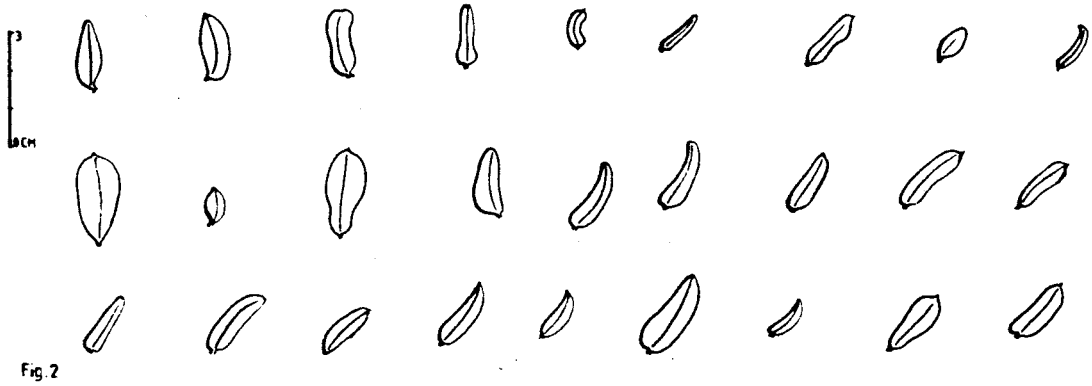


Fig.2

Albizia odoratissima

Fig.1 A. Flowering twig, B. Flower, C. Calyx, D. L.S. of flower, E. Androecium, F. Corolla, G. Stamen, H. Pistil.
Fig.2 Leaflet variation diagram.
Fig.3 Phenological graph.

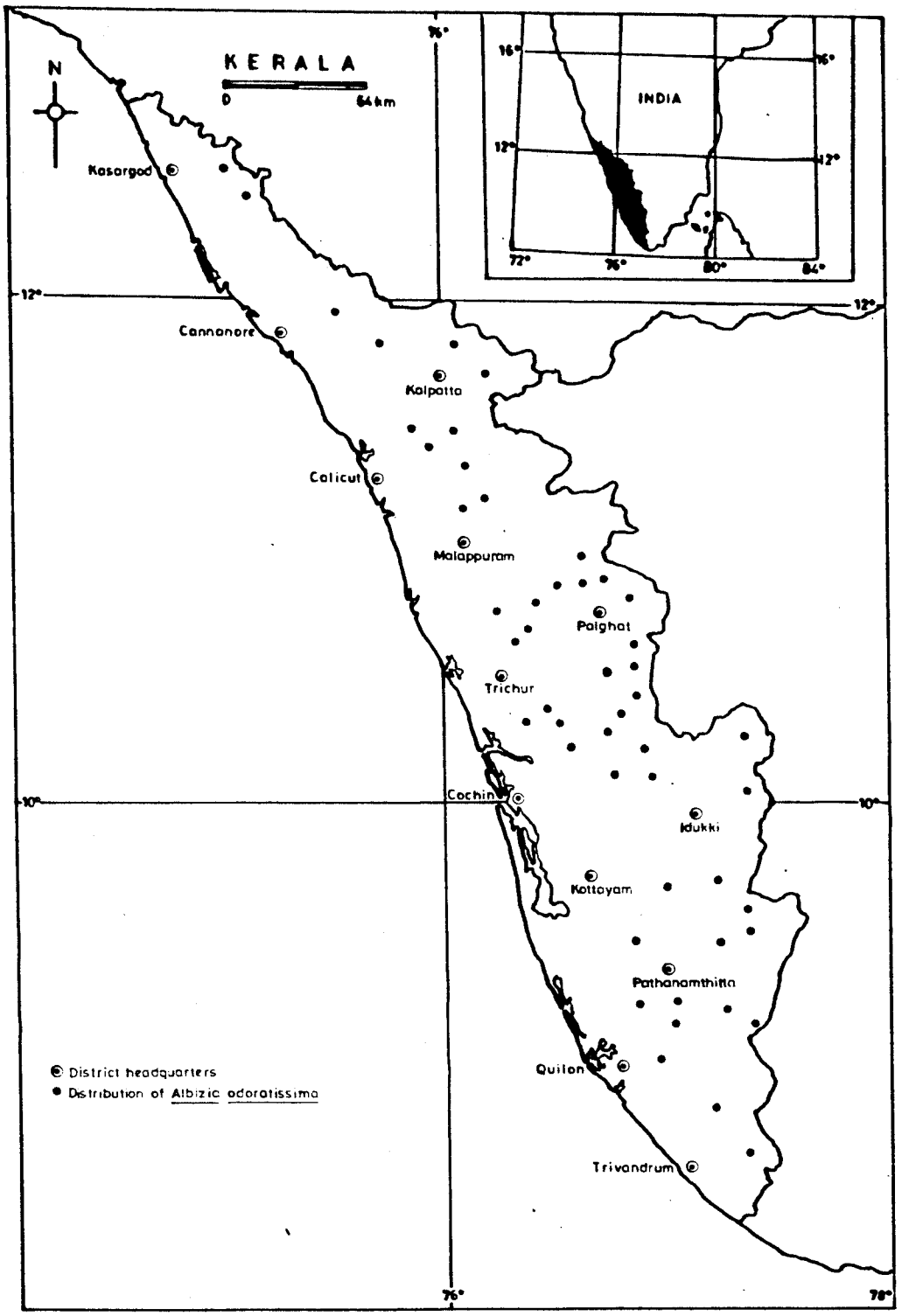


Fig.4 Distribution map of *A. odoratissima* in Kerala.

1.4 cm (short), 1.4 to 2 cm (medium long) and 2 to 2.6 cm (very long) for leaflet length, and 0.3 to 0.5 cm (narrow), 0.5 to 0.7 cm (medium broad) and 0.7 to 0.9 cm (very broad) for leaflet breadth. The data thus assembled were subjected to cluster analysis.

The cluster diagram (Fig 5.1) demonstrates the coincidence of characters in all the 20 OTUs. It shows that medium long compound leaves, and medium broad leaflets are narrowly oblong, narrowly obvate, entire, obtuse at apex and obtuse, oblique or truncate at base. Likewise, specimens with maximum breadth for leaflets are often narrowly ovate in shape and acute at apex. All other character variants namely compound leaves with maxlmum length, leaflets with minimum and maximum length, leaflets with minimum breadth and leaflets which are narrowly elliptic, linear, narrowly oblique, obovate or elliptic in shape and those with apiculate, retuse or mucronate apex and cuneate base do not form clusters with any other character used in the analysis.

In the cluster analysis conducted to find out similarity among specimens from different parts of the State (Fig 5.2), there were only three clusters which showed at least 50% similarity among the specimens. They were of specimens from:

i. Aryankavu, Thenmala, Mannarappara, Marayur, Orukombam in Parambikulam and Achenkvoil in Thennmala Division.

ii. Palappilly, Peechi, Karulai, Adirappilly and Achenkovil, and

iii. Ksrimala, Vadakkancherry, Nelliampathy and Dhoni in northern Kerala.

With regard to the length of compound leaves, the shortest

ones (3.5 cm) were from Varhani in Trichur Division and those with maximum length (15.5 cm) were from Mannarappara Range in Konni Division. Likewise, shorest leaflets measruing 0.9 cm in length were noted for specimens from Vazhani Range in Trichur Division and longest leaflets among all samples collected (2.6 cm) were from Marayur in Munnar Division. With regard to the breadth of leaflets, it was minimum (0.3 cm) for specimens from Achenkovil in Thenmsla Division and maximum (0.9 cm) for those from Karimala Range in Parambikulam Division.

4.1.10. Specimens examined

Chandanakampara, Kasaragod Distrct, 15.5.1982, V.J. Nair 73899 (MH); Thaliparamba farm, Malabar, 19.5.1906, C.A. Barber 7748 (MH); Kannoth, Malabar, 8.12.1913, C.A. Barber 9501 (MH); Trissleri, Cannanore District, 5.5.1979, V.S. Ramachandran 62275 (MH); Begur RF, Cannanore District, 23.6.1979, V.S. Ramachandran 62744 (MH); Kuthirakode RF, Begur Range, Wynad Division, 23.11.1983, K.N.Subramanian 9790 (FRI); Sultan's Battery, Wynad Division, 12.8.1964, J.L. Ellis 19923 (MH); Karulai Range, Nilambur Division, 15.6.1989, K.K.N. Nair 6506 (KFRI); Karimala Range, Parambikulam Division, 19.5.1988, K.K.N. Nair 6355 (KFRI); Orukomban Range, Parambikularn Division, 19.5.1988, K.K.N. Nair 6341 (KFRI); Chungam Range, Parambikulam Division, 19.5.1988, K.K.N. Nair 6346 (KFRI); Walayar RF, Palghat Division, 13.6.1989, K.K.N. Nair 6396 (KFRI); Walapar, Palghat, Sept. 1936, Without collectors' name and number (MH); Agali, Attappady valley, Palghat, 23.1.1911, C.E.C. Fischer 2476 (FRI); Mukkali to Pathanthode, Mannarghat Range, Palghat Division, 14.6. 1989, K.K.N. Nair 6503 (KFRI); RF, Palghat Division, 13.6.1989, K.K.N. Nair 6400 (KFRI); Pankarappally, Vadakkancherrp Range,

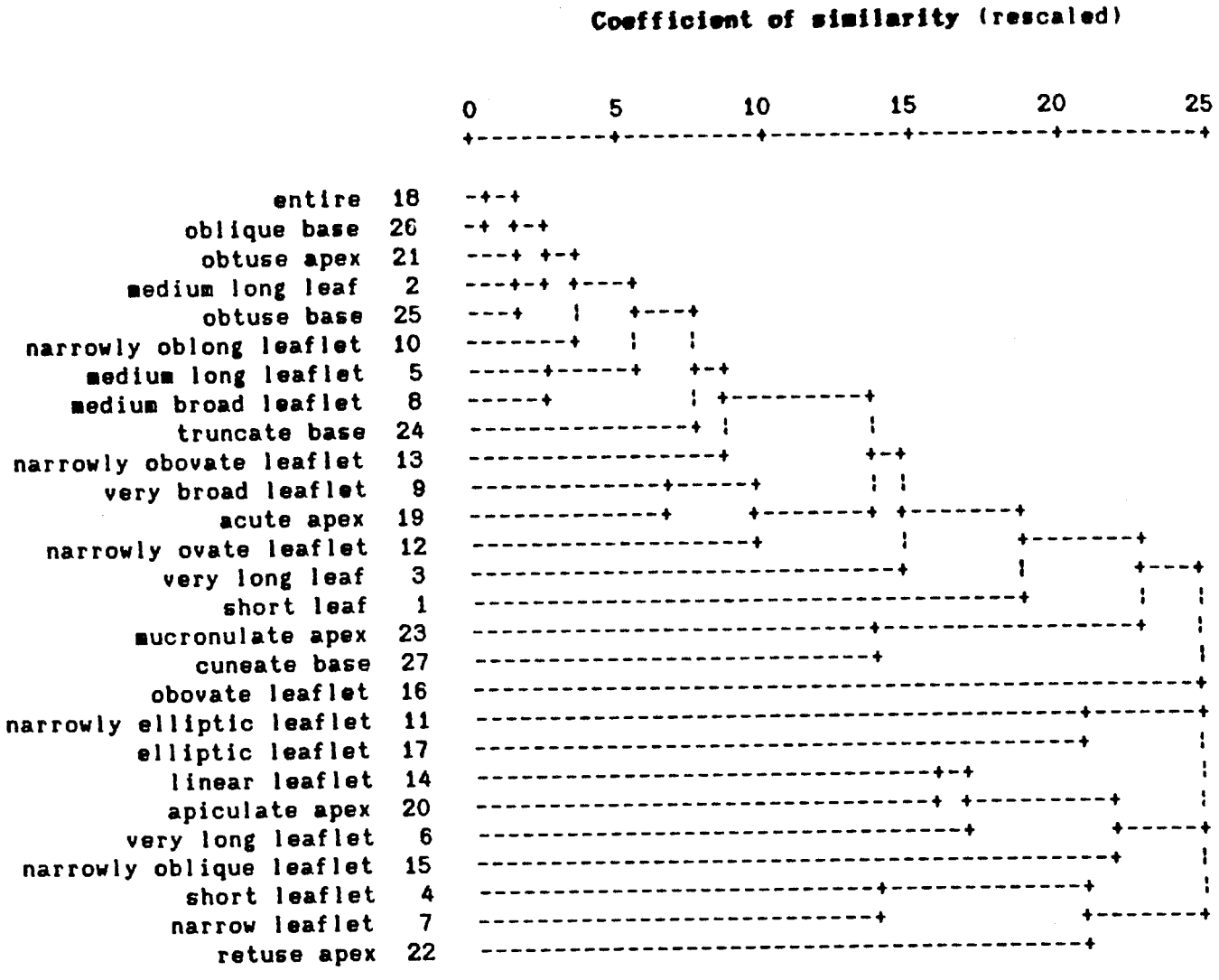


Fig. 5.1 Phenogram based on coefficient of Jaccard of leaf characters of **A. odoratissima** from different locations in Kerala.

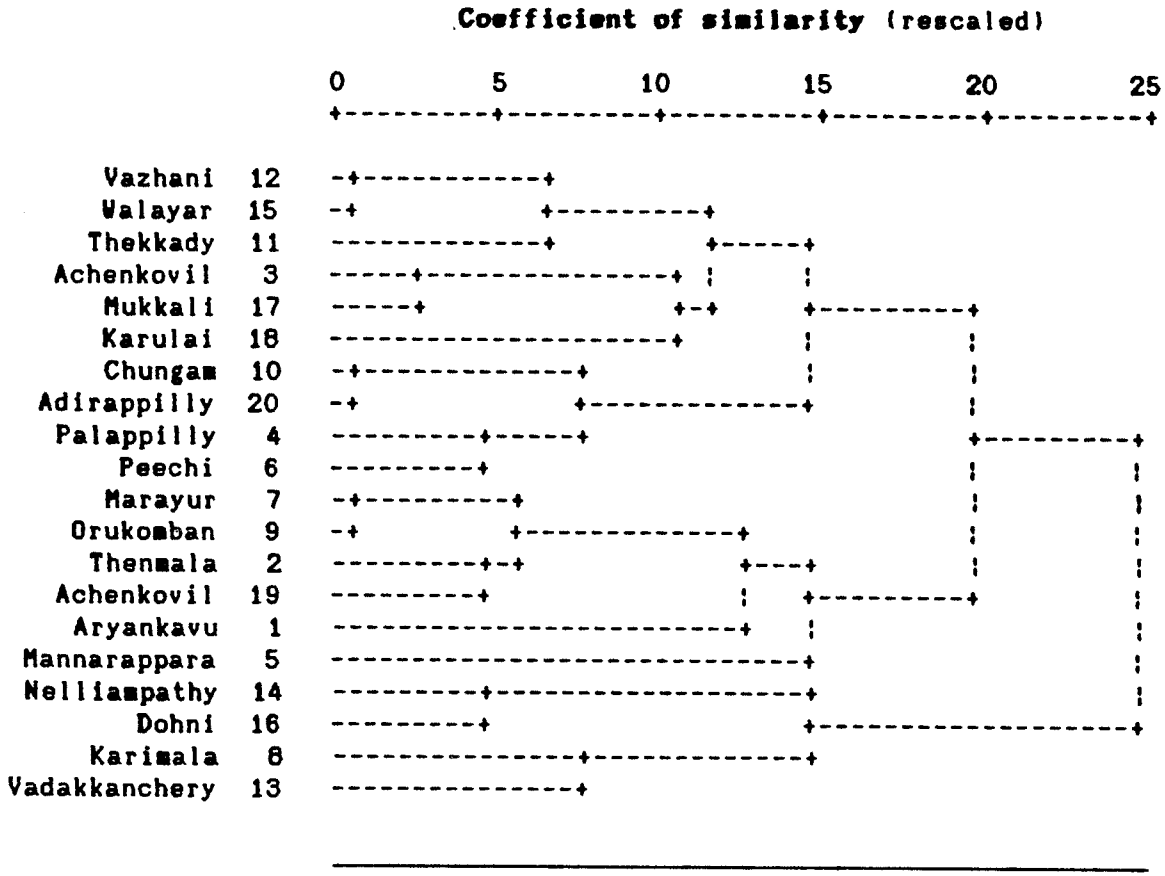


Fig. 5.2 Phenogram based on coffecient of Jaccard of specimens of **A. odoratissima** from different locations in Kerala.

Trichur Division, 11.4.1989, K.K.N. Nair 6384 (KFRI); Vazhani dam catchment, Machad Range, Trlchur Division, 11.4.1989, K.K.N. Nair 6382 (KFRI); Peechl Range, Trichur Division, 4.5.1988, K.K.N. Nair 6328 (KFRI); Nelliampathy Range, Nemmara Division, 6.6.1989, K.K.N. Nair 6385 (KFRI); Palappilly Range, Chalakudy Division, 23.3.1988, K.K.N. Nair 6316 (KFRI); Marayur Range, Munnar Division, 18.5.1988, K.K.N. Nair 6333 (KFRI); Chinnar to Marayur, Munnar Division, 19.4.1964, K.M. Sebastine 18311 (MH); Vallakadvu, 1965 Eucalypt plantation, Thekkady Division, 15.7.1983, K.N. Subramanian 9474 (FRI); Vallakadvu Eucalypt plantation, Thekkady Division, 14.7.1983, K.N.Subramanian 9432 (FRI); Thekkady Range, Thekkady Divsion, 31.3.1989, K.K.N. Nair 6376 (KFRI); Mannarappara Range, Konni Division, 23.4.1988, K.K.N. Nair 6323 (KFRI); Way to Katlappara, Thenmala Range, Thenmala Division, 29.12.1989, K.K.N. Nalr 6304 (KFRI); Thenmala Division, 14.7. 1918, K.N. Subramanian 7366 (FRI); Aryankavu Range, Thenmala Division, 12.11.1987, K.K.N. Nair 6303 (KFRI); Manalar, Achenkovil Range, Thenmala Division, 30.12.1987, K.K.N. Nair 6308 (KFRI); Attappady, Achenkovil Range, Thenmala Division, 1.12.1987, K.K.N. Nair 6310 (KFRI).

4.2. ECOLOGY

Ecological information gathered during field studies on the natural stands of *A. odoratissima* in Kerala is given below.

Associations: Terminalia - Wrightia

Parent tree distribution : Rare

Biotic interference: Highly disturbed

Regeneration status:	Three
Young seedlings:	
(upto 30 cm ht.)	Insufficent numbers
Older seedlings:	Limited
(31 cm to 1 m ht.)	
Sapiings:	
(more than 1 m ht.)	Occasional
Mortality rate:	High
Remarks:	Found in pockets of high moisture regime.

4.3. UTILIZATION ASPECTS

4.3.1. Bole characteristics

Mature trees grow to a diameter of 90 cm and a height of 30 m, with a straight clear bole of even upto 12 m length. The stem is almost cylindrical and lacks flutes or buttresses. The common defects in the stem include branches, decayed branch stubs, fork and decay cavities. The wood is more commonly interlocked-grained. Due to branching and spreading habit, very often the length of the straight bcle is limited to 4 to 6 m in certain localities. Wyanad in the northern region and Ranni and Konni in the South showed comparatively better stem form with few defects and stralght bole.

4.3.2. Wood properties

Basic density of wood varied from 586.3 kg/m^3 to 729.8 kg/m^3 with an average of 656.8 kg/m^3. Analysis of variance showed that

Table 1. ANOVA of basic density and heartwood percentage of *A. odoratissima* between different regions and localities in Kerala

Source of variation	Basic density			Heartwood percentage		
	DF	Mean square	F-value	DF	Mean square	F-value
Region	2	2830.133	1.924(ns)	2	59.394	0.944(ns)
Locality	2	1422.963	0.967(ns)	3	172.422	2.742(ns)
Residual	20	1471.251		16	62.889	
Total	24	1518.978		20	69.625	

ns = non significant

there was no significant difference in basic density either between the northern, central or southern regions or between the three localities of the central region (Table 1). Similarly, the heartwood percentage showed no significant difference between the regions and between different localities (Table 1). On the other hand, heartwood percentage showed a significant positive correlation (R = 0.7476) with stem diameter.

4.3.3. Wood structure

Growth rings are generally indistinct but are distinguishable microscopically. The ring-like markings on cross sectional discs are partly related to changing grain direction. However, the rings are reported to be distinct and inconspicuous (Pearson and Brown,

Vessels distributed in singles or short radial multiples, rarely in long radial multiples of upto 12 vessels and clusters, solitary vessels typically round, heartwood vessels partly blocked by gummy deposits; perforation simple; pitting alternate, pits small and narrowly bordered, pits to parenchyma distinct by their distribution.

Parenchyma abundant, aliform to alifom-confluent, parenchyma demarcating the growth rings also present; diffuse parenchyma consisting mostly of chambered crystalliferaus cells, fusiform cells present among the paratracheal parenchyma, cells contiguous to vessels with prominent pits; extractives scanty.

Rays 1- to 3–seriate; commonly 2- to 3-seriate, homogeneous, conspicuously broader when surrounded by parenchyma; crystals absent, extractives abundant in heartwood rays; pits to vessels in horizontal rows.

Fibres thin–walled and septate, without pronounced difference between earlywood and latewood in wall thickness; extractives scanty; crystals not found as contrary to their reported presence (Chauhan and Dayal, 1985).

4.4. SILVICULTURE AND PLANTATION TRIALS

4.4.1. Seed collection

Ripened fruits were collected from Nilambur during March to early May. According to Troup (1983) fruits of *A. odaratissima* ripens during January–February in North India. From the present study it was clear that seeds could be collected at any time from March till May. The frults (pods) were collected both from the ground as well as from the trees. The pods split open when

dried in the sun. The unopened pods were manually broken to release the seeds. In some places pods were beaten with sticks to release the seeds. The seeds were cleaned by winnowing.

4.4.2. Seed weight

Samples collected from Nilambur contained 20,000 seeds per kilogram. Sengupta (1937) has reported a seed weight of 15,521 and 22,928 per kg in the case of different samples from North India.

4.4.3. Germination capacity

Freshly collected seeds registered only 33% geermination without any pretreatment. This is much below the germination capacity of 47% already reported (FRI, 1983). Seeds can be stored for long periods without loosing much of its germination capacity (FRI, 1983).

4.4.4. Nursery technique

About 1 to 2 kg of seeds are required for sowing on standard nursery beds of 12 m X 1.2 m. Seeds were sown in March and germination commenced in around 4 to 6 days and continued upto 45 to 50 days. The seedlings were ready for potting in April and attainted plantable size in the following season. Polythene bags of 22.5 cm x 17.5 cm size are adequate for maintaining the seedlings upto a period of 15 months.

4.4.5. Plantation trials

4.4.5.1. Survival of seedlings

After 24 months, *A. odoratissima* seedlings showed a very poor survival of 7% in the pilot plantation trials of 1988 (Fig.

6). However, the species attainted a maximum height of 102 cm during this period.

The survival percentage of the species in pure and mixed plantations of 1989 was also below 20%. Maximum survival was 18% in a 50% mixed plantation of AP. In other 50% mixtsres like AH and AX, the survival further declined to 15 and 7% respectively. The performance of the species in a 25% mixture of AGHP appeared to be better (13%) than the 50% mixture of AX. Lowest survival was 4% observed in the pure plantations of the species. The statistical analysis of the data on survival of seedlings at the 13th month did not show any significant difference between the performance of the species in pure and mixed plantations (Table 2).

Table 2. Analysis of variance of survival of seedlings in pure and mixed plantations of *A. odoratissima*

Source of variation	DF	MSS	F-Values
Treatment	4	75.643	0.967(ns)
Replication	2	34.619	
Residual	8	78.213	
Total	14		

ns = not significant

4.4.5.2. Height growth

Mean values of height after 12 months showed wide variation. The species registered maximum height of 150 cm in the 25% mixed

Fig. 6

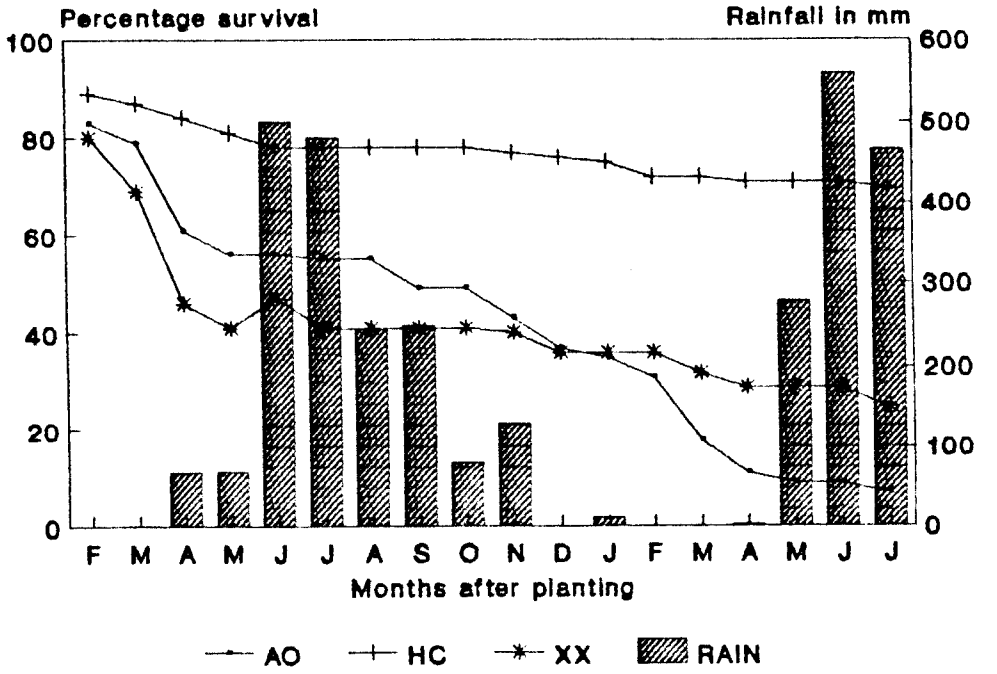


Fig. 7

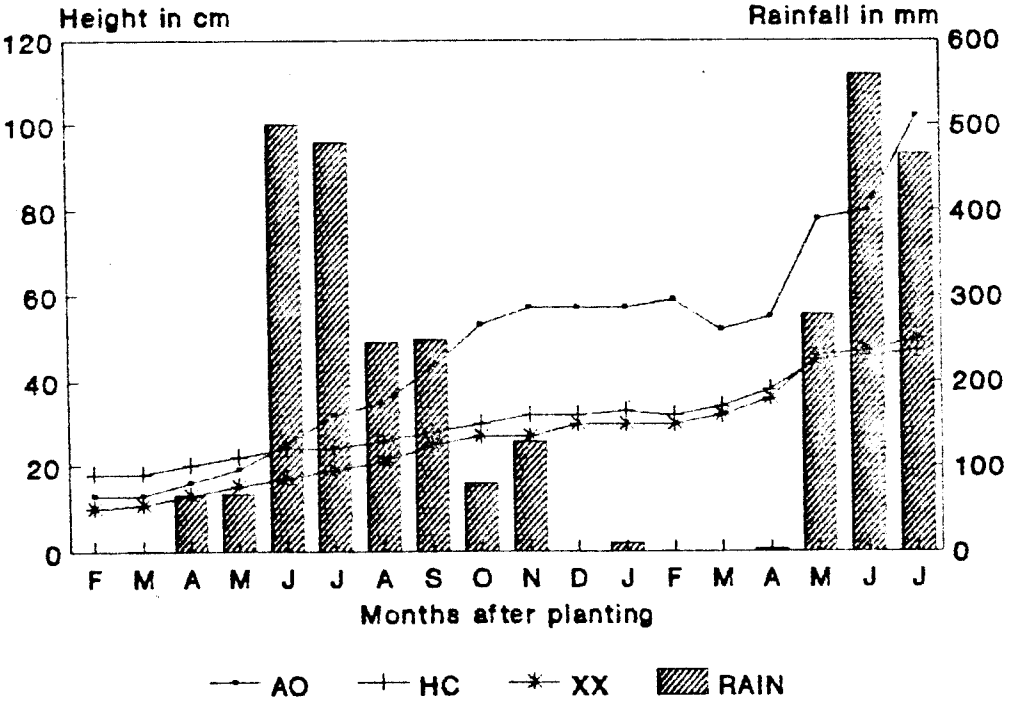


Fig. 6. Survival percentage of seedlings in pure plantations of *A. odoratissima*, *H. cordifolia* and *X. xylocarpa* in the 1988 trial.

Fig. 7. Height growth of the seedlings in pure and mixed plantations of *A. odoratissima*, *H. cordifolia* and *X. xylocarpa*.

plantation of AGHP. Even though the species ina 50% mixture of AP had maximum initial height at the commencement of the trial, it declined to 87 cm mean height after a period of 12 months. Performance of the species was lower in 50% combinations of AH and AX, where the heights recorded were 82 and 58 cm respectively. Lowest height growth was observed in the pure plantations of *Albizia* which was 48 cm (Fig. 7). Even though the mean values showed variation, it was statistically not significant (Table 3).

Table 3. Analysis of variance of height of seedlings in pure and mixed plantations of *A. odoratissima*

Source of variation	DF	MSS	F-values
Treatment	4	0.662	3.0935 (ns)
Replication	2	0.389	1.8178 (ns)
Residual	8	0.214	
Total	14		

ns = not significant

4.4.5.3. Mean annual height increment (MAHI)

Mean annual height increment of the species in pure and mixed plantations is shown in Fig. 8. The spcies recorded very fast rate of growth in a 25% mixed plantation of AGHP reaching 108 cm. In 50% mixtures of AP and AH the height increment was comparatively less being only 37 cm. MAHI was less in the combination AX and lowest in pure plantation with 21 cm and 7 cm,

Table 4. Analysis of variance of MAHI in pure and mixed plantations of *A. odoratissima*

Source of variation	DF	MSS	F-Values
Treatment	4	1.306	2.2595 (ns)
Replication	2	0.719	1.2439 (ns)
Residual	8	0.578	
Total	14		

ns = not significant

respectively. Analysis of variance, however, did not show any significant difference in MAHI of the specis in pure and mixed plantations (Table 4).

4.5. PEST PROBLEMS AND CONTROL

4.5.1. Insect pests in natural stands

The trees were comparatively free from pest attack in their natural stands in the State, although at one or two locations mild attack by the caterpillars of *Archips* sp. and *Phycita* sp. and by a bug *Oxyrschis tarandus* was noticed (Table 5). The caterpillars characteristically webbed the tender leaves and fed from within. However, they did not cause any serious damage to the foliage.

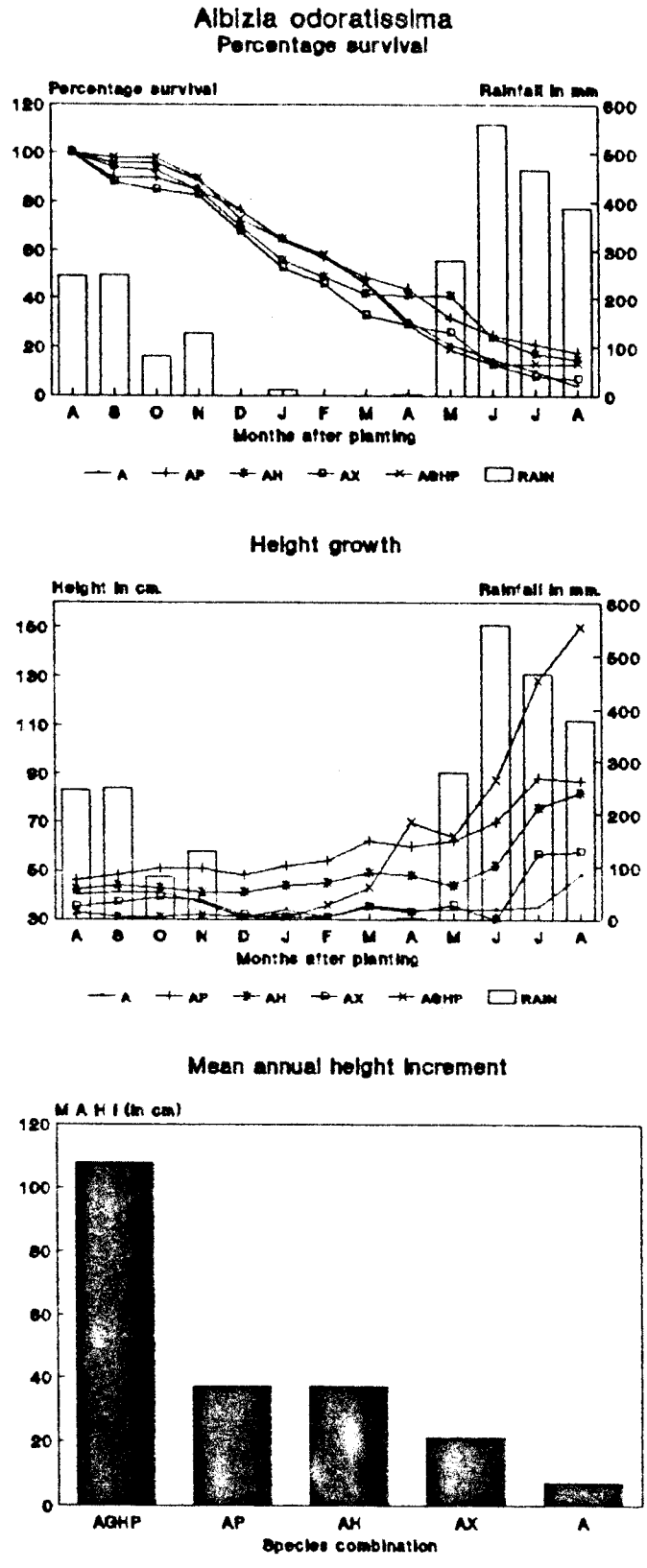


Fig. 8. Survival percentage, height growth and MAHI of seedlings in pure and mixed plantations of *A. odoratissima*.

Table 5. Insect pests collected from the natural stands of *A. odoratissima* in Kerala

Insect species	Place of colln.	Nature of damage
Archips sp. (Lepidoptera, Tortricidae)	Peechi, Vazhsni	Leaf webbing
Phycita **sp.** (Lepidoptera, Phycitidae)	Idukki	Leaf webbing
Oxyrachis tarandus Fb. (Homoptera, Membracidae)	Wilambur, Peechi	Sap sucking

Earlier, six species of insects including the bug, ***O. tarandus*** were reported from *A. odoratissima* trees in India (Browne, 1968). ***O. tarandus*** is reported to be a minor pest associated with various species of Albizias, usually infesting the saplings and causing stunting and die-back of the shoots. This insect is tended by ants particularly *Crematogaster* spp. which may also play a role in its distribution.

4.5.2. Pest problems in trial plantations

In pure plantings, attack by an unidentified psyllid bug was the most serious problem leading to stunting and die-back of transplanted seedlings. About of the seedlings were heavily affected by this insect in one block under observation. In addition to this, incidence of leaf feeding insects, mainly the caterpillars of *Archips* sp. was also noticed (Table 6). The intensity of damage was low in all other combinations. About 25% of the seedlings were found to be attacked by this Insect in pure

plantings.

Table 6. Percent incidence of leaf-webbing caterpillers in the trial plantstions of *A. odoratissima*

Conbinations with *A. odoratissima*	Tree species A	P	X	H	G	Percent infestation* Mar	Apt	May	Jun	Jul
A	1.00	0.00	0.00	0.00	0.00	1.56	1.56	0.00	14.06	25.00[a]
AP	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	6.25	31.25[b]
AX	0.50	0.00	0.50	0.00	0,00	0.00	0.00	3.12	15.62	18.75[c]
AH	0.50	0.00	0.00	0.50	0.00	3.12	0.00	0.00	25.00	37.50[d]
APHG	0.25	0.25	0.00	0.25'	0.25	0.00	0.00	12.50	19.75	0.00[e]

The values given in the column are significant at 6% probability

The 50% mixture with the combination AX showed least (18.75%) damage. Interestingly no instance of attack was noticed in the 25% mixture of APHG combination.

4.5.3. Nursery pests

Two species of insect pests were recorded in the nursery established at Peechi. They are listed in Table 7. Among them, the unidentified psyllid caused serious damage to the seedlings throughout the period of observation resulting in the stunting of seedlings, formation of several lateral shoots at the tip and subsequent mortality. When the infestation by this insect was noticed in September, 1989, about 31.43% of the plants were affected which became 98% by June, 1990. The intensity of attack

was heavy and was ranked under score 4. The infestation continued even when the seedlings were transplanted in the field. In the insecticide trials, a 0.05% spray of Nuvacron (monocortophos) at fortnightly Intervals was found to be an effective control for this pest. Mathur (1975) has reported *Psylla oblonga* on *A. odoratissima* but no large scale build up has been reported so far.

Table 7. Insect pests in the nursery of *A. odoratissima*

Insect species	Place of colln.	Nature of damage
Rhesela moestslis Kslker (tepidoptera, Tortricidae)	Peechi	teef webbing
Unidentified Psyllid	Peechi, Nilambur	Sap sucking

Apart from the above, mild build up of the defoliator, *Rhessla moestalis* was also noticed In dune, 1989. This insect is a well known defoliator of Albizias in India (Das and Sengupta, 1960) and is potentially capable of building up in epidemic proportions. Incidence of the Albizia butterflies, *Eurema blanda* and *E. hecabe* were surprisingly not noticed during the period of study. Species belonging to *Eurema* are known to cause severe damage to seed ings and sapl ngs of seversl species of Albizias in India and are ranked as potential nursery pests (Browne, 1968).

4.5.4. Seed pests

Two species of seed pests belonging to the colepteran family Bruchidae were recorded during the study, as listed In Table 8. Among them, *C. serratus* was the most serious pest of the seeds of *A. odoratissima* at Peechi. Over 70% of the seeds stored without sufficient chemical protection was found to be affected by this insect. *B. chinensis* is a cosmopolitan pest in various pulses and other leguminous seeds. Several species of Bruchus have been reported as seed pests of various species like *B. bilineatopygus* in *A. procera, B. pisorum* and *B. sparsomaculatus*

Table 8. Seed pests of *A. odoratissima*

Insect species	Place of colln.	Nature of damage
Bruchus chinensis	Peechi	Seed boring
Caryedon serratus (O1iver)	Marayoor	do

in *A. lebbeck* and *B. uberatus* in *A. amara* (Beeson, 1941). Infestation by *C. serratus* was noticed in the seeds collected from Marayoor.

4.6. DISEASE PROBLEMS AND CONTROL

4.6.1. Seed pathological studies

4.6.1.1. Incubation tests

Relative percent incidence of seed microflora in *A. odoratissima* is given in Table 9. other than *F. moniliforme* which was found to have an RPI of 7%, other fungi were common storage fungi, viz. *A. flavus, A. niger* and species of *Penicillium* and *Rhizopus.* The RPI of these fungi ranged from 5 to 9%. In addition to these common storage fungi, a gram(–)ve bacterium was also

Table 9. Spermoplane microorganisms and their relative percent incidence on seeds of *A. odoratissima*

Microorganisms recorded	Relative percent incidence (RPI)
Aspergillus flavus	6.0
A. niger	7.0
Fusarium moniliforme	7.0
Penicillium sp.	9.0
Rhizopus sp.	5.0
Bacteria (gram(-)ve)	15.0

found to occur with an RPI of 15%. Most of the spermoplane microflora apparently harboured only the seed surface. But a few

species of *Aspergillus, Penicillium* and *Rhizopus* possibly would have penetrated seeds and caused infection leading to seed rotting. The major problem of seeds under storage is due to insects which bored the seeds, thereby facilitating easy penetration of commonstorage fungi causing seed rotting.

4.6.1.2. Effect of fungicides on seed borne fungi

Results pertaining to the effect of seed dressing on the reduction of microflora infection of the seeds is presented in Table 10. From the results it is apparent that the seeds of *A. odoratissima* can be protected from seed microflora using seed dressers. Hancozeb was the most effective fungicide in inhibiting the microbial growth, followed by MEMC, carbendazin and carboxin. Out of the 6 microorganisms recorded, 5 were controlled by mancozeb, 4 by MEMC, 3 by carbendazim and 2 by carboxin. Interestingly the bacterium could not be fully controlled by any of these fungicides, their RPI reduced to around 2.5–3% as compared to 15% in untreated seeds.

For storing the seeds for 90 days after treatment, mancozeb was very effective followed by MEMC, carboxin and carbendazim. Here also the bacterium could not be eradicated, but their RPI reduced from 14.5% to ca. 2.5% Interestingly, carbendazim treatment did not show any control of the bacterium, showing 13.5% and 11.5% RPI for one and ninety days after treatment, respectively.

Table 10. Effect of fungicides on seed microflora of A. odoratissima, one and ninety days after treatnent

Microorganisms recorded	RPI in various treatments									
	Control		catbendazim		MEMC		. carboxin		mancozeb	
	0	90	0	90	0	90	0	90	0	90
Aspergillus flavos	6.0	8.0	1.0	5.0	-	-	1.0	-	-	-
A. *niger*	7.0	9.0	3.0	2.5	-	-	-	-	-	-
F. moniliforme	7.0	5.0	-	-	-	-	3.5	-	-	-
Penicillium sp.	9.0	10.0	-	-	-	-	1.5	-	-	-
Rhizopus sp.	5.0	8.5	-	-	1.0	-	-	-	-	-
Bacterium (gram(-)ve)	15.0	14.5	13.5	11.5	2.5	2.5	5.0	3.0	3.0	2.5

4.6.2. Diseases in nurseries

In nurseries, no seedling disease was recorded.

4.6.3. Diseases in natural stands

4.6.3.1. Leaf rust

Leaf rust in A. odoratissima is not widespread in Kerala and was seen only In one locality near Nemmara in the Nemmara Forest Division. Approximately 25% leaflets were affected by the rust. The disease was observed during January-April, especially on the older leaves. The upper surface of affected leaflets showed dull green spots corresponding to orange yellow uredinia on the lower surface. From A. odoratissima trees, *Sphserophragmium acaciae,*

Ravenelia odoratissima and *R. japonica* have been reported to cause rust diseases (Barua *et al.,* 1982; Kapoor and Agarwal, 1972; Sydow *et al.,* 1937). But in the present study, identity of the causal organisms could not be ascertained. Rust was not observed on seedlings in nurseries. However during the present investigation rust of *Albizia* was not noticed during rainy or autumn seasons and was seen only by the begining of summer.

4.6.3.2. Phanerogamic parasite (mistletoe)

Mistletoe infection of *A. odoratissima* trees by *Dendrophthoe falcata* is widespread throughout the State. However *Viscum orientale* was observed only in a few places. On an average, 5 - 10 clumps of *D. falcata* were seen on an affected tree. Branch mortality due to this mistletoe infection was also seen occasionally. At present a practice of mechanical removal of the parasite from teak trees is followed in Kerala. Ghosh *et al.* (1984) attempted the chemical control of teak mistletoe through tree injection. However, it is difficult to practice mechanical removal of the parasite from *A. odoratissima.* During the course of our investigation, mistletoe infestation was observed throughout the State. At Moolapady of Begur Range in Wynad Forest Division, 18-20 clumps of *D. falcata* were seen affecting a single tree. Even young trees were seen affected by mlstletoe. But infestation of *V. orientale* is not commonand is confined to central Kerala.

4.8.4. Root nodulation studies

Performance of *A. odoratissima* with and without *Rhizobium* inoculation is given in Table 11. In general, nodulation and biomass production was more in inoculated seeds, as compared to uninoculated seeds. Nodulation was almost double In treated

Table 11. Performance of A. odoratisima with and without Rhizobium treatments

Growth parameters	Inoculated		Uninoculated	
	6 weeks after treatment	4 months after treatment	6 weeks after treatment	4 months after treatment
Shoot length (in cm)	**59.0**	**117.5**	**50.0**	**96.4**
Root length (in cm)	86.6	**114.3**	**60.0**	**90.7**
Average no.of nodules	**3.3**	**7.9**	2.0	**3.6**
Biomass				
Dry weight (in g)	**0.04**	1.3	**0.02**	**0.12**

seedlings, whereas increase in biomass was also observed in the case of treated seeds after 4 months. Here also, pelleting seeds with natural *Rhizobium* is beneficial as the number of nodules and biomass increased considerably than the control.

In general no serious disease was recorded from *A. odorati ssima* in Kerala. Leaf rust caused by *Ravenelia japon ica* was reported from China, Japan and India (Bakshi, 1976). Other records of rust fungi which include *R. odoratissima* and *Sphaerophragmium acaciae* were also reported from India (Tyagi and Prasad, 1978; Sydow *et al.,* 1937). Sootymould caused by *Meliola albizia* in Assam (Kapoor and Tandon, 1967), wood canker caused by *Hypoxylon denstium* (Agnihothrodu, 1964) from Assam and anthracnose caused by *Colletotrichum* sp. (Patel *et al.,* 1949) and leaf spot by *Endodothella kanarensis* (Ramakrishnan, 1952) were not observed during the present survey. But infestation of

mistletoe due to *Dendrophthoe falcata* was found throughout the State causing branch dieback in severe cases. In nurseries, no seedling disease was observed.

5. GREWIA TILIIFOLIA

(Chadachi)

5.1. BOTANY

5.1.1. Nomenclature

Grewia tillifolia Vahl,' Symb. Bot. 1:35.1790; Roxb. Fl. Indica 2:587. 1832; Wt. *et* Arn. Prodr. Fl. Penin. Indiae Orient. 1: 80. 1834; Mast. in Hook. f. Fl. Brit. India 1: 386. 1874 *(pro parte);* Bourd. For. Trees Travanocre 52. 1908; Rama Rao, Fl. Pl. Travancore 52. 1914; Dunn in Gamble, Fl. Presid. Madras 1: 118. 915; Burett, Notistbl. Bot. Gart. Berlin–Dahlem 9: 659. 1926; Blatter, J. Bombay nat. Hist. Soc. 34: 887-88. 1931. Matthew, Fl. Tamilnadu Carnatic 3(1): 173. 1983; Ramach. et Nair, Fl. Cannanore 71. 1988.

Grewia asiatica L. var. *tiliaefolia* Brandis, Indian Trees 98. 1906; Blatter, J. Bombay nat. Hist. Soc. 34: 887-88. 1931.

Grewis arborea Roxb. *ex* Rottler, Ges. Naturf. Freunde Berlin Neue Schriften 4: 205. 1803; Roth, Nov. Pl. Sp. 247. 1821.

Type: Not known.

5.1.2. Local names

Chadachi, Unnam,

5.1.3. Botanical description

Trees, 5-15 m high; bark often fissured, pale brown; young shoots densely pubescent; young leaves flesh–red in colour. Leaves simple, petiofate, 5.5 - 23.5 x 4 - 14.5 cm, elllptlc, ovate,

obovate or rarely broadly–ovate, serrate, dentate, undulate-serrate, crenate, incised or serrulate, minutely stellate–hairy or subglabrous on the upper side, hoary–tomentose and pubescent along the margins on the lower surface, oblique, subcordate, unequilateral, truncate, cordate, obtuse or rarely cuneate at base, acuminate, obtuse, acute or rarely truncate at apex, 6-nerved with 3 nerves on the larger side of the midrib; petioles 0.8 – 4.10 cm long, pubescent; stipules upto 1.3 cm long, leafy, somewhat falcate or sagitate, obtusely lobed towards base, veined. Inflorescence umbellate, axillary, 3 or more in a cluster, on thick peduncles equalling the petioles in length; flower buds tomentose, green. Flowers ±1.5 cm long, yellow or creamy–white with reddlsh or deep–yellow anthers, fragrant; bracts linear-lanceate; pedlcels 5 to 10 in a cluster, divergent, pubescent; sepals 5, distinct, upto 1 cm long, oblong, subacute at apex, pubescent externally, glabrous within; petals yellow, upto 0.5 cm long, oblong or spathulate, entire or nouched, densely white–villous along the margins, glandular about one-third of their length; stamens numerous, inserted on a short or elongated, often glandular, ribbed, glabrous torus with 5 obscure, villous teeth at the apex; anthers deep yellow, reddish-yellow or red in colour; ovary 2 to 4 or many ovuled, spuriously septate between seeds, villous; styles longer than the stamens, subulate; stigma somewhat irregularly 2 to 5 lobed. Drupes light green, maturing light grey, yellowish grey or black, ± 0.8 cm long, didymous, glaborous 3t maturity, globose or rarely 2 or upto 4 lobed with 2–loculed stones; seeds ascending or horizontal with copious fleshy albumen; cotyledons flat, foliaceous or fleshy (Figs. 1 2).

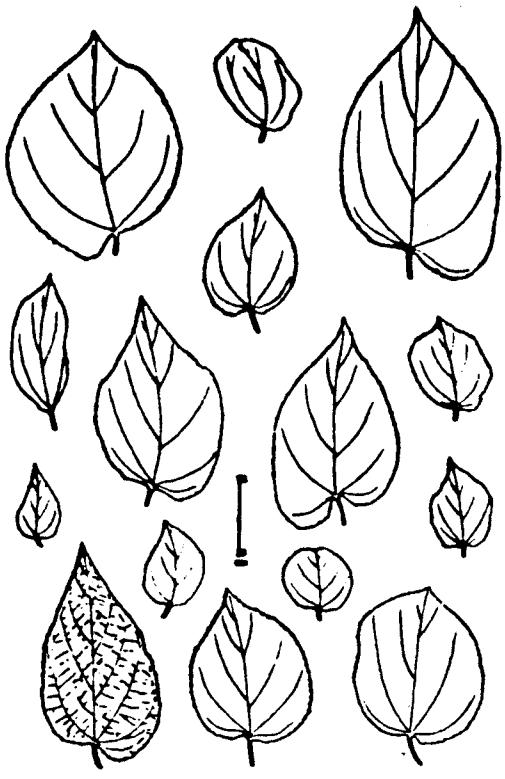


Fig 2

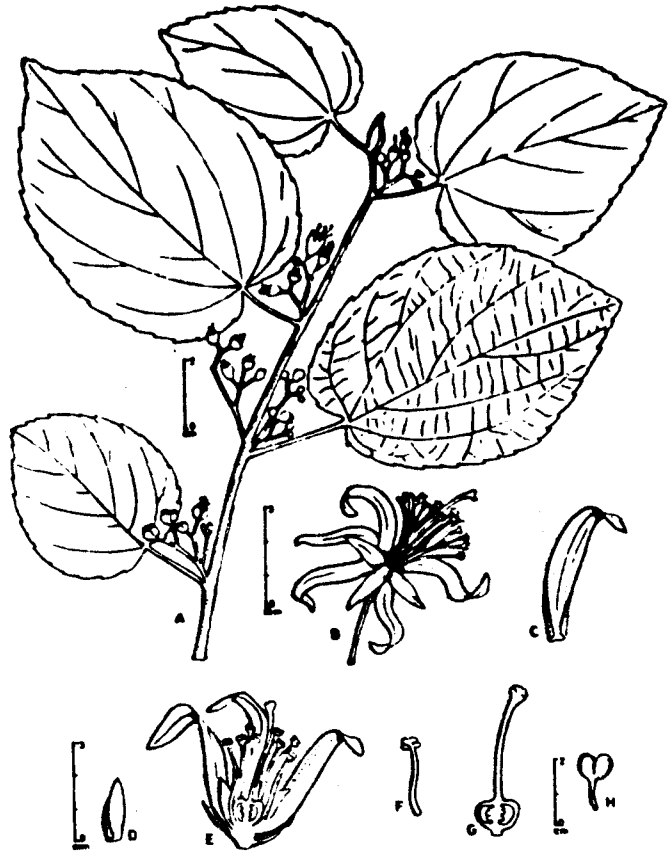


Fig.1

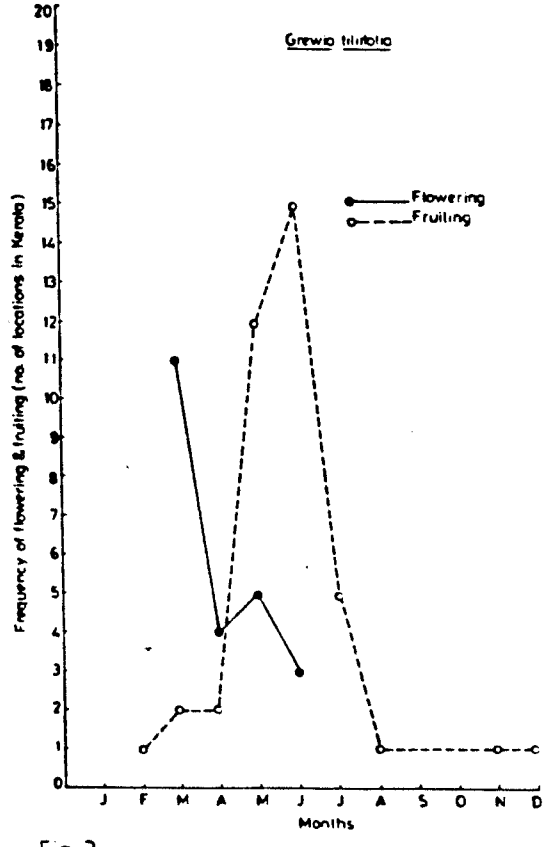


Fig.3

Grewia tiliifolia

Fig.1 A. Flowering twig, B. Flower, C. Sepal, D. Petal, E. L.S. of flower, F. Stamen, G. L.S. of pistil, H. Fruit.
Fig.2 Leaf variation diagram.
Fig.3 Phenological graph.

5.1 4. Field notes

Trees with spreadlng crown, common in the dry and moist deciduos forest tracts throughout the State, even on poor and rocky soils.

5.1.5. Phenology

Flowering mostly from Msrch to June, but maximum during the summer months of March and April; fruiting from March to July, rarely extending upto next March (Fig. 3).

5.1.6. World distribution

Subhimalayan tracts to Peninsular India, Sri Lanka, Burma and tropical Africa.

5.1.7. Distribution in Kerala

Trivandrum, Thenmala, Punalur, Konni, Ranni, Kottayam, Munnar, Kothamangalam, Mankulam, Malayattoor , Vazhachal, Chalakudy, Trichur, Nemmara, Palghat, Parambikulam, Calicut, Nilambur and Wynad Forest Divisions, in almost all Forest Ranges (Fig. 4).

5.1.8. Notes

Hole (1917) has well documented the confusion that exsisted in literature on the identity and nomenclature of this species, especially In Hooker's Flora of British India. However, the identity of the species as distinct from Grewia asiatica L., G. vestitia Wall. and G. elastica Royle is now well established. Similarly, the local name Pai-paroea, Couradi in Hortus Malabaricus of van Rheede (Hort. Malab. 5: 91-92. t. 46. 1685) was earlier referred to several species under the genus *Grewia,*

like *G. orientalis* L., *G. columnaris* Smith, *G. pilosa* Lamk. and *G. damine.* Cooke (1903) and Blatter (l.c.) reduced the species *Grewis leptopetala* Brandis to a variety under *G. tiliifolia* and this variety is rather confined to the hills of Poona (Maharashtra State) in Western India.

5.1.9. Within species variation

Data on leaf variation were gathered from 38 herbarium specimens collected from different locations in the State. Depending upon the number of leaves present on each sample, upto 5 variants were recorded for every character from each sample.

The ranges of quantitative characters were divided into class intervals, namely 5.5 to 11.5 cm (short), 11.5 to 17.5 cm (medium long) and 17.5 to 23.5 cm (very long) for leaf length, 4 to 7.5 cm (narrow), 7.5 to 11 cm (medium broad) and 11 to 14.5 cm (very broad) for the breadth of leaves, and 0.8 to 1.9 cm (short), 1.9 to 3 cm (medium long) and 3 to 4.1 cm (very long) for petiole length. The incidence of specimens in the above groups served as dichotomous variables for these characters. Together with qualitiative characters, there were 31 such character variables for the 38 specimens of the species.

The cluster diagram (Fig. 5.1) demonstrates the coincidence of characters in all the 38 samples. It shows that very long, very broad and medium broad and medium long and medium long-petioled leaves are obovate in shape, serrate along the margins, acuminate at apex and subcordate or truncate at base. Similarly, short, narrow, short-petioled leaves are mostly elliptic or ovate in shape with an oblique base. Further, broadly ovate leaves are mostly with dentate margins. It has also been noted from the cluster diagram that qualitative characters like crenate,

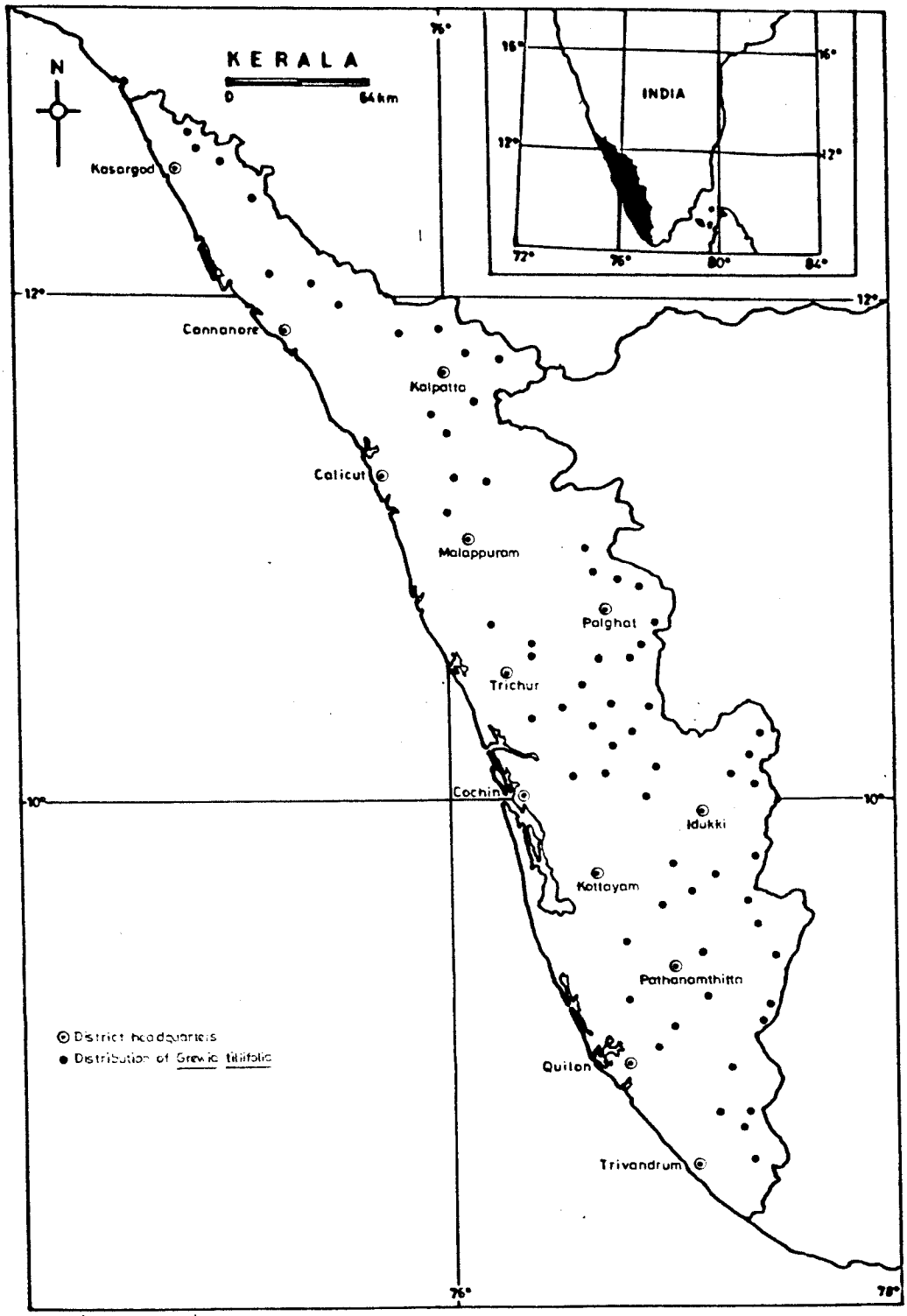


Fig.4 Distribution map of *G. tiliifolia* in Kerala.

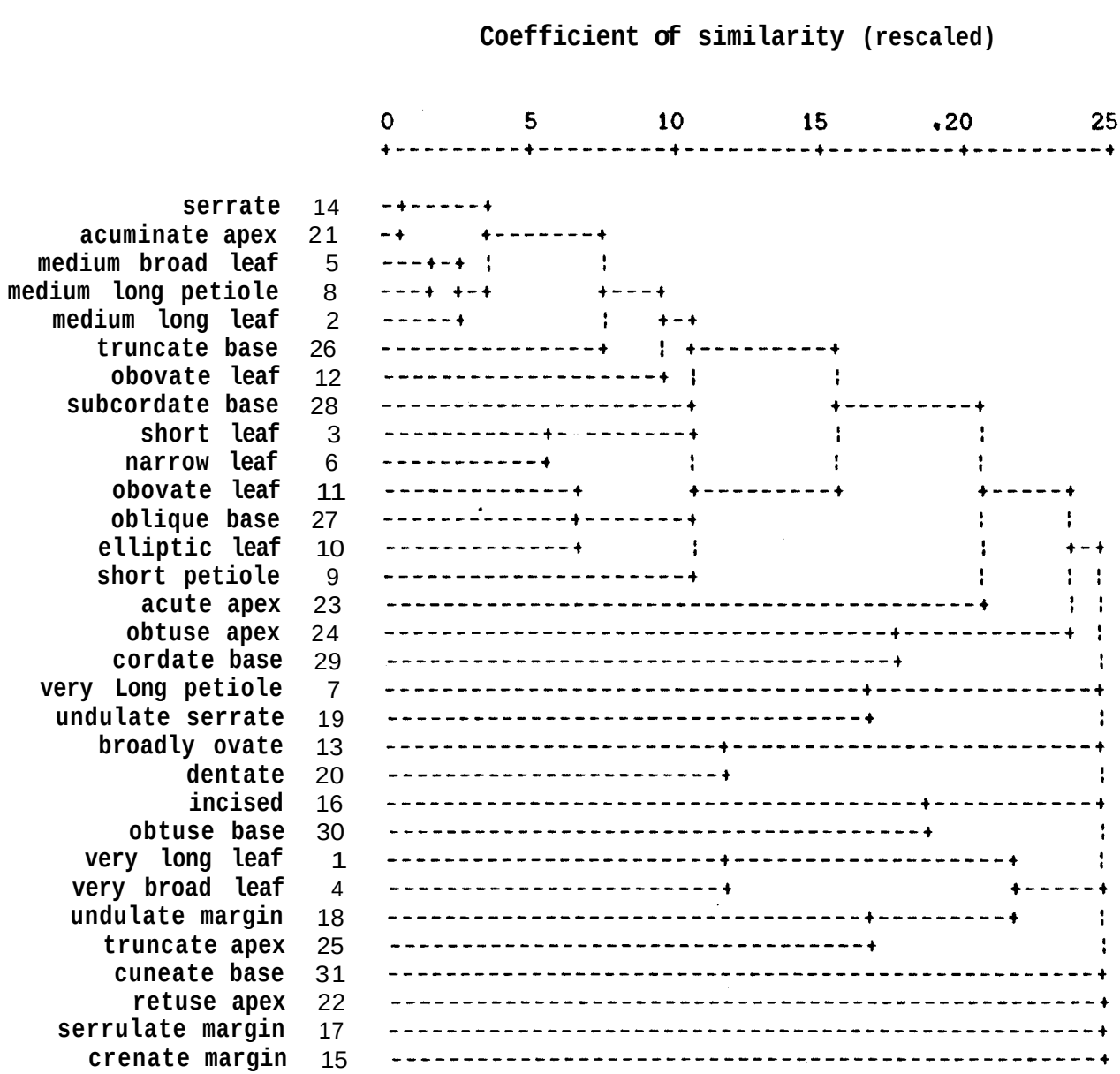


Fig. 5.1 Phenograa based on coefficient of Jaccard of leaf characters of G. tiliifolia from different locations in Kerala.

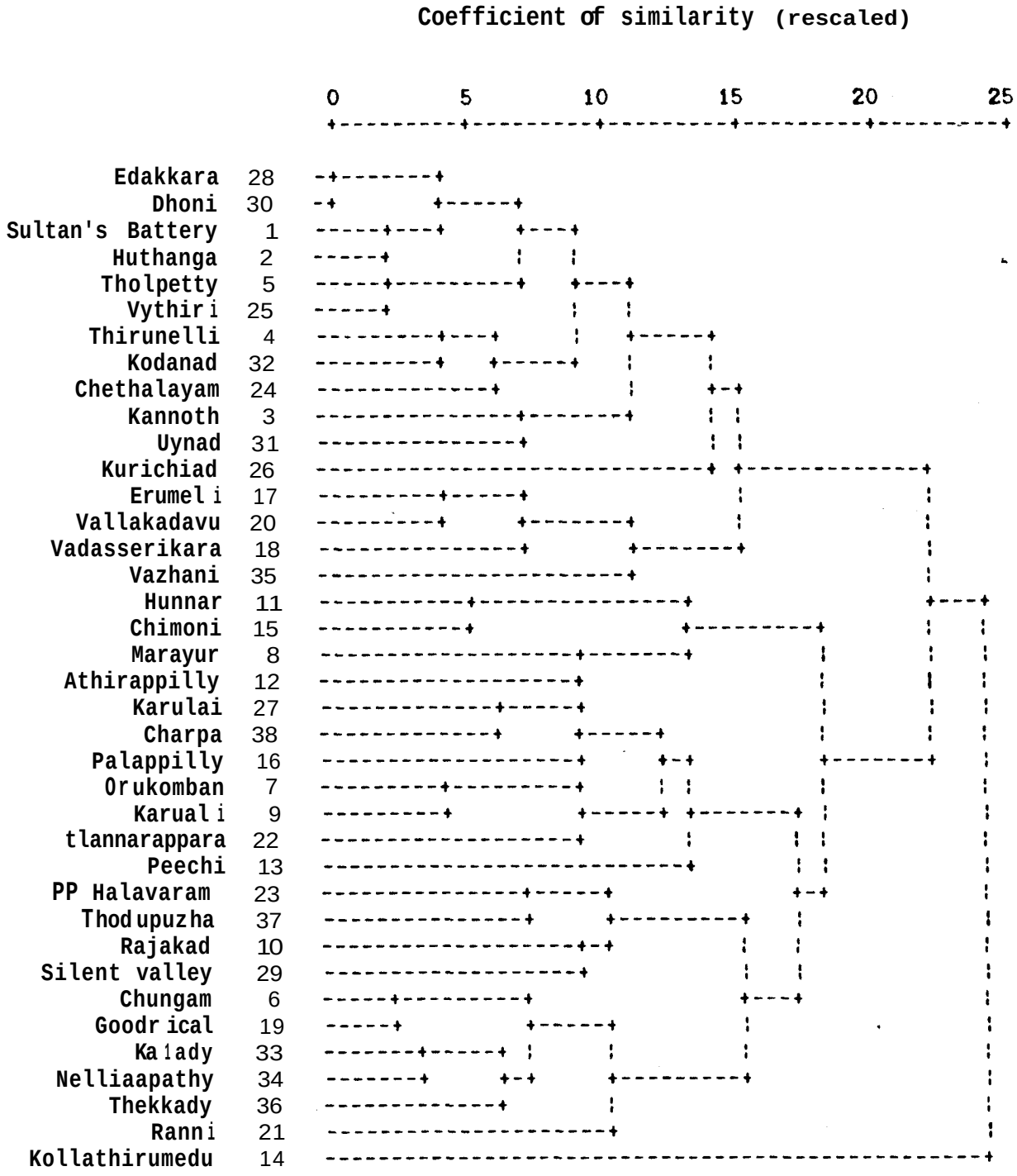


Fig. 5.2 Phenogram based on coefficient of Jaccard of specimens of G. tiliifolia from different locations in Kerala.

serrulate, undulate, incised and undulate-serrate margined leaves, leaves with retuse, obtuse or truncate apex and cordate, obtuse or cuneate base occur irrespective of the size (ie. length and breadth) and shape of the leaves.

Cluster diagram (Fig. 5.2) depicts similarity of specimens from different locations in Kerala with regard to all the 31 characters analysed. Ensuring at least 50% resemblance within a cluster, seven distinct populations of the species could be identified from the State. They are from:

i. Sultan's Battery, Muthanga, Kannoth, Thirunelli, Tholpetty, Chethalayam and Vythiri.
ii. Chungam, Goodrical and Ranni.
iii. Orukomban, Karulai, Peechi, Palappilly and Mannarappara.
iv. Marayur, Munnar, Athirappilly and Chimoni.
v. Rajakad and PP Malavaram.
vi. Kollathirumedu.
vii. Erumeli, Vadasserikkara and Val lakadavu.

It may be noted from the above list that most of the populations from northern Kerala belong to one set with at least 50% similar characters, whereas rest of the populations of the specices in the State, except those frcm Kollathirumedu, do not show any such region-wise similarity. With regard to the Kollathirumedu population, it stands distinct from all other populations of the species in Kerala.

When the variations in quatitative characters were taken into account, leaves with maximum length and breadth (23.3 cm and 14.5 cm, respectively) were noted in the population of Kollathirumedu Range in Vazhachal Division and those with minimum length and

breadth (5.5 cm and 4 cm, respectively) were characteristic to the samples from Vadasserikkars Range in Ranni Division. In the case of petiole length, longest petioled leaves (ie. 4.10 cm) were collected from Ranni Range in Ranni Division, whereas it was very short (0.8 cm) in the samples from Vadasserikkara Range, again in the Ranni Forest Division.

5.1.10. Specimens examined

Ezhimalai, Kasaragod District,. 14.5.1982, V.J. Nair 73880 (MH); Begur RF, Cannanore District, 5.5. 1979, V.S. Ramachandran 62279 (MH); Tholpetty, Cannanore District, 9.7.1978, V.S. Ramschandran 57503 (MH); Tholpetty Range, Wynad Division, 21.6.1988, K.K.N. Nair 6348 (KFRI); Thirunelli RF, Cannanore District, 8.5.1979, V.S. Ramachandran 52710 (MH); Thirunelli reserve, Wynad Division, 2.16.1988, K.K.N. Nair 6351 (KFRI); Kurichiad Range, Wynad Division, 22.6.1988, K.K.N. Nair 6359 (KFRI); Sultan's Battery Range, Wynad Division, 22.6.1988, K.K.N. Nair 6358 (KFRI); Vattapoil. Periya RF, Kannoth Range, Wyand Divisioin, 10.7.1982, K.N. Subramanian 8372 (FRI); Kolayad, Kannoth Range, Wynad Division, 21.6.1988, K.K.N. Nair 6354 (KFRI); Kannoth, Malabar, 17.12.1913, C.A. Barber 9471 (MH); Thaliparamba farm, Malabar, 19.5.1906, C.A. Barber 7731 (MH); Thaliparamba farm, Malabar, 15.6.1905, C.A. Barber 7381 (MH); Mananthody–Kuthuparamba Road, Wynad Division, 11.2.1983, K.N. Subramanian 7852 (FRI); Peria, Cannanore District, 11.11.1978, V.S. Ramachandran 58682 (MH); Thariode, Chethalayam Range, Calicut Division, 22.6.1988, K.K.N. Nair 6361 (KFRI); Between Vythiri and Thamarasseri, Calicut Divislon, 23.6.1988, K.K.N. Nair 6360 (KFRI); PP Malavaram Range, Calicut Division, 23.6.1988, K.K.N. Nair 6364 (KFRI); Kuttiyadi submergible area,

Calicut District, **25.6.1965, B.D.** Naithanl 24622 **(MH);** Edakkara Range, Nilambur Division, **10.6.1989,** K.K.N. Nair **6505** (KFRI); Karulal Range, Nilambur Division, **16.6.1989, K.K.N.Nair 6505** (KFRI); **Karuali** Range, Nilambur Division, **16.6.1989,** K.K.N. Nair 6507 (KFRI); Sides of Parambikularn **dam,** Karimala Range, Parambikulam Division, **17.5.1988, K.K.N.Nair,** 6336 (KFRI); Orukomban Range, Parambikulam Division, **19.5.1988,** K.K.N. Nair **6339** (KFRI); Chungam Range, Parambikulam Division, **19.5.1988,** K.K.N. Nair **6342 (KFRI);** Karimala Range, Parambikulam **Division, 15.5.1988,** K.K.N. Nair **6346** (KFRI); Walayar, Palghat Division, **1.7.1977,** K.N. Subramanian **6785 (FRI);** Walayar RF, Palghat Division **, 13.6.1989,** K.K.N. Nair **6393** (KFRI); Bhavani river bank, Attappady, Palghat Division, **31.5.1966, E.Vajravelu 27745 (MH);** Karivara slopes, Palghat Division, **2.5.1980,** V.J. Nair **67436** (MH); Mukkali to Panthanthodu, Mannarghat Range, Palghat Division, **14.6.1898,** K.K.N. Nair **6398** (KFRI); **Vattapparai** to Inchikuzhi, Siruvani western slopes, Palghat Division, **29.5.1979, E. Vajravelu 62864 (MH);** Malampuzha, Palghat, **30.5.1964, E. Vajravelu 20024** (MH); **Peechi** Range, Trichur Division, **4.5.1988,** K.K.N. Mair 6327 (KFRI), **Vazhani,** Machad Range, Trichur Division, **24.3.1983,** K.N. Subramanian **9292** (FRI); Nelliampathy Range, Nemmara Division, 6.6.1989, K.K.N. **Nair** 6354 (KFRI); Poringal, Vazhachal Division, 24.3.1988, **K.K.N.** Nair 6525 (KFRI); Kollathirumedu Range, Vazhachal Division, **24.3.1988,** K.K.N. Mair 6318 (KFRI); Adirappilly Range, Vazhachal Division, 24.3.1988, K.K.N. Nair 6321 (KFRI); Kalady Range, Vazhachal Division, 24.3.1988, K.K.N. Nair 6390 (KFRI); Thundathil, Kodanad Range, Malayattur Division, 7.6.1989, K.K.N. Nair 6392 (KFRI); Molamkuzhy, Kalady Range, Malayattoor Division, 12.7.1985, K.N. Subramanian 11157 (FRI); Marayur Range, Munnsr Division,

18.5.1988, K.K.N. Nair 6332 (KFRI): Rajakad RF, Munnar Division, 17.5.1988, K.K.N. Nair- 6330 (KFRI); Puduppadi, Kottayam, 14.7.1981, Cherian Jacob 1900 (MH); Kanakapalam, Erumeli Range, Kottayam Division, 30.3.1989, K.K.N. Nair 6374 (KFRI); Santhanparai, Idukki District, 21.4.1964, K.M. Sebastine 18365 (MH); Peerumedu to Pambanar, Kottayam District, 24.5.1965; K. Vivekanandan 24312 (MH); Kumily to Thekkady, 28.5.1965, K. Vivekanandan 24357 (MH); Way to Mangaladevi, Idukki District, 27.8.1979, K. Vivekanadan 50554 (MH); Way to Mangaladevi, Thekkady, 31.3.1989, K.K.N. Nair 6377 (KFRI); Vallakadavu, 1955 Eucalypt plantation, Thekkady, 14.7.1983, K.N. Subramanian 9449 (FRI); Vallakadavu Range, Thekkady, 29.3.1989, K.K.N. Nair 6370 (KFRI); Vadasserikara Range, Ranni Division, 29.3.1989, K.K.N. Nair 6372 (KFRI); Goodrickal Range, Ranni Division, 29.3.1989, K.K.N. Nair 6371 (KFRI); Rajampara, Ranni Range, Ranni Division, 29.3.1989, K.K.N. Nair 6368 (KFRI); Mannarappara Range, Konni Division, 28.3.1989, K.K.N. Nair 6535 (KFRI); Southern side of Kulathupuzha, Thenmala Division, 14.4.1976, K.N. Subramanian 5974 (FRI); Kalathuruthy river bank, Thenmala Range, Thenmala Division, 8.3.1975, K.N. Subramanian 5127 (FRI).

5.2. ECOLOGY

Ecological information gathered during field studies on *G. tiliifolia* from the natural stands of the species in Kerala is given below.

Associations: *Xylia - Lagerstroemia*

Parent Tree source: Medium

Parent tree distribution:	Occasional
Biotic interference:	Partially disturbed
Regeneration status:	Sufficient numbers
Older seedlings: (31 cm to 1 m in ht.)	Limited
Saplings: (more than 1 m in ht.)	Rare
Mortality rate:	Medium
Remarks:	No specific edaphic condition required; found throughtout the State.

5.3. UTILIZATION ASPECTS

5.3.1. Bole characteristics

Mature trees growing to a height of about 15 m and a diameter of 70 cm are not uncommon. However, the stem form is found to be generally very poor due to the occurrence of a variety of defects. The most common among them are crook, sweep, adventitious bud clusters, branch stubs, seam, decay cavities, etc. Yet another defect common in certain localities is the exposed and damaged sapwood resulting from partial removal of the bark. Wood grain is irregular as evident from the external appearance of the bark. Length of the nearly straight sawlogs available is commonly upto 5 to 6 m.

5.3.2. Wood properties

Basic density of wood showed a wide range of variation from 507.0 kg/m^3 to 716.5 kg/m^3 between the different regions studied. The average density at breast height was 621.2 kg/m^3 .

Although the scuthern region apparently recorded higher density values, ANOVA revealed that there is no significant difference in density either between the regions or between the localities

Table 1. ANOVA of basic density and heartwood percentage of G. *tiliifolia* between different regions and localities

Source of variation	Basic density			Heartwood percentage		
	DF	Mean square	F-value	DF	Mean square	F-value
Region	2	**3343.912**	1.366(ns)	**2**	**69.979**	1.196(ns)
Locality	2	**4240.451**	1.732(ns)	**2**	135.130	
Residual	**21**	**2448.557**		**15**	**58.503**	
Total	**25**	**2588.729**		**19**	**63.278**	

ns = non significant

(Table 1). The difference in heartwood percentage between the three regions and between the localities was also non-significant (Table 1). The heartwood percentage was significantly correlated with stem diameter (R = 0.8700).

5.3.3. Wood structure

Growth rings are distinct, mainly due to the thick-walled latewood fibres and thin-walled earlywood fibres.

Vessels mostly solitary as well as in short radial multiples of 3 to 4 pores, rarely in small clusters, diffuse porous, but with a tendency for semi-ring porous arrangement in some samples,

commonly vessels smaller at the beginning and end of a growth ring; vessel elements indistinctly storied; perforation simple and pitting alternate, pits minute and narrowly bordered, pits to parenchyma and ray cells not distinctly larger; tyloses and extractives present in heartwood vessels.

Parenchyma scanty, paratracheal forming inconspicuous sheath around vessels; diffuse parenchyma also present as fine lines, storied; fusiform parenchyma absent; crystals not found, parenchyma in the heartwood with small droplets of extractives.

Rays of two types based on their height; taller rays 3- to 7-seriate and not storied whereas shorter ones 1- to 4–seriate and storied; the former uptc 50 or more cells high especially when fused vertically; shorter rays uptc 10 to 15 cells high; heterogeneous with upright and 'square cells, tails shorter than the body and commonly composed of a single cell; uniseriate rays composed of procumbent, upright and square cells thus partly conforming to heterogeneous type **II** of Kribs's classification (Barefoot and Hankins, **1982).** Ray tissue in some members of Tiliaceae belongs to heterogenous type **11** A or B of Kribs's classification according to Metcalfe and Chalk **(1950).** Crystals present in some upright and square cells, extractives present.

Fibres non–septate, the wider part of the fibres showing a tendency for storied arrangement, thin–walled and thick-walled respectively in earlywood and latewood.

5.3.4. Relationship between ring width and other anatomical characters

The interrelationship between growth ring width and proportion of tissues is presented in Table 2. It is seen that ring width is negatively correlated with vessel frequency

(number of vessels/mm^2), vessel area percentage and proportion of parenchyma, and positively correlated with prcportion of fibres and rays. Thus, it is evident that with increasing width of growth rings there is a decrease in the proportion of vessels (void spaces) and parenchyma (soft tissue) in the wood with

Table 2. Correlation between ring width and other anatomical parameters in G. tiliifolia

	Rins width	Vessel frequency	Vessel area %	Paren-chyma %	Fibre %	Rays %
Ring width	1.0000					
Vessel frequency	-0.6458**	1.0000				
Vessel area %	-0.6832**	0.6234**	1.0000			
Parenchyma %	-0.3231	0.2864	0.4530*	1.0000		
Fibre %	0.3438	-0.4122	-0.4563*	-0.4118	1.0000	
Rays %	0.3636	-0.2390	-0.5730**	-0.4152	-0.3865	1.0000

* Significant at P = 0.01 level; ** Significant at P = 0.001 level.

consequent increase in the proportion of fibres and rays. The positive correlation between vessel number and vessel ares is also signficant suggesting that the increase in vessel area is acccmpanled by an increase in their number when the ring width decreases. The negative correlation between vessel area and proportion of rays i,s also significant. However, there is no satisfactory reason for this relationship. The negative correlation between proportion of fibres and vessels supports the normal expectation that when the void areas increase

proportion of denser tissues such as fibres, decreases. The positive relationship between the parenchyma and vessel area is mainly because of the paratracheal (associated with vessels) distribution of parenchyma.

5.4. SILVICULTURE AND PLANTATION TRIALS

5.4.1. Seed collection

Ripened fruits were collected from Peechi from ground during May–June. Seed collection coincided with the onset of monsoon showers. Each fruit generally had two seeds which were extracted by depulping and washing in water. The seeds were then sun-dried.

5.4.2. Seed weight

About 6,600 seeds weighed one kilogram before depulping. Sengupta (1937) has reported 19401/kg for freshly pulped seeds and 5,29l/kg for seeds with pulp.

5.4.3. Germination capacity

Freshly collected seeds registered only 10% germination without any pretreatment. Seeds remain viable at least upto 4 months or possibly much longer (Dent, 1948).

5.4.4. Nursery technique

Freshly collected seeds were sown in raised nursery beds during May–June when the intensity of rains decreased. About 10-15 kg seeds were required for a standard nursery bed of 12 m X 1.2 m. Seeds started germinating from the 5th day onwards

and was complete in about 55–60 days. The seedlings can be pricked out after a month of sowing. Polythene bags of 22.5 cm X 17.5 cm are required for maintaining the seedlings upto a period of 13 months in the nursery before outplanting. Seedlings attain an average height of 35 cm by this time (Fig. 7).

5.4.5. Plantation trials

5.4.5.1. Survival of seedlings

A highest survival of 93% was observed in the pure plantations of G. *tiliifolia.* The seedlings registered high survival rate in both the 25% mixed plantations, viz., AGHP (90%) and GHPX (88%) (Fig. 6). ANOVA showed no difference between the pure and mixed plantations of the species with respect to survival percentage (Table 3) of the seedlings.

Table 3. Analysis of variance of survival of seedlings in pure and mixed plantations of *G. tiliifolia*

Source of variation	DF	MSS	F-values
Treatment	2	24.324	1.403(ns)
Replication	2	59.575	3.437(ns)
Residual	4	17.333	
Total	8		

ns = not significant

5.4.5.2. Height growth

Comparatively maximum height growth was recorded both in pure and mixed plantations *Grewia.* Performance of the species was

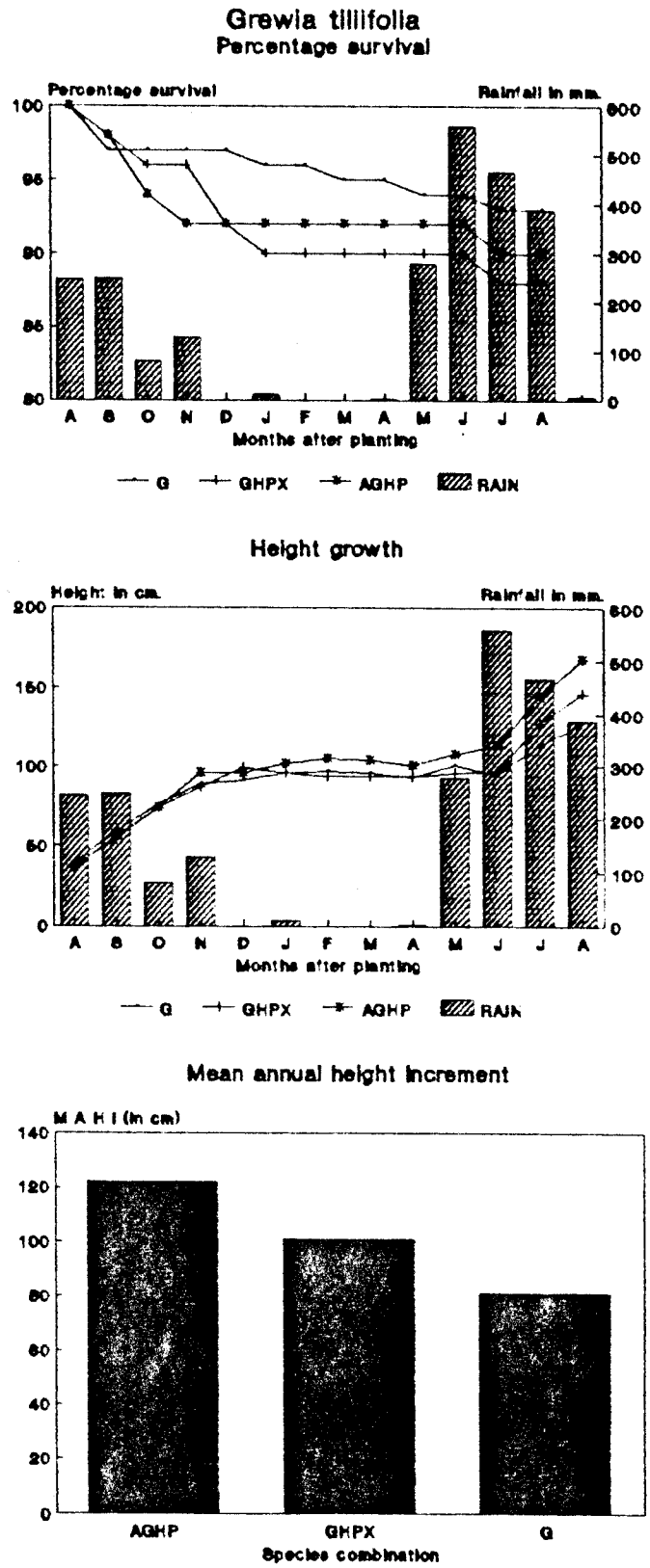


Fig. 6. Survival percentage, height growth and MAHI of seedlings in pure and mixed plantations of *G. tiliifolia*

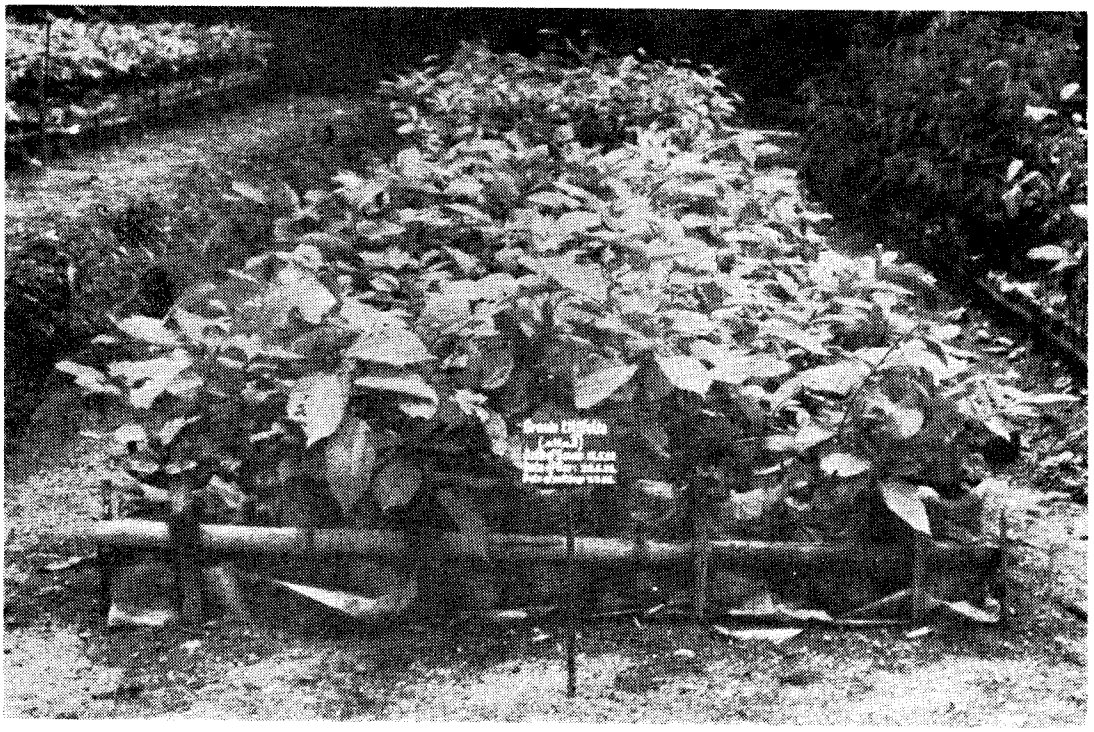


Fig. 7. Seedlings of *G. tiliifolia* raised for plantation trial.

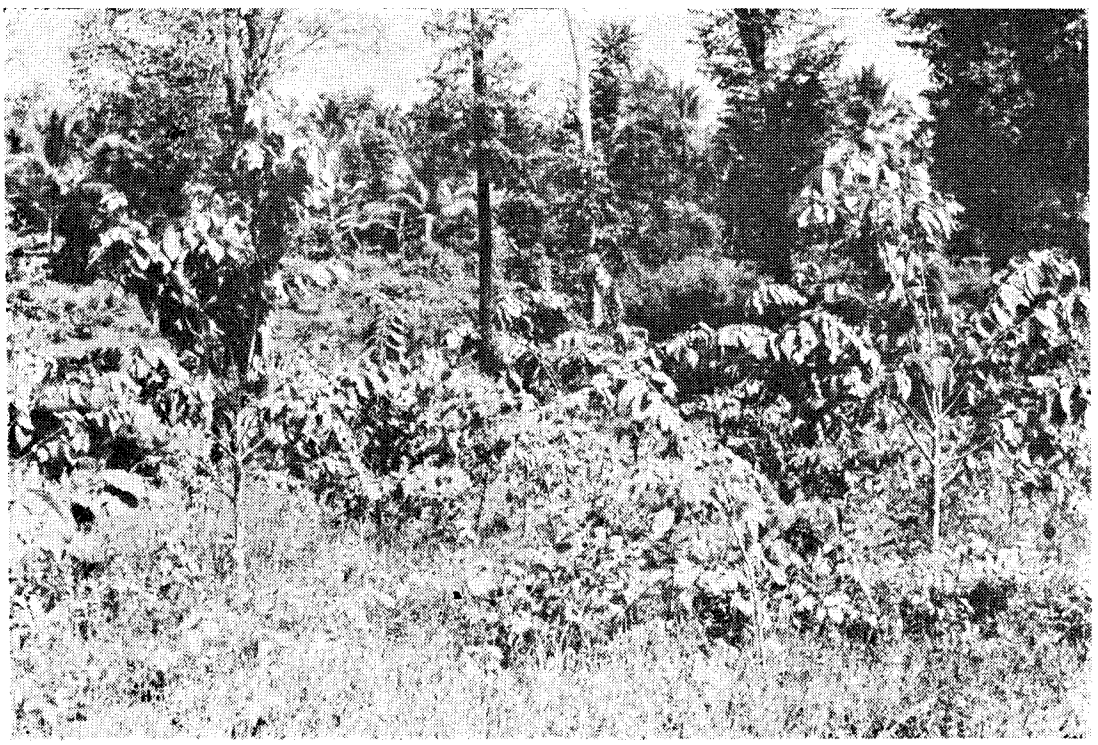


Fig. 8. Pure plantation trial plot of *G. tiliifolia* at Nilambur.

better in mixed plantations than in the pure (Fig. 8). Height

Table 4. Analysis of variance of height of seedlings in pure and mixed plantations of G. tiliifolia

Source of variation	DF	MSS	F-value
Treatment	2	0.054	1.3846(ns)
Replication	2	0.028	0.7179(ns)
Residual	4	0.039	
Total	8		

ns = not significant

growth of 186 cm and 146 CM was recorded in mixed plantations of AGHP and GHPX, respectively (Fig. 9). The seedlings recorded a height of 127 CM in pure plantations which was lesser than that in the mixtures (Fig. 6). Variation In height growth was, however, not statistically significant (Table 4).

5.4.5.3. Mean annual height increment (MAHI)

Mean Annual Height Increment also followed a similar pattern as height growth (Fig. 6). Faster growth was registered by the species in the mixed plantations. MAHI was maximum in the 25% mixture of AGHP with 122 cm, and slightly lesser in GHPX (101 cm). Pure plantations recorded a MAHI of 81 cm only. indicating better performance of the species in mixtures. The variation was , however, statistically not significant (Table 5).

Table 5. Analysis of variance of Mean annual height in pure and mixed plantations of *G. tiliifolia*.

Treatment	2	0.111	1.881(ns)
eplication	2	0.077	1.305(ns)
Residual	4	0.059	
Total	8		

ns = not significant

5.5. PEST PROBLEMS AND CONTROL

5.5.1. Insect pests inthe natrual stands

Although a large number of insects were recorded no major build up was noticed in the natural stands of G. *tiliifolia* in Kerala. The insect activity was high during the months of June-October. Leaf webbing by *Lygropia orbinusalis,* defoliation by *Hypasidra talaca* and *Henicolabus octomaculatus* were quite frequent on saplings. In an earlier study (Nair *et al.,* 1986) the latter species was reported to cause over 50% defoliation in some trees. About 42 species of insects been recorded earlier from this tree (Browne, 1968; Mathew & Mohanadss 1989). Insects collected from natural stands of *G. tililfolia* are listed in Table 6.

Fig. 9. A 25% mixed plantation trial of GHPX combination.

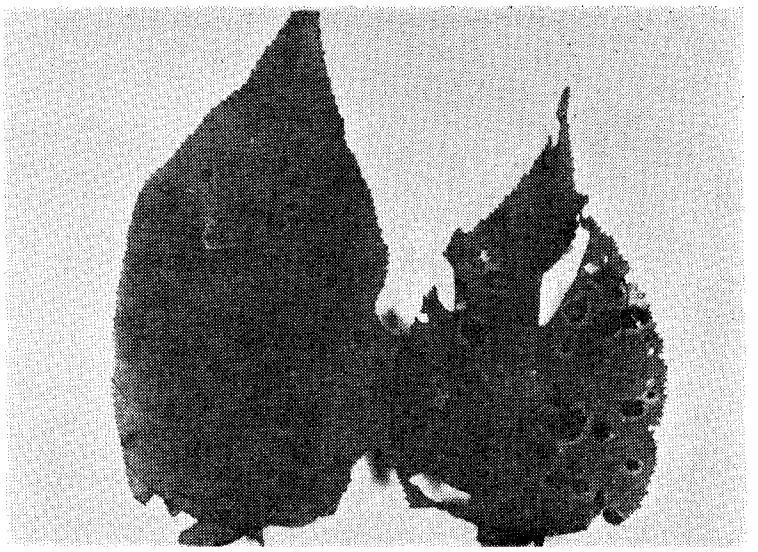


Fig. 10. Leaf-spot disease of *G. tiliifolia*.

Table 6. Insect pests in the natural stands of *G. tiliifolia* in Kerala

Insect species	Place of colln.	Nature of damage
Lygropis orbinusalis (Lepidoptera, Pyraustidae)	Peechi	Leaf webbing
?Tadaxa sp. (Lepidoptera, Noctuidae)	Parambikulam, Vazhachal	Defoliation
Anomis fig?ina (tepidoptera, Noctuidae)	Vazhachal	Leaf feeding
Symitha nolalella Wlk. (Lepidoptera, Noctuidae)	Vazhachal	Leaf feeding
Unidentified Noctuidae (Lepidoptera)	Vazhachal	Skeletonizing
Hyposidra talaca Wlk. (Lepidoptera, Geometridae)	Peechi	Leaf feeding
Unidentified Sphingidae (Lepidoptera)	Munnar	Defcliation
My?*locerus* sp. (Coleoptera, Curculionidse)	Several places	Leaf feeding
Henicolabus octomaculatus Tek. (Coleoptera, Curculionidae)	Peechi, Nilambur	Leaf feeding
Pseudoclytra plagiata (Oliver) (Coleoptera, Chrysomelidae, Clythrinae)	Vazhachal	Leaf feeding
Unidentified gall insect	Nilambur, Peechi	Leaf galls

5.5.2. Pest problems in trial plantations

Defoliation, leaf rolling and gall formation are the three important types of damage noticed in trial plantations. Defoliation by an unidentified caterpillar was the most serious problem, both in pure as well as mixed plantings. About 89% plants in the pure and 62.5% plants in the APHG mixture showed damage by the insect (Table 7).

Table 7. Percent incidence of defoliator in the trial plantations of *G.tiliifolia* in pure and mixed

Combinations with *G. tiliifolia*	Tree species A	P	X	H	G	Percent infestation during* Mar	Apr	May	Jun	Jul
G	0.00	0.00	0.00	0.00	1.00	87.50	50.00	82.91	99.06	99.06[3]
APHG	0.25	0.25	0.00	0.25	0.25	62.50	52.50	93.75	87.50	62.50[5]
PXHG	0.00	0.25	0.25	0.25	0.25	37.50	56.25	0.00	56.25	37.50[c]

* Figures given in the last column ~ r significant at 5% probability level

The incidence of this insects in the mixture PXHG was low (37.5%). Leaf rolling by the caterpillars of *L.* was noticed on 21.8% seedlings in the pure stands. In mixtures it was 37.5%, and 31.25% in the combination PXHG and APHG. The proportion of infestation was found to be significant in all the combinations. The intensity of attack was however low.

Gall formation by an unidentified psyllid was noticed on about 37% of seedling both in the pure as well as mlxed

plantings. The galls were of the pouch type, developed on the leaf stalk as well as on major veins of tender foliage leading to distortion and drying up of leaves. The intensity of infestation was moderate.

The lepidopteran pests particularly the unidentified defoliator are considered as a potential pests of this tree in trial plantations.

5.5.3. Nursery pests

No serious pest problem was noticed in the nursery of *G. tiliifolia* except for mild leaf webbing by *Archips* sp.(tepidoptera, Tortricidae) and sporadic mild defoliation by *Myllocerus* sp. (Coleoptera, Curculionidae). Both the insects are considered to be minor pests in the nursery. The incidence by these insects was noticed in May-August.

5.5.4. Seed pests

Seeds of *G. toliifolia* were almost free from any major pest attack, as evidenced by the study.

5.6. DISEASE PROBLEMS AND CONTROL

5.6.1. Seed pathological studies

5.6.1.1. Incubation test

Seeds of G. *tiliifolia* harboured nine pathogens as shown by the standard blotter test (Table 8). The RPI of *A. flavus* was the highest (60.5%) followed by *A. niger* (50%), *A. ochraceous* (30%), *A. candidus* (25%) and *Rhizopus* sp.(25%). *Fusarium*

monilifcrme, F. semitectum and *Botryodiplodia theobromae* had RPI of 5% each. No bacterial ooze was detected from the seeds. Compared to other indigenous tree species tested, seeds of *G.tiliifolia* harboured more storage fungi, viz. *Aspergillus* sp. and *Rhizopus* sp. and these fungi caused seed rotting and germination was seriously affected. In addition to these common storage fungi, spermoplane microflora comprised of some potential pathogens, which are also known to be seed-borne in various crops (Neergaard, 1977). *F. moniliforme*, a pathogen, has a wide range of hosts and cause seedling blight, stunting and fcot rot (Bootb, 1971). Seed mortality due to this fungus is ccmmon in G. *tiliifolia* as it invades the seed tissue. *8. theobromae* is known for causing discoloration of seeds in other crops.

5.6.1.2. Effect of fungicides on seed microflora

Results of the effect of fungicides on elimination of seed microflora is presented in Table 9. Mancozeb and MEMC were the best among them followed by carbendazim and carboxin. In seeds, treated with carboxin, *Rhizopus* sp. could not be inhibited, whereas in the case of carbendazim treated seeds, surprisingly, *F. moniliforme* was observed.

In a warm and humid State like Kerala, the rich seed microflora could be due to high humidity and temperature which contribute to the growth of several saprophytic and potential pathogenic organisms. This can be avoided by storing seeds under proper storage conditions. In the absence of effective storage procedures for forest seeds, it would be worth to treat them with the effective seed dressers and store them till they are sown. Seeds of G. *tiliifolia* can be stored upto 90 days dressed with either mancozeb (3g/kg) or MEMC (2g/kg).

Table 8. Spermoplane microorganisms and their relative percent incidence on the seeds of G. *tiliifolia*

Microorganisms recorded	Relative percent incidence(RPI)
Aspergillus candidus	25.0
A. flavus	60.5
A. niger	50.0
A. ochraceous	30.0
A. versicolor	10.0
Botryodiplodia theobromae	5.0
F. moniliforme	5.0
F. semitectum	5.0
Rhizopus sp.	25.0

5.6.2. Diseases in nurseries

In the nurseries of *G. tiliifolia* no seedling disease was recorded.

5.6.3. Diseases in natural stands

5.6.3.1. Leaf spot

Leaf spot is widespread in G. *tiliifolia* throughout the State. the leaf spots were seen during South-West monsoon period and continued till December. Approximately 25-30% of the

Table 9. Effect of fungicides on seed microflora of *G. tiliifolia* one day and 90 days sfter treatment

Microorganisms recorded	RPI in various treatments									
	control		carbendazim		MEMC		carboxin		mancozeb	
	0	90	0	90	0	90	0	90	0	90
A. candidus	25.0	25.0	-	-	-	-	-	-	-	-
A. flavus	60.5	62.0	-	-	-	-	-	-	-	-
A, niger	50.0	48.5	-	-	-	-	-	-	-	-
A. ochraceous	30.0	32.5	-	-	-	-	-	-	-	-
A. versicolor	10.0	11.5	-	-	-	-	-	-	-	-
B. theobromae	5.0	5.0	-	-	-	-	-	-	-	-
F. moniliforme	5.0	5.0	4.0	-	-	-	-	-	-	-
F. semitectum	5.0	5.0	-	-	-	-	-	-	-	-
Rhizopus sp.	25.0	27.5	-	-	-	-	-	-	-	-

leaves were affected with various degrees of infection. In severe cases defoliation was observed. Water soaked lesion of 2–3 mm diameter appeared scattered on the leaves, which sometimes coalesed to form larger blighted areas (Fig. **10).** Leaves of all age groups were affected and *Colletotrichum gloeosporioides* (Penr.) Penr. & Sacc. anamorph of *Glomerella cingulata* (Stonem) Spauld & Schrenk. **(IMI** No. 325766) was identified the causal agent.

5.6.3.2. Phanerogamic parasite (mistletoe)

Mistletoe infection is very common in *G. tiliifolia* throughout the State. Out of the three mistletoes recorded, *Scurrula parasitica* was observed in all the areas, while the other two, viz. *Viscum nepalense* and *Dendropthoe falcata* were seen in lesser proportions. On an average, 3–5 clumps were seen in one affected tree. Interestingly, in a few cases, all the three mistletoes were seen infecting the same tree. In case of severe infection, branch mortality was noticed. During the course of the investigation mistletoe infection was noticed in all the forest circles surveyed. Out of the three mlstletoe species recorded, *S. parasitica* was the most common species and was observed in all *Grewia* growing localities. In some cases, 10-18 clumps were seen affecting a single tree and causing at times, branch mortality.

In nursery, there is no disease observed, but in natural stands, a few diseases causing leaf spot, stump rot and occurrence of three types of mistletoe causing branch die back were observed. Gallsmut of stem aid petiole caused by *Pericladium tiliacearum* (Thirumalachar, 1950), leafspots caused by *Phyllosticta grewiae* (Sohi and Prakash 1969), *P.sedgewikii* (da Costa and Hundukur, 1949) and *Septoria grewiae* (Sukapure and Thirurnalachar, **1959)** were the other diseases reported from G. tiliifolia India. Stump rot caused by *Ganaderma applantatum* was recorded as early as **1874 by** Currey followed by reports by **Lloyd** (1918 –1925) and Bose **(1979-1928).** But during the course of the investigation, *Phellinus* **sp.** was found to be the causative organism of stumprot from various parts of Kerala.

Mistletoe infection was observed to be a serious problem in almost all areas surveyed. Especially in Central part of the State *Sccrulla parasitica* was found causing branch die back in serious cases.

6. HALDINA CORDIFOLIA

(Manja-kadambu)

6.1. BOTANY

6.1.1. Nomenclature

Haldina cordifolia (Roxb.) Ridsd. Blumea **24** (2): **361. 1978;** Ramach. *et* Nair, **Fl.** Cannanore **215. 1978.**

Nauclea cordifolia Roxb. **Corom. Pl. 1:40. t. 53.1795;** Roxb. Fl. Indica ed. 2. **1:514.1832; Wt.** *et* Arn. Prodr. Fl. **Penin. Indiae** Orient. **391. 1834;** Bedd. **Fl.** Sylvat. **1: t. 33.1879.**

Adina cordifolia **Hook. f.** (Benth. *et* **Hook. f. Gen. Pl. 2:31. 1873)** ***ex*** Brandis, For. **Fl. N.W.** & C. India 263. **1874; Hook. f.** Fl. Brit. India **3:24. 1880; Havil. J. Linn. Soc.** Bot. 33: **47. 1897;** Gamble, Man. **Indian** Timb. ed. 2, **1902,** repr.ed. **401. 1972;** Gages, Rec. **bot.** Surv. India 3: 65. **1904;** Brandis, Indian **Trees 368.** 1906; Bourd. For. Trees Travancore **212. 1908;** Rama Rao, **Fl. Pl.** Tranvcore 201. **1914;** Gamble, **Fl. Presid.** Madras 2: **584. 1921;** Cox, **Ind.** For. Dept. For. Bull. **42:** 1-23. **1921;** Blatter, **J . Bombay** nat. **Hist. Soc. 36: 781. 1933;** Gandhi in Saldanha *et* **Nichol.** (eds.) **Fl.** Hsssan Distr. Karnataks **572. 1976.**

Nauclea sterculiaefolia **A.** Rich. Mem. Fam. **Rub.** 209. **1830** & Mem. **Soc. Hist.** nst. Paris **5:** 289. **1834.**

Type : Roxburgh *s.n.* (Herb. Smith **316/5, LINN).**

6.1.2. Local **names**

Manja-kadambu, Katamps, **Beembu.**

6.1.3. Botanical description

Deciduous trees, 10–20 m high; trunk often buttressed, flutted, rough, flaking; bark thick, grey, rough, reddish brcwn, scalloped externally; inner bark wine–cloured to brown; branchlets glabrous, often terete with conspicuous petiolsr scars, horizontal at seedling stage; branching strongly sympodial; stipules reddish, 0.5 - 1.8 x 0.4 - 0.8 cm, oblong, strongly keeled, pubescent, upto 1.5 cm long, cauducous. Leaves simple, peticlate, opposite, distichous;. petioles 1.4 - 16 cm long, reddish, densly pubescent; lamina 5.5 - 23.5 x 4.5 - 25 cm, obovate, very obovate, broadly elliptic, transversely elliptic or rarely tranversly broadly ovate or ovate, entire or rarely with undulate margins, subcoriaceaous, sparsely hairy above, densely pubsecent beneath, drying chocolate–brown or pattid to yellowish green, acuminate, acute or rarely cuspidate at apex, cordate, subcordate or rarely truncate at base. Inflorescence yellowish, solitary or in panicles of peduncled heads, 0.5 cm - **0.3** cm in diameter across calyces; floral bracts upto 0.3 cm long, paleaceous. Flowers creamy–white with slightly rose–coloured petals or brownish with a rose or red tinge; calyx 5-angled, 5-lobed, 0.4 - 0.8 cm long; corolla 0.7 - 0.8 cm long, sympetalous, funnel–shaped at apex, glabrous, valvate; corolla lobes 0.1 - 0.3 cm long, ovate or oblong, densely fine–hairy outside, almost papillose inside the tube; stamens 5, epipetalous at the mouth of the corolla tube; filaments short; anthers 0.1 - 0.2 cm long, oblong; pistil 0.4 - 0.7 cm long; ovary 2–loculed; ovules numerous on a pendulous placenta in each locule; style 0.3 - 0.6 cm long, filiform, exserted; stigma ovoid to subglobose, clavste or capltate. Fruiting heads 0.8 –1.5 cm

across, globose, with a cluster or capsules, each seperating into two folicular cocci; seeds with winged testa, tailed above, oblong, ovoid or trlcornuate, bilatesrally flattened, with two claw-like short prcjections at the apex; albumen fleshy; cotyledons flat; radicle superior, cylindric (Figs. 1 & 2).

6.1.4. Field notes

Trees with dense crown, few branches and almost clean trunk, common in the deciduous forests of Kerala, often as isolated stands.

6.1.5. Phenology

Flowering form April to September, maximum in June; fruiting from October to January, sometimes extending to Apri1, but maximum during October, November and December (Fig. 3).

6.1.6. World distribution

India, Sri Lanka, eastwards to South China and Vietnam and southwards to Peninsular Thailand (Surat Thani).

6.1.7. Distribution in Kerala

Trivandrum, Thenmala, Ranni, Kottayam, Kothamangalam, Malayattoor, Trichur, Chalakudy, Vazhachal, Nemmara, Palghat, Calicut, Milambur, Wynad, Thekkady, Idukki and Parambikulam Forest Divisions; not recorded from Munnar Division during the present study (Fig. 4).

6.1.8. Notes

Haldina is a monotypic genus recently circumscribed by Ridsdsle (l.c.) to include that part of ***Adina*** Slaisb. ***(sensu***

lato) with the terminal vegetative bud pyramidal to conical in shape, stipules deltoid to narrowly triangular or oblong, sometimes narrsowly nouched at the apex, inflorescence with numerous flowering heads, generally over 7, and ovules 4 to 12 in each locule of the ovary. In the case of *Adina* (*sensu stricto*) the terminal vegetatlve bud is ill-defined and loosely surrounded by the stipules, the stipules deeply bifid for over two-third of their length and flowering heads solitary, rarely upto 7, arranged like a simple thyrse; ovules upto 4 per locule.

6.1.9. Within species variation

Data on leaf variation from 22 samples collected from different locations in the State were used for the statistical analysis. Altogether, 24 characters were recorded from the 22 specimens. Quantitative characters were divlded into class Intervals; 5.50 to **11.33 cm** (short) **11.33** to **17.16** cm (medium long) and **17.16** to 23.00 (very long) for leaf length; **4.5** to **11.3** (narrow), **1.33** to **18.6** cm (medium broad) and **18.16** to 25 cm (very broad) for leaf breadth; **1.40** to 6.26 cm (short), 6.26 to **11.13** cm (medium long) and **11.3** to **16.00** cm (very long) for petiole length. From the cluster analysis among characters (Fig. **5.1**), it was observed that leaves with medium length, medium breadth and medium long petioles are mostly broadly ovate in shape. Similarily, leaves which are short and narrow with minimum petiole length are entire, acuminate at apex and cordate or subcordate at base. Further, long-petioled leaves are broadly obovate In shape. OTUs with very long, very broad leaves, very broadly - ovate leaves, transversely broadly ovate leaves, transversely elllptic ovate leaves, broadly elliptic and very broadly obovste leaves, and those leaves with undulate marigns,

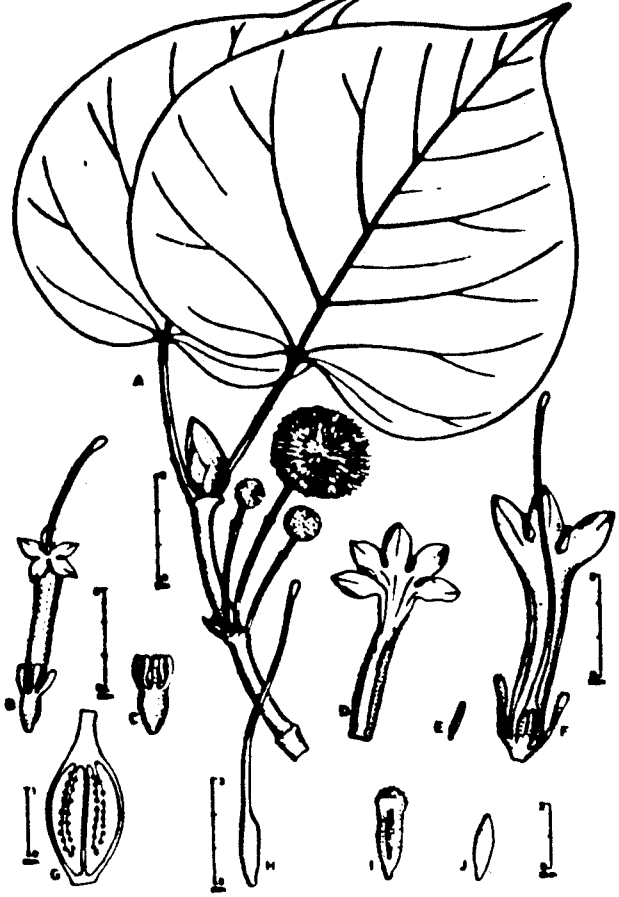


Fig.1

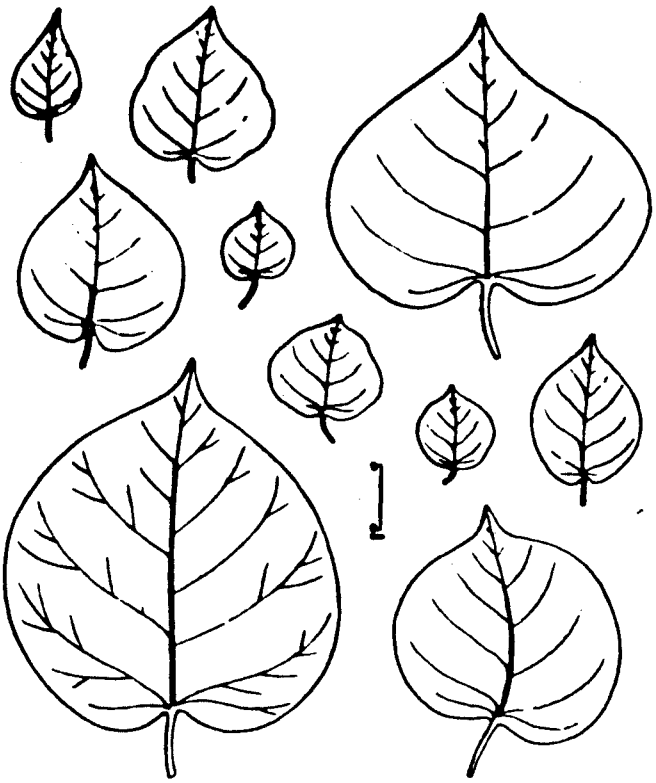


Fig.2

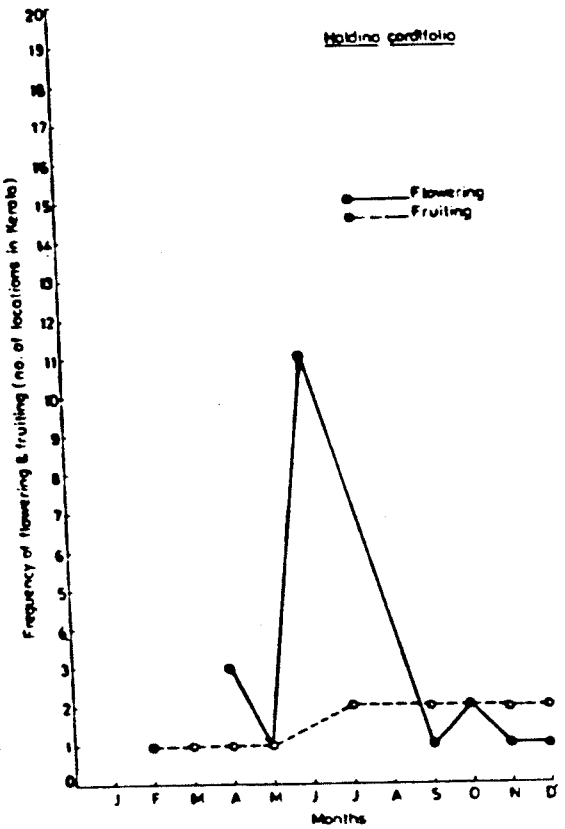


Fig.3

Haldina cordifolia

Fig.1 A. Flowering twig, B. Flower, C. Calyx, D. Corolla, E. Stamen, F. L.S. of flower, G. L.S. of ovary, H. Pistil, I. Fruit, J. Seed.
Fig.2 Leaf variation diagram.
Fig.3 Phenological graph.

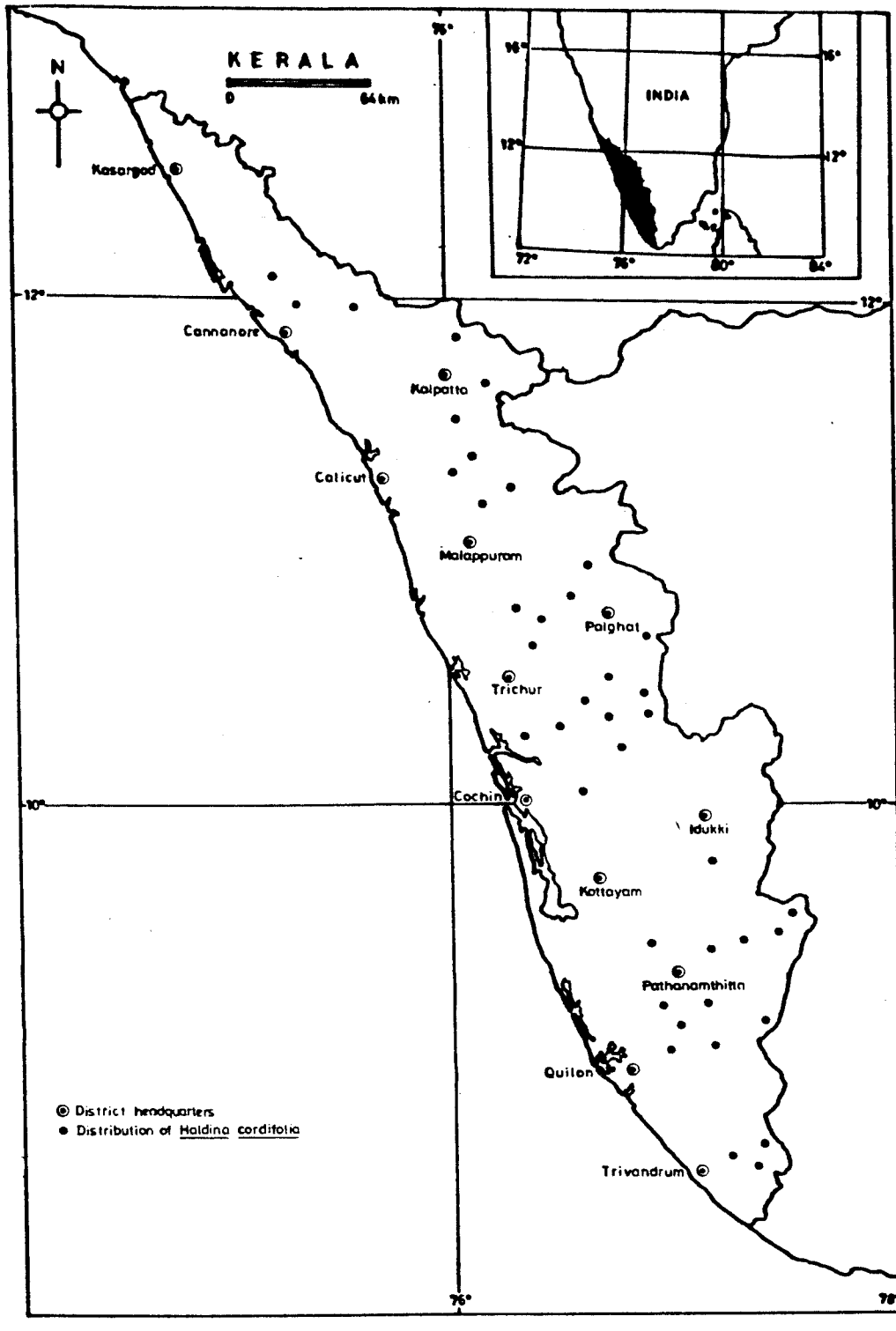


Fig.4 Distribution map of *H. cordifolia* in Kerala.

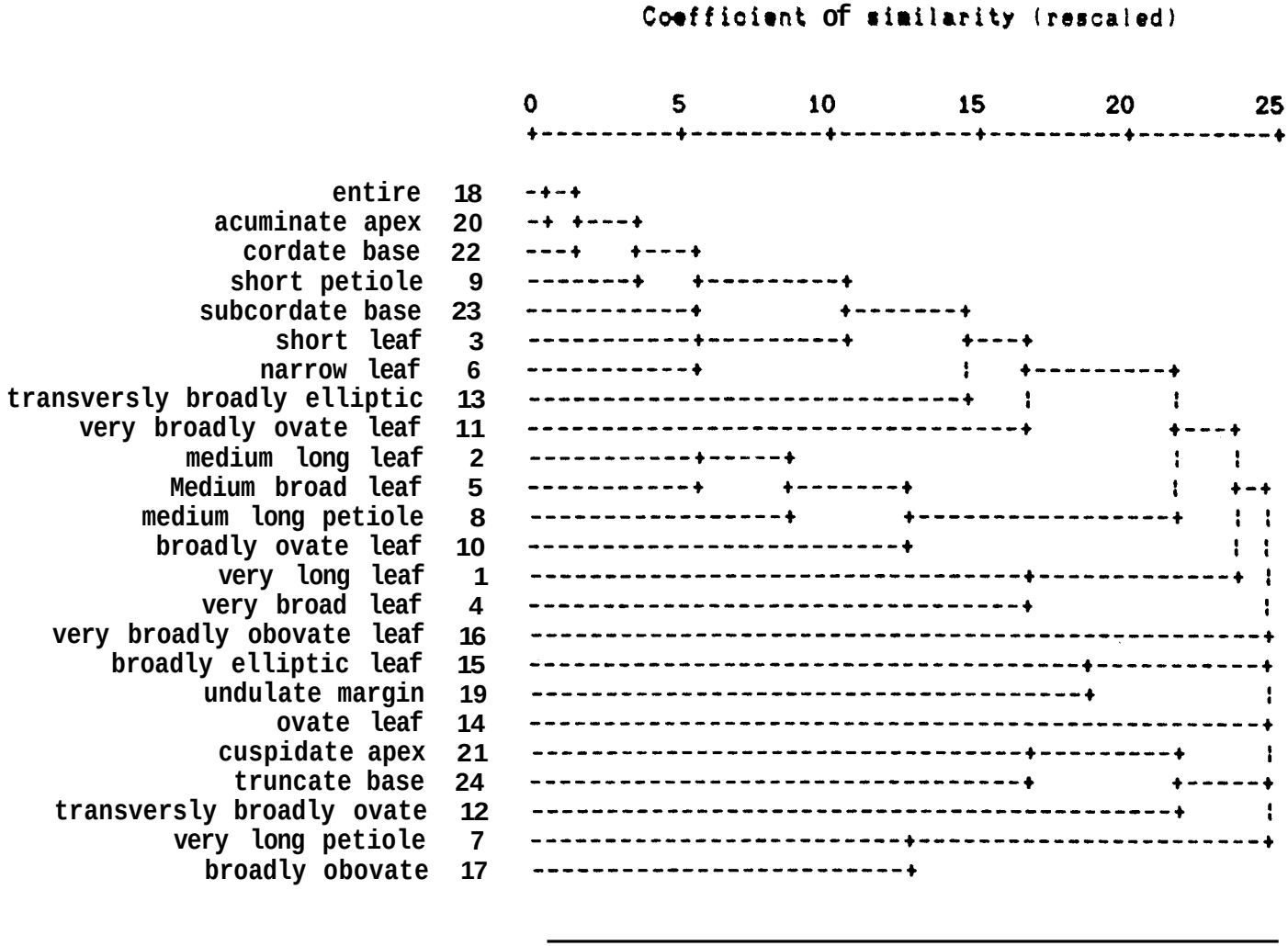


Fig. 5.1 Phenogram based on coefficient of Jaccard of leaf characters of **H. oordifolia** from different locations in Kerala.

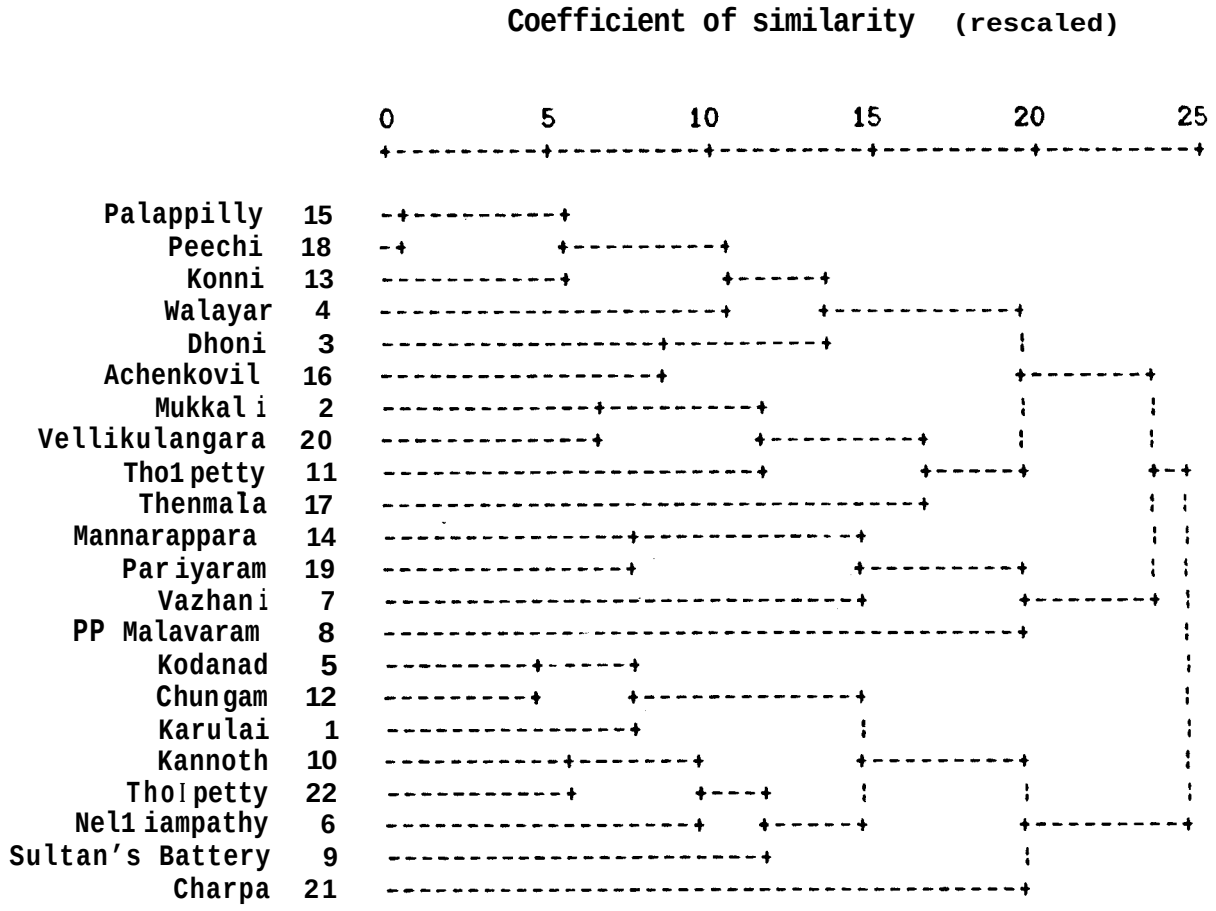


Fig. 5.2 Phenogram based on coefficient of Jaccard of specimens of H. cordifolia from different locations in Kerala.

cuspldate apex and truncate base does not form part of any cluster.

Resemblence by at least 50% characters among specimens from different parts of the State by the cluster diagram (Fig. 5.2) is as follows:

i. Specimens from Karulai, Kondanad, Nelliampathy, Sultan's Battery, Kannoth, Chungsm and Tholpetty.

ii. Mukkali, Tholpetty and Velikullangars.

iii. Dhoni, Walayar, Konni, Palappily, Achenkovil and Peechi

iv. Vazhani, Mannarappara and Pariyaram.

v. Specimens from PP Malavaram, Thenmala and Charpa ranges do not form part of any cluster, ie. they form isolated populations with regard to the characters considered.

With regard to the size of leaves, those with least length (5.5 cm), least breadth (4.5 cm) and least petiole length (1.4 cm) were recorded from Vazhani Range of Trichur Forest Division and leaves with maximum length (23 cm) and maximum breadth (25 cm) were those from PP Malavaran Range in Kozhikode Division. In the case of petiole length, it was Thenmala collections which were having a maximum (16 cm) value.

6.1.10. Specimens examined

Cannanore, Parappa, **4.7. 1980,** R. Aansari **67974 (MH);** Thaliparamba farm Cannanore, **17.2.1913,** C.A. Barber **8773 (MH);** Thaliparamba, Malabar, **19.5.1906,** C.A. Barber **7744 (MH);** Kannoth, Malabar District, **25.19.1913,** C.A. Barber **9414 (MH);** Sultan's Battery Range, Wynad Division, **23.6.1988, K.K.N.** Nair **6349** (KFRI); Karulai Range, Nilambur Division, **16.6.1989,** K.K.N. Nair

6509 (KFRI); Chungam Range, Parambikulam Division, **19.5.1988,** K.K.N. Nair **6344** (KFRI); Walayar, Palghat Division, Sept. **1936,** C.C. Monnappa *s.n.* (FRI); Palghat, **17.11.1976,** J. Joseph **17048 (MH);** Walaysr RF, Palghat Division, **13.6. 1989,** K.K.N. Nair **6399** (KFRI); Palghat, **1870,** Major **R.H.** Beddcme *s.n.* **(MH);** near Wadakkancherry, Trichur District, **9.9.1976,** K. Ramamurthy **48425 (MH);** Vazhani dam catchment, Trichur Division, **11.4.1989,** K.K.N. Nair **6381** (KFRI); KFRI Campus, Peechi Range, Trichur Divislon, **12.11.1987,** K.K.N. Nair **6301** (KFRI); Nellismpathy Range, Nemmara Division, **6.6.1989,** K.K.N. Nair **6388** (KFRI); Chalakudy-Mala rcute, Chalakudy Division, **10.2.1984,** K. Ramamurthy **8048 (MH);** Palappilly, Chalskudy Division, **23.3.1988,** K.K.N. Nair **6312** (KFRI); Athirappilly Range, Varhachal Division, **17.8.90,** K.K.N. Nair **6528** (KFRI); Thundathil, Kodanad Range, Malayattoor Division, 7.6.1989, K.K.N. Nair **6391** (KFRI); Idukki, lower camp to Kumily, **26.12.1974,** K. Vivekanantan **45718 (MH);** Manalar, Achenkovil Range, Thenmala Division, **30.12.1987,** K.K.N. Nair **6307** (KFRI); Villumala, Thenmala Division, **2.6.1964,** Subramanian **1543** (FRI); Villumala, Thenmala Divisioin, **6.6.1964,** K.N. Subramanian **5922** Kallada, Thenmala Division, **22.4.1976,** K.N.Subramanian **5922** (FRI); Katlappara, Thenmala Division, **29.12.1987,** K.K.N. Nair **6306** (KFRI); Perumalal, Konni RF, Konni Division, **18.11.1976, M.** Chandrabose **49114** Mannarappara, Konni Range, Konni Division, **23.4.1988,** K.K.M. Nair **6322** (KFRI); Thavalappara, Konni Range, Konni Division, **23.4.1988,** K.K.N. Nair **6324** (KFRI).

6.2. ECOLOGY

Details on regeneration status and species association of *H. cordifolia* in the natural forests of the State is as follows.

Associations:	Grewia - Dellenia
Parent tree source:	Medium
Parent tree distribution:	Occasional
Biotic interference:	Partially disturbed
Regeneration status:	Three
Young seedlings:	
(upto 30 cm ht.)	Sufficent
Older seedlings:	Limited
(31 cm to 1 m ht.)	
Saplings:	Rare
(more than 1 m ht.)	
Mortality rate:	High

6.3. UTILIZATION ASPECTS

6.3.1. Bole characteristics

Mature trees of *H. cordifolia* grow to a height of 15 to 20 m and a diameter of over a metre. The length of clear straight bole may be upto 20 m or more as fcund in certain localities like Parambikulam and at Bavali in Wyanad. The stem log is almost cylindrical (Fig. 7). However, very old trees possess irregular

fluting and buttresses, Other defects with the stem log are occasional forking at a lower height level and butt rot.

6.3.2. Wood properties

The wood is found to be uniformly fine textured and straight grained. The basic density ranged between 503.0 kg/m^3 and 663.5 kg/m^3. Average density at breast height level was 596.7 kg/m^3. Samples collected from Central Kerala showed slightly higher density than rest of the regions but there was no significant difference in density between the various regions and localities as indicated by the analysis of vsrlance (Table 1). The estimation and comparison of heartwood proportion was not possible in this species since it was not readily distinguishable from sapwood.

Table 1. ANOVA of basic density of *H. cordifolia* wood from different regions and localities in Kerala

Source of variation	DF	Mean Square	F-value
Region	2	2072.628	1.497 (ns)
Locality	2	751.269	0.543 (ns)
Residual	18	1384.416	
Total	22	1391.913	

ns = non significant

6.3.3. Wood structure

Growth rings are indistinct in the wood of this species but they can be approximately demarcated in sections from vessel size and distribution.

Vessels small and angular in outline, although short and long radial multiples present solitary vessels more common, pore clusters rarely present; perforation simple; pits minute and alternate, pits leading to parenchyma distributed In small groups; tyloses and extractives not found in the vessel lumen.

Parenchyma scanty and not very distinct in cross section, diffuse in aggregates and non-storied; crystals not found but yellow coloured, particulate extractives present; pits having narrow border.

Rays 1- to 2- seriate, rarely upto 3-seriate, commonly 10 to 35 cells high, heterogeneous with tails longer thsn the body; thus conforming to heterogenous type I of Kribs's classification (Barefoot and Hankins, 1982); the multiseriate portion of rays not much wider than uniseriate part; some rays vertically fused; crystals absent but particulate extractives present in ray cells.

Fibres non-septate and thin-walled; pits narrowly bordered; with no appreciable difference between earlywood and latewood fibres in wall thickness.

6.4. SILVICULTURE AND PLANTATION TRIALS

6.4.1. Seed collection

Seeding occurs almost annually and seeds should be collected from the trees when ripe. The seeds are minute snd often by mistake heads which have already shed their seeds are collected (FRI, 1985). The period of ripening of seeds varies

depending upon the locality. The best time for collection of seeds is February in West Bengal, February to May in Uttar Pradesh and December to March in Maharashtra (Troup, 1983). The maturity of fruits has to be carefully observed. When the heads become ripe they turn yellowish black in colour and the carpels become flesh red. Ripe fruits (Fig. 8) were collected from Nilambur during February. The heads were then put in cloth bags and sun dried for a few days. The fruits opened and the seeds escaped when the branches were tapped with a stick. The seeds were then cleaned by winnowing. Though other methods for extraction of seeds are also practised (FRI, 1985) they are not simple and efficient.

6.4.2. Seed weight

About 10,000,000 seeds weighed one kilogram and it almost agreed with the reported figure of 10,765,624 - 11,287,678 seeds per kg (Senguptha, **1937).**

6.4.3. Germination capacity

Germinability of *H. cordifolia* seeds is highly variable. Seeds in the present study gave a germination of 54-97%. Sengupta (1937) has reported 90% germination for seeds from West Bengal. Seeds stored for a short duration is reported to have improved germinability (FRI, 1985). Tests at Dehrs Dun have indicated that the seeds could be stored for about an year in sealed tins or gunny bags. Dent (1948) recommends that the seeds of *H. cordifolia* could be kept for the next season, but not 1onger.

6.4.4. Nursery technique

As the seeds are minute, for best results, they were sown in germination trays filled with forest soil free from debris of roots, stones and clods. About 10 gm of seeds were sown in a tray of 50 cm X 50 cm, during February. Seeds germinated In about 5–15 days and germination was complete by about 30 days. Seedlings were pricked out into polythene bags (22.5 cm X 17.5 cm size) filled with fertile soil. The seedlings attained about 15 cm height in about 16 months (Fig. 9) when they were out planted in the field by June–July.

6.4.5. Plantation trials

6.4.5.1. Survival of seedlings

Seedlings of *H. cordifolia* registered maximum survival of 70% and moderately good height growth in the pilot plantations of 1988. In the 1989 trials, performance of the seedlings was better in mixed plantations than in pure, unlike *G. tiliifolia* where the reverse was the trend (Figs. 10 & 11). Mean survival

Table 2. Analysis of variance of survival of seedlings in pure and mixed plantations of *H. cordifolia*

Source of variation	DF	MSS	F-values
Treatment	5	111.794	1.6618(ns)
Replication	2	388.753	5.7787 **
Residual	10	67.274	
Total	17		

ns = not significant; ** P = 0.01

values in 50% and 25% mixed plantations of HP, HX and AHGP, GHPX showed only minor variations. Maximum survival was 95% in HP followed by 94% in AGHP, 92% in HX and 90% in GHPX . Performance of the species in its pure plantation was better (79%) than in 50% mixture of AH (77%) (Fig. 6). The variation in survival percentage was not statistically significant (Table 2).

6.4.5.1. Height growth

The mean values of height showed only minor variations in pure and mixed plantations. However, the seedlings showed better height growth in pure plantations. Even though maximum height of 104 cm was observed in a 50% mixture of HX, pure plantations of

Table **3.** Analysis of variance of height growth in seedlings of pure and mixed plantations of *H. cordifolia*

Source of variation	DF	MSS	F-value
Treatment	**5**	**0.013**	**0.4333(ns)**
Replication	**2**	**0.121**	**4.0333(ns)**
Residual	**10**	**0.030**	
Total	**17**		

ns = not significant

the species recorded 102 cm average height. A 25% mixture of GHPX registered 98 cm height followed by a 50% mixture of AH reaching a height of 93 cm. Minimum height of 92 cm was observed in two combinations of 25% and 50% mixtures. The combinations were AGHP and HP respectively (Fig. 6). Analysis of variance

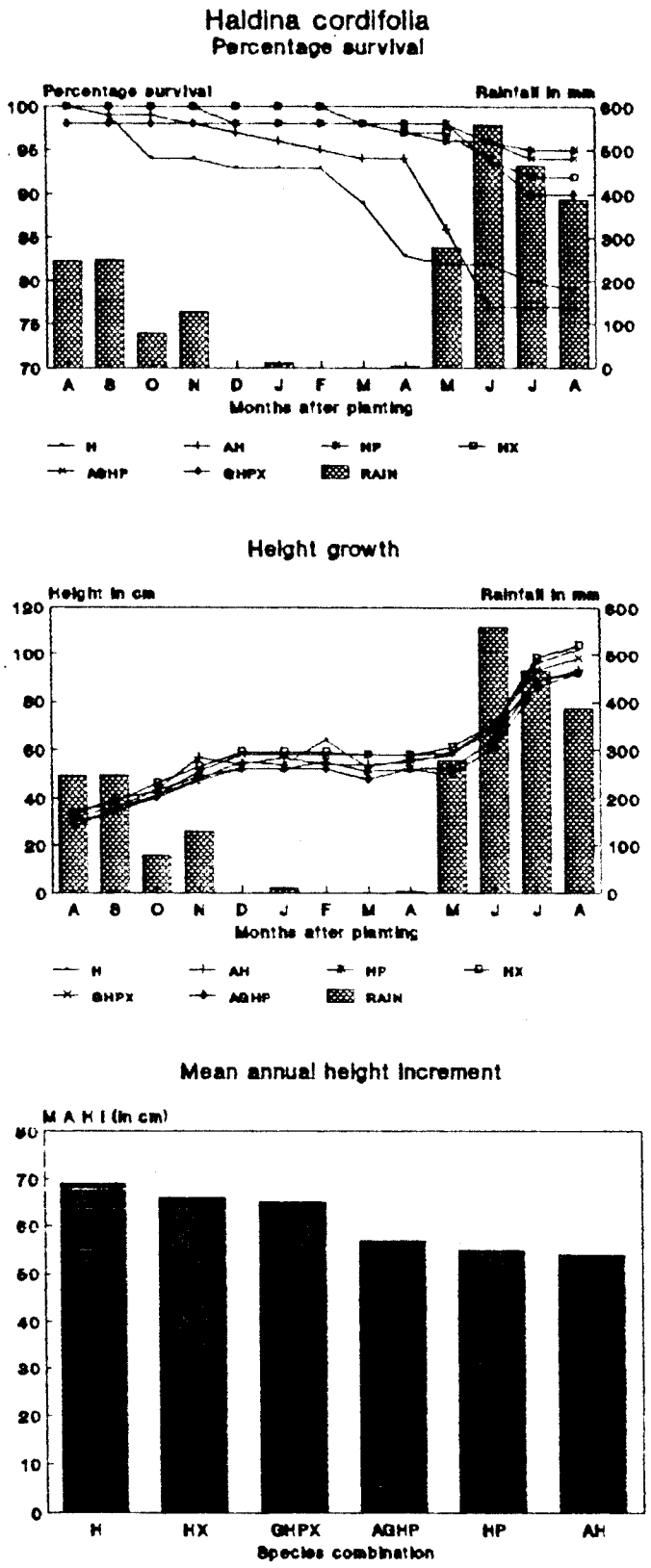


Fig. 6. Survival percentage, height growth and MAHI of seedlings in pure and mixed plantations of *H.cordifolia*

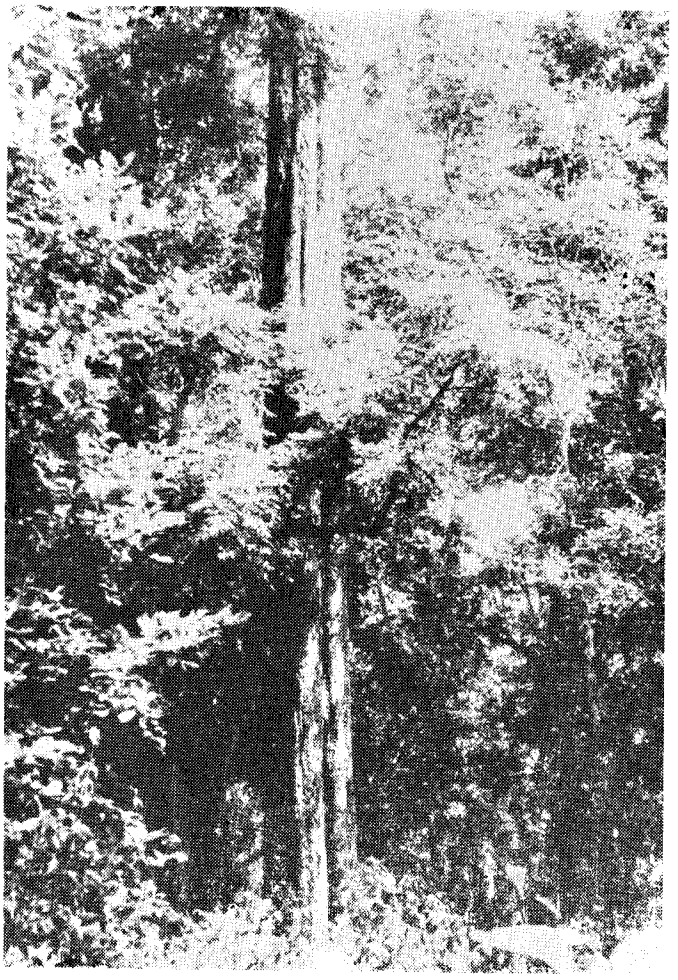


Fig. 7. Bole characteristics of *H. cordifolia* in natural stands.

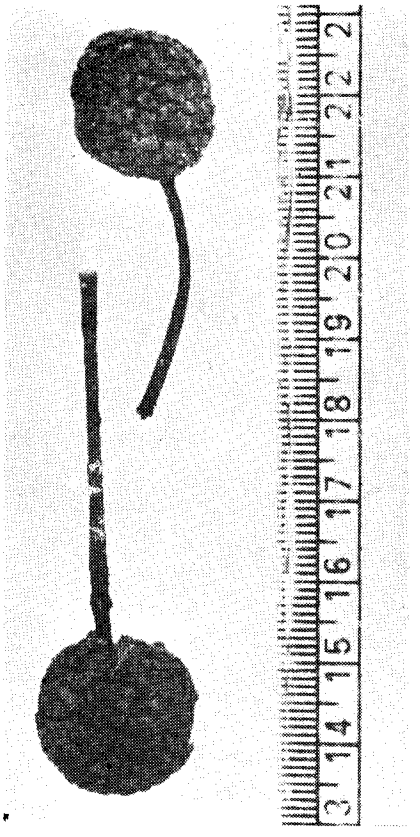


Fig. 8. Fruits of *H. cordifolia*.

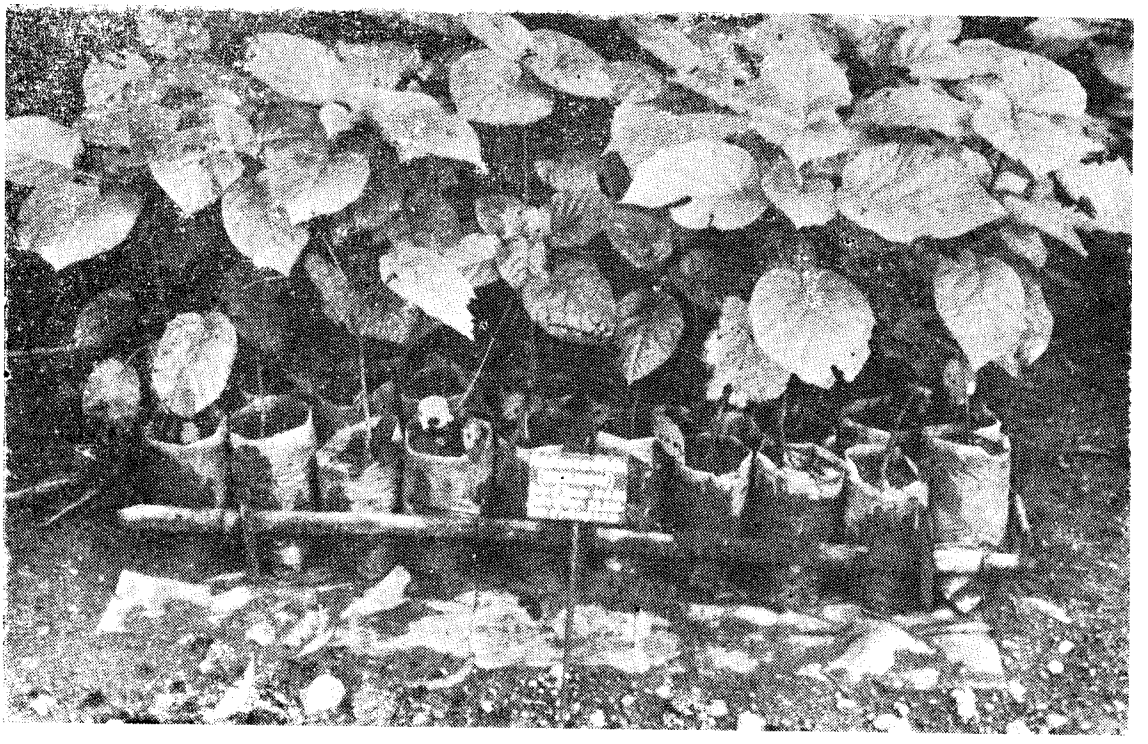


Fig. 9. Seedlings of *H. cordifolia* raised for plantation trial.

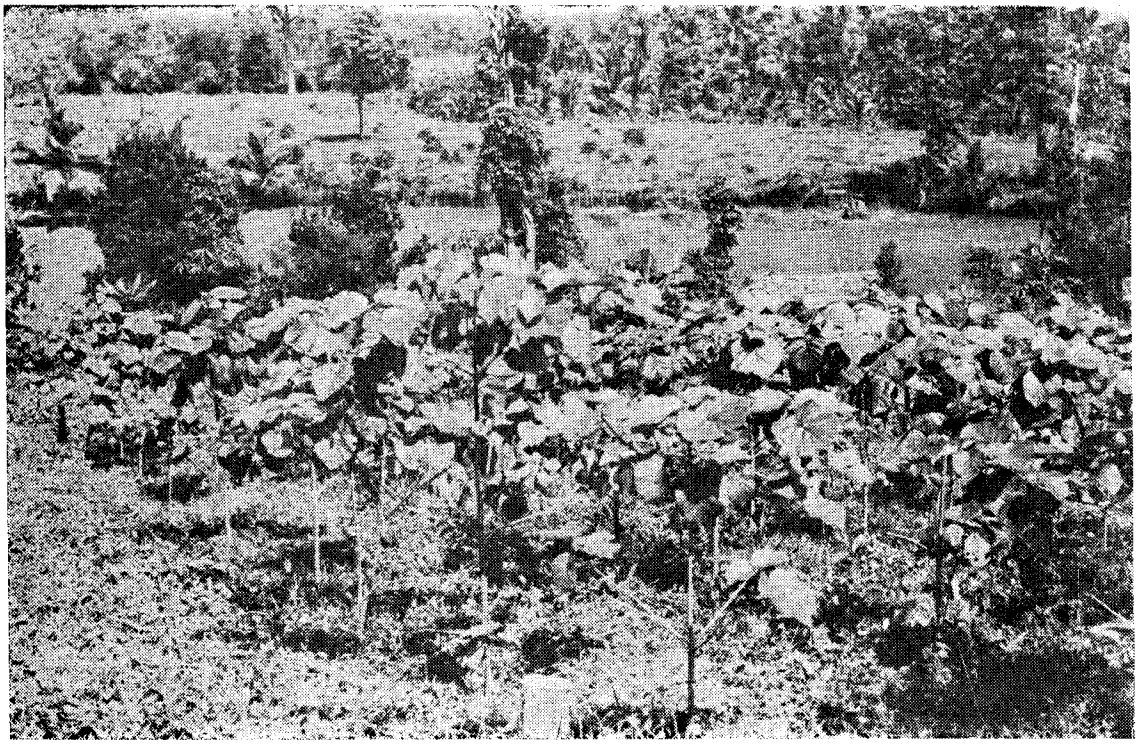


Fig. 10. Pure plantation trial of *H. cordifolia* at Nilambur.

Fig. 11. Plantation trial plot with a 50% combination of *H. cordifolia* and *X. xylocarpa*.

showed no significant difference between the treatments (Table 3).

6.4.5.2. Mean annual height increment (MAHI)

MAHI was maximum in pure plantations of *H. cordifolia* reaching 69 cm. The species performed better in two other combinations. When 66 cm height increment was observed in a 50% mixture of HX, 65 cm increment was observed in the 25% mixture of GHPX. The species registered 57 cm increment in AGHP combination, 55 cm in HP mixture and 54 cm in AH mixed plantations (Fig. 6). Statistical analysis showed no significant

Table 4. Analysis of variance of mean annual height increment in seedlings of pure and mixed plantations of *H.*

Source of variation	DF	MSS	F-value
Treatment	5	0.046	1.0000(ns)
Replication	2	0.037	0.8043(ns)
Residual	10	0.046	
Total	**17**		

ns = not significant

differences between the mean annual height increment of the species in pure and mixed plantation (fable 4).

6.5. PEST PROBLEMS AND CONTROL

6.5.1. Insect pests in natural stands

H. cordifolia trees in the natural stands seldom showed any major damage by insects although occasionally, leaf rolling (by *Parotis vertumnalis*) and leaf feeding (by an unidentified beetle) were noticed at severs? places in Kerala (Table 5). Of them, *P. vertumnalis* caused over 50% damage to foliage by folding the leaves and feeding from within. Usually only a sing e larva was present per leaf, although during heavy infestat on, sev ral larvae were found to attack a single leaf. Instances of total defoliation of young trees by the gregareous caterpillers of *Epiplema quadricaudata* have also been recorded. Although this insect *is* not regarded as a set-laus pest in natural stands, it is potentially capable of causing heavy damage in plantations.

6.5.2. Pest problems in trial plantations

In the pure plantation of *H. cordifolia*, 95.31% of the seed?ings were moderately damaged by an unidentified defoliator

Table 5. Insect pests in the natural stands of *H. curd:folia*

Insect *species*	Place of colln.	Nature of damage
Epiplema quadricaudata (Lepidoptera, Epiplemidae)	Several places in Kerala	Defoliation
Parotis vertumnalis Guenee (Lepidoptera, Pyraustidae)	Vazhani, Peechi	Leaf webbing
Unidentified Coleoptera	Vazhani	Leaf feeding

Table 6. Percent incidence of defoliator in trial plantations of *H. cordifolia*

Combinations with H. *cordifolia*	Tree species A	P	X	H	G	Percent infestation Mar	Apr	May	Jun	Jul*
H	0.00	0.00	0.00	1.00	0.00	3.21	0.00	34.31	60.62	95.31[a,b]
PH	0.00	0.50	0.00	0.50	0.00	6.25	0.00	53.12	81.25	96.87[b]
AH	0.50	0.00	0.00	0.50	0.00	3.12	3.12	0.00	84.37	96.87[c]
XH	0.00	0.00	0.50	0.50	0.00	9.37	0.00	84.37	93.75	96.87[b]
PXHG	0.00	0.25	0.25	0.25	0.25	6.25	50.00	0.00	75.00	93.75[b]
APHG	0.25	0.25	0.00	0.25	0.25	12.50	0.00	37.50	93.75	100.00[d]

* figures superscribed by the sane letter under the last colunn are not significantly different at 5X probability level,

during July, 1990. In the 50% mixtures (XH and AH), about 97% of the seedlings were seen attacked. In the 25%, mixtures of APHG (100%) and HPXG (93.75%), the incidence was very high. The intensity of attack however was very low in all the combinations. No instance cf defoliation by the *Haldina* defoliator *E. quadricandata* was noticed in the trial plantings during the period of study.

6.5.3. Nursery pests

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

6.5.4. Seed pests

Seeds of the species was almost free from any attack by pests, even in stored conditions.

6.6. DISEASE PROBLEMS AND CONTROL

6.6.1. Seed pathological studies

6.6.1.1. Incubation tests

Compared to other indigenous species included in the study, seeds of *H. cordifolia* harboured fewer microflora with very less relative percent incidence (Table 7), the maximum being only 4% caused by *A.flavus,* followed by *Rhizopus* sp. (3%) and *Fusarium* sp. and *Curvularia* sp. with a RPI of 2% each. Storage fungi, viz. *Aspergillus* and *Rhizopus* were less frequently observed, the reason may be the smaller size of the seed. The germination percentage is also very high and no seed rotting was observed due to any of the seed microflora.

Table 7. Relative percent incidence of microflora on the seeds of *H. cordifolia*

Microorganisms	Relative percent incidence
Curvularia sp.	2.0
Fusarium sp.	2.0
Aspergillus flavus	4.0
Rhizopus sp.	3.0
Penicillium sp.	1.0

6.6.1.2. Effect of fungicides on seed borne fungi

Carbendazim was the most effective fungicide in controlling the spermoplane microflora of *H. coridifolia,* followed by mancozeb and carboxin (Table 8). Eventhough MEMC treated seeds showed the growth of three fungi compared to five from untreated seeds, their RPI was very low (0.5%).

Table 8. Effect of fungicides on seed microflora of H, cordifolia, one and ninety days sfter treatment

Hicroorganisms recorded	RPI in various treataents									
	Contrcl		carbendazim		MEMC		carboxin		mancozeb	
	0	90	0	90	0	90	0	90	0	90
Aspergillus flavus	4.0	6.0	-	-	0.5	-	0	1.0	-	-
Curvularia sp.	2.0	2.0	-	-	-	-	-	-	0.5	-
Fusarium	2.0	2.0	-	-	-	-	3.0	3.0	-	-
Penicillium sp.	1.0	2.0	-	-	0.5	-	-	-	-	-
Rhizopus	3.0	4.0	-	-	0.5	-	-	-	1.0	1.0

6.6.2. Diseases in nurseries

Leaf spot which is common in nurseries and natural stands of the species is dealt with under the item **6.6.3.**

6.6.2.1. Damping-off

Damping-off of *H.* seedlings was observed in the nursery at Peechi (Trichur Forest Division). The disease was

observed within two weeks of the germinatlon of seeds, when the first pair of leaves start emerging and caused ca. 30–40% mortality of seedlings. The disease appeared in the form of irregular patches (Fig. 12) and the patches get enlarged rapidly from periphery, affecting the nelghbouring healthy seedlings under high soil moisture. Water soaked lesions appeared on the hypocotyl near the ground level. These lesions turned brown in color and the affected portion got shrunken resulting in a prominent ccnstricticn causing the seedlings to fall on the ground. The causal srganism has been identified as *Pythium* sp. This disease occur during warm weather under high soil moisture and dark shade. At Peechi, the damping–off pathogen was prevalent during May and once the seedlings were grown–up and sturdy, the disease was on the decline. As soon as the disease was noticed, watering of beds was reduced, and this minimised the incidence and spread of the pathogen. Thatching, if dense, should be reduced to allow sunlight to reach the nursery bed.

As the dlsease caused high mortality of seedlings, attempts were made for its chemical control. Out of the ten fungicides tested by poison food technique, only MEMC (6% Hg) was effective in all concentrations, viz. 0.006, 0.012 and 0.025% a.i. tested. However, TMTD, captafol, copper oxychloride and captsn were effective at higher concentrations of 0.2 and 0.1% a.i. Nursery trials using MEMC, copper oxychloride, TMTD and captafol indicated that damping–off can be effectively controlled by application of 0.012%(a.i.) of MEMCgiven as a soil drench at the rate of 25–30 litres of solution per standard bed. Another soil drench, if necessary, may be applied after 15–20 days, if the disease reappears.

Fig. 12. Damping-off disease affecting seedlings of *H. cordifolia* in the nursery.

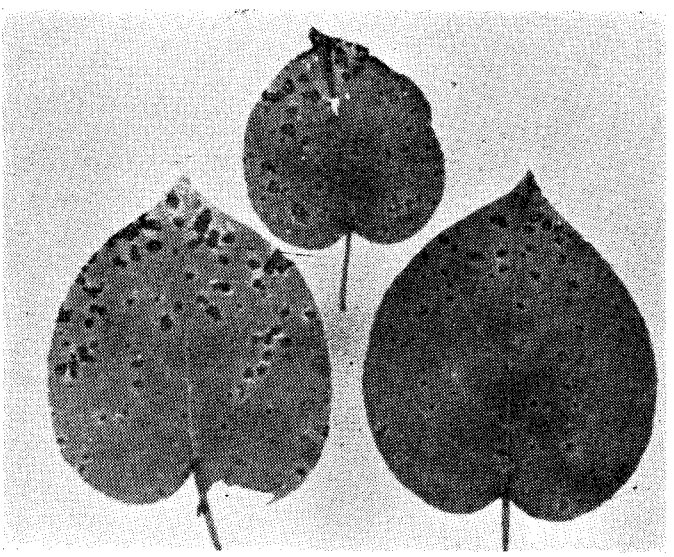


Fig. 13. Leaf-spot disease of *H. cordifolia* in the natural stands.

Pythium sp. is a common damping-off pathogen capable of causing large scale mortality of young seedlings under favourable conditions. Post emergence damping-off probably is the one and the most serious nursery disease. Damping-off of eucalypt seedlings reported to be caused by a number of pathogens, viz. *R. solani*, species of *Cylindrocladium, Pythium* and *Fusarium.* Although two species of *Pythium,* ie. *P. deliense* and *P. myriotylum* were found to be associated with damping-off of eucalypts, their occurrence was uncommon. However, the disease was controlled by soil drenches with csrbendazim (0.1% a.i.) and MEHC (0.0125% a.i.) (Sharma *etal.*, 1984). Damping-off of *Ailanthus triphysa* seedlings caused by *Pythium* sp. was observed at Peechi (Trichur Forest Divsion) and Thirunelli (Wynad Forest Division) causing 50-60% mortality and was effectively controlled by two soil drenches of msncozeb (0.05% and 0.02% a.i.) applied at weekly intervals (Sharma *et al.*, 1984). But carbendazim, mancozeb or ziram were not effective against the damping-off pathogen of *H. cordifolia.* Only MEMC (0.0125% a.i.) was effective in controlling the disease , which is a new disease record.

6.6.3. Diseases in natural stands

6.6.3.1 Leaf spot

Leaf spot is wide spread in *H. cordifolia* throughout the State. Usually the disease starts as small pink colored spots on the leaf blade. The spots rapidly enlarge in size and mature spots get surrounded by a peripheral zone of buff pink colour. Coalescence of spots are very rarely seen. In severely infected leaves, the spot covers a major portion of the lamina, with one

or two larger spots. Leaves of all age groups were affected. *Phoma* sp. (IMI. No. 328627) was identified as the causal organism (Fig. 13).

Chandra and Tandon **(1965)** reported the occurrence of a leaf spot caused by *Phyllosticta halduana* from Allahabad. The report from CAB IHI stated that this particular species of *Phoma* is similar to *P. haludana* as described by Chandra and Tandon (1965).

7. LAGERSTROEMIA MICROCARPA

(Venthekku)

7.1. BOTANY

7.1.1. Nomenclature

Lagerstroemia *microcarpa* Wt. Ic. Pl. Indiae Orient. t. 109. 1839; Bedd. Fl. Sylvat. t. 30. 1869; Nair *et* Henry (eds.) Fl. Tamilnadu 1: 165. 1983; Ramach. *et* Nair, Fl. Cannanore 192. 1988.

Lagesrstroemia lanceolata Wall. *(Cat. No. 2120. 1828 nom. nud.)* ex Clarke in Hook. f. Fl. Brit. India 2: 576. 1879; Wt. *et* Arn. Prodr. Fl. Penin. Indiae Orient. 309. 1834: Gamble, Fl. Presid. Madras 1: 513. 1918; Brandis, Indian Trees 338. 1906; Bourd. For. Trees Travancore 175. 1908; Rama Rao, Fl. Pl. Travancore 180. 1914.

Lagerstroemia thomsonii Koehne in Engl. Das Pflanzenr. 17:251. 1903.

Type: Not known.

7.1.2. Local names

Venthekku, Vellilavu.

7.1.3. Botanical description

Deciduous trees 10–30 m high; bark smooth, pale-white or ash-coloured, peeling off as large, thin strips; young branches ashy with a reddish tinge. Leaves simple, entire, petiolate, 4 - 12.5 x 2 - 16 cm, broadly ovate, elliptic-lanceate, broadly-elliptic,

ovate, elliptic, narrowly-elliptic, obovate or broadly-obovate, light green, glabrous above, hoary-tomentose or glabrous beneath, acute, acuminate, obtuse or rarely cuspidate at apex, obtuse, cuneate or rarely attenuate at base; stipules 2, deciduous; petioles **0.4-1.1** cm long, slender. Inflorescesnce in axillary or terminal racemes, compounded into trichotomous panicles; bracts 2 at the apex of the peduncle; bracteoles 2 on the pedicels, short, pubescent. Flowers white with a rose tinge, ± **0.6** cm long; calyx less than 0.5 cm long, hoary, patent or often reflexed with csmpanulate, coriaceous, smooth or ribbed tube; corolla with often 6 petals; petals **6** (sometimes 7 to **9),** 0.3 - 0.5 x **0.1** cm, oblong-obovate or orbicular, inserted on the tip of the calyx tube with a slender claw, wrinkled, with the margins crisped, erose or fimbriate; stamens numerous, inserted near the base of the calyx tube, exserted; filaments long, exserted; anthers yellow; ovary sessile, **3 - *6*** loculed; ovules numerous, ascesnding on axile placenta; style long, curved; stigma capitate. Capsules & **1** cm long, ellipsoid, not ribbed, glabrous, yellowish-brown, loculicidal, 3 -6 valved with persistent, reflexed calyx lobes; seeds numerous, upto 0.6 cm long, flat, erect, falcately winged at apeax, cultriform; testa hard; cotyledons orbicular, thin, convolute (Figs. **1** & 2).

7.1.4. Fleld notes

Trees prominent for their clean, white trunk, in the deciduous forests of Kerala; apical portion of the trees are narrow and often with only few branches; common in the openings and less stocked forest areas.

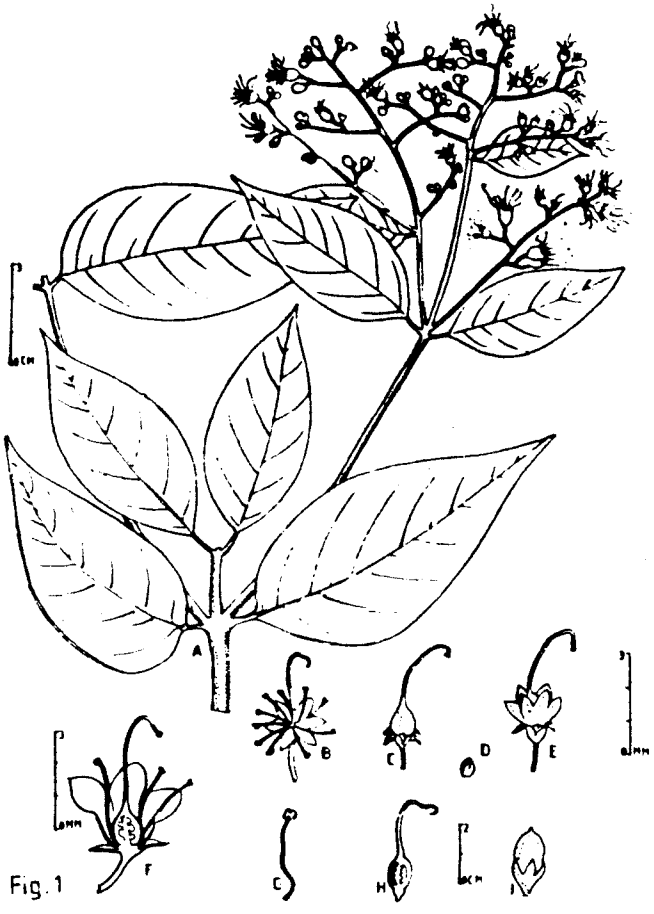


Fig.1

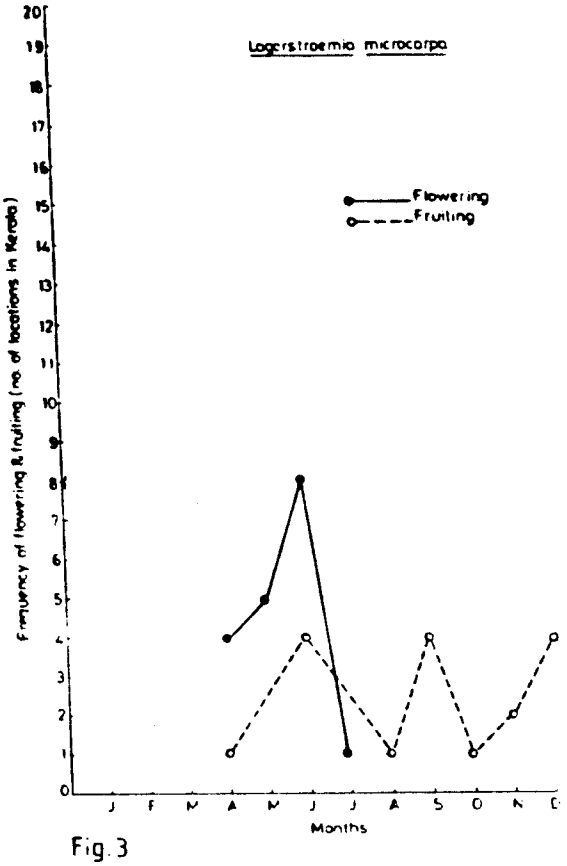


Fig.3

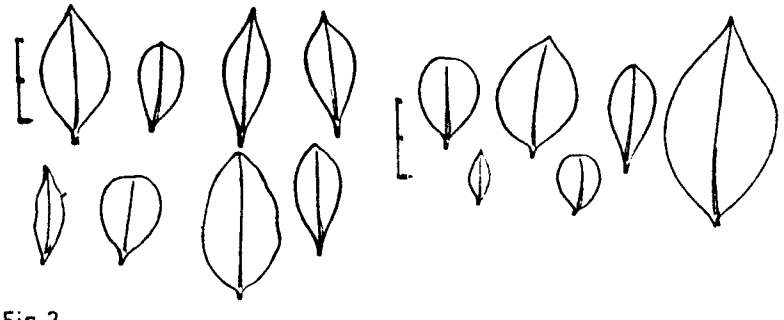


Fig.2

Lagerstroemia microcarpa

Fig.1 A. Flowering twig, B. Flower, C. Calyx and pistil, D. Sepal, E. Calyx, corolla and pistil, F. L.S. of flower, G. Stamen, H. L.S. of pistil, I. Fruit.

Fig.2 Leaf variation diagram.

Fig.3 Phenological graph.

7.1.5. Phenology

Flowers from May to July, maximum in June; fruits from June to December, maximum and maturing in December (Fig. 3).

7.1.6. World distribution

Tropical Asia and Australia.

7.1.7. Distribution In Kerala

Trivandrum, Thenmala, Konni, Ranni, Thekkady, Kottayam, Idukki, Munnar, Kothamangalam, Mankulam, Malayattoor, Vazhachal, Chalakudy, Trichur, Palghat, Parambikulam, Calicut, Nilambur and Wynad Forest Divisions. Almost throughout the State (Fig. **4).**

7.1.8. Notes

Without assigning any reason, Clarke **(l.c.)** used the Wallichian name *Lagerstroemia parviflora* for the species, a *nomen nudum* at the time of its publication, and later validated **by** Clarke **(l.c.)** by providing a description in **1879.** This is not in acccrdance with the *International Code* of *Botanical Nomenclature* (1998). Before the Wallichian name was validated, Robert Wight **(l.c.)** used the specific epithet *microcarpa* for the species and the later specific epithet has priority of publication over *parviflora* **(1879)** and hence accepted here as the legitimate specific epithet fcr the taxon. The conspecificity of *L. microcarpa* and *L. parviflora* **was** first pointed cut **by** Wight and Arnott *(l.c.),* eventhough they delt with them seperately. The persistent calyx lobes on the fruits of this tree is a reliable diagnostic feature.

7.1.9. Within species variation

A total of 18 samples and 28 character variants were used in the cluster analysis. Quantitative characters recorded as measurements were realized into the following classes, *ie.* 4 to 6.3 cm (short) 6.3 to 9.6 cm (medium long) and 9.6 to 12.5 cm (very long) for the length of leaves, 2.1 to 3.4 cm (narrow), 3.4 to 4.7 cm (medium broad) and 4.7 to 6 cm (very broad) for leaf breadth and 0.3 to 0.5 cm (short), 0.5 to 0.8 cm (medium long) and 0.8 to 1.1 cm (very long) for the length of petioles.

The clustesr diagram (Fig. 5.1) demonstrates the coincidence of characters in various clusters. The diagram shows that medium long, medium broad and medium long-petioled leaves are elliptic in shape, entire, acute or acuminate at apex and obtuse or cuneate at base. Similarly, very long leaves are broadly elliptic in shape, narrow leaves are short petioled and leaves with very long petioles are undulate along their margins. However, very broad leaves, ovate leaves, broadly cvate 'leaves, narrowly elliptic leaves, obovate leaves, broadly obovate leaves, narrowly ovate leaves and leaves that are obtuse at apex and truncate or attenute at base occur independent of the size and shape of leaves, whereas, leaves which are cuspidate at apex are invariably cuneate at their base.

Analysis to find out a resemblence among specimens collected from different parts of the State (Fig. *5.2)* showed that populations of the species from following areas resemble at least In *50%* of their leaf characters.

i. Aryankavu, Mukkali, Tholpetty, Thenmala, Kannoth and Sultan's Battery.

ii. Achenkovil, Tholpetty and Vazhani.

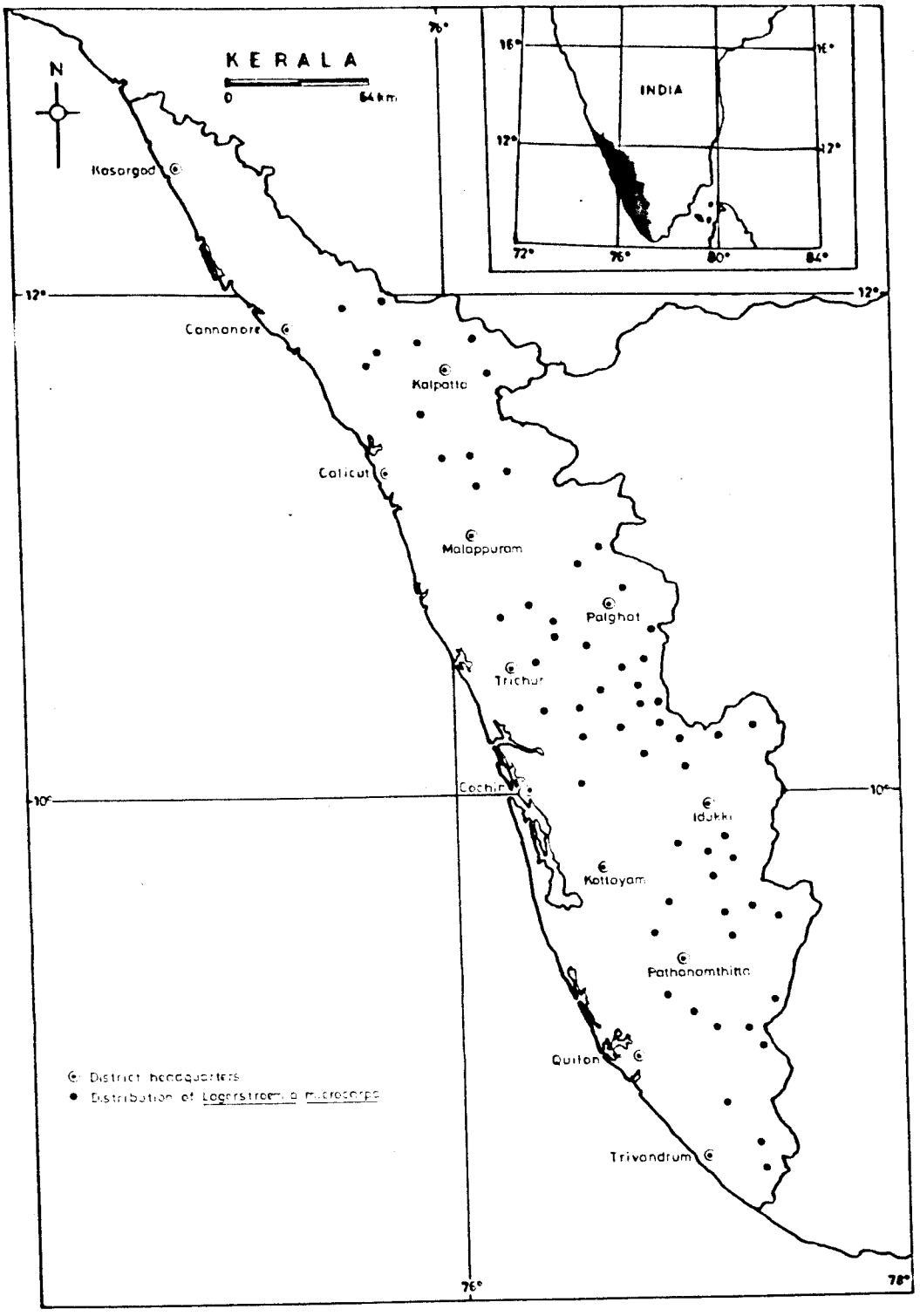


Fig.4 Distribution map of *L. microcarpa* in Kerala.

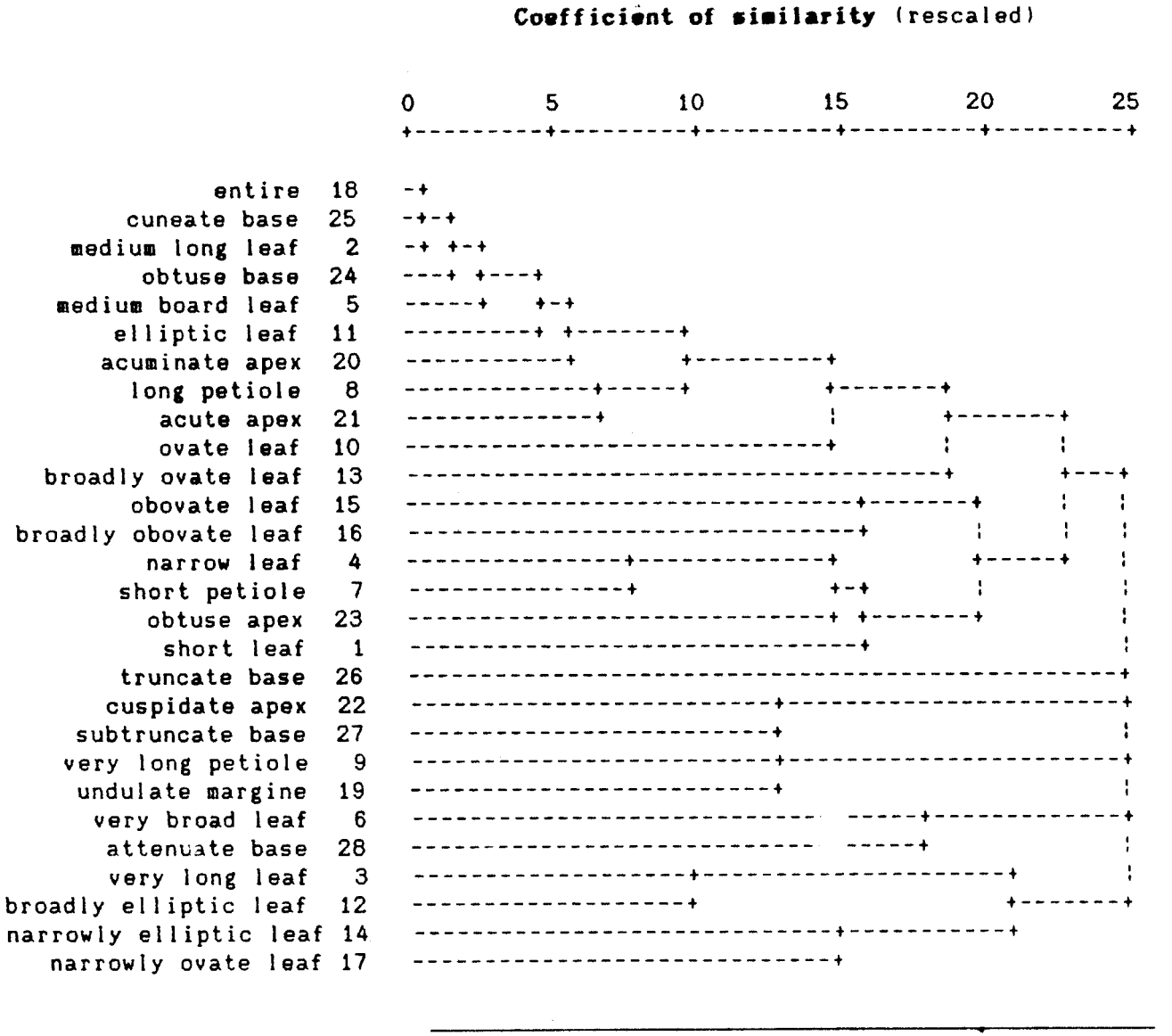


Fig. 5.1 Phenogram based on coefficient of Jaccard of leaf characters of **L. microcarpa** from different locations in Kerala

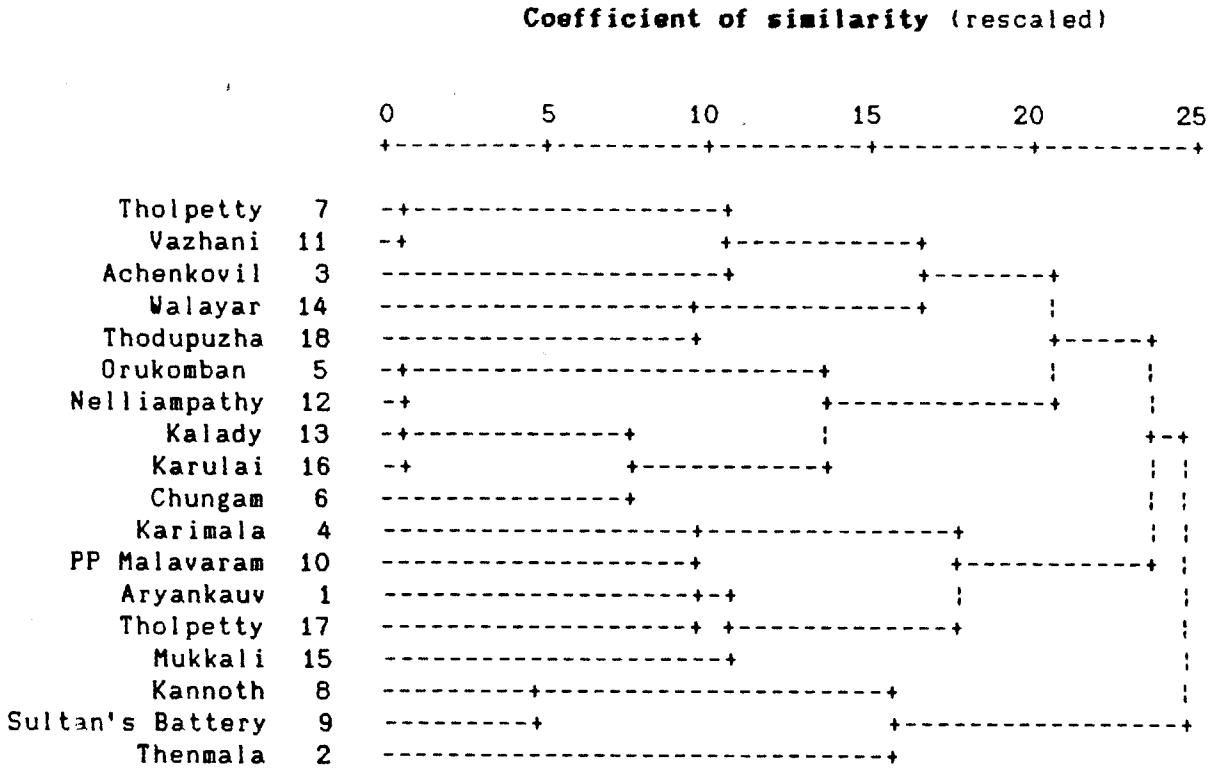


Fig. 5.2 Phenogram based on coefficient of Jaccard of specimens of **L. microcarpa** from different locations in Kerala.

iii.Karimala and P P Malavaram.

iv. Orukombam, Chungam, Nelliampathy and Kalady.

v. Karulai, Walayar and Thodupuzha.

Among the **18** specimens, samples with maximum length **(12.5** cm) and maximum breadth **(6** cm) for leaves were those from Kannoth Range in Wynad Division. Specimens with minimum leaf length **(4** cm) were recorded from Nelliampathy and those with minimum breadth **(2.1** cm) and minimum petiole length **(0.3** cm) were those from Kalady Range in Malayattoor Division. Petioles with maximum length **(1.10** cm) were seen in the leaves of specimens collected from Achenkovil and PP Maravaram ranges in the Thenmala and Calicut Forest Division, respectively.

7.1.10. Specimens examined

Kannoth, Malabar District, **8.112.1913,** C.A. Barber **9512 (MH);** Kolayad, Kannoth Range, Wynad Division, **21.6.1988,** K.K.N. Nair **6354** (KFRI); Chzndansthodu**,** Cannanore, **3.11.1965,** V.S. Ramachandran ***s.n.*** **(MH); Sul**tan's Battery, Wynad Division, **22.6.1988,** K.K.N. Nair **6356** (KFRI); Tholpetty forest, Cannanore, **21.6.1988, V.S.** Ramachandran **52238 (MH);** Tholpetty Range, Wynad Division, **21.6.1988,** K.K.N. Nair **6447** (KFRI); Begur RF, Cannanore District, **23.6.1979, V.S.** Ramachandran **62742 (MH);** Pavagada, Calicut Distict **12.5.1965, J.L.** Ellis **24068 (MH);** Kuttiyadi submergible area, Calicut Division, **24.6. 1965,** B.D. Naithani **24187 (MH);** . Karulai Range, Nilambur Division, **16.6.1989,** K.K.N. Nair **6508** (KFRI); Karimala Range, Parambikulam Division, **19.5.1988,** K.K.N. Nair **6340** (KFRI); Chungam Range, Parambikulam Division, **19.5.1988,** K.K.N. Nair **6343** (KFRI); Walayar RF, Palghat Division, **13.6.1989,** K.K.N. Nair 6397

(KFRI); Mukkali to Panthanthodu , Mannarghat Range, Palghat Division, 14.6.1989, K.K.N. Nair, 6501 (KFRI); Panthanthodo, Palghat Division, 18. 12. 1969, E. Vajravelu 27811 (MH); Chindaki forest, Palghat District, 1.6.1966, E. Vajravelu 27754 (MH); Ommala, Palghat District, 29.4.1987, E. Vajravelu 49823 (MH); Vazhani dam catchmment, Trichur Division, 11.4.1989, K.K.N. Nair 6379 (KFRI); Pullankandam RF, Trichur Division, 11.4.1977, K Ramamurthy 49301 (MH); Machand mala RF, Trichur Division, 6.4.1977, K. Ramamurthy 49244 (MH); Nelliampathy Range, Nemmara Division, 6.6.1989, K.K.N Nair 6387 (KFRI); Poringal, Vazhachal Division, 17.8.1990, K.K.N. Nair 5526 (KFRI); Vazhachal, Trichur District, 23.9.1982, K. Ramamurthy 74725 (MH); Poringalkuthu, Vazhachal Division, 10.7.1985, K.N. Subramanian 11124 (FRI); Kurisumudi, Kalady Range, Malayattoor Division, 7.6.1989, K.K.N. Nair 6389 (KFRI); Vallakadvu 1965 Eucalypt plantation, Thekkady Division, 15.7.1983, K.N. Subramanian 9484 (FRI); Thenkachi, Idukki District, 24.9.1972, B.D. Sharma 40999 (MH); Pamba to Vandiperiyar, 28.6.1968, D.B. Deb 30466 (MH); Plappilly to Nilakkal, Quilon District, 3.9.1977, N.C. Nair 50863 (MH); Alappady, Achenkcvil Range, Thenmala Division, 30.12.1978, K.K.N. Nair 6309 (KFRI?; Aryankavu Range, Thenmala Division, 29.12.1987, K.K.N. Nair 6302 (KFRI); Near Katlappara, Thenmala Range, Thenmala Division, 29.12.1987, Y.K.N. Nair 6305 (KFRI); Travancore, June 1938, Herb. Wight 971 MH); Ammangada, Travancore, 14.10.1928, V. Narayanaswami 7734.4 (MH); Forests of Neyyar dam, Trivandrum Division, 17.4.1973, J. Joseph 44125 (MH).

7.2. ECOLOGY

Details on the ecology of *L. microcarps* are as follows.

Associations:	Xylia–Terminalia
Parent tree sources:	Good
Parent tree distribution:	Frequent
Biotic interference:	Partially disturbed
Regeneration status:	Two
Young seedlings:	
(upto 30 cm ht.)	Sufficient numbers
Older seedlings:	Limited
(more than 1 m ht.)	
Mortality rate:	Medium
Remarks:	Percentage germination of seeds are low; found through out in all zones.

7.3. UTILIZATION ASPECTS

7.3.1. Bole characteristics

Trees of *L. microcarps* grow upto a height of 30 m and a diameter of 80 cm. The main bole is straight and branch-free for most part in most semievergreen localities and upto 15 m long straight bole can be obtained (Fig. 7). In more open areas, branching or forking at a lower level are prevalent. Fluting is not found and buttresses not very conspicuous. Defects are comparatively limited in this species except for the bumps on main bole and branches. In almost all localities surveyed trees

were sound without any indication of irregularity of grain.

7.3.2. Wood properties

Basic density of wood ranged from 528.0 kg/m^3 to 657.8 kg/m^3 between various regions. The average for different locations was 593.0 kg/m^3. Ranni and Konni of Southern Kerala showed slightly lower density as compared to rest of the regions which had almost equal values. The results of analysis of variance are given in Table 1, which show that the difference between the regions as well as the localities is statistically non-significant. Table 1 also shows that the difference in heartwood proportion is not significant. A high degree of positive correlation (R = 0.8820) was observed between heartwood proportion and stem diameter.

Table 1. ANOVA of basic density and heartwood percentage of *L. microcarpa* between different regions and localities in Kerala

Source of variation	Basic density			Heartwood percentage		
	DF	Mean square	F-Value	DF	Mean square	F-Value
Region	2	1797.307	1.637(ns)	2	14.981	0.261(ns)
Locality	2	1943.155	1.770(ns)	2	43.831	0.763(ns)
Residual	21	1097.964		17	57.447	
Total	25	1222.633		21	52.732	

ns = non significant

7.3.3. Wood structure

Growth rings are distinct as the wood is semi-ring porous.

Vessels commonly in singles but occasionally in short radial multiples of 2 to *5*, clusters rare; vessel perforation simple and pitting alternate; vessel pits occasionally coalesced to appear as parallel horizontal furrows, pits to parenchyma and ray cells grouped; heartwocd vessels plugged by tyloses; the latter of two types, thin-walled and thick-walled.

Parenchyma abundant, ranging from aliform confluent to paratracheal banded; parenchyma delimiting growth rings also present in the earlywood, portions of parenchyma cells subdivided into chambers enclosing rhomboidal crystals; fusiform parenchyma absent; scanty extractives present as globules in heartwood parenchyma.

Rays closely spaced, uniseriate, biseriate rays extremely rare, homogeneous and upto 20 cells high, ray cells in the heartwood containing abundant extractives.

Fibres thin- to thick-walled from earlywood to latewood, septate, portions of fibres transversely subdivided into crystal1iferous chambers.

7.3.4. Relationship between ring width and other anatomical characteristics

Table 6 indicates the relationship between width of the growth ring and other anatomical characteristics. The ring width is negatively correlated with vessel frequency (number of vessels/mm^2), vessel cross sectional area, proportion of parenchyma and rays, and positively correlated with fibre proportion. This indicates that when the growth ring width

Table 6. Correlation between ring width and other anatomical parameters in *L. microcarpa* wood

	Ring width	Vessel frequency	Vessel area %	Parenchyma %	fibre %	Rays %
Ring width	1.0000					
Vessel frequency	-0.3810*	1.0000				
Vessel area X	-0.4856**	0.1004	1.0000			
Parenchyma %	-0.3376	0.2052	-0.1297	1.0000		
fibre X	0.5275**	-0.1992	-0.7237**	-0.4939**	1.0000	
Rays %	-0.0063	-0.0447	0.1003	-0.1370	-0.2052	1,0000

* Significant tt P = 0.01 level; ** Significant tt P = 0.001 level

increases the proportion of vessels (voids) and parenchyma (soft tissue) decreases with corresponding increase in proportion of fibres. There is a significant negative corelation between fibre proportion on one hand, and vessel and parenchyma proportion on the other. This further strengthens the above relationship that the fibre proportion on one hand and the vessel and parenchyma proportion on the other, are mutually complementary. Increase in vessel area is not accompanied by a corresponding increase in the vessel frequency as indicated by the poor correlation between the two. Similarly, the correlation between the vessel and parenchyma proportions is weak and negative.

7.4. SILVICULTURE AND PLANTATION TRIALS

7.4.1. Seed collection

Ripened capsules were available from January to May at Nilambur and seeds collected during February and March gave maximum germination percentage. The ripe capsules were obtained from trees before they dehisce and fall off. The capsules were filled loosely in cloth bags and sundried. The capsules broke open to release of minute winged seeds which were separated and cleaned by winnowing. It was found that the cleaned seeds could be stored in gunny bags for about 6 months without loss of viability.

7.4.2. Seed weight

About **2,63,000** seeds weighed one kilogram. Reports from Maharashtra, Tamil Nadu and Karnataka show **2,68,082** (Sengupta-**1937) 1,95,380** and **2,67,490** (FRX, **1984)** seeds per kg, respectively.

7.4.3. Germination capacity

Very low germination of 2–20% is reported (FRI, 1984) for this species. In the present study, the percentage germination was recorded as 5-11% for both fresh and stored (for 6 months) seeds. Seeds stored beyond 6 months showed marked decline in germination.

7.4.4. Nursery technique

Not less than 300 gm seeds is required for a standard nursery bed of 12 m X **1.2 m.** Seeds were sown during February and early March. Germination commenced after 5-7 days and was

over by around **20–25** days. The seedlings were pricked out into polythene bags of **12.5** cm **X 17.5** cm by the middle of April when the average height was around **4–6** cm. Out-planting was done in July and **by** then the seedlings attained an average height of **11–13** cm.

7.4.5. Plantation trials

7.4.5.1. Survival of seedlings

Only pure plantations of the species could be raised (Fig. **8)** as part of the experiment. Percentage of survival of seedlings was 55% which *is* higher than the survival rate of the pure plantations of ***AIbizia*** and *Xylia* (Fig. 6).

7.4.5.2. Height growth

The seedlings registered a height of 82 cm within **12** months which is comparatively higher than height growth of the pure plantations of *X.* ***xylocarpa,*** *P. marsupium* and *A. odoratissima.*

7.4.5.3. Mean annual height increment **(MAHI)**

The species recorded a MAHI of **67** cm in pure plantations and this is again quite high as compared to the above mentioned trees investigated.

7.5. PEST PROBLEMS **AND CONTROL**

7.5.1. Insect pests **in** natural stands

This tree *is* practically free from any serious pest attack in the natural stands. However **10** species of insects causing

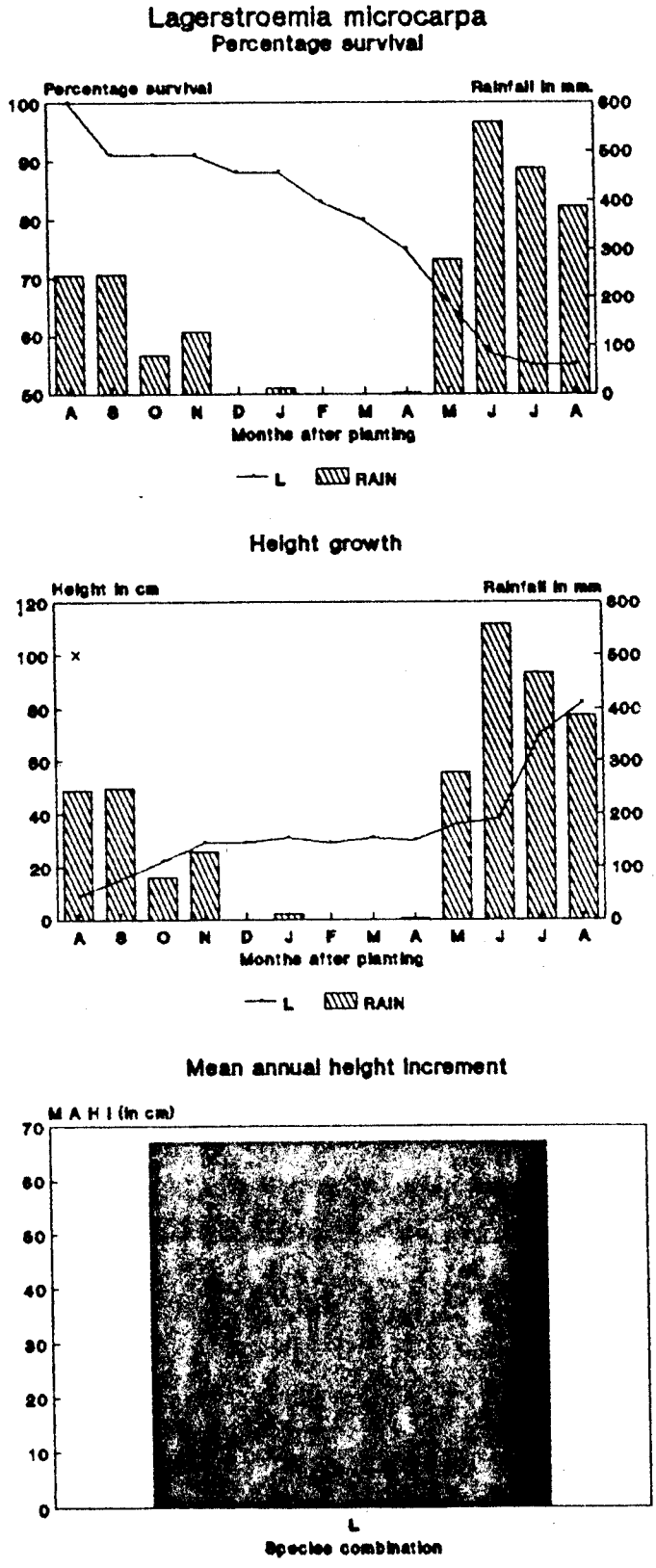


Fig. 6. Survival percentage, height growth and MAHI of seedlings in pure plantations of *L. microcarpa*.

Fig. 7. A clear and straight bole of *L. microcarpa* tree in the natural forest.

Fig. 8. A pure plantation trial of *L. microcarpa* at Nilambur.

occasional minor damage to fresh foliage were recorded during the study (Table 3).

7.5.2. Pest problems trial in plantations

Mild leaf feeding by a few unidentified insects was noticed on 76.6% of the seedlings in pure plantings. In addition to this, build up of a leaf webbing caterpillar was also noticed on some seedlings. The caterpillars characteristically fed beneath a silken web on the leaf surface causing wilting of the foliage and drying up of the terminal bud. There was no mixed plantation trial of *L. microcarpa* and hence oberverations could not be made with regard to insect pests in mixtures with the species.

Table 3. Insects attacking L. *microcarpa* trees in natural stands

Insect species	Place of colln.	Nature of damage
Symitha nolalella Wlk. (Lepidoptera.,Noctuidae)	Vazhachal	Leaf feeding
Eupterote sp. (Lepidoptera, Eupterotidae)	Wadakkanchery	Leaf feeding
Deracetina brettinghami (Baly) (Coleoptera, Chrysomelidae, Gallerucinae)	Palghat	Leaf feeding

contd.....

Insect species	Place of colln.	Nature of damage
D.collina (Weise) (Coleoptera, Chrysomelidae, Gallerucinae)	Palghat	Leaf feeding
Monolepta longitarsis (Jacoby) (Coleoptera, Chrysomelidae, Gallerucinae)	Palghat	Leaf feeding
Diapromorpha turcica (Fb.) (Coleoptera, Chrysomelidae, Clythrinae)	*Peechi*	*Lesf feeding*
Microserica sp. (Scarabaeidae, Melolonthinae)	Vazhachal	Leaf feeding
Cryptocephalus sexsignatus Fb. (Scarabaeidae, Cryptocephalinae)	Vazhachal	Leaf feeding
Unidentified bug (Homoptera, Flattidae)	Vazhachal	Sap sucking
Unidentified mite (Acari)	Mukkali, Peechi, Nilambur	Whitish growth on the leaf surface

7.5.3. Nursery pests

The following insects were recorded (Table 4) as pests of seedlings in the nursery.

Table 4. Insects attacking seedlings of *L. microcsrpa* in nursery

Insect species	Place of colln.	Nature of damage
Phycits sp. (Lepidoptera, Phycitidae)	Nilambur, Peechi	Leaf and shoot webbing
Unidentified caterpillar (Lepidoptera, Tortricidae)	Nilambur, Peechi	Webs the top shoot and leaves
Indomias cretaceus (Faust) (Coleoptera, Curculionidae)	Peechi	Leaf feeding
Unidentified mite (Acari)	Peechi	Cushion-like growth on leaf surface

All the insects recorded in the nursery caused moderate to heavy damage to seedlings. Among them, the unidentified species of mite which caused a fluffy overgrowth on the leaf surface was the most serious pest. Infestation by this species was first noticed in July, 1985 which persisted until November 1990. The peak infestation was noticed in December 1989 (39.49%). The affected seedlings showed stunting and poor growth when out planted. Application of dicofol (Kelthane) at 0.05% a.i. at fortnightly intervals effectively controlled this pest. Attack by the unidentified topshoot webber was also noticed in the nursery. The light reddish coloured caterpillars of this insect webbed the tender leaves and shoots and fed from within. As feeding by this insect caused damage to the terminal shoot,

growth was retarded and about 20% of the seedlings suffered by the attack.

The weevil, *I. cretaceus* attacked the tender foliage of seedlings causing withering of the leaves. Damage by this insect was noticed during the months of August–October.

7.6. DISEASE PROBLEMS AND CONTROL

7.6.1. Seed pathological studies

7.6.1.1. Incubation tests

Table 4 gives the, important seed microflora of *L. microcarpa* which is ccmparatlvely very few in number as compared to other tree species studied. *A. niger*, a common storage fungus showed an RPI of 2.5%, while a bacterium (gram (-)ve) occourred in almost 98% of the seeds showing a brown coloured ooze on them. Those affected seeds failed to germinate or their germination percentage was very low, ranging from 7 to 10%.

Table 4. Relative % incidence of microflora on the seeds of *L. microcarpa*

Microorganisms recorded	Relative % incidence
Aspergillus niger	2.5
Bacteria gram(-)ve)	98.0

7.6.1.2. Effect of fungicides on seed-borne microflora

All the four fungicides tested, viz. carbendazim, carboxin, MEMC and mancozeb were equally effective in controlling the growth of *A. niger*, 1-day and 90 days after treatment. However a gram(-)ve bacterium which affected about 98.0% of seeds in untreated samples, could not be checked by any of the seed dressers tried except for MEMC. In MEMC treated seeds, the RPI of this bacterium was ca. 60.0% (Table *5).*

7.6.2. Diseases in nurseries

7.6.2.1. Damping-off

Post emergence damping-off of seedlings was observed causing ca.35% mortality in Nilambur where the seed beds were raised in wooden trays. However, in the nursery beds at Peechi, this disease was less frequent causing ca. 10% mortality. The disease appeared within two weeks after germination of seeds and is seen in the form of irregular patches usually from the edges of the beds and spreading towards the centre, affecting healthy seedlings under high soil moisture. Water soaked necrotic lesions appeared near the ground level and turn brown and the affected area get shrunken resulting in a constriction causing the toppling of the seedlings. *Rhizoctonia solani* Kuhn anamorph of *Thanatephorus cucumeris* (Frank) Donk (IMI No.326295) has been identified as the causal agent. At Nilambur and Peechi, damping-off pathogen was prevalent during May which was favoured by warm weather, high soil moisture and dark shade. Chemical control experiments undertaken in the laboratory had shown that MEMC (0.0125% a.i.) and carboxin (0.2% a.i.) were highly effective in inhibiting the growth of the mycelium in soil. Field trials also indicated that soil drenching of MEMC (0.0125% a.i.) and carboxin

Table 5. Effect of fungicides on seed microflora of *L. microcarpa*, 1 day and 90 days after treetment

Hicrcorganisms reccrded	RPI in various treatment									
	Control		carbendazim		HEMC		carboxin		mancozeb	
	0	90	0	90	0	90	0	90	0	90
Aspergillus niger	2.5	3.5	-	-	-	-	-	-	-	
Bacterium (gram(-)ve)	98.0	97.0	98.0	94.0	61.0	60.0	98.0	96.0	95.0	94.0

(0.2% a.i.) @ 25-30 litres/standard bed was effective in checking the spread of the disease. However, since this disease is favoured by high soil moisture, seedling density and dense shading, minimising the incidence and spread of the disease can be achieved by reducing the watering schedule and thatching to allow light to fall on the bed. High seedling density may also be avoided.

R. solani is world wide in distribution and known to be pathogenic to a large number of plants (Parmeter, 1970) and in Kerala it has emerged as one of the major seedling pathogens affecting *Ailanthus triphysa* (Florence *et al.*, 1985), *Albizia falcataria* (Sharma and Sankaran, 1985) and *Azadirachta indica* (Sankaran et *al.*, 1986). A few fungicides such as PCNB (Bains and Jhotty, 1983) and carbendazim (Grover and Kataria, 1985) which have been reported to be effective against *R. solani* were not found promising against the damping-off pathogen of *L.*

microcarpa. This could possibly be due to differential behaviour of the isolates of *R. solani* to various fungicides as reported by various workers (Thomas, **1962;** Martin *et al.*, **1984).** This **Is** the first report of *R. solani* causing post emergence damping-off in *L. microcarpa.*

7.6.3. Diseases in natural stands

7.6.3.1. Tar spot

Tar spot caused by *Rhytisma lagerstroemiae* is common on leaves of *L. microcarpa,* usually during the south-west monsoon (June-September) period and continued **till** December. The older leaves were more susceptible to infection and **ca.25%** of the leaves were affected. In some cases, the tar spots are very few and in others almost ca.75% of the lamina is covered **by** the spot. Elevated black spots of various sizes appear on the adaxial surface of the leaves with **a** yellow halo around the spots. Black spot .on leaves caused by *Rhytisma lagerstroemiae* was reported from Tamil Nadu **by** Rabenhorst **as** early as **1878.** This fungus appears to be common on leaves of various species of *Lagerstroemia* (Anonymous, **1950).** Recently *R. lagerstroemiae* as reported from Bombay on *L. microcarpa* and on *Lagerstroemiae* sp. from Mysore. This is the first report of *R. lagerstroemiae* causing tar spot on *L. microcarpa* in Kerala.

8. PTEROCARPUS MARSUPIUM

(Venga)

8.1. BOTANY

8.1.1. Nomenclature

Pterocarpus marsupium **Roxb.** Corom. **Pl. t. 116.1799 & Fl.Indica 3: 234.1832;** Wt. *et* Arn. Prodr. **Fl. Penin.** Indiae Orient. **266.1834;** Bedd. **Fl.** Sylvat. **t.21.1869;** Baker in Hook.f. Fl. Brit. India **2: 239.1876;** Brandis, Indian Trees **240.1906;** Bourd. For. Trees Travancore **120.1908;** Rama Rao, **Fl.** Pl. Travancore **131.1914;** Gamble, **Fl.** Presid. Madras **1:385. 1918;** Rojo, Pterocarpus **58. 1972;** Nair *et* Henry (eds.), **Fl.** Tamilnadu **1:118. 1980;** Matthew, **Fl.** Tamilnadu Carnatic **3(1):445.1983;** Ramach. *et* Nair, **Fl.** Cannanore **152.1988.**

Pterocarpus bilobus Roxb. *ex* G.Don, Gen. Syst. **2: 376.1831-38.**

Type: Not known.

8.1.2. Local names

Venga, Chola-venga, Karinthakara, Malanthakzra.

8.1.3. Botanical description

Semievergreen trees, 10-25m high; bark corked, thick, yellowish-grey; young leaves reddish. Leaves compound, alternate, imparipinnate, 5 to 7 foliate, 9.5-18 cm long; rachis upto 5cm long, glabrous, prolonged beyond the insertion of the upper lateral leaflet; leaflets 5-10.5 x 3.8-6 cm, obovate, broadly obovste, elliptic, broadly elliptic, ovate, broadly ovate or

rarely oblong, entire, coriaceous, glabrous, retuse or obtuse at apex, obtuse, truncate or cuneate at base, with close, prominent, pararallel side-nerves; stipules small, deciduous; petiolules 0.6-1.1 cm long, stout. Inflorescence terminal, fusco-pubescent, paniculate racemes, shorter than the leaves; bracts small, deciduous; bracteoles 2, cauducous. Flowers yellow, scented, upto 1.5 cm across; pedicels short, articulated below the flowers; calyx upto 0.7cm long, campanulate, somewhat curved, brown-pubescent; calyx teeth very short, broadly triangular, the upper two lobes often connate and larger; corolla exserted, upto 1.2 cm long, with crisped margins; petals long-clawed; vexillum upto 1.2 x 0.8 cm, orbicular, prominently nerved; wing petals upto 0.8 cm long, oblique; keel petals upto 1x0.5 cm, oblique, sllghtly connate towards apex; stamens 10 in number, 0.5-0.8 cm long, monadelphous towards base; staminal tube often split along the sides making the stamens isodiadelphous (5+5); pistil upto 1 cm long, shortly stalked; ovary 2 to 6 ovuled; style filiform, incurved, beardless, with the stipe upto 0.5 cm long; stigma capitate. Pods 3.5-5x3 -3.8 cm, suborbicular, winged, stipitate, upto 0.4 cm long, glabrous with veined wings; seeds one or rarely 2, oblong or subreniform; hilum small (Figs. 1 & 2).

8.1.4. Field notes

Densely foliated trees with often fissured bark exuding copious resin which dries into solid blocks. Flowering branches very showy and often visible from a distance. Trees common in and around grasslands, rocky forest fringes and along the sides, of ravines.

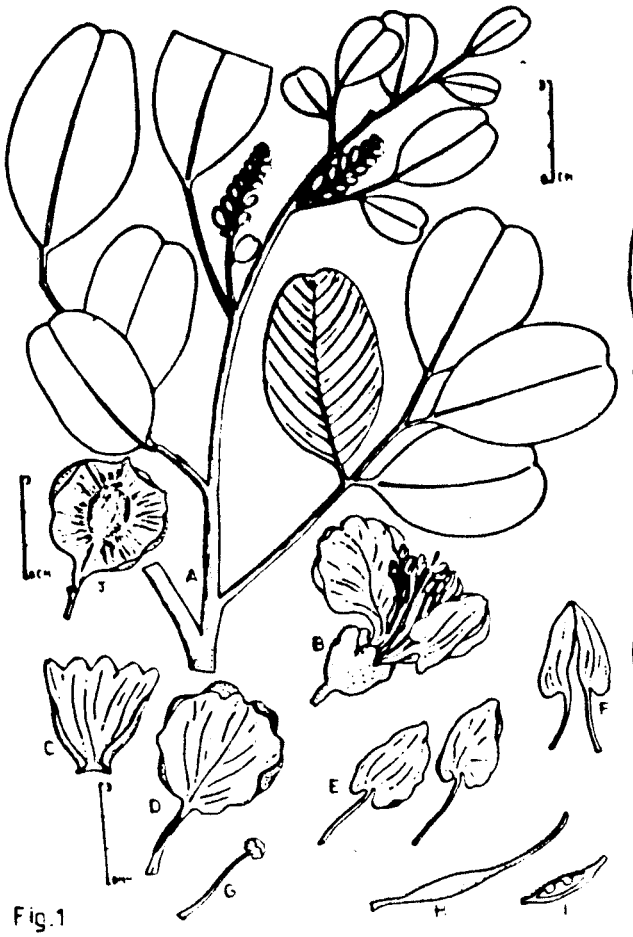


Fig.1

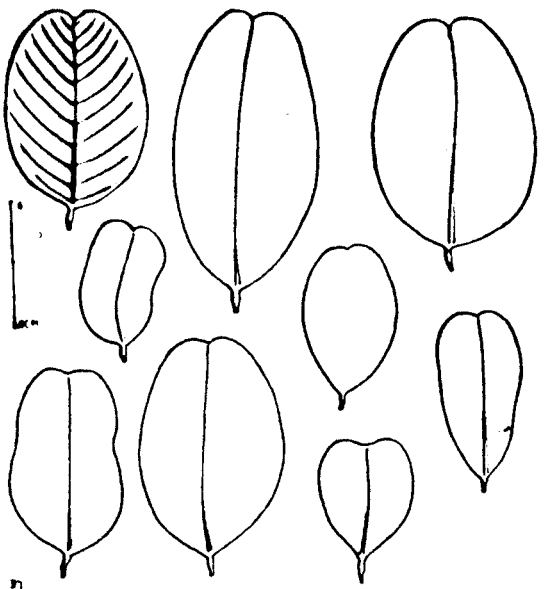


Fig.2

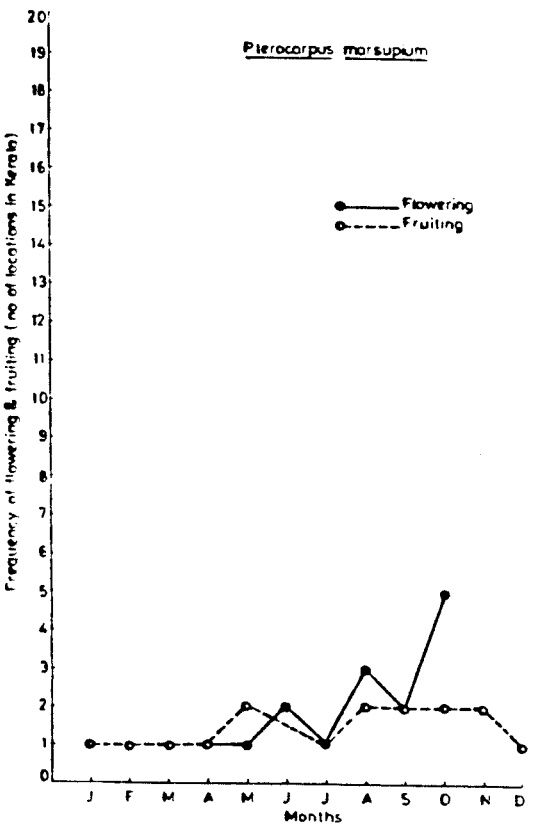


Fig.3

Pterocarpus marsupium

Fig.1 A. Flowering twig, B. Flower, C. Calyx, D. Vexillum, E. Wing petals, F. Keel petals, G. Stamen, H. Pistil, I. L.S. of ovary, J. Fruit.
Fig.2 Leaflet variation diagram.
Fig.3 Phenological graph.

8.1.5. Phenology

Flowers from May to October, maximum during October and occasionally during April and May. Fruits during October to March, but mostly during October–November. As noted in the field, the flowering period of the trees is rather irregular (Fig.3).

8.1.6. World distribution

Peninsular India, Sri Lanka.

8.1.7. Distribution in Kerala

Trivandrum, Thenmala, Punalur, Konni, Ranni, Thekkady, Kottayam, Idukki, Munnar, Kothamangalam, Malayattoor, Trichur, Chalakudy, Vazhachal, Nemmara, Palghat, Parambikulam, Calicut, Nilambur and Wynad Forest Divisions (Fig. 4).

8.1.8. Notes

While enumerating species of *Pterocarpus* in India, Prain (1891) identified two varieties and two forms under each of the variety, namely:

var.a	form 1.	*biloba*
	form 2.	*vera*
var.b	form 3.	*acuta*
	form 4.	*acuminata*

From the taxonomic characters given by Prain (1891), specimens cf the species from Kerala belong to the var.a form *vera* with leaves elliptic or oblong, slightly noutched and obtuse

or rarely subacute at apex. This form is reported only from South India at Nilgiris, Cuncor, North Arcot, Nellore, Carnatic, Cuddapah, Bellary, Kurnool, Kistna and Hysore (Prain, 1891). However, Cooke (Fl. Presid. Bombay 1:428.1901) recognized only one variety under the species, namely var. *acuminata* Prain (J. Asiat. Soc. Bengal 66: 455. 1898) which *is* reported from Konkan and Canara regions of the erstwhile Bombay Presidency. Similarly, Gamble (*l.c.*) described the variety *canus* Gamble which again is based on a specimen of Beddome from the hills of Kistna District in Andhra Pradesh, characterized by branchlets, leaflets beneath, calyx and rachis white-silky pubescent, leaflets much smaller and small flowers in short racemes, as compared to the species proper.

8.1.9. Within **species** variation

Data on leaf variation were gathered from 4 specimens. Being a compound-leaved species, the length of the same was also used in the analysis apart from various characters of the leaflets. For quantitative characters, class intervels identified in the analysis were 9.5 to 12.3 cm (short), 12.3 to 15.1 cm (medium long) and 15.1 to 18 cm (very long) for compound leaf length, 5 to 6.8 cm (short), 6.8 to 8.6 cm (medium long) and 8.6 *to* 10.5 cm (very long) for the length of the leaflets, 3.8 to 4.5 cm (narrow), 4.5 to 5.2 cm (medium broad) and 5.2 to 6 cm (very broad) for breadth of leaflets and 0.6 to 0.7 cm (short), 0.7 to 0.9 cm (medium long) and 0.9 to 1.1 cm (very long) for petiolule length. Along with the qualitative characters, there were 25 such character variants used in the analysis.

In the cluster analysis *to* find out the coincidence of different characters (Fig. 5.1) that showed variation, it was

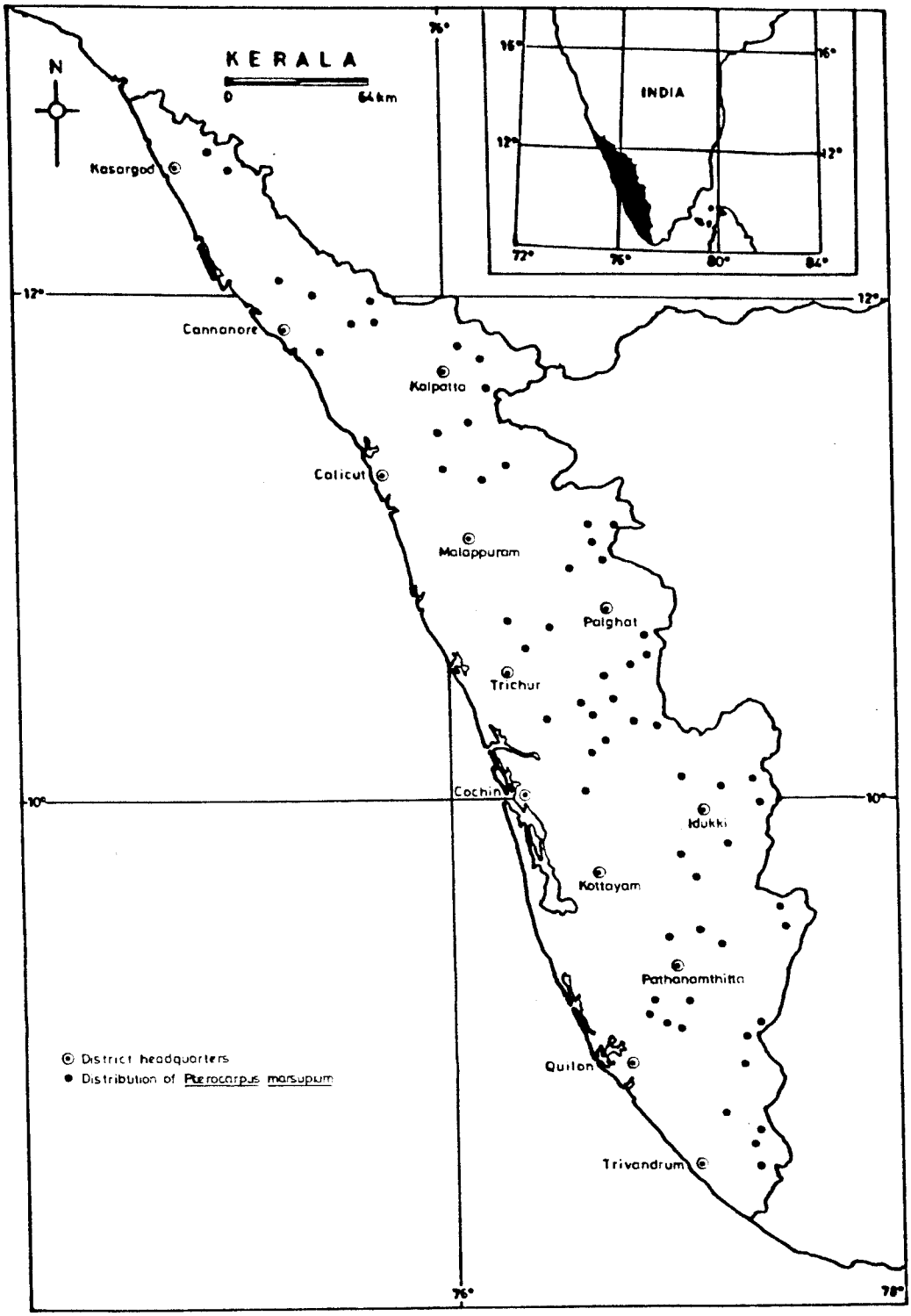


Fig.4 Distribution map of *P. marsupium* in Kerala

observed that medium long compound leaves do not occur in relation to any other character. But, short compound leaves posess broadly-elliptic leaflets which are obtuse at apex and cuneate at base. Similarly, very long compound leaves with very long, very broad and very long petiolules for individual leaflets are obovate or elliptic in shape and entire, retuse at apex and obtuse at base. Another cluster identified in the analysis showed that short and medium long leaflets are normal or medium broad with short or medium long petiolule and are broadly-obovate in shape with a truncate base.

In the cluster analysis (Fig. 5.2) to derive resemblence among specimens collected from different parts of the State, the following conclusions could be arrived at. Specimens from Paruthippilly Range in Trivandrum Division and those from Ranni Range in Ranni Division show resemblence at least in 50% of their characters, whereas those from Rajakad and Charpa ranges stood isolated showing no resemblence, either among themselves or to those from Paruthippilly or Ranni.

In general, compound leaves with maximum length (18 cm) were seen in specimens from Charpa Range in Vazhachal Division and those with minimum length (3.5 cm) were collected from Paruthippilly Range in Trivandrum Division. With regard to leaflet size, those with maximum length (10.5 cm) were seen in specimens from Rajakad in Munnar Division and Charpa in Vazhachal Division and those with minimum length (5 cm) were seen in the materials collected from Paruthippilly Range in Trivandrum Division. Broadest leaflets (6 cm) were characteristic of Paruthippilly (Trivandrum Division) collections, eventhcugh specimens with shortest leaflet also were reported from there. Narrowest (3.8 cm) leaflets amcng all samples analysed was from

Rajakad wherefrom those with maximum length were also reported. Petiolules were the shortest (0.6 cm) in specimens from Ranni whereas it was the longest in those samples from Rajakad in Munnsr Division.

8.1.10. Specimens **examined**

Beemanadi, Kasaragod District, **27.9.1982,** R. Ansari **74351 (MH);** Thaliparamba **farm,** Cannanore, **14.2.1930, C.A.** Barber **8700 (MH);** Chedleth, Wynad, **20.8.1964, J.L.** Ellis **20500** (MH); PP Malavaram Range, Calicut Division, **23.6.1988,** K.K.N. Nair **6362** (KFRI); Walayar, Palghat Division, Aug. **1932, Mimuddin** *s.n.* (FRI **Acc. No. 2168);** Walayar, Palghat Division, Aug. **1932, N.** Velayudhan Nair *s.n.* (FRI Acc. No.2165); Above Eswaran Estate, Palghat Division, **23.4.1977,** E. Vajravelu **49750 (MH);** Attappady RF, Palghat, **12.10.1965, E. Vajravelu 26196 (MH);** Chindaki, Palghat Division, **16.10.1979,** N.C. Nair **64673 (MH);** Poopara, Rajakad, Munnar Division, **17.5.1988,** K.K.N. Nair **6331** (KFRI); Santhanpara, Kottayam District, **21.4.1964,** K.M. Sebastine **18360 (MH);** Thannikudi, Thekkady, Idukki District, **20.10.1972,** B.D. Sharma **42382 (MH);** Rajampara, Ranni Range, Ranni Division, **29.3.1989,** K.K.N. Nair **6367** (KFRI); Kallar, **Travancore, 6.11.1928,** V. Narayanaswamy **77825 (MH);** Mangode, Paruthipilly Range, Trivandrum, **10.7.1978,** K.N. Subramanian **7238 (FRI);** Forests between Vithura and Bonacaud, Trivandrum, **22.8.1975,** J. Joseph **46477 (MH);** Ponmudi, Trivandrum District, **11.6.1976,** C.E. Ridsdale **129 (MH);** Kottur RF, Paruthippilly **Range,** Trivandrum Division, **1.1.1988,** K.K.N. Nair **6311** (KFRI).

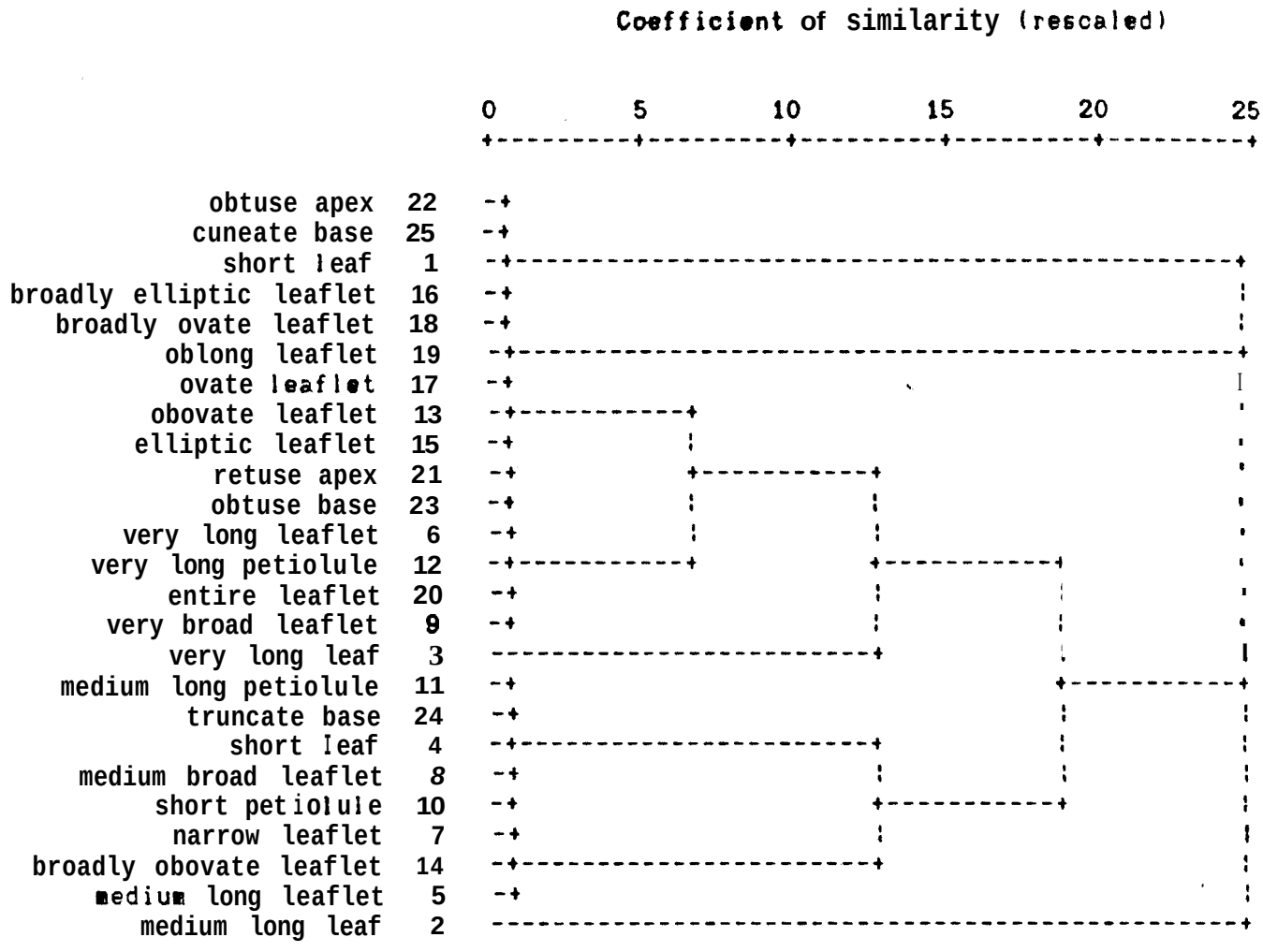


Fig. 5.1 Phenogram based on coefficient of Jaccard of leaf characters of P. marsupium from different locations in Kerala.

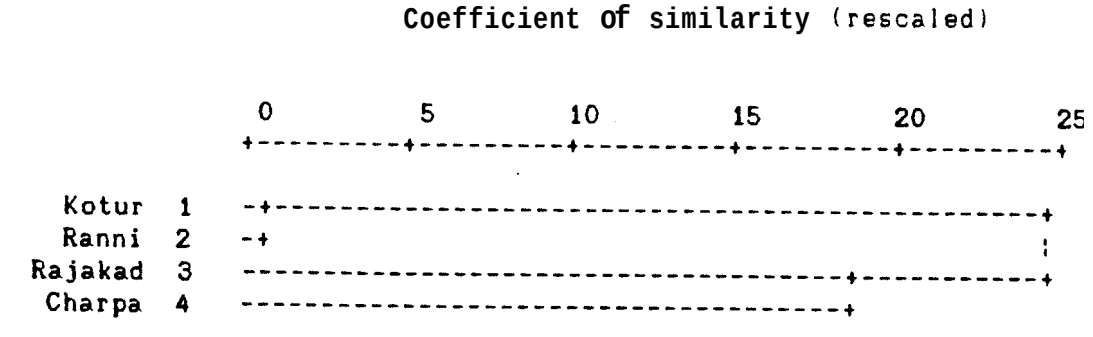


Fig. 5.2 Phenogram based on coefficient of Jaccard of specimens of P. marsupium from different locations in Kerala.

8.2. ECOLOGY

From the natural *P. marsupium* growing areas in Kerala, following details pertaining to to the ecology of the species could be gathered.

Associations:	Cleistanthus - Bridelia
Parent tree sources:	Poor
Parent tree distribution:	Rare
Biotic interference:	Highly disturbed
Regeneration status:	Three
Young seedlings:	
(upto 30 cm ht.)	Insufficient numbers
Older seedlings:	Limited
(31 cm - 1 m ht.)	
Saplings:	
(more than 1 m ht.)	Rare
Mortiality rate:	High
Remarks:	More common in rocky and dry habitat.

8.3. UTILIZATION ASPECTS

8.3.1. Bole characteristics

Mature trees of *P. marsupium* grow to a height of about 25 m and a diameter of over 80 cm. The bole is more or less straight and cylindrical, and lacks flutes or buttresses. The major defects in the stem log are crook, fork, butt scar, decay

cavities and decayed branch stubs. The bole form, in general, Is not very satisfactory in most of the localities although exceptionally, trees with better form were also noticed. Mature trees can usually yield upto 8 m long nearly straight stem log. Wood Is commonly interlocked-grained.

8.3.2. Wood properties

Basic density of wood ranged between 603.1 kg/m^3 to 727.0 kg/m^3 with an average of 668.6 kg/m^3. Wyanad in the Northern Kerala recorded slightly lower basic density as compared to the central and southern regions. However, the difference was not

Table 1. ANOVA of basic density and heartwood percentage of *P. marsupium*, between different regions and localities in Kerala

Source of variation	Basic density			Heartwood percentage		
	DF	Mean square	F-value	DF	Mean square	F-Value
Region	2	720.196	0.844(ns)	2	119.721	2.177(ns)
Locality	2	414.931	0.487(ns)	2	212.275	3.861*
Residual	19	852.840		16	54.986	
Total	23	885.816		20	67.694	

ns = non significant * significant at P = 0.05 level

statistically significant as indicated by the analysis of variance (Table 1). Similarly, the difference between the three localities of Central Kerala was also non-significant. On the other hand, the difference in heartwood percentage between the 3 localities of Central Kerala was significant while the difference between the regions was not significant. The percentage of heartwood was positively correlated with stem diameter (R=0.8484).

8.3.3. Wood structure

Growth rings are indistinct.

Vessels commonly solitary, less commonly in short or long radial multiples of even upto 8 vessels, rarely in double rows and sm groups; vessel elements storied and with simple perforation and alternate pitting; heartwood vessels blocked by gummy deposits.

Axial parenchyma ranging from scanty paratrscheal or vasicentric to banded; bands 2 to 5 cells wide, wavy, continuous or discontinuous; diffuse parenchyma scanty, parenchyma storied, usually subdivided into two or rarely more locules, chambered crystalliferous cells present but not abundant; fusiform parenchyma present; granular extractives present in heartwood cells.

Rays commonly uniseriate, rarely 2-seriate, storied and therefore of uniform height having 5 to 8 cells along the height, homogeneous; crystals absent but extractives present.

Fibres non-septate and thin-walled; the wider portions showing a tendency for storied structure; extractives scanty in fibre lumen.

8.4. SILVICULTURE AND PLANTATION TRIALS

8.4.1. Seed collection

Pods were collected during February -May from the ground or by plucking from the trees. They were then sundried and stored in gunny bags.

8.4.2. Seed weight

About 2,000 fruits weighed 1 kilogram. Earlier, Sengupta (1937) reported that 1620, 1590 and 1940 fruits collected from different localities of Tamil Nadu formed 1 kilogram.

8.4.3. Germination capacity

The germinability of seeds was within the range of 40-97% (FRI, 1983). However, in the present study seeds collected during April gave a germinability of only 27%.

8.4.4. Nursery technique

Pods can be stored upto one year in gunny bags (FRI, 1983). Fruits available during April were sown as pods without extracting the seeds, in standard nursary beds. About 5-6 kg of seeds were required for this. Germination started by the 10th day and was completed in about 35-40 days. Seedlings could be pricked out after 30 days in the nursery bed into polythene bags (22.5 cm X 17.5 cm size). The seedlings were retained in the nursery for about 14 months prior to outplanting during monsoon. Seedlings had attained an average height of 29 cm by that time (Fig. 7).

8.4.5. Plantation trials

8.4.5.1. Survival of seedlings

Mixed plantings gave higher survival percentage in of *P. marsupium.* Seedling survial was better in 25 % mixed plantations of GHPX (92%) and AGHP (90%). A survival of 89% was observed in a 50% mixture of HP. In pure plantations, survival was 76% followed by two 50% mixtures of AP and PX with 69% each (Fig. 6). ANOVA showed no significant difference between the treatments (Table 2).

Table 2. Analysis of variance of survival of seedlings in pure and mixed plantations of *P. marsupium*

Source of variation	DF	MSS	F-value
Treatment	5	171.017	1.8283(ns)
Replication	2	790.321	8.4492**
Residual	10	93.538	
Total	17		

ns = not significant ; ** P = 0.01

8.4.5.2. Height growth

The seedlings showed better height growth in mixed plantations, especially in 25% mixtures. A maximum height of 100 cm was observed in GHPY, mixture and 89 cm in AGHP . In 50% mixtures, the seedlings recorded a maximium height of 80 cm in AP followed by 76 cm in HP and 69 cm in PX combinations. Pure plantations of *P. marsupium* recorded only 65 cm height growth for

the seedlings which was the lowest value for the species.

Analysis of variance (Table 3) showed that performance of the species in pure and mixed plantations were statistically significant at 1% level (fable 2). According to the analysis, height observed in both the 25% mixed plantations were significantly different from the remaining treatments (50% mixed and pure plantations).

Table 3. Analysis of variance of height in seedlings of pure and mixed plantations of *P. marsupium*

Source of variation	DF	MSS	F-value
Treatment	5	0.093	6.2000**
Replication	2	**0.115**	**7.6667****
Residual	**10**	**0.015**	
Total	**17**		

** P = 0.01

8.4.5.1. Mean annual height increment (MAHI)

MAHI also followed a similar trend as height growth with a maximum increment in 25% mixtures of GHPX and AGHP. The increment was 64 cm and 52 cm respectively. MAHI of the species in 50% mixtures were 48 cm in AP, 43 cm in HP and 40 cm in PX combinations. Lowest MAHI was 33 cm and was seen in pure plantations of *P. marsupium* (Fig. 6). ANOVA showed significant difference between treatments at 5% level (Table 4).

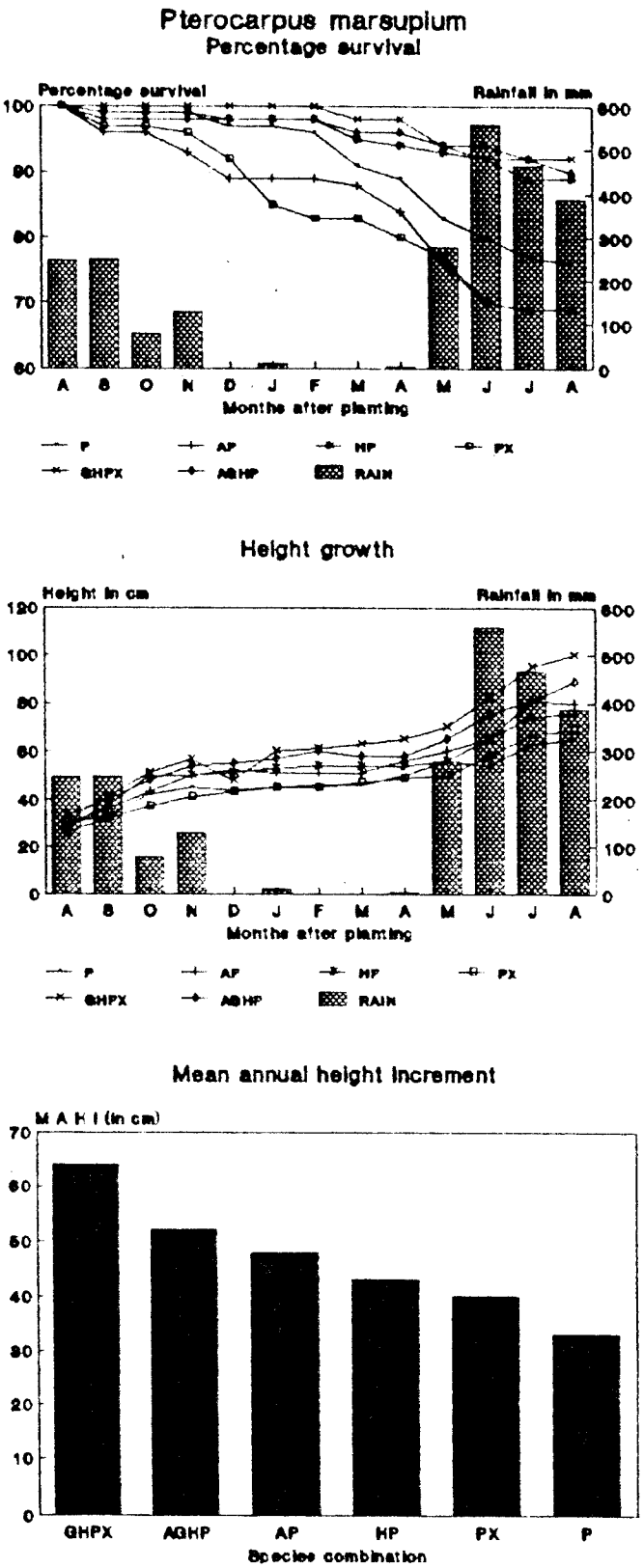


Fig. 6. Survival percentage, height growth and MAHI of seedlings in pure and mixed plantations of *P. marsupium*

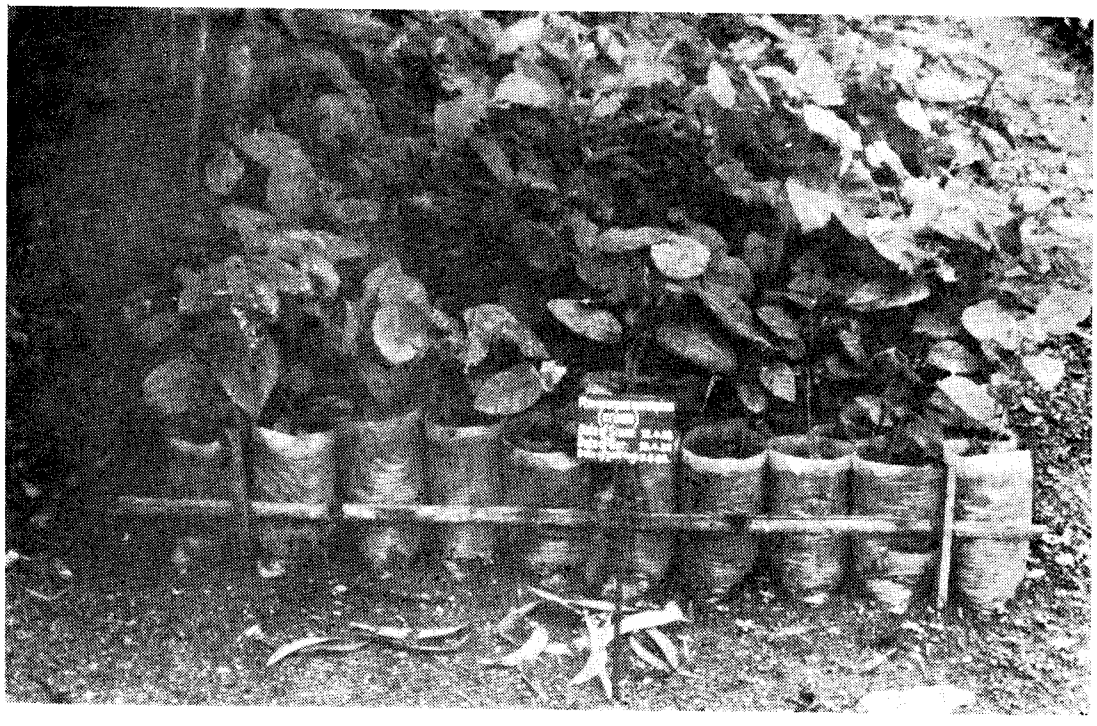


Fig. 7. Seedlings of *P. marsupium* raised for plantation trial.

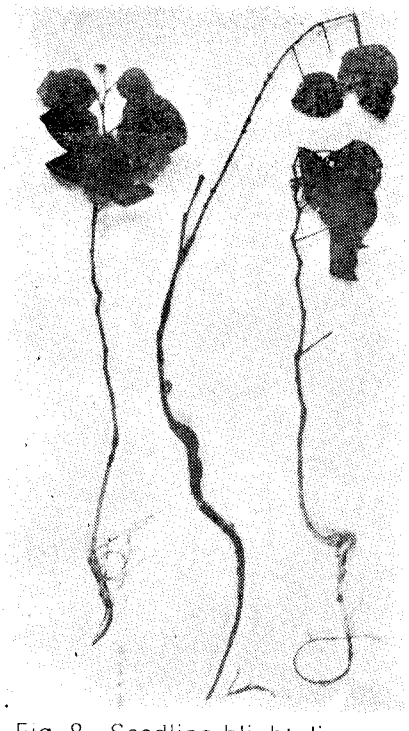


Fig. 8. Seedling blight disease of *P. marsupium*.

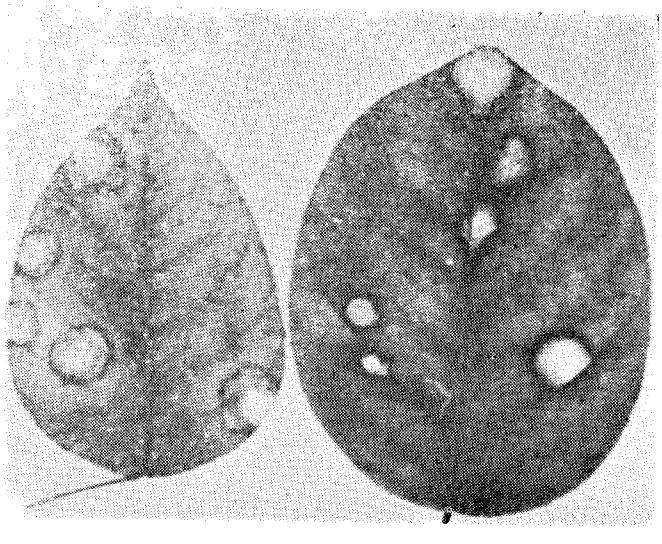


Fig. 9. Leaf-blight disease of the seedlings of *P. marsupium*.

Table 4. Analysis of variance of mean annual height Increment in seedlings of pure and mixed plantations of *P. marsupium*

Source of variance	DF	MSS	F-value
Treatment	5	0.176	4.2927*
Replication	2	0.039	0.9512(ns)
Residual	10	0.041	
Total	17		

* significant at P = 0.05; ns = not significant

8.5. PEST PROBLEMS AND CONTROL

8.5.1. Insect pests in natural stands

Six species of insects were found to attack *P. marsupium* in their natural stands, as listed in Table 5.

All the pests listed above except *Eucosma* sp. caused only mild damage of the tender foliage. The buprestid *Sphenoptera indica* which gnawed the tender leaf tissues caused moderate damage to the foliage of saplings raised at Nilambur. The caterpillers of *Eucosma* sp. tunnelled the stalks of the inflorescence leading to withering and premature shedding of the flower buds.

Table 5. Insect pests in the natural stands of Venga

Insect species	Place of colln.	Nature of damage
Eucosma sp. (Lepidoptera, Eucosmidae)	Munnar	Bores in young inflorescence
Redoa sp. (Lepidoptera, Lymantriidae)	Vazhachal	Leaf feeding
Euproctis sp. (Lepidoptera, Lymantriidse)	Peechi	Leaf feeding
Aetheomorpha? malayana (Baly) (Coleoptera, Gallerucinae, Clythrinae)	Peechi	Leaf feeding
Sphenopters indica Lap. et Gory (Coleoptera, Buprestidae)	Nilambur	Gnaws on the leaf surface
Spanioneura sp. (*quadrimaculata* group) (Hornoptera, Psyllidae)	Vazhani, Nilambur, Peechi	Sap sucking

8.5.2. Pest problems in trial plantations

Leaf feeding and gall formation were the important types of damages to field planted seedlings. Incidence of an unidentified defoliator was high in most of the *mixed plantations* which ranged from 6.25-93.753 (Table 6). Attack by a gall insect was also noticed on 21.87% seedlings in the pure plantations and small scale build up of this insect was noticed in various mixtures as well. Although the intensity of infestation was

moderate on most of the affected plants there were signs of the damage becoming serious in a few seedlings.

Table 6. Percent of incidence defoliator in trial plantations of *P. marsupium*

Combinations with *P. marsupium*	Tree species					Percent infection during *				
	A	P	X	H	G	Mar	Apr	May	Jun	Jui
P	0.00	1.00	0.00	0.00	0.00	37.50	31.25	21.87	61.18	96.87[a]
AP	0.50	0.50	0.00	0.00	0.00	43.75	25.00	45.47	59.37	81.25[b]
PX	0.00	0.50	0.50	0.00	0.00	14.75	21.87	15.62	34.37	87.50[c]
PH	0.00	0.50	0.00	0.50	0.00	37.50	21.47	15.62	84.37	93.75[a]
PHXG	0.00	0.25	0.25	0.25	0.25	56.25	25.00	0.00	50.00	6.25[d]
APHG	0.25	0.25	0.00	0.25	0.25	43.75	9.37	43.75	87.58	87.50[c]

* Figures superscribed by the same letter in the last column are not significantly different at 5% probability level

The gall insect is likely to become a potential pest in **young** plantations, especially in monoculture.

8.5.3. Nursery **pests**

The psyllids were the major pests of seedlings in the nursery (Table **7**). Species of *Spanioneura* caused leaf vein galls and crinkling of the leaves leading to severe stunting of the seedlings. The nature of damage is similar to the one caused by *Arytaina* **sp.** (Kandasamy and Thenmozhi, **1985).** The infestation when first noticed during September **1989,** was **10.8%** which

persisted until November, 1990 when about 42% of the seedlings were affected. Besides *Spanioneura* sp., another unidentified species of psyllid was also noticed to cause serious damage to seedlings and saplings by forming 'pouch galls' on the foliage.

Table 7. Nursery pests of *P. marsupium*

Insect species	Place of colln.	Nature of damage
Indomias hispidulus (Marshall) (Coleoptera, Curculionidae)	Peechi	Feeds on tender foliage
Spanioneura (quadrimaculata group) (Homoptera, Psyllidae)	Peechi	Sap sucking
Unidentified Psyllidae	Nilambur, Peechi	Sap sucking

Both the species of psyllids are considered as major nursery pests. Application of 0.05% a.i. monocrotophos (Nuvacron) at fortnightly intervals was found to give effective control against their attack in the nursery.

The weevil, *I. hispidulus*, caused punctures on the leaves by feeding on the tissue leading to withering of the leaves. Its attack was noticed from July–September when the new leaves appeared.

8.5.4. Seed pests

A species of *Eucosma*, different from the one found boring the flower stalk, was also recorded as a borer in young fruits, eating sway the endosperm of seeds and thus affecting the

viability of the propagules. Observations made at Peechi indicate that about 12.9% of the seeds were damaged by this insect in the field. The infestation started while the fruits were getting ripe. The infested fruits could be recognised from a pin hole type puncture in the centre of the fruits on one side and accumulation of dried exudation at this point. The larvae matured in about 10 days during which period the endosperm was completely eaten up.

8.6. DISEASE PROBLEMS AND CONTROL

8.6.1. Seed pathological studies

8.6.1.1. Incubation tests

Relative percent incidence of seed microflora is presented

Table 8. Spermoplane microorganisms and their relative percent incidence on seeds of *P. marsupium*

Microorganisms recorded	Relative percent incidence
Aspergillus candidus	60.0
A. flavus	100.0
A. niger	100.0
A. ochraceous	70.0
A. versicolor	70.0
Rhizopus sp.	80.0
Actinomycetes	100.0

in Table 8. Most of the spermoplane microorganisms affecting the winged seeds of *P. marsupium* belonged to *Aspergillus* sp. and *Rhizopus* sp. Of them, *A. niger*, *A. flavus* and *Rhizopus* sp. were the prominent ones. In addition, actinomycetes were also recorded with an RPI of 100%. Most of the infection started from the wings and spread to the centre.

8.6.1.2. Effect of fungicides on seed microflora

Carbendazim and HEMC were highly effective in reducing the RPI of spermoplane microflora of *P. marsupium*. *A. niger* was the lonely fungus growing on seeds treated with carbendazim, whereas

Table 9. Effect of fungicides on seed microflora of *P. marsupium*, one day and ninety days after treatment

Hicrcorganisms recorded	Percent incidence in various treatment									
	Contra?		carbendazim		MEMC		carboxin		mancozeb	
	0	90	0	90	0	90	0	90	0	90
A. candidus	60.0	65.0	-		-			-	-	
A. flavus	100.0	100.0	-	-		-	32.0	38.0	51.0	43.0
A. niger	100.0	100.0	60.0	65.0	-	-	48.0	50.0	-	-
A. ochraceous	70.0	69.5	-	-	-	-	-	-	12.0	18.5
A. versicolor	70.0	70.0	-	-	-	-	-	-	-	-
Rhizopus sp.	80.0	70.0		-	51.5	43.5	26.0	25.0	-	
Actinomycetes	100.0	100.0		-		-	-		-	

Rhizopus sp. grew on **MEMC** treated seeds. Mancozeb and carbc-in were not effective and two and three microorganisms grew on treated seeds, respectively (Table 9) . MEMC, which was effective in reducing *Rhizopus* sp. infection in other indigenous tree seeds was not effective in the seeds of ***P. marsupium,*** perhaps due to strainal variation or being a different species. However growth of actinomycetes was inhibited by all the fungicides tested.

8.6.2. Diseases In nurseries

8.6.2.1. Seedling blight

Leaf blight caused by *Sclerotium rolfsii* is a serious disease, widely seen in nurseries. Usually this disease appeared after the onset of monsoon, i.e. June, and become serious in July and August and declines by September-October. Nearly **15%** of the plants were affected. Usually severe leaf blight was followed by stem infection which killed the seedlings. In plants with medium or low levels of infection, affected leaves were defoliated and growth of the plant is affected. The appearance of small circular yellowish brown spots in concentric rings was the initial symptom of the disease. The spots later increased in size due to wet weather conditions to form larger blighted areas in the leaves (Fig. 8). The defoliated leaves thus fall on the ground and by contact with stem cause shoot blight which result in death of seedlings. On the affected leaves and stem, white sclerotial bodies were also seen, which was identified as *Corticium rolfsii* curzi Sclerotial state *Sclerotium rolfsii* Sacc. **(IMI** No.336504).

Out of the fungicides tested in soil method, **TMTD**, carboxin and **MEMC** were effective in all the concentrations tested. However captan and **PCNB** were effective only in higher concentrations of 0.2% a.i. Drenching the beds with **MEMC (0.0125** a.i.) or **TMTD**

(0.2% a.i.) completely controlled the disease and avoided further spread. S. *rolfsii* is a common soil-borne pathogen and is known to infect seedlings of various tree species (Browne, 1968). Leaf blight and stem rot of *Azadirachta indica* (Sankaran *et al.*, 1986), leaf blight of *Bombax ceiba* and *B. insigne* (Florence *et a?.*, 1985), leaf blight of *Gmelina arborea* (Maria Florence and Sankaran 1987), leaf blight of *Pterocarpus santalinus* (Sankaran *et al.*,1984) and leaf spot of teak (Sharma *et al.*, 1984) were the earlier reports of S. *rolfsii* causing leaf blight. Generally, incidence of leaf blight disease was high when seed beds were overcrowded with seedlings, and high soil moisture due to excessive watering and thick shade. If proper nursery practices together with appropriate fungicidal treatments are follcwed, this disease can be kept under check.

8.6.2.2. Leaf spat

This disease was observed in one of the nurseries of State Forest Department maintained at Begur (Wynad Division), during March of 1988. Premature defoliaticn was observed. Nearly 75% of the leaves were affected and shot holes were seen in the case of severe infection. Leaves of all stages were equally susceptible to infection. Small brown necrotic spots 2-3 mm across appeared scattered on the leaflets; sometimes the necrotic tissues were shed leading to the appearance of shot-holes. *Glomerella cingulata* (Stonem) Spauld & Schrenk (IMI No.325768) was isolated and identified to be the causal agent of this disease. Leaf spot of *P. marsupium* caused by G. *cinqulata* is a new disease record. This disease could be evaded by avoiding crowding of seedlings. Eventhough ca. 75% of the leaves were affected, the new flush appearing after the natural leaf shedding

were free from the disease. In case the control measures are necessary, a foliar spray of mancozeb (0.1% a.i.) may be attempted.

8.6.3. Diseases in natural stands

8.6.3.1. Leaf blight

This disease was observed in many trees at Noolpuzha during December, 1988. Almost 50-60% of the leaves were affected and severe blighting of leaves was seen (Fig. 9). However, the disease was not observed in any other area of the State. The affected leaves showed prominent dark brown blighted areas, which sometimes, coalesed to form larger blighted areas. Such affected leaves fall down prematurely. *Glomerella cingulata* (Stinem) Spauld & Schrenk conidial state of *Colletotrichum gloesporioides* (Penz.) Penz & Sacc. (IMI No.336503) was isolated from the blighted tissues and pathogenecity tests were positive. Leaf blight disease of *P. marsupium*, eventhough serious, was observed in only one area at Noolpuzha, and this disease was not seen in other places surveyed, indicating that this disease might have attained serious proportions due to the favourable predisposing factors present at Noolpuzha, which is in the high ranges of Wynad Forest Division. This is a new disease record from *P. marsupium* in Kerala.

8.6.4. Root nodulation studies

Generally, in *P. marsupium*, nodulation was good in Peechi soils, where the pH of soil ranged between 6.0 and 6.2. Uninoculsted seedlings, after 6 weeks, showed an average of 10 nodules/plant, while it was 13/plant for inoculated seedlings. Similarly, it was 10.77 and 13.5/plant for uninoculated and

Table 10. Performance of *P. marsupium* with and without *Rhizobium* inoculation

Growth parameters	Inoculated		Uninoculated	
	6 weeks after treartment	4 months after treartment	6 weeks after treatment	4months after treatment
Shoot length (in mm)	124.0	203.85	**85.0**	172.5
Root length (in mm)	145.0	261.77	100.0	210.15
Average no. of nodules	15.0	13.5	10.0	**10.77**
Biomass (in gm)				
Fresh weight	**1.70**	10.53	**0.57**	5.14
Dry weight	0.33	2.85	0.10	**1.85**

inoculated seedlings, respectively, four months after inoculation. Biomass was also more in inoculated seedlings. Compared to uninoculated seedlings noculated seedlings fared better indicating that *Rhizobium* pelleting of seeds is effective in increasing the number of nodules and biomass (Table 10).

9. XYLIA XYLOCARPA

(Irul, Irumullu)

9.1. BOTANY

9.1.1. Nomenclature

Xylia xylocarpa (Roxb.) Theob. in Mason Burma ed. Theob. **2: 541. 1883** & in **Taub.** Bot. Centralbl. **47: 395. 1891** & in Engl. *et* Prantl, Das Pflanzenr. 3(3): **122. 1903**; Gamble, **Fl. Presid.** Madras **1: 417.1918**; Benn. *et* Bahadur, Indian For. **104: 621-624. 1978**; Mabberley, Taxon **24: 155. 1985**; **Ramach.** *et* Nair, Fl. Cannanore **172. 1983.**

Mimosa xylocarpa **Roxb.** Corom. Pl. **100. 1798** & Fl. Indica **2: 543. 1832.**

Inga xylocarpa DC. Prodr. **2: 439. 1825**; Wt. *et* Arn. Prodr. Fl. Penin. Indiae Orient. **1: 269. 1834.**

Xylia dolabriformis Benth. in Hock. **J.** Bot. **4: 417. 1844** *(nom. illeg.)*; Bedd. **Fl. Sylvat. t. 186. 1869-74**; Baker in Hook. **f.** **Fl. Brit.** India **2: 286. 1878**; Rama Rao, **Fl. Pl.** Travancore **146. 1914**; **Brandis,** Indian Tress **262. 1906**; Bcurd. For. Trees Travancore **134. 1908.**

Type: Not known.

9.1.2. Local names

Irul, Irumulu, Kadamaram, Kada pangal.

9.1.3. Botanical description

Deciduous trees, **10-25** m high; bark rough reddish grey; young

parts tomentose, tender leaves dull brawn. Leaves 5.5 - 23 cm long, bipinnate; pinnae 2, terminal one 2 - 5.5. cm long; rachis with a gland at the apex between the pinnae. Leaflets 2 to 10 pairs, 3.5 - 16.5 cm x 1.8 - 6.7 cm, obovate, narrowly obovate, elliptic, narrowly elliptic, ovate or narrcwly ovate, entire, acute, acuminate or rarely obtuse at apex, cuneate, obtuse or rarely truncate at base, subcoriaceous, glabrous; petiolules 0.2 - 0.5 cm long; stipules small, deciduous; stipels absent. Inflorescence axillary, peduncled, fascicled or racemose, in dense globose heads, 1 - 1.5 cm in diameter; peduncles 5 - 8 cm long, slender, on soft, puberulous branchlets with tender leaves, thickening in fruit. Flowers creamy-white, light yellow or yellowish-white; calyx 0.2 - 0.3 cm long, tubular, campanulate, 5-lobed, valvate; corolla 0.3 to 0.4 cm long; petals valvate, slightly connate at base; stamens 10, free, exserted; filaments slender; anthers crested when young, tipped with a stalked and early decidous gland; pistil 15 cm long; ovary sessile; sytle filiform; stigma minute, terminal; ovules many. Pods 12.5 - 16 x 3.5 - 6.5 cm, woody, oblong-falcate, oblong or broadly-falcate, flat, rusty-tomentose, septate between seeds, finally dehiscent; seeds 4 - 10 per fruit, 0.9 - 1.5 x 0.5 -1 cm, oblong-ellipsoid, smooth, polished, brown (Figs. 1 & 2).

9.1.4. Field notes

Dry deciduous forests , specially in rocky, degreded areas.

9.1.5. Phenology

Flowers from March to May when the trees are mostly deciduous, but rarely during February also, Fruits from May to December, but maximum during June to September. Fruits, after

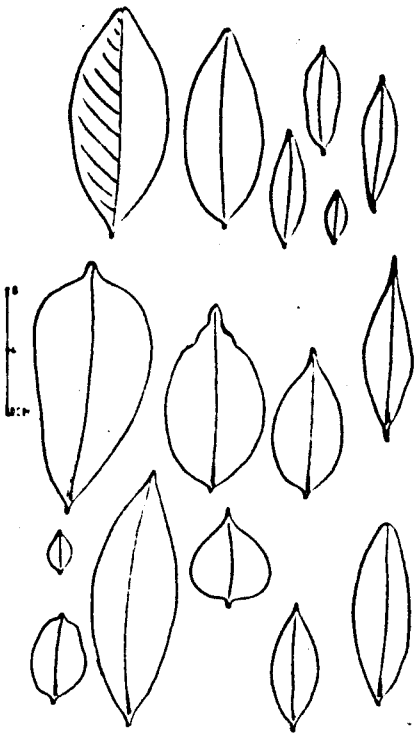


Fig.2

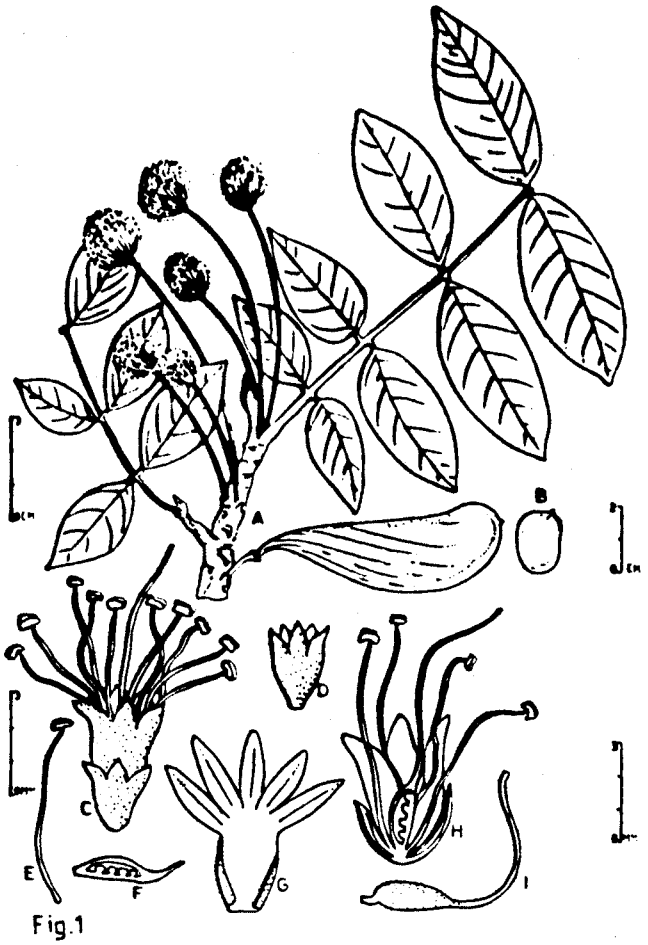


Fig.1

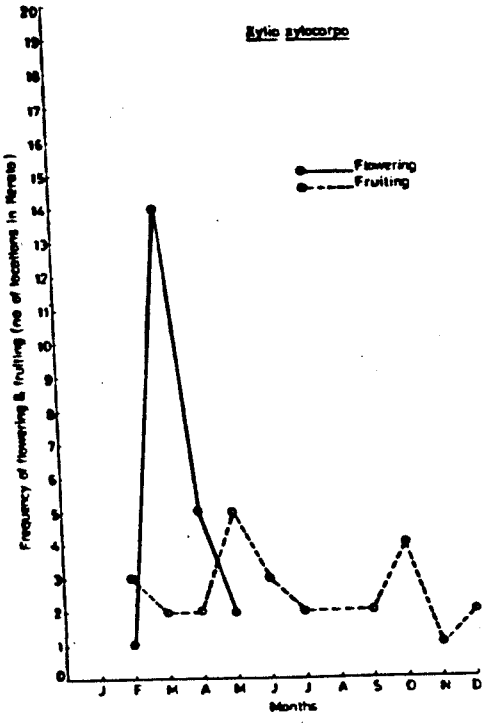


Fig.3

Xylia xylocarpa

Fig.1 A. Flowering twig, B. Seed, C. Flower, D. Calyx, E. Stamen, F. L.S. of pistil, G. Corolla, H. L.S. of flower, I. Pistil
Fig.2 Leaflet variation diagram.
Fig.3 Phenological graph.

the dispersal of seeds, sometimes hang on the trees during the next flowering season (Fig. 3).

9.1.6. World distrlbutlon

Peninsular and Central India, extending upto Orissa.

9.1.7. Distribution in Kerala

Thenmala, Punalur, Konni, Ranni, Thekkady, Kottayam, Munnar, Kothamangalam, Munkulam, Malayattoor, Vazhachal, Chalakudy, Trichur, Nemmara, Palghat, Parambikulam, Calicut, Nilambur and Wynad Forest Divisions (Fig. 4); not recorded from Trivandrum Forest Division.

9.1.8. Notes

In forestry circles, there are two timber types, namely *Irul* and *Pyinkado,* both assaigned to the species *Xylis xylocarpa* (as *X. dolabriformis)* form the Indo-Malayan region. Recently, Bennett and Bahadur (*l.c.)* have identified *Pyinkado,* a common timber of Burma and Indo-Malayan region, as belonging to the species *Xylia kerrii Crsib* et Hutch. (*Kew Bull. 1909:* 357. *1909)* which is not naturally growing in India, eventhough there is a trial plantation of it in Assam in North-East India. Therefore, *Irul* is the timber solely from the species *X. xylocarpa* which is indigenous tc South and Central India and not naturally growing in Burma or Malayan Islands. The two closely allied species can be differentiated by the following characters.

Calyx villous outside; petals oblanceolate, mid-nerve prominent, the other two nerves faint; ovary villous ..... *X. kerrii*

Calyx not villous, more or less pubescent, petals narrowly oblong, conspicuously 3 - 5 narved; ovary more or less pubescent. .....*X. xylocarpa*

9.1.9. Within species variation

Data on variation in length with regard to the imparipinnate compound leaves and also individual leaflets were gathered from 15 specimens collected from different parts of the State. Upto five data variants were noted from them depending upon their availability in each sample. They were compound leaf length, length of individual leaflets, breadth of corresponding leaflets, length of their petiolules, shape of leaflets, nature of leaf margins, and characters of leaf and leaflet base and apex.

Quantitative characters were divided into three class intervals each, i.e., 5.5 to 11.3 cm (short), 11.3 to 17.1 cm (medium long) and 17.1 to 23 cm (very long) for the length of compound leaves, 3.5 to 7.8 cm (short), 7.3 to 12.1 cm (medicm long) and 12.1 to 16.5 cm (very long) for leaflet length, 1.8 to 3.4 cm (narrow), 3.4 to 5 cm (medium broad) and 5 to 6.7 cm (very broad) for leaflet breadth and 0.2 to 0.3 cm (short), 0.3 to 0.4 cm (medium long) and 0.4 to 0.5 cm (very long) for petiolule 1ength.

Cluster diagram (Fig. 5.1) demonstrates the coincidence of characaters in different groups (clusters) in all the 15 OTUs. It may be observed that medium long compound leaves with leaflets showing maximum length, maximum breadth and maximum petiolule length are mostly narrowly elliptic or ovate in shape, entire, acute or acuminate at apex and cuneate or obtuse at base. Likewise, leaflets with minimum or medium length, medium breadth and medium petiolule length form one set and narrowly obovate and

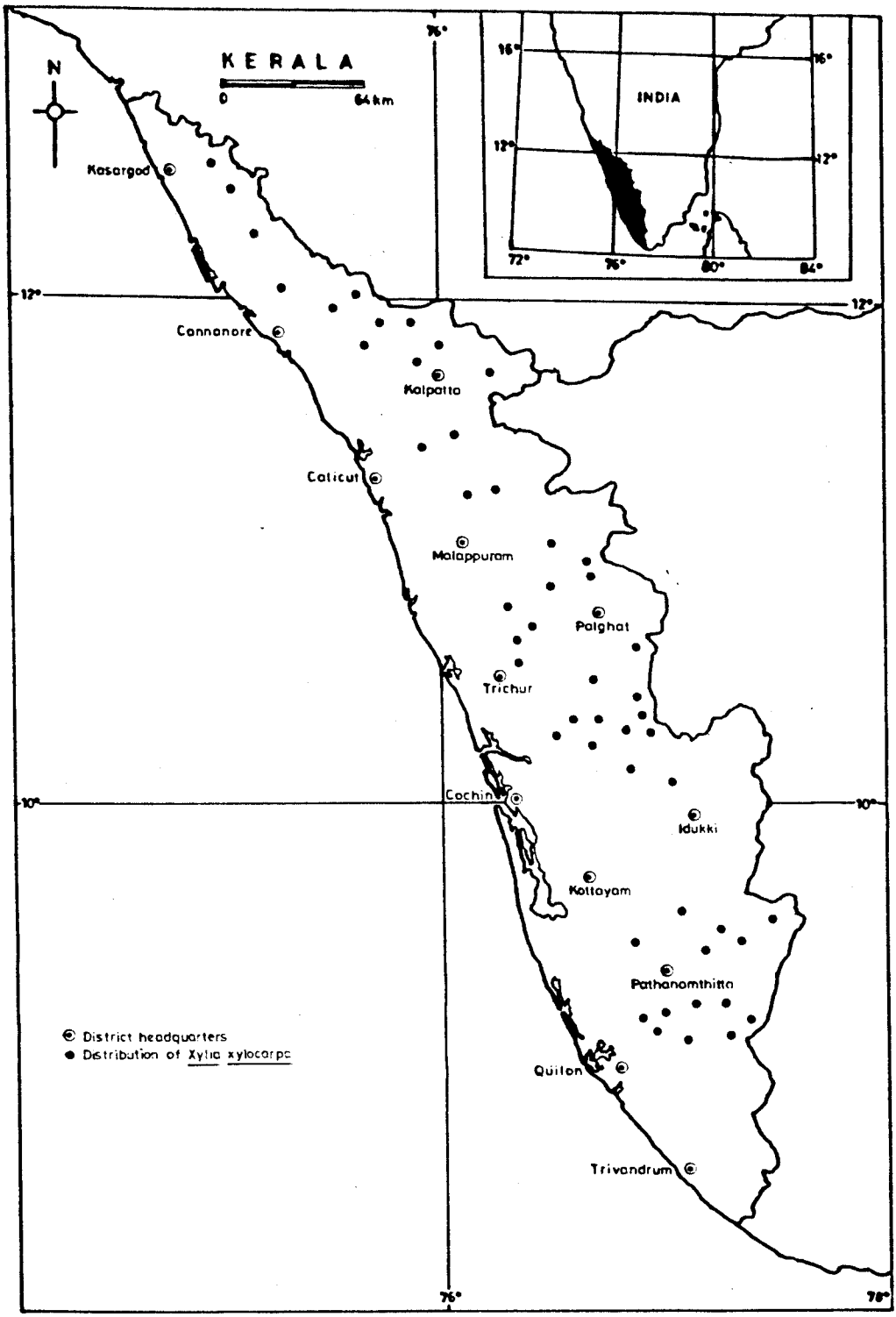
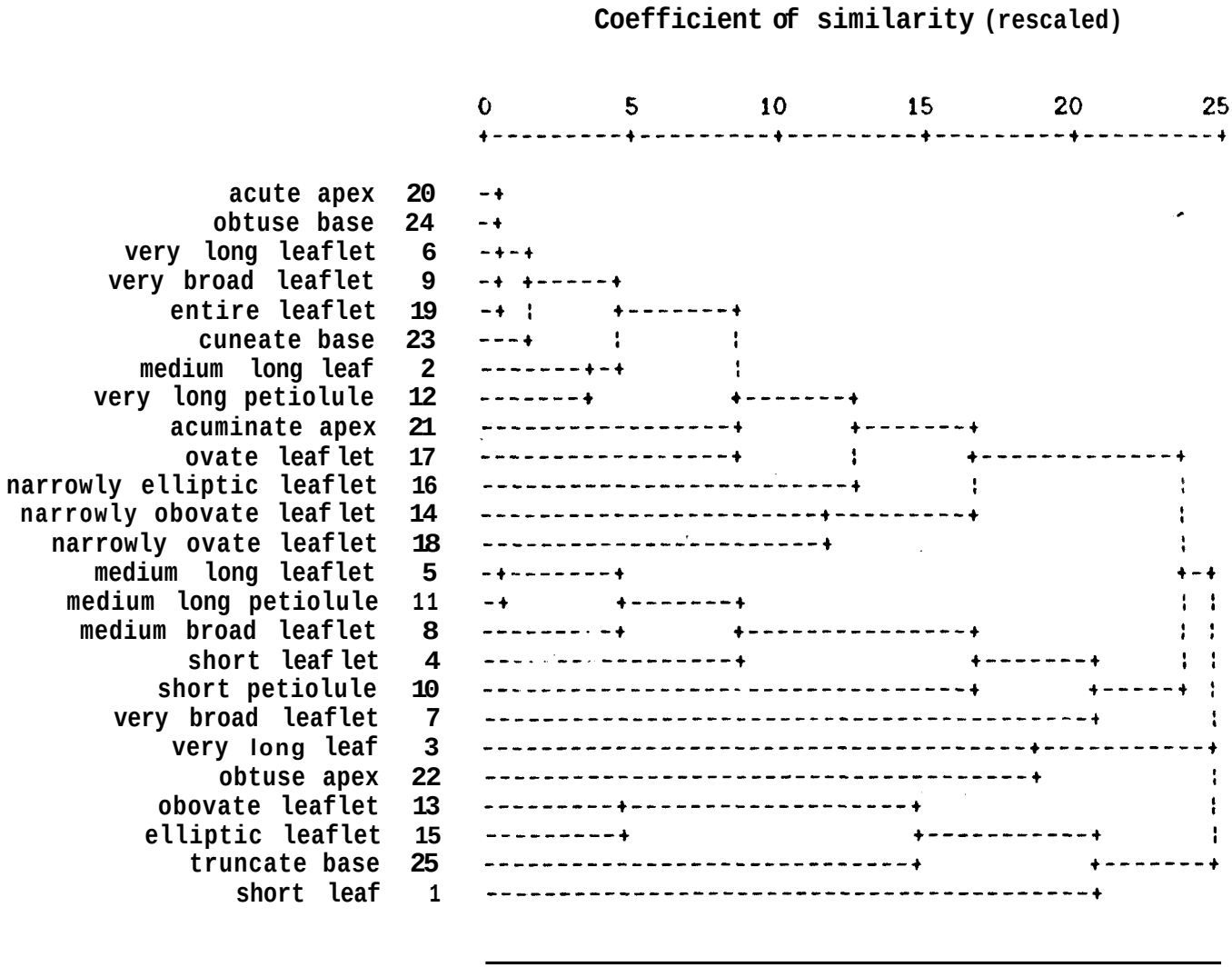


Fig.4 Distribution map of *X xylocarpa* in Kerala.



Fig, 5.1 Phenogram based on coefficient of Jaccard of leaf characters of X. xylocarpa from different locations in Kerala.

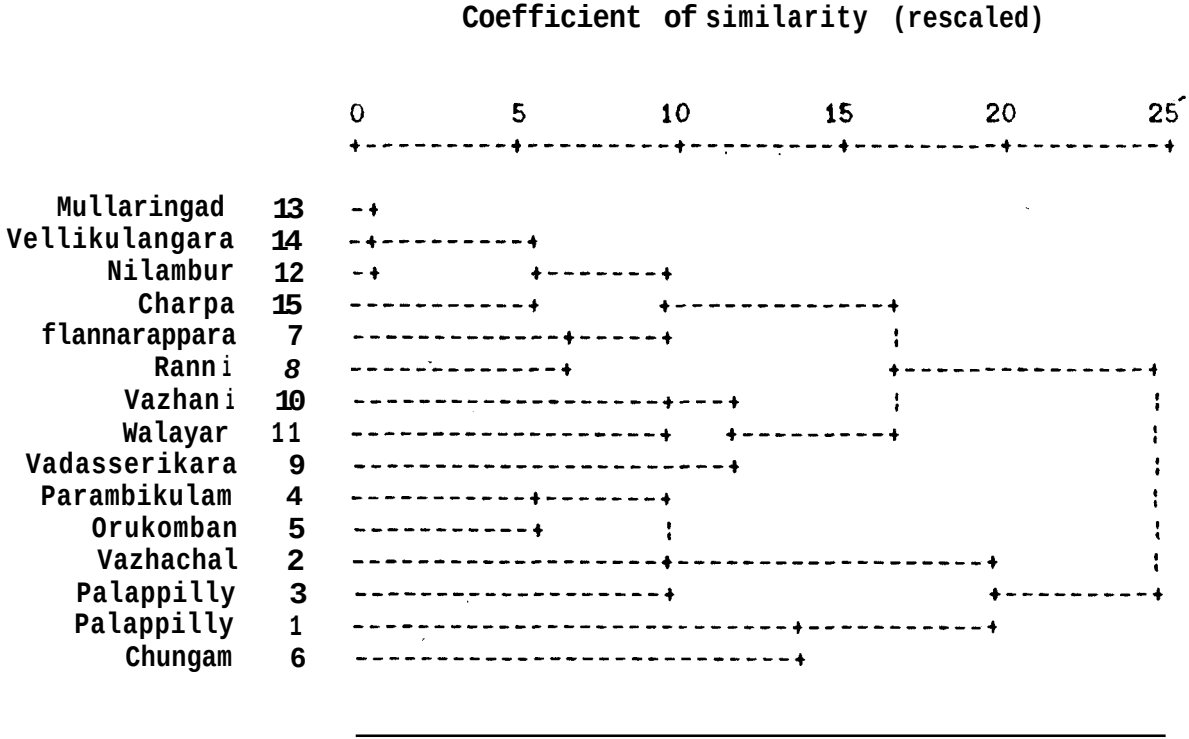


Fig. 5.2 Phenogram based on coefficient of Jaccard of specimens of X. xylocarpa from different Locations in Kerala.

narrowly ovate leaflets form another cluster. Yet another group is with obovate and elliptic leaflets. Compound leaves with minimum and maximum length, leaflets with maximum breadth, least petiolule length and truncate base or obtuse apex occcr independantly and has no correlation with other characters used In the analysis.

In the cluster analysis to assess similarity among specimens from different parts of the State (Fig. **5.2**), specimens from Palappilly, Vazhachal, Prambikulam, Orukomban and Chungam Ranges showed similarity at least in **50%** of their characters. Similarly, specimens from Mannarappare, Ranni, Vadasserikkara, Vazhani, Walayar, Nilambur, Mullaringad, Vellikulangara and Charpa from another set with at least **50%** resemblence.

Among the total number of samples analysed, compound leaves with maximum length **(23** cm) were recorded from Chungam Range in Parambikulam Division and those with very short compound leaves *(5.5* cm) were seen in specimens from Palappilly in Chalakudy Division. Leaflets with maximum length **(16.5** cm) and breadth (6.7 **cm)** were also seen for species collected from Chungam Range of Parambikulam Division. Leaflets shortest in length **(3.5 cm)** were ,collected from Ranni and those with least breadth **(1.8** cm) were characteristic of Mannarappara collection from Konni Division. With regard to petiolule length, in samples from Palappilly, Hannarappara, Ranni and Walayar, they were the least (0.2 cm) and in Vellikulangara (Chalakudy Division) specimens, it was maximum **(0.5** cm).

9.1.10. Specimens examined

Pariyaram, Kasaragode, **14.5.198**, V.J. Nair **73872 (MH)**; Thaliparamba farm, Malabar, **13.2.1913**, C.A. Barbar **8682 (MH)**;

Thaliparamaba, Malabar, **19.5.1906,** C.A. Barbar **7756 (MH);** Thaliparamba farm, Malabar, **12.6.1905,** C.A. Barbar **7363 (MH);** Ambayathodu, Cannanore District, **15.12.1979,** V.S. Ramachandran **65224 (MH);** Parappa, Cannanore, **31.12.1980,** R. Ansari **70083 (MH);** Kannoth RF, Cannanore, **25.2.1979,** V.S. Ramachandran ***s.n.*** **(MH);** Nilambur, Malappuram District, **2.3.1910,** J.L. Ellis **33645 (MH);** KFRI Subcentre Campus, Nilambur, **16.6.1989,** K.K.N. Nair **6510** (KFRI); Nilambur, Malappuram District, **1872,** R.H **Beddome** *s.n.* **(MH);** Dhoni RF, Palghat, **19.7.1963, J.** Joseph **17215** (MH); Walayar RF, Palghat Division, **13.6.1989,** K.K.N. Nair **6395** (KFRI); Chungam Range, Parambikulam Division, **19.5.1988,** K.K.N. Nair **6345** (KFRI); Orukomban Range, Parambikulam, **19.5.1988,** K.K.N. Nair **6338** (KFRI); Parambikulam Range, way to Kuriarkutty, **19.5.1988,** K.K.N. Nair **6337 (KFRI);** Parambikulam submergible ares, **7.4.1963,** K. Ramamurthy **16140** (MH); Parambikulam Range, **19.5.1988,** K.K.N. Nair **6337** (KFRI); Walayar RF, Pullimanpatti, Palghat District, **4.9.1975,** K.N. Subramanian **5274** (FRI); Anamooly, Mukkali slcpes, Palghat, **13.7.1969, E.** Vajravelyu **60560** (MH); Mukkali, Palghat, **27.2.1975, E.** Vajravelu **32070 (MH);** Adiparanda, Palghat, **27.2.1975, E.** Vajravelu **45776** (MH); Vazhani dam site, Machad Range, Trichur, **24.3.1983,** K.N. Subramanian **9293** (FRI); Varhani dam catchment, Trichur Division, **11.4.1989,** K.K.N. Nair **6380** (KFRI); Peechi dam site, Trichur Division, **20.3.1980,** K. Ramamurthy **66224** (MH); Peechi Range, Trichur Division, **18.5.1966,** K.M. Sebastine **27180 (MH);** Machad mals **RF,** Trichur Division, **6.4.1974,** K. Ramamurthy **49238 (MH);** Palappilly, Chalakudy Division, **23.8.1988,** K.K.N. Nair **6313** (KFRI); Kandankuzhi, Chalakudy Division, **18.3.1966,** K. Ramamurthy **15978 (MH);** Athirappilly range, Vazhachal Division, **24.3.1988,** K.K.N. Nair **6320** (KFRI); Athirappilly water falls, Vazhachal Division,

17.3.1982, R. Rajan **73040 (MH);** Vazhachal, Vazhachal Division **24.4..1988,** K.K.N. Nair **6319** (KFRI); Poringal, Vazhachal Division, **17.8.1990,** K.K.N. Nair **6527** (KFRI); Vazhachal to Sholayar, **23.9.1982,** K. Ramamurthy **74753** (MH) ; Kurishumudi, Malayattoor Division, **14.2:1970,** B.V. Shetty **33506 (MH);** Valiyakavu, Ranni Range, **22.2.1983,** K.N.Subramanian ***s.n.*** (FRI); Rajampara, Ranni Range, **29.3.1989,** K.K.N. Nair **6369** (KFRI); way to Sabarimala, Pathanamthitta, Attathodu RF, **26.4.1984, E.** Vajravelu **80605 (MH);** Maniyar, Vadasserikkara Range, Ranni Division **29.3.1939,** K.K.N Nair **6373** (KFRI); Mannarappara, Konni Division, **28.3.1989,** K.K.N. Nair **6366** (KFRI); Kumaramperur RF, Konni Division,, **13.11.1975, M.** Chandrabose **49012 (MH);** Yerur RF, Punalur, **4.3.1982,** K.N. Subramanian & Venkatsubramsnian **8029** (FRI); Kalathurthy, Thenmala Range, Thenmala Division **8.3.1975,** K.N. Subramanian **5079** (FRI); Thenmala Range, Sanyasipara, Thenmala Division, **8.3.1975,** K.N. Subramanian **5079** (FRI).

9.2. ECOLOGY

With regard to the ecology of ***X. xylocarpa,*** following observations could be made in the natural areas of the species in Kerala.

Associations:	Grewia- Lagerstroemia
Parent tree sources:	Good
Biotic interference:	Partially disturbed
Regeneration status:	One

Young seedlings:	Sufficient Nos
(upto 30 cm ht.):	
Older seedlings:	Unlimited
(31 cm to 1 m ht.)	
Saplings:	
(more than 1 m ht.)	Occasional
Mortality rate:	Low
Remarks:	Restricted to lateritic soils.

9.3. UTILIZATION ASPECTS

9.3.1. Bole characteristics

X. xylocarpa trees normally grow upto a height of 25 m and a diameter of 60 cm. The main bole is very rarely straight and cylindrical. Length of straight log from main stem may be normally upto 6 m. The most common defects are branches, decayed branch stubs, fork, fluting and crook. Bole form was comparatively better around certain semievergreen areas (Fig. 7) of Ranni Division of Southern Kerala. Although no external indications are found, the wood is more commonly interlocked-grained.

9.3.2. Wood properties

The range of basic density observed was 680.3 kg/m^3 to 807.1 kg/m^3, the average being 746.6 kg/m^3. Wyanad in the Northern Kerala recorded comparatively lower density. Nevertheless, the difference was not statistically significant (Table 1). Similarly, the difference in density between the

Table 1. ANOVA of basic density and heartwood percentage of *X. xylocarpa* between dlfferent regions and localities in Kerala

Source of variation	Basic density			Heartwood percentage		
	DF	Mean square	F-value	DF	Mean square	F-value
Region	2	4368.515	5.433(ns)	2	234.290	3.812*
Locality	2	193.812	0.241(ns)	2	91.428	1.488(ns)
Residual	19	804.100		16	61.464	
Total	23	1135.104		20	77.124	

ns = non significant *significant at P = 0.05 level

three localities of Central Kerala was not significant. On the other hand, there was significant variation in heartwood proportion between the three regions while the variation between the localities was not appreciable (Table 1). The heartwood percentage showed high positive correlation (R = 0.8065) with stem diameter.

9.3.3. Wood structure

Growth rings are not distinct but 3re detectable in sections.

Solitary vessels as well as short radial multiples equally common, but vessel groups rarely present, heartwood vessels blocked by extractives; perforation simple; pits small and

alternate, coalescent pits appearing fusiforrn shaped, pits to parenchyma not much distinct from intervessel pits in their size and distribution but pits to rays arranged in horizontal rows.

Axial parenchyma vasicentric to aliform confluent, sometimes forming an incomplete sheath around vessels, parenchyma delimiting growth rings present but inconspicuous, diffuse parenchyma scanty, fusiform parenchyma rarely present; crystals present in chambered cells; extractives abundant in parenchyma cells.

Rays 1- to 3-seriate, commonly 2- to 3-seriate, rarely upto 4-seriate; homogeneous, upto 50 cells high especially when fused vertically, commonly upto 35 cells high, non–storied; extractives abundant but crystals not found.

Fibres thick walled, both septate and non–septate types present although said to be non–septate (Pearson and Brown, 1932); extractives scanty in fibre 'lumen.

9.4. SILVICULTURE AND PLANTATION TRIALS

9.4.1. Seed collection

Ripened seeds were available during Janusry–March. The ripe pods were gathered from the ground soon after dehiscence. Seeds collected by the end of February and beginning of March gave maximum germinability. The pods, when sundried, split open releasing the seeds which were dried and stored in gunny bags.

9.4.2. Seed weight

About 4,000 seeds made one kilogram. Sengupta (1937) recorded 3,200 – 3,500 seeds/kg from Tamil Nadu.

9.4.3. Germination capacity

Fresh seeds gave 72% germination without any pretreatment. Germinability of Irul seeds declined after three months of storage. Dent **(1948)** reported that seeds remain viable for at least one year. However, trials in Tamil Nadu indicated that seeds were viable only upto 3 months when stored in gunny bags or airtight tins (FRI, **1983).**

9.4.4. Nursery technique

Soaking the seeds in cold water accelerated germination (FRI, **1983).** Seeds can **be** sown in March on raised nursery beds of **12** m **X 1.2 m** size. About **3–4** kg of seeds were required to cover a standard nursery bed of the above mentioned size. Germination started on the 3rd day and continued upto 8th day and was over within 20 days. When the seedlings attained one month's growth they were pricked out into polythene bags of **17.5** cm **X 12.5** cm size. Outplanting could be done only during the forthcoming season when the seedlings were around **15** months old and about **15** cm in height (Fig **8).**

9.4.5. Plantation trials

9.4.5.1 Survival of seedlings

X. *xylocarpa,* in the pilot plantations of **1988,** showed a survival of **25%** after **24** months of growth in the field. Similarly, the seedlings recorded an average height growth of ***50*** cm during this period (Fig. 6). In the **1989** trials, survival **of** the seedlings was comparatively lower than that of *Grewia, Haldina, Pterocarpus* and *Lagerstremia,* but better than *Albizia.* The survival percentage in pure and mixed plantations showed **only**

minor variation. The species recorded a maximum survival of 63% in a 50% mixed plantation of HX. Performance of the species in pure plantation and in a 25% mixed plantation of GHPX combination was almost similar with 54% survival. Survival of 43-44%, lowest among all the species was observed in the two *50%* combinations of PX and AX respectively (Fig. 6). However, the mean survival values when statistically analysed showed no significant difference between them (Table 2).

Table 2. Analysis of variance of survival in pure and mixed plantations of **X.** *xylocarpa*

Source of variation	DF	MSS	F-Val ue
Treatment	4	93.063	0.8722(ns)
Replication	2	8.771	0.0822(ns)
Residual	8	106.702	
Total	**14**		

ns = not signifcant

9.4.6. Height growth

X. ***xylocarpa*** seedlings showed lowest height growth when compared to all other species in the trial. The variation among pure and mixed plantations were also very little and statistically non-significant (Table 3).

Fig. 6

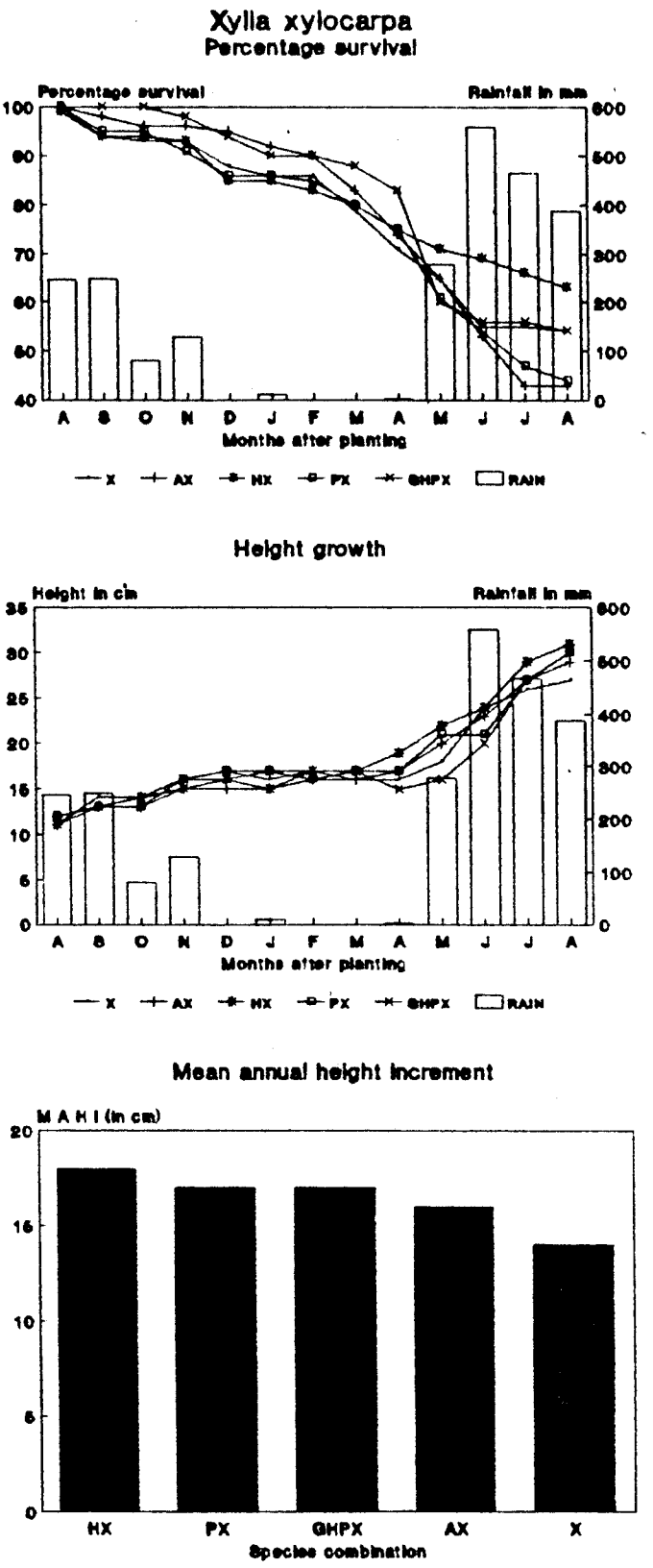


Fig. 6. Survival percentage, height growth and MAHI of seedlings in pure and mixed plantations of *X. xylocarpa*.

Fig. 7. Bole characteristics of *X.xylocarpa* Trees in the natural stands.

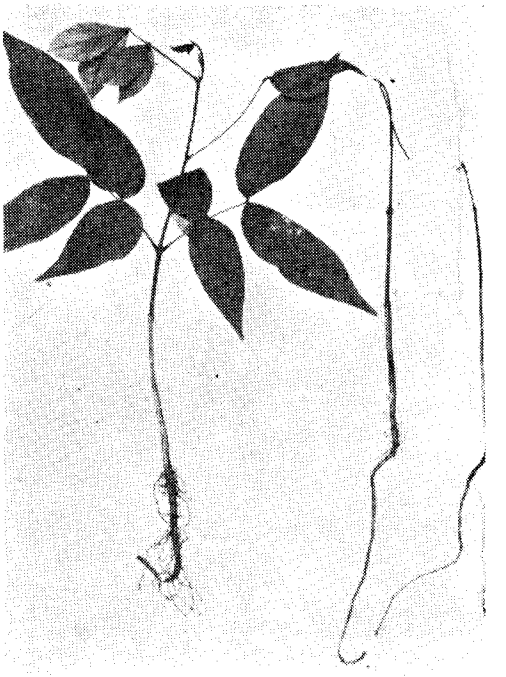


Fig. 9. Seedling blight disease of *X. xylocarpa* in the nursery.

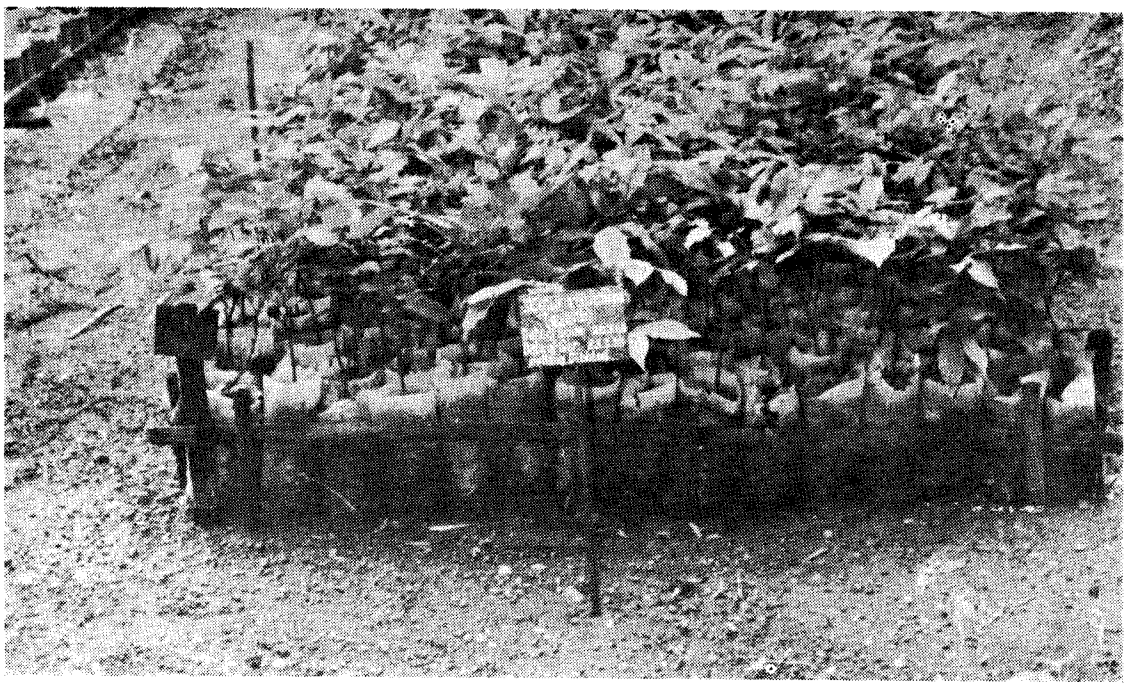


Fig. 8. *X. xylocarpa* seedlings raised for plantation trial,

Table 3. Analysis of variance of height growth in seedlings of pure and mixed plantations of *X. xylocarpa*

Source of variation	DF	MSS	F-Value
Treatment	4	0.002	0.0769(ns)
Replication	2	0.016	0.6154(ns)
Residual	8	0.026	
Total	14		

ns = not significant

Maximum height growth of 31 cm was observed in a *50%* mixture of HX combination. A height growth of 30 cm was recorded in mixtures of PX and GHPX, 50% and 25% combinations respectively. The AX combination, another 50% mixture, showed 29 cm height growth while the minimum height (27 cm) was observed in the pure plantations of *X. xylocarpa* (Fig. 6).

9.4.6.1. Mean annual height increment (MAHI)

Very low mean annual height increment was observed both in the pure and mixed plantations of *X. xylocarpa.* The variation was marginal and ranged between 14–18 cm (Fig. 8). The species registered better annual height increment in mixed plantations than in pure stands. The values showed no significant difference between the treatments (Table 4).

Table 4. Analysis of variance of mean annual height increment in seedlings of pure and mlxed plantations of *X. xylocarpa*

Source of variation	DF	MSS	F-Value
Treatment	4	0.008	0.1250(ns)
Replication	2	6.068	1.0625tns)
Residual	8	0.064	
Total	14		

ns = not significant

9.5. PEST PROBLEMS AND CONTROL

9.5.1. Insect pests in the natural stands

Eventhough a number of insects were found to be associated with *Xylia* trees in their natural stands in Kersla (Table 5), none of them caused any serious damage. About 50% defoliation of saplings during the months June to October by ***Oenospila quadraria***, ***Sauris* sp.** nr. *cinerosa* and ***Buzura* sp.** was noticed, but the infestation was not serious. ***Maruca testulalis***, ***Agrotera bssinotata*** and ***Rhodoneura*** sp. nr. ***myrtacese*** folded the leaves and fed from within, but the damage never exceeded **25%.** All the other insects listed in Table 5 caused only minor damages.

Table 5. Insects collected from the natural stands of *X. xylocarpa* in Kerala

Insect species	Place of colln.	Nature of damage
Azanus or related genus (Lepidoptera, Lycaenidae)	Vazhachal	Leaf feeding
Curetis sp. (Lepidoptera, Lycaenidae)	Vazhachsl, Peechi	Leaf feeding
Maruca testulalis Geyer (Lepidoptera, Pyraustidae)	Vazhachal, Peechi, Nilambur, Erumeli	Leaf webbing
Agrotera basinotata (Lepidoptera, Pyraustidae)	Nilambur	Leaf webbing
Oenospila quadraria (Lepidoptera, Geometridae)	Vazhachal, Peechi	Defoliation
Buzura sp. (Lepidoptera, Geometridse)	Vazhachal, Peechi	Defoliation
Sauris sp. nr. *cinerosa* Warren (Lepidoptera, Geometridae)	Vazhachsl, Peechi	Defoliation
Rhodoneura sp. nr. *myrtaceae* Orury (Lepidoptera, Thyrididae)	Peechi	Leaf webbing

9.5.2. Pest problems in trial plantations

Mild incidence of a few unidentified leaf feeding Insects was noticed on **54.6%** seedlings of *X. xylocarpa* in pure plantations.

Table 6. Percent incidence of leaf feeding insects in the trial plantations of *X. xylocarpa*

Combinations with	Tree species					Percent infestation during*				
X. xylocarpa	A	P	X	H	G	Mar	Apr	May	Jun	Jul
X	0.00	0.00	1.00	0.00	0.00	0.00	0.00	4.68	26.56	54.68[a]
PX	0.00	0.50	0,50	0.00	0.00	15.62	3.12	9.37	6.25	40.62[b]
AX	0.50	0.00	0.50	0.00	0.00	2.50	15.62	25.00	50.00	71.87[c]
XH	0.00	0.00	0.50	0.50	0.00	12.50	0.00	15.62	59.37	56.25[a]
PXHG	0.00	0.25	0.25	0.25	0.25	6.25	12.50	0.00	31.25	0.00[d]

* Figures superscribed by the same letter are not significantly different at 5% probability level.

Among the various mixtures, the 25% mixture (PXHG) was completely free from pest incidence by leaf feeding insects although 41% to 72% pest incidence was recorded in the 50% mixtures (PX, AX and AH). However, the intensity of attack was very low and the insects are not considered as potential pests in plantations (Table 6).

9.5.3. Nursery pests

No serious pest problem was noticed in the nursery of *Xylia* except for the damage caused by the weevil *Indomias hispidulus* which attacked the tender foliage of the seedlings leading to withering of the leaves. Incidence of this insect was noticed throughout the year and the attack was within 12% to 41%, depending upon the season.

9.5.4. Seed pests

The seed pest, *Caryedon serratus* (Coleoptera, Bruchidae), caused about 35% damage to stored seeds in a span of 3 weeks. Infestation was noticed in samples collected from Palappilly.

9.6. DISEASE PROBLEMS AND CONTROL

9.6.1. Seed pathological studies

9.6.1.1. Incubation tests

Xylia xylocarpa seeds harboured eleven microorganisms of which *A. niger*, ***Rhizopus* sp.** and actionomycetes were the dominent ones (Table 7). In addition to these common storage microflora, *Botrytis* sp. and a gram (–)ve bacterium were alsc seen with RPI of **10–15%.** Actinomycetes were also seen profusely growing on seed surface as well as on germinating seeds in soil. But they caused no damage tc the **seeds** or seedlings. However *Rhizopus* sp and *A. flavus* which were frequently observed on seeds in the **soil** caused rotting and in fact they were the most common microorganisms causing rotting of the seeds in nurseries. Other than these fungi, no seedling disease of economic importance was seen in nurseries.

9.6.1.2. Effect of fungicides on seed microflora

Mancozeb and **MEMC** were found to be effective fungicides in the elimination of seed mycoflora of *X. xylocarpa* (Table 8). From the seeds treated with both the fungicides, only bacteria was observed. But from seeds treated with carbendazim and carboxin, *Rhizopus* sp. was seen growing, thereby inferring that

Table 7. Spermoplane microflora and their relative % incidence on the seeds of *X. xylocarpa*

Microorganisms recorded	Relative % incidence
Aspergillus candidus	16.0
A. flavus	15.0
A. niger	37.5
A. versicolor	20.0
Botrytis sp.	10.0
Cladosporium sp.	14.0
F. moniliformae	10.0
Penicillium sp.	13.0
Rhizopus sp.	40.0
Bacteria(-ve)	15.0
Actinomycetes	30.0

the above two fungicides may not be effective for seed dressing. Viability of seeds stored for 90 days did not alter appreciably, in treated as well control seeds.

9.6.2. Diseases *in* nurseries

In nurseries no seedling disease was recorded. However, in container seedlings, leaf spot and seedling blight diseases were recorded. Leaf spot disease which is common in natural stands *is* dealt with under 9.6.3.

Table 8. Effect of fungicides on seed mlcroflora of *X. xylocarpa*, one and ninety days after treatment

Microorganisms recorded	Percent incidence in various treatment									
	Control		carbendazim		MEMC		carboxin		Mancozeb	
	0	90	0	90	0	90	0	90	0	90
A. candidus	16.0	10.0	-	-	-	-	-	-	-	-
A. flavus	15.0	12.0	-	-	-	-	-	-	-	-
A. niger	37.5	12.0	-			-	10.0	10.0	-	-
A. versicolor	20.0	5.0	-	-	-	-	-	-	-	-
Botrytis sp.	10.0	5.0	-	-	-	-	-	-	-	-
Cladosporium sp.	14.0	10.0	-	-	-	-	-	-	-	-
F.moniliformae	10.0	8.0	-	-	-	-	10.0	6.0	-	-
Penicillium sp.	13.0	10.0	-	-	-	-	-	-	-	-
Rhizopus sp.	40.0	32.0	34.0	32.0	-	-	10.0	10.0	-	-
Bacteria (-ve)	15.0	-		-	15.0	-	-	-	2.0	-
Actinomycetes	30.0	40.0	-	-	-	-	-	-	-	-

9.6.2.1. Seedling blight

The seedlings were to be transplanted into polythene containers and maintained for nearly ten months till the next planting season. During this period, especially during monsoon season, seedling blight was observed in less than 5% of the seedlings maintained at Milambur. In severe cases, complete defoliation occurred and the whole plant dried. Initially, the: leaves became light yellow, and within a week, all the leaves were affected and the apical portion of seedlings showed wilting.

In severe cases complete defoliation occurred (Fig. 9). *Rhizoctonis solani* Kuhn. anamorph of *Thanatephorus cucumeris* (Frank) Donk **(IMI No.326296)** was found to cause the seedling blight. Laboratory screening indicated that carbendszim and MEMC were most effective in inhibiting the growth of the pathogen in poison food technique. However, in soil method these fungicides were effective only at higher concentrations, viz. 0.2% and 0.025% a.i., respectively. *R. solani* is a common soil-borne pathogen and is known to parasitize seedlings of various plant species, Since no root infection was observed in the affected seedllngs, this strain of *R. solani* may be an aerial strain. But it is neither a serious nor a common disease.

9.6.3. Diseases in natural stands

9.6.3.1. Leaf blight

Usually this disease was observed during monsoon season and continued till December. Small dark brown spots were noticed on the leaves spread and causing shot holes and affected leaves were shed prematurely. All stages of leaves were susceptible and ca. 20-30% of the leaves were affected. Dull to dark brown spots appeared on the leaves and they enlarged in size and turned dark brown with yellowish margins. In some cases the spots coalesed covering large portions, resulting in leaf blight. *Colletotrichum gloeosporioides* (Penz.) Penz & Sacc. anamorph of *Glomerella cingulata* (Stonem) Spauld & Schrenk (IMI No.328622) was found to be associated with the disease. Eventhough the leaf blight infection of the leaves of *X. xylocarpa* was observed year after year causing premature defoliation, ,control measures are impracticable in the field.

Earlier reports indicated the presence of a stump rot caused by *Fomes fastusus*, *Polystictus steinheilliances* and *Trametes serpens* from Andra Pradesh and Orissa (Hennings, 1901; Anonymous, 1950). However during the present study, stump rot caused by *Phelinus* sp. is reported from *X. xylocarpa* in Kerala.

9.6.4. Root nodulation studies

Performance of *X. xylocarpa* with and without *Rhizobium* inoculation is given in Table 9. In general, nodulation was not seen in uninoculated seedlings 6 weeks after germination.

Table 9. Performance of *X.xylocarpa* with and without *Rhizobium* inoculation

Parameters	Inoculated seedlings		Uninoculated seedlings	
	6 weeks after treatment	15 weeks after treatment	6 weeks	15 weeks
Shoot length	150.77	167.0	108.33	149.90
Root length	184.11	276.66	136.66	197.66
Average no. of nodules	2.55	9.58	-	4.9
Biomass(in gm				
Fresh weight	2.30	5.149	2.01	4.873
Dry weight	0.632	2.81	0.59	1.010

However, nodulation was noticed after 15 weeks. But in inoculated seedlings, nodulation as well as biomass production were almost double as compared to uninoculated seedlings, indicating the effectiveness of the ***Rhizobium*** isolate. The pH of soil around Peechi was found to be around **6.0** to 6.2 which is close to neutral and effective nodulaticn shculd have been cbserved in such soils. However, nodulation was seen moderate in uninoculated seedlings, perhaps due the insufficient natural *Rhizobium* population present in the soil. But if inoculation cf specific ***Rhizobium*** is carried out, it may be possible to increase the nodulaticn as well the biomass of *X.* ***xylocarpa*** seedlings.

10. GENERAL OBSERVATIONS

10. 1. BOTANICAL STUDIES

In general, all the timber species considered in a plantation perspective during the study, are distributed almost throughout Kerala, in the moist or dry deciduous forest tracts. However, it was observed during field surveys that *H. cordifolia* and *X. xylocrapra* are not distributed *in* Munnar and Trivandrum Forest Divisions, respectively. It was also evident during the field surveys that natural populations of all the six species are fairly rich and as compared to the other five species, population of *ti. cordifolia* in the State is poor, so also the regeneration status of the species.

Phenologically, summer months of March, April and May are the flowering months of *A. odoratissima, G. tiliifolia, L. microcarpa* and *X. xylocarpa*. With regard to *P. marsupium* and *H. cordifolia*, it is the rainy season that promote flowering. Eventhough, maturity and ripening periods of fruits vary for each of the species, fruiting branches can be seen for all the six species during September to December. Ripened fruits of most cf the species sre available during December, January or February.

With regard to variation in leaf characteristics, cluster analysis bad shown that there is no definite pattern of similarility or co-existence of either different characters or resemblence among specimens form different regions of the State.

10. 2. ECOLOGICAL STUDIES

10.2.1. Regeneration and climate

Important climatic factors that affect the regeneration of trees are mean temperature of the coldest month of the year and annual precipitation. The months with precipitation ranging from 25–100 mm is usually considered as dry months (Meher-Homji, 1979). This is in accordance with the definition of Bagnouls and Gaussen (1957) and is true for India (Meher-Homji, 1955). On the analysis of Ombrotherms (Meher-Homji, 1979), the alternation of rainy season and dry season, a phenomenon so typical of the tropical climate, is very clear. The sharp alternation of dry and wet season is baneficial to regeneration, because the fruits which are shed towards the beginning of the dry season weathers during that season, soak in the pre-monsoon showers of April-May, dries out in the monscon break that follows and finally soaks again by the monsoon. If the break between the pre-monsoon and monsoon is too long, then there is every chance that the seeds whose germination would start in the pre-monsoon rain will die (Seth and Kaul, 1978). The alternation of dry and wet season can be observed in study areas identified also.

10.2.2. Structural and functional variations

The structural and functional variations are related to the development phase of stands or groups of trees. This variation is largely controlled by destructive forces causing openings in the forest. Gaps caused by lightenings and wind usually occupy between 0.5% and 3% of the area (UNESCO, 1978). The size of the gap and regeneration determine the nature and sequence of floristic and architectural structure. The knowledge of this

kind and complexity of variation in relatlon to the avallable flora is essential for the assessment of variation in function. Hence the structural aspects of the selected sample plots were studied. The species selected for the present regeneration study are the components of moist deciduous, and to a limited extent, dry deciduous vegetation types. The moist deciduous forests, as the name denotes is in leafless condition, especially the upper canopy, during the dry season, ie. from January to March. Before the onset of rains, a large number of trees come to new leaf. Since annual fire is a common feature in such areas, it plays an important role in regeneration of tree species. With regard to the vegetational structure of the study area, the top canopy species comprises of *Albizia odoratissims, Alstonia scholaris, Grewia tiliifolia, Dalbergia* sp., *Haldina cordifolia, Largerstroemia microcarpa, Miliusa tomentosa, Pterocarpus marsupium, Tectona grandis, Terminalia bellerica* and *Xylia xylocarpa.* Of them, species like *Pterocarpus marsupium and Albizia odoratissims* show scattered distribution, whereas the other species mentioned above are common in most of the localities. The lower canopy species consists of plants like *Bridelia squamosa, Careya srbores, Cassia fistula,* etc. mostly of less valuable timber species. *Xylia xylocarpa, Grewia tiliifolia* and *Lsgerstroemia microcarpa* often form dominant communities in most of the study plots, whereas *Pterocarpus marsupium* and *Albizia odoratissima* are of rare occurrence throughout. The restricted distribution of *Xylia xylocarpa, in* the lateritic soils of central Kerala is noteworthy. This species *is* highly dominant in the Kuriyarkutty study plat of Parambikulam Division. With regard to tree density, all the sample plots are medium dense in nature and there is no

'character species' for the area. With respect to the biotic interference, the Bavali plot in Wynad region is highly disturbed partially due to selectlve extraction of timber species and partly due to annual fire, whereas in Vazhani area firewood collection and cattle grazing are the major biotic factors. The Thellikkal plot and Kuriyarkutty plot in Parambikulam Oivision and Peruvannamuzhy plot in Wynad Oivision are comparatively less disturbed. The relative removals have a direct bearing on regeneration (Rai, **1989).** This is true in Bavali area of northern Kerala, where, trees of one or two species of and above certain dimensions were selectively removed.

10.2.3. Species composition and vegetation status

From the evaluation of vegetation status of each of the study area, it was clear that Vazhani and Parambikulam in central Kerala are more or less similar in vegetation structure and species composition. The major species found in the area and the dominants and sub-dominant ones are the same . Species like *Lagerstroemia microcarpa*, *Xylia xylocarpa* and *Grewia ti?lifolia* are of common occurrence. The *Xylia* dominant Kuriyarkutty releve and non-availability of *Xylia* in Thellikkal releve, etc. are exceptional features observed. Similarly, the Bavali and Peruvannamuzhy stands are of uniform phytosociological status. Almost all typical moist deciduous species are observed in the releves irrespective of the locality and distribution of the species.

10.2.4. Germination status

Yet another aspect which received attention is the germination status of the six selected species in field

conditions. Most of the moist deciduous species germinate immediately after natural stratification, but many newly germinated seedlings fail to survive because of the low moisture level and high temperature. This phenomenon is true to some extent, at least in the case of *Haldina*. The time of seedfall and the length of time the seed is exposed to dormancy breaking conditions influence the germination capacity of seeds and survival percentage of seedlings. Hence, a very detailed phenological study of the species is much desired.

10.2.5. Soil moisture status

Soil moisture is another bioclimatic factor determining species compositicn and their dominance. Many of the hardwood species in moist deciduous forests are shallow rooted. In forest situations, more than 90% of the feeder roots of trees are distributed in the top three or four inches of soils. The lached A2 horizons usually prevents any significant root development and penetration into underlying regions. This restricts soil water availability to young seedlings. Forest disturbances or draught that tend to dry out the upper soil layer may affect small seedling stands, profoundly on soils that have shallow rooting zones because of leached layer, high ground water or bed rock (Tubbs, 1977). The soil is extremely dry and temperature regime is on the higher side in the study plots, with low moisture content. Among the species considered, only species with high 'ecological efficiency' like *Xylia*, *Grewia* and *Lagerstroemia* are able to withstand to some extent and hence having fairly good regeneraticn in the area, whereas species like *Haldina*, *Albizia*, etc. show poor regeneration (Table 1). Although there is an optimum combination of light, moisture and temperature for each

species, single species performance in the forest depends manily on its ability to compete successfully with other stands. However, during the present study, the aspect of mutual species competition is not covered, even though it is a vital part of such a study.

Table 1. Percentage of regeneration of the six indigenous species in five stud;, plots selected in Central and North Kerala

Species	Localities				
	Bavaili	Peruva-nnamuzhi	Kuriyar-kutty	Thalli-kkal	Vazhani
X. xylocarpa	**	**	*****	*	***
G. tiliifolia	***	***	**	***	***
L. microcarpa	**	***	**	****	***
H. cordifolia	***	*	*	**	**
A. odoratissima	*	**	-	**	*
P. marsupium	**	*	-	*	*

% Regeneration

* = 0 - 20%

** = 21 - 40%

*** = 41 - 60%

**** = 61 - 80%

***** = 81 and above

10.2.6. Tolerance

Tolerance of a specie:, to varying light conditions is another factor that received attention in the present regeneration studies. Only a particular set of combinations which ensure filtered light and partial shade to the young seedlings support regeneration (Rai, **1989).** The distinct periodicity of moist deciduous forest species makes the system more complex. The initial growth of the seedlings in shades **of** other **trees is** more in many places, but the subsequent growth is retarded because of lack of light due to thick undergrowth, as observed in Parambikulam region in Central Kerala or due to more light available due to large canopy openings as observed in Vazhani area. It **was** also observed that many of the seedlings can survive for a long period without considerable growth increment. The general behaviour of tree seedlings under various light conditions depends on many site factors, such as moisture, temperature and nutrients, as they are reflected **by** seed bed, soils and amount and composition of over-storey as well as competitive potential of other plants. The scattered distribution and community formation of one of the selected species, ie. *X. xylocarpa* in central Kerala **is** thus partly due to the soil characteristics and *is* evident by the lateritic soil composition in Kuriyarkutty study site. The high and patchy distribution and regeneration of *X. xylocarpa* in the Central Kerala region can be accounted by this phenomen. Similarly, the low seedling rate of *Albizia* and *Haldina* species can also be attributed to the low light condition in Thellikkal **and** Peruvannamuzhy study plots , where ground vegetation is much more, which often prevents the initial growth of seed?ings. Thus

constraints and low lighting condition due to ground coverage are some of the limiting factors affecting regeneration of *Haldina* and *Albizia* in these areas. In *Pterocarpus* , the situation is slightly different. Here, the major limiting factor is not temperature and light conditions, but the distribution. This species can be found throughout Kerala, restricted in distribution to specific localities like Chinnar Wildlife Sanctuary in Central Kerala. The rocky terrain and dry bicclimatic condition of this area can be one of the reasons for the restricted and localized distribution of the species. Thus, the low regeneration rate of this species in north and central region of Kerala can be correlated to the rare occurrence of parent trees (limiting seed source) in the area.

The fairly good regeneration of *Grewia* and *Lagerstroemia* in south, central and northern Kerala is due to many factors. The phytosociological study on the distribution status obtained from species abundance–frequency ratio (Fracker and Brischle, **1944)** reveals that their distribution is more uniform throughout Kerala and often form dominant communities in many localities. Thus, the availability of sufficient quantity of seeds and high ecological efficiency of the species to exposure to adverse conditions are some factors governing their regeneration.

10.2.7. Biotic interferences

From field observations, it was evident that even for those species with high rate of regeneration, the mortality rate is much more in later stages. The percentage of seedling height class is more in the initial stages, ie. up to 30 cm range and decreases as they grow . This phenomenon can be assigned only to the high degree of biotic interference such as grazing, removal

of ground cover etc. for various purposes. This is evident from the observations made in the Bavali study plot in North Kerala, where periodical ground clearing and ground fire are of common occurrence.

10.3. UTILIZATION ASPECTS

Bole form is one of the main considerations apart from wood properties while assessing the timber quality of a species because highly defective logs lead to loss in both quality and quantity of timber. At least some such undesirable traits which frequently occur in natural populations of various species seem to be controllable in partially controlled conditions such as a plantation If appropriate management practices are adapted. Therefore, it is essential, as a first step, to identify these traits which require particular attention from the point of view of improving timber quality.

Among the six species, L. *microcarpa* and *H. cordifolia* and to some extent, *A. odoratissima* can be ranked as comparatively less defective. Defects are more prevalent in G. *tilliifolia*. The growth-related defects common to almost all the species are fork and branches. The former can be found at any height level of trees, even below breast height level in extreme cases. On the other hand, presence of branches in the stem bole is very common in *X. xylocarpa* but less predominent in rest of the species. However, G. *tilliifolia* often produces new shoots from adventitious bud clusters. Some of the defects like branch stubs, butt scars, decay cavities and exposed sapwood in different species originate as a consequence of mechanical injury

to living trees due to various reasons like biological organisms or other natural phencmena.

Among the six timber species studied, wood density was the highest for *X. xylocarpa* and lowest for *L. microcarpa. H. cordifolia* had almost the same density as *L. microcarpa.* Basic density of no timber was found to vary between different regions of the State or between the three localities of Central Kerala. This indicates that climatic or other site factors are not much different between these regions so as to affect the wocd characteristics. Various studies carried out in this regard, mostly on softwoods and a few hardwoods, have shown contrasting results. While a few Investigations have shown no significant difference between different locations (Taylor, 1975; Tsoumis and Panagiotidis, 1980), a number of studies have indicated appreciable variaton in density (Harris, 1977; Purkayastha *et al.*, 1984). It has been suggested that environment, particularly the climatic factors, are more correlated to density (Purkayastha *et al.*, 1973).

The proportion of heartwood which *is* another parameter of wood quality, was not found to be significantly variable between the different regions and localities. The significant difference obtained between localities for *P. marsupium*, and between regions for X. *xylocarpa* is probably due to difference in average age or maturity of the sampled trees. This conclusion is further supported by the high correlation obtained between heartwood percentage and stem diameter. It is generally accepted that the heartwood formation is an sge-related change. Therefore, its proportion is often found correlated with tree age or stem dlameter (Carrodus, 1972; Cown *et al.*, 1984).

Yet another significant observation made during the present study concerns the interrelationship between the growth ring width and tissue proportion. Both in the diffuse porous G. *tiliifolia* and semi-ring porous *L. microcarpa*, increase in ring width is accompsnied by increase in fibre proportion and decrease in vessel and parenchyma percentage. Thus the results partly agree with earlier observations by Taylor **(1975)** on sycamore and black willow. On the other hand, observations on teak (Rao, *et al.*, 1966) have shown no definite relationship between ring width and tissue proportions. The present observations, however, indicate that faster rate of growth has the likelihood of being advantageous as compared to slow growth from the point of view of fsvourable wood quality characteristics.

10.4. SILVICULTURE AND PLANTATION TRIALS

Seeds of all the six indigenous species were collected from Nilambur and/or Peechi forest divisions. Since the seed production is during January-June every year, unless the seeds are ripe and ready by Feburary-March, outplanting may not be possible the same year. In that case, the seedlings may be retained in the nursery upto the next planting season. Sturdy seedlings will only ensure higher survival in the field. Quantity cf seeds required for a standard nursery bed will alsc vary as per the germination capacity of the seeds. The size of the polyethene bags to be used depends on the duration to which the seedlings are to be maintained in the nursery. Larger bags will enable better and healthy root growth especially when the

seedlings are to be maintained in the nursery for longer periods and will also ensure higher survuval rate in the field.

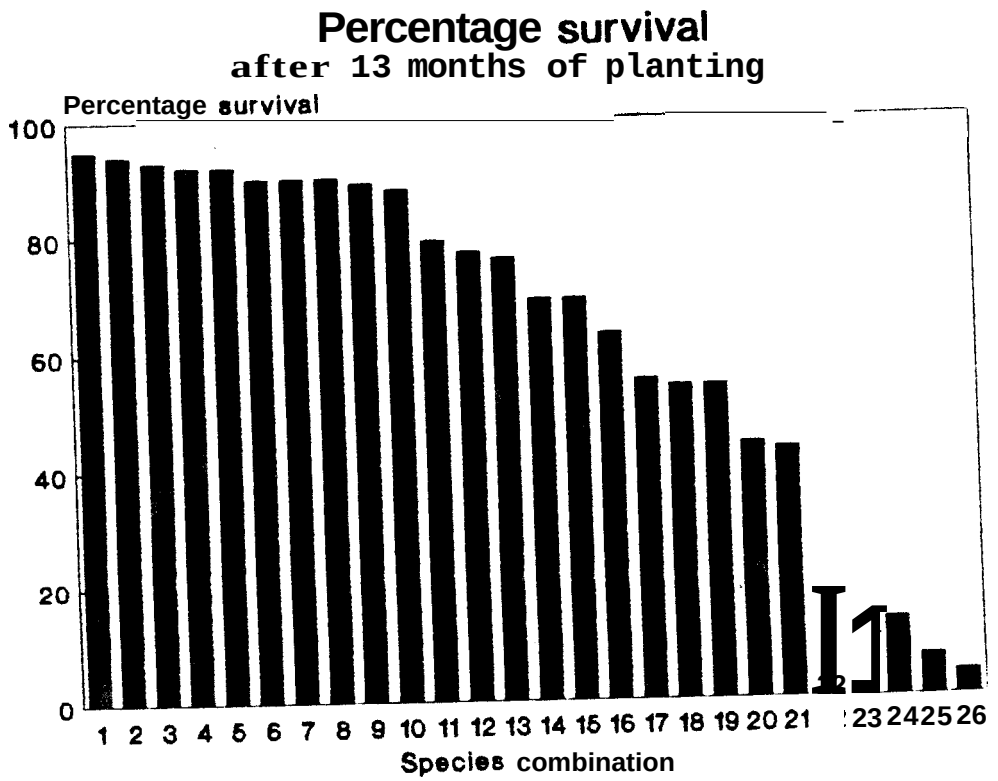
As a thumb rule, a plantation with a stocking of above 70% is considered as successful and those upto 40% stocking as moderately successful (Qureshi, 1968). Results from the present study indicate that pure and mixed plantations of G. *tiliifolia*, *H. cordifolia* and *P. msrsupium* with a stocking of above 70% can be regarded as successful plantations.

Among the pure plantations, G. *tiliifolia* recorded the highest survival followed by *H. cordifolia* and *P. msrsupium*. However, the performance of *H. cordifolia* and *P. marsupium* Is better in mixed plantations than in pure stands whereas the reverse was the trend with G. *tiliifolia*. A general observation from the present study *is* that seedlings showed higher survival rates in 25% mixed plantations than 50% mixtures. This is true with *ti. cordifolia* and *P. marsupium.* Among the 50% mixed plantations also higher survival *is* observed in mixtures with *H. cordifolia* or *P. msrsupium,* thus confirming the superiority of these species over the rest (Fig. 1).

In the second category *of* plantations (survival between 40-70%) are included the pure and mixed plantations of *L. microcarpa* and *X. xylocarpa*. However, the highest survival in this category is recorded for *P. marsupium* in two mixtures of AP and PX. This also gives an indication that *P. marsupium* is the species to be preferred to *A. odoratissima* and X. *xylocarpa*. In terms of a higher survival percentage, *X. xylocarpa* performed moderately good in the pure and 25% mixed plantations.

A. odoratissima showed very poor survival in pure and mixed plantations. This may probably be due to the frequent and heavy infestations by pests. The pure plantation of the species

Fig. 1



1. HP-H
2. AGHP-H
3. G
4. HX-H
5. GHPX-P
6. AGHP-G
7. GHPX-H
8. AGHP-P
9. HP-P
10. GHPX-G
11. H
12. AH-H
13. P
14. AP-P
15. PX-P
16. HX-X
17. L
18. X
19. GHPX-X
20. PX-x
21. AX-X
22. AP-A
23. AH-A
24. AGHP-A
25. AX-A
26. A

Fig. 1. Survival percentage of the seedlings of the six species tried in pure and mixed plantation experiments.

recorded only 4% survival confirming the susceptibility of this species to pests.

According to Qureshi (1988), mean annual height increment (MAHI) of above 60 cm is the standard for a species to qualify it as fast growing during the early years of growth. In the present study faster growth is observed in pure plantations of G. *tiliifolia*, *H. cordifolia* and *L.microcarpa*. The MAHI of *H. cordifolia* is better in 25% mixed plantations than in the pure stands. However, *H. cordifolie* showed better growth in pure plantations also. A general trend with regard to MAHI is that this species performs better both in pure and 25% mixed plantations (Fig. 2).

None of the pure plantations appeared in the second category of species with moderately fast growth. In the case of *H. cordifolia* and *P. marsupium*, 25% mixed plantations showed better growth than their 50% mixtures.

Pure plantations of *P. marsupium*, *X. xylocarpa* and *A. odoratissima* recorded poor height increment. *P. marsupium* in the mixed plantations showed better growth than in its pure plantations. Eventhough A. odoratissima showed faster rate of growth in a 25% mixture, general performance of the species in other combinations was poor. *X. xylocarpa* also confirmed its slow growth during initial stages of growth in the plantation trial.

10.5. PEST PROBLEMS AND CONTROL

10.5. Pest problems in nurseries

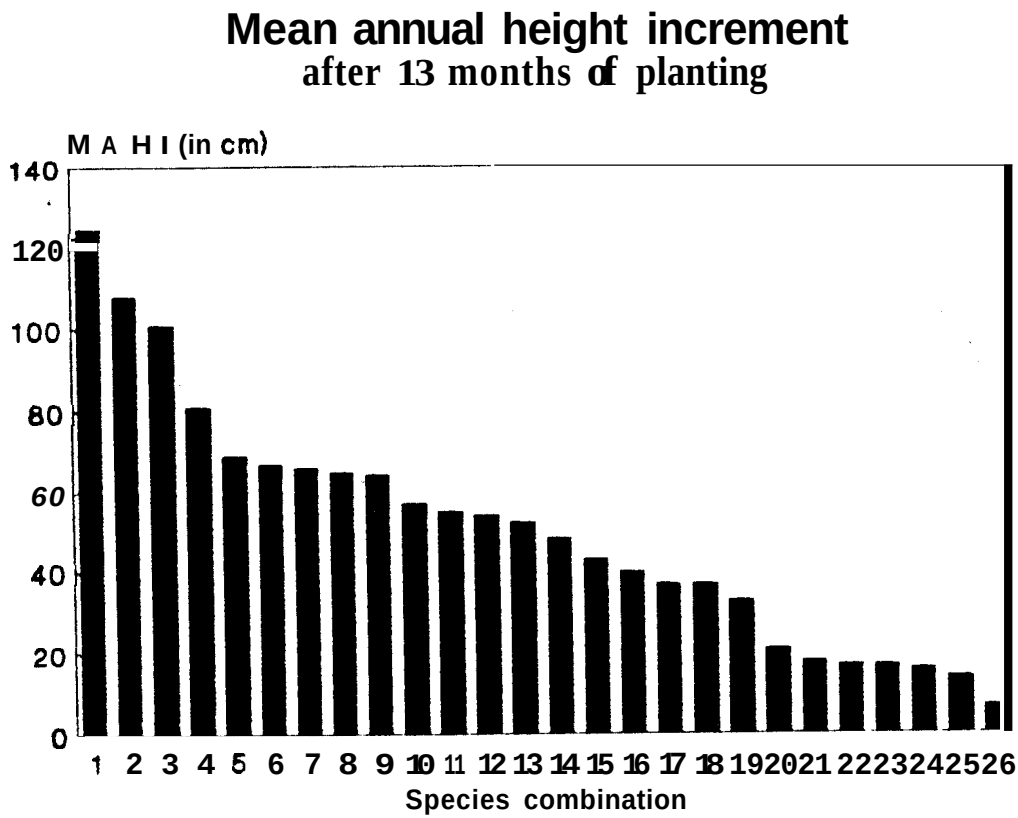
Incidence of insect pests is an important factor which

precludes the successful establishment of plantations. Data gathered in this regard during the study indicate that 3 out of the 6 species tried were moderately to heavily susceptible to various nursery pests. They are *A. odoratissima* attacked by an unidentified Psyllidae, *Pterocarpus marsupium* attacked by the psyllid *Spanioneura* sp. and *L. microcarpa* attacked by an unidentified species of mite. All the other species studied were almost free from any major pest damage.

10.5.2. Pest problems in trial plantation

With regard to pest attacks, both in the pure and mixed plantations trials, the trend was almost similar to that of the nursery experiment. The very same insects which affected the nusery seedlings were also found to attack the field planted seedlings. Due *to* pest incidence, saplings of *A. odoratissima*, *P. marsupium* and *L. microcarpa* suffered serious damage in monoculture. However, the incidence rate of these insects in various mixtures could not be fully evaluatead due to insufficent data. In natural stands G. *tiliifolia*, *H. cordifolia* and *Xylia xylocarpa* were found to be only occasionally attacked by insect pests - G. *tiliifolia* by the leafwebber *Lygropia orbinvsabis*, *H. cordifolia* by the leaf roller *Parotis vertumnalis* as well as the defoliator *Epiplema quadricaudata* and *X. xylocarpa* by the defoliators *Oenospila quadraria*, *Bugura* sp. and *Ssuris* sp. nr. *Cirurosa*. Although no instance of large scale build up by any of the above mentioned insects was noticed in the trial plantations, the possibility of their assuming pest status in subsequent phases of growth cannot be ruled out. Only continued observations will yield enough data to conclude whether or not

Fig. 2



1. AGHP-G
2. AGHP-A
3. GHPX-G
4. G
5. L
6. H
7. HX-H
8. GHPX-H
9. GHPX-P
10. AGHP-H
11. HP-H
12. AH-H
13. AGHP-P
14. AP-P
15. HP-P
16. PX-P
17. AP-A
18. AH-A
19. P
20. AX-A
21. HX-X
22. PX-x
23. GHPX-X
24. AX-X
25. X
26. A

Fig. 2. Mean Annual Height Increment of the seedlings of different species in pure and mixed plantation trials.

any of the insects recorded during the study from natural stands will become potentially serious pests In plantations.

Another observation made during the study was that, despite severity of attack, none of the pests seen in the natural stands seriously affected their growth. This is possibly due to the natural balance operating in natural forests, where natural mortality factors play 3 major role in regulating pest outbreaks beyond a certain limit. The extent of structual diversity attained in man-made plantations *is* good enough to create such a balance leading to natural regulation of insect pests beyond a limit.

Data gathered during the study indicate that pests adversely affect the successful establishment of nursery seedlings as well as saplings. Therefore, adequate chemical protection is essential during the initial phases of plantation raising. Once the seedlings are established, it will be appropriate to leave them without any chemical treatment so as to enable the natural pest mortality factors to become operational.

10.6. DISEASE PROBLEMS AND CONTROL

10.6.1. Seed patholgical studies

Seed pathology of the six species investigated has shown that the magnitude of attack on seeds by spermoplane micrcflora *is* varied. *L. microcarpa seeds harbour* only two pathogens whereas X. *xylocarpa* had a maximum number of eleven species affecting seed viability. *Aspergillus* sp. and *Rhizopus* sp. were the most common fungi attacking seeds of all the species except *L. microcarpa*, where it was a gram (-)ve bacterium. Most of the

spermoplane orgaanisms were confined to seed surface and a few species of *Aspergillus, Penicillium* and *Rhizopus* pentrated the seeds and caused seed rotting. Seed dressing with fungicides was effective in controlling the spermoplsne microflora of all the six species studied. In general, carbendazim, MEMC and mancozeb were the effective fungicides.

10.6.2. Diseases in nurseries

In general, only very few serious diseases were observed in nurseries. *A. odoratissima* and G. *tiliifolia* were the two species without any seedling disease. In the case of the remaining four species seedling diseases were mainly due to soil pathogens like *Pythium* sp. and *Rhizoctonia solani*, for which adequate control measures are suggested in the report. MEMC (0.0125/a.i.) as a soil drench was found to be effective in checking the spread of the above mentioned pathogens in most of the cases.

10.6.3. Root nodulation studies

Root nodulstion studies pertaining to the leguminous species included in the study indicated that pelleting the seeds with local *Rhizobium* sp. is effective in enhancing the number of nodules and thereby the biomass.

10.6.4. Diseases in natural stands

In addition to the few leaf and stem diseases causesd by fungi, mistletoe attack was prevalent in the natural stands of two species namely viz. *A. odoratissima* and G. *tiliifolia*.

11.1. *Albizia odoratissima* (Kunni-vaka)

This tree species is almost free from disease problems at seed, seedling and plantation trial stages. Better performance of the seedlings can also be ensured by *Rhizobium* application. Further, log quality of the timber of *A. odoratissima* is found to be better as compared to the other five species investigated in this project. But, in plantation, the species can not be considered as 'fast growing' and survival percentage of seedlings is also comparatively low. Pest attack was severe on the seedlings of this species, both in nursery and in the plantation trial experiments. For raising seedlings in bulk, availability of seeds from the natural stands is essential and as shown by the natural distribution of the species in the State, there will not be any constraint in procuring the same from the natural stands. Ecologically, the species is well suited to the moist deciduous tracts of the State, where forest plantations are often raised. Based on the observations made during the study, the species is recommeded to be grown in mixtures, with species like G. *tiliifolis,* and proper pest management stratagies as suggested in this report may be adpoted in the seedling stage, both in nursery and in plantation.

11.2. *Grewia tiliifolia* (Chadachi)

During the investigation on the plantation potential of this tree, mistltoe attack and defective log quality noted in the natural stands are the only two negetative aspects identified,

which can be regulated by proper silvicultural and management practices when raised on a large scale as plantations. Otherwise, the tree belongs to the category of 'fast growing' as proven by the plantation trial experiment. Very high survival rate of out-planted seedlings and resistence to serious pests and diseases at all stages of plantation raising are the salient features of this species. In addition, the species performs very well both as monoculture and in mixtures among the species considered, eventhough it performed better in mixtures rather than in monoculture. Seed availability frcm the natural stands will also be very good as *Grewia* trees are well distributed almost throughtout the State in the moist deciduous tracts, and is ecologically suited to degraded forest gaps and tracts.

11.3. *Haldina cordifolis* (Manja-kadambu)

Results of the nursery and plantation trial experiment have shown that Haldu trees, a class one plywood species, is a very potential plantation species for Kerala, mainly because it has proved to be 'fast growing' in plantation trial and is almost free from seed disorders, seedling defects and disease and pest attacks in plantation. Survey of the natural stands of the species has also proved that log quality of its timber is very good. As shown by the study, a mixed plantation of *P. marsupium* and *H. cordifolia* will be ideal and more productive. Seed collection and handling is very easy and seed germination percentage is quite high. Moist deciduous forest tracks of the State can be choosen as areas for raising plantations of *H. cordifolis* either as monoculture or in mixtures, preferably with *P. marsupium*.

11.4. *Lagerstroemia microcarpa* (Venthek)

This *is* proved to be a disease free tree species in seed, nursery and plantation trail stages, but with serious pest problems both in the nursery and in the plantation trial experiment. If pest attack can be controlled at various stages, being a species proved to be 'fast growing' in the plantation trial experiment with very good log quality in the natural stands can prove itself to be a very potential species suited for raising on a large scale in the moist decidous tracts of the State. Seed source is also very promising as Venthek trees are common throughout the moist decidous forests of the State and procuring and handlings of large quantities of seeds is also not difficult.

11.5. *Pterocarpus marsupium* (Venga)

In mixtures, especially with *H. cordifolia*, Venga can be safely recommended for raising plantations in Kerala. Survival percentage of seedlings is quite high in the case of field planted propagules. Potential pests and diseases affecting the seed and seedling stages cf the species are also very few and those present can be controlled easily by using pesticides or fungicides, as recommended in this report. Further, *Rhizobium* application can ensure a better performance of the seedlings in plantation. Log quality of the timber, as assesed from its natural stands, is also promising. Further, the seed source of the tree at present is very good. However, it has been observed in the field that both in the flowering stage and also at seed setting period, there are potential pests which cause

damage to the seeds, often eating them away on the tree itself. Otherwise, as *Pterocarpus* trees are common at present in the moist decidous forests its seed availability is quite good for raising seedlings in bulk. The species is suited for raising plantations in the moist decidous areas of the State.

11.6. *Xylia xylocarpa* (Irul)

Eventhough seedlings of Irul outplanted in the plantation trial plot at Nilambur showed very high survival rate, their growth was rather slow and could not be ranked as a "fast growing species". Further, a maximum number of pathogenic microflora were seen infesting the seeds of this tree species causing seed disorders. However, pest attack is rare both for seeds and seedlings in the nursery and tria? plantation, as compared to the other five species studied. Density of wood is comparatively the highest for the species and ?og quality of timber as assessed from the natural stands is rather good. In plantation experiment, the species performed better in monoculture than in mixtures and can be considered for large scale raising in degraded forest tracts and forest gaps with poor and rocky soil. Seeds are available in plenty from the natural stands, but its collection in large quantities can be ensured only by a careful obsearvation of their maturity time, as the seeds get dispersed to distances, by the elastic breaking of the fruits while attached to the parent tree. If the log quality of this timber tree can be improved by suitable sllviculural and management practices, it can form a highly poential suitable species for plantation growth in Kerala, as it requries only poor sites and local demand for Irul wood *is* quite high.

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