GENERATION AND TRANSFER OF SILVICULTURE AND HARVESTING TECHNOLOGY OF SELECTED MEDICINAL PLANTS FOR THE SUSTAINED UTILISATION OF THE WASTELANDS OF KERALA

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ABSTRACT

Seedlings of ten selected medicinal tree species were raised in a central nursery and outplanted in farmers' wastelands and institutional lands in Palakkad and Thrissur Districts of Kerala State, India. The species tried in the wasteland rehabilitation experiment were *Aegle marmelos* (L.) Corr., *Caesalpinia sappan* L., *Cinnamomum zeylanicum* Breyn., *Oroxylum indicum* (L.) Vent., *Phyllanthus emblica* L., *Pterocarpus santalinus* L.f., *Punica granatum* L., *Saraca asoca* (Roxb.) de Wilde, *Syzyguim aromaticum* (L.) Men. *et* Perr. and *Wrightia tinctoria* R. Br. The programme was accomplished through active participation of the beneficiaries as well as co-operation of the local agricultural officers of Kerala State Agricultural Department. Training was also given to farmers in seed processing, nursery establishment, nursery techniques and plantation aspect like aligning, pitting, planting and aftercare of outplanted seedlings. During the 2 $^{1}/_{2}$ years of project implementation, more than 89,000 seedlings were raised and planted in 45 ha of farmers' and institutional wastelands in the two districts.

Species preference by farmers was mostly guided by the size of their land holdings. Small holding farmers preferred species like *Punica granatum* and *Syzygium aromaticum* to plant mostly in their homestead wastelands whereas large holding farmers preferred species such *as Aegle marmelos, Caesalpinia sappan* and *Pterocarpus santalinus,* whose products are of industrial demand and which require less attention for survival and growth of outplanted seedlings. In the case of institutions, species of medicinal use in pharmaceutical industry such as *Aegle marmelos* and *Saraca asoca* were preferred than the other species. Sufficient financial assistance for nursery and plantation activities, and facilities for marketing of products can enable the rehabilitation of the wastelands in Kerala using medicinal plants, as proved by the success of the programme.

1. INTRODUCTION

National Wasteland Development Board (NWDB) and the Department of Wasteland Development (DoWD) established in 1992 were constituted as part of the Ministry of Rural Areas and Employment, Government of India. They are the apex bodies at the national level responsible for the transformation of country's less productive, non-forest areas, considered as wastelands, into productive zones with inputs from scientific and technological advancement. The Technology Development and Extension Scheme (TDET) of the DoWD is in operation since May, 1994 and the Scheme (TDET) aims not only in the physical development of the under-utilized land in the country but also to develop and transfer the restoration technology to the rural populations. It is under this national scheme that the project **Generation and transfer of silviculture and harvesting technology of selected medicinal plants for the sustained utilization of the wastelands of Kerala** was sanctioned for the Institute, in December, 1994.

1.1. Objectives and targets of the scheme

This technology development, extension and training project envisages the cultivation of ten selected species of medicinal plants in the under-utilized and degraded wasteland areas of Palakkad District in Kerala State with a component on training and extension of the technology developed, to the beneficiaries. There is also provision in the project to grow the species in limited areas of Institutional lands in Thrissur District of the State. The specific objectives and physical targets of the project are as follows:

i. To raise 1,50,000 seedlings of selected species of medicinal plants.
ii. To plant them in 60 ha of farmers' land in Palakkad District and 15 ha of Institutional land in Thrissur District of Kerala State.
iii. To train 400 farmers and 80 Agriculture officers, as part of the technology transfer programme.

Though the project was sanctioned for a period of 4 years, ie. financial years 1994-95 to 1998-99, it was operational for two years only, ie 1995-96 and 1996-97, as funds were not released for the remaining two financial years. However, more than half the physical targets of the project could be achieved during the two year period, which include establishment of nursery, plantation and extension activities.

1. 2. Review of literature

Wastelands are defined as land areas which are degraded and are therefore remaining unutilized or under-utilized, except as current fallows, due to different constraints. In India, as estimated by National Remote Sensing Agency in 1985. About 16% of the total land cover of the Country belongs to this category. Such areas are present in almost all States including Kerala. Literature on the reclamation and use of wastelands in India mainly covered aspects like survey, classification and mapping of such areas in the Country. Also, economic and socio-cultural aspects and reclamation management issues were also sometimes addressed. Details of procedures and results achieved with regard to land development experiments conducted in specific ecological regimes in India like sand dunes, ravine lands, saline and alkali lands, etc. were also dealt with for certain specific areas of the Country. Several such direct and cross references are available in the Proceedings of the Symposium on Use of Wastelands in India (INSA, 1972). Also, FAO (1989), Patel (1986), Sastry (1990) and Tewari (1983) had dealt with the topic in the Indian context. Also, authors like Ruffuer and Steiner (1973) and Srivastava and Qureshi (1972) had evaluated or tried the suitability of certain species for wasteland reclamation.

Details on the botanical and utilization aspects of the species tried in the present experiment are available in CSIR (1951-1984) and also several other plant products dictionaries, manuals (Nair, 1996), research reports (Nambiar *et al.*, 1985), glossaries, and so on. The species selected for the experiment are also well known for their products in the Pharmaceutical Industry (Indian System) and also to Ayurvedic doctors and practitioners. Scanty details on the silvicultural aspects of some of the species, whose nursery and plantation techniques were evolved during the study, are also available in Troup (1921) and FRI (1975-85), but mainly for other States or areas, that too in a forestry context. However, literature on the plantation aspects of the species, especially in different agroclimatic conditions of any given State and also the Country in the context of wastelands development, is practically nil.

1.3. Wastelands in Kerala

Kerala State Landuse Board (KSLUB, 1989) had brought out a booklet giving details on the wastelands of Kerala. The details given there include wasteland areas in the State, their locations and location-specific broad strategies for rehabilitation. In Kerala, wastelands

represent almost 8.15% of the total geographical area or 11.09% of the total non-forest area of the State. Such areas in the State of Kerala are identified in the Districts of Kasaragod, Cannanore, Wyanad, Malappuram, Palakkad and Idukki by the Kerala State Landuse Development Board (1989). The extent of wastelands in various districts of the State and their percentage as compared with the total geographical area of the State and District wherein they occur are given in Table I.

Table 1. Wastelands in different districts of Kerala State and their percentage in the total District and State areas.

Districts	Total area (ha)	Total WL area (ha)	% State area	%District area
Kasaragod	196100	9814	5.00	26.92
Cannanore	299700	6980	2.33	7.90
Wynad	213200	5184	2.43	7.17
Malappuram	314800	12367	3.93	9.04
Palakkad	439200	28356	6.45	11.56
Idukki	506100	34813	6.89	13.56
Total	**19,69,000**	**97,514**	**27.03**	**--**

Palakkad District, where the programme has been mainly executed, is one of the two Districts in the State where an area of 28356 ha is in record as underproductive. This is mainly because of the rainshadow location of the District and also the presence of Palakkad gap in the Western Ghats, which exposes the area to the dry Carnatic Plains of the Country. Water scarcity is yet another reason for the under-utilization of many of the areas in the District.

The areas brought under the scheme in Thrissur district are institutional lands and are not belonging to the category of wastelands. In fact, the institutional lands were included in the rehabilitation programme as per the physical targets specified in the sanction of the project by the Ministry of Rural Areas and Employment.

2. METHODOLOGY

This restoration cum technology transfer programme mainly involved aspects like identification of degraded areas for restoration, selection of species suitable for such areas with the acceptance of farmers and selected institutions. The methodology tried in the programme with regard to area selection, species identification and extension components of the scheme are detailed here along with the procedures followed to generate silvicultural data of the species tried, like production of seedlings, survival of out-planted seedlings and their growth in the wasteland conditions of the implementation areas.

2.1. Area selection

The scheme envisaged the rehabilitation of both farmers' and Institutional lands, the former in Palakkad District and the latter in Thrissur District. Palakkad District, where the rehabilitation experiment was conducted, has both forest and non-forest areas belonging to the category of Wastelands. Of the total 28,400 ha of Wastelands in the District, 11,200 ha are within forest boundaries (Forest Wastelands) and the remaining 17,200 ha are non-forest wastelands, which includes undulating upland scrubs, steep sloping land and barren rocky or stony areas (Kerala State Landuse Board, 1989). With this background, an area of 60 ha was identified as the rehabilitation site in Kollengodu Taluk of the District, owned by the local farmers (Map 1). The areas selected comes within the Muthalamada Panchayath jurisdiction and are mostly barren and stony landscapes or failed agricultural lands. Here, the annual rain fall is as low as 169 mm and most of the months remain dry. The mean maximum temperature is 44^{o}C and the mean minimum is 21.1^{o}C. The methodology followed for area identification was mainly Participatory Rural Appraisal (PRA), where a series of formal and informal meetings where organised to explain the objectives, targets, uses of medicinal plants, etc used in the restoration scheme. Details of the PRA exercises adopted are given under the subheading 2.5. Extension and transfer of technology.

In Thrissur District (Map 1) where there is no wastelands recorded by the National Wasteland Development Board (NWDB) and Kerala State Landuse Board (KSLUB), Institutional lands were identified in two locations where the programme was implemented, as specified in the work programme. Campus of Oushadhi, the Pharmaceutical Corporation of Kerala Limited (Indigenous System of medicine) in Kuttallenoor Panchayath and Sanjeevani Nature Cure Sanitarium campus, Peramangalam Panchayat, were the two

Institutional areas adopted for the scheme. The Oushadhi campus area is an abandoned agricultural land with flat terrain and rich soil whereas the Sangjeevani Sanatorium plot owned by the State Government and leased to the Institution for 99 years possess very poor soil, gravelly and dry, with scattered culms of fodder grasses, cultivated and failed in the past. Both the Institutional lands, being located in the windward side of the Western Ghats, receive heavy rain fall of about 2400 mm to 2900 mm, mainly distributed during June-September and November-December as South-West and North-East monsoons. The mean annual temperature of the area is 32.2^{o}C and the mean minimum is 21.1^{o}C.

2.1.1. Farmers' wastelands

The selection process of farmers was commenced in March, 1995. The help of the local key persons, such as Panchayath President, a retired primary school Headmaster and also a registered society of active farmers called the Team Farmers, was taken to assist with the programme in the village. Also field officials of the State Agricultural Department were consulted before the selection process was initiated. A meeting of local farmers was called by the Key persons and Team Farmers to assess their interest in the programme by elucidating the need for the implementation of the programme, to improve the productivity of their degraded lands. Similarly, few more meetings were organised with the help of the farmers' forum "The Team Farmers" to explain the specific objectives of the programme and to identify interested farmers to be included in the scheme. Ultimately, a total of ninety farmers with wasteland holdings of varying sizes were chosen. Socio-economic status of the farmers selected was also determined by a relative wealth ranking exercise (Grandin, 1987) which was based on ownership of land, occupation, income source of the household, and other indicators such as ownership of livestock, consumer items such as televisions and nature and condition of the dwellings in terms of number of rooms, construction materials used, etc. This led to a three tier stratification of the households as low, middle and high income groups. This data was useful to decide upon the strategy and financial input required for the seedling transportation, distribution, pitting, planting and tenting activities, etc. at a later stage. The chapter dealing with the physical targets achieved provides details of the farmers who volunteered to rehabilitate their barren areas using medicinal plants and details of the locations and species tried by them. For practical purposes, the farmers were divided into large and small-holding groups depending upon the area available for restoration.

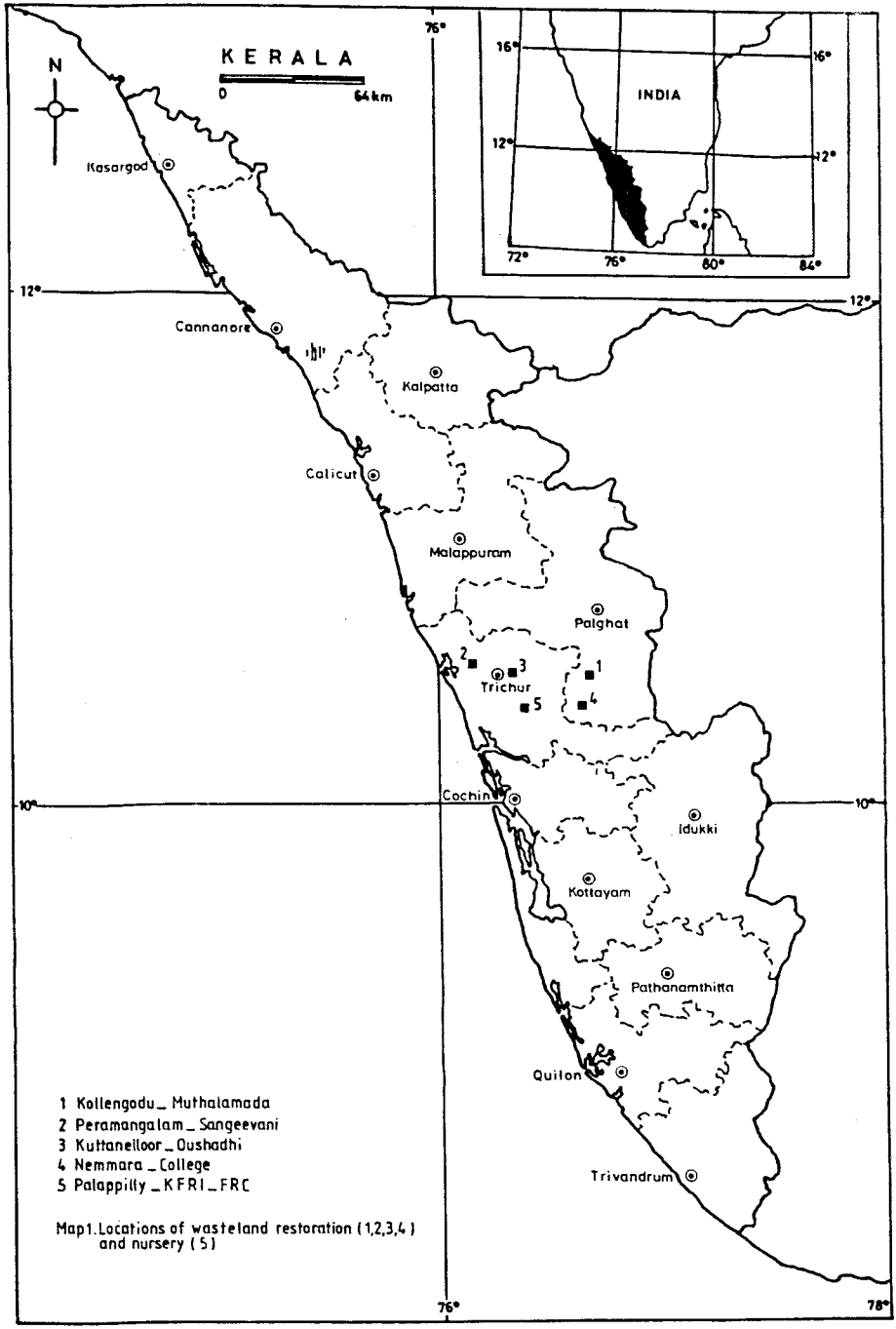
In general, the farmers possessed either extensive wastelands or homesteads in which unproductive areas are available for planting of the medicinal species. In fact, the wastelands of Palakkad District suffer from draught and degraded soil conditions, where, occasionally, the farmers cultivated *Arachis hypogea* L. (Groundnut). This crop, stated to be not economical, is not preferred by many farmers. This is because, cultivation of this crop plunch them into increasing debts and consequent land disposals. Instead, the farmers were willing to grow the medicinal trees on a long term basis, and for shorterm benefits, some of them also intended to intercrop with groundnut for 2 or 3 years in the same area, before the seedlings of medicinal plants grow and shade the plot. However, most of the farmers selected for the scheme possessed land areas which are totally barren and such areas were also more preferred for planting the medicinal species as part of the scheme.

2.1.2. Institutional lands

The Institutional lands (Map 1) included in the present scheme are mainly located in two Panchayaths, namely Kuttenelloor and Peramangalam in Thrissur District. The Kuttanelloor Panchayat plot is part of the factory campus of Pharmaceutical Corporation of Kerala (Indian System), popularly known as Oushadhi. The wasteland area selected here is a reclaimed paddy field, where, Oushadhi had tried to grow the medicinal species *Adhathoda vasica*, but failed in the attempt. The area was flat, covered with weeds which was cleared mechanically and manually before the planting of medicinal plants.

The highly degraded and unproductive area of the Sanjeevani Sanatorium owned by the Prakrithi Chikitsa Samithy in Peramangalam Panchayath is a dry, gravelly area, where cultivation of fodder grasses failed in the past. The land is under lease to the Institution by the State Government for 99 years to establish the campus of the Sanitarium, and almost 95% of it remains barren, with occasional clumps of the fodder grasses and sometimes few plants of *Manihot utilissima* (tapioca) , seasonally grown and harvested by the Sanatorium staff. Acute scarcity of water is the main adverse factor operating in the campus, which is otherwise protected with a compound wall, preventing grazing and ensuring protection to the seedlings planted.

Both the Institutional areas were permitted by the concerned organisations to be restored by the growth of medicinal plants and this was possible by appraising them the details of the programme and the uses of the products which they can either use in their own factory or



Map1. Locations of wasteland restoration (1,2,3,4) and nursery (5)

sanitarium or sold to similar industries, of which they are quite aware. As the benefits that accrue from the restoration programme, namely the plant products, solely vests with the land owner, both the Institutions co-operated with the programme and permitted to use the barren areas in the two campuses for planting. A live collection of all the species of medicinal plants tried in the rehabilitation programme was also established in the campus of the Field Research Station of the Institute. Also, the barren areas in the campus of the NSS College, Nenmara, Palakkad District, 5 species of the medicinal plants were planted as part of the programme.

2.2. Species selection

A total of 10 tree species were to be selected for technology development and planting trial under the programme. The Kerala State Landuse Development Board (1989), while suggesting solutions for the development of wastelands in Palakkad District, had also mentioned about the cultivation of suitable perennial crops. In the species selection process, this was regarded as a basic strategy. In other words, only tree species were decided to be used for the restoration planting, so that, once they are planted and their survival ensured, such species will grow and green the area for decades and the products, if harvested in a sustainable manner, the plantation as such can survive indefinitely. Added to this, initial expenditures essential for repeated planting every year or once in two years, as in the case of annuals and biennials, is also not required in the case of tree crops. Tending operations will also be minimized by this approach and once the trees are established, they can grow by themselves without much inputs like watering, weeding, tilling, manuring, and so on.

With this background and with the help of local key persons and the 'Team Farmers' organisational set-up, PRA and extension classes were conducted for the farmer groups in Kollengode Taluk, in three locations within the Muthalamada Panchayat. Of them, the first two meetings were for land-owners with wasteland areas more than 1 ha, where at least 500 seedlings can be planted. The third set of meetings were attended by small scale farmers who were in a position to allot wastelands in their homesteads or adjoining barren areas, where, less than 500 seedlings can only be accommodated. Familiarisation of 20-30 potential species with regard to their habit, products, uses, etc. through interaction seminars and demonstrations in the two sets of meetings resulted in the selection of the 10 tree species of medicinal value and commercial demand for the rehabilitation experiment. They are *Aegle marmelos* (L.) Corr., *Caesalpinia sappan* L., *Oroxylum indicum* (L.) Vent.,

Cinnamomum zeylanicum Breyn., *Syzygium aromaticum* (L.) Merr. et Perr., *Saraca asoca* (Roxb.) de Wilde, *Punica granatum* L., *Pterocarpus santalinus* L.f., *Phyllanthus emblica* L. and *Wrightia tinctoria* R. Br. Botanical details of the species, their growth habit, part useful as product and major uses of the product are as given along with the results of the trial experiments.

2.3. Nursery techniques

An ideal site for nursery in the Institute's Field Research Station at Veluppadam, Thrissur District was identified, and a shade-net nursery with potting shed and watering facilities was developed there. Nursery beds of 12 m length, 1.2 m width and 30 m height were prepared on one portion of the shade-net nursery shed and the other portion was left vacant for hardening the polypotted seedlings, before field-planting.

Seeds were either procured from the Seed Range, Forest Genetics Division, Tamil Nadu Forest Department, Coimbatore, or collected locally from healthy mature mother trees growing in either homesteads or forest areas. Seed biological data including fruit weight, seed weight, seed pre-treatments, seed germination percentage, plant percentage, etc., were gathered in the laboratory and nursery, following standard procedures (Willan, 1985). The standard nursery beds were used for germinating the seeds. Adequate care was taken to ensure that regular watering and weeding were carried out in the nursery bed till the stage of potting of seedlings in polythene bags. Polythene bags used for potting were of the size 13 cm x 23 cm and 250 gauge (thickness). Potting media was prepared of cleaned and sieved forest soil (5 parts), sand (3 parts) and dried and powdered farmyard manure (1 part).

After potting, seedlings were kept under the shade-net (ie. agro shade-nets restricting 50% light intensity). Watering was done three times daily till the seedlings established well in the polythene bags. The frequency of watering was then reduced to twice a day for the next month and subsequently once in a day. Gradually, the regular watering was also discontinued and the seedlings were watered just to avoid wilting of the seedlings. The polypotted seedlings were also shifted periodically to avoid the roots striking the soil.

2.4. Plantation technology

Since planting was to be carried out in degraded sites, cleaning and weeding were restricted to the planting spots only so as to avoid complete removal of existing biomass and

further drying and desiccation of the soil system. Knife weeding and mild scrape weeding were also carried out at each of the planting spots, at a diameter of one metre and pits of 30 cm x 30 cm x 30 cm were dug at a spacing of 2 m x 2m in the block planting design. However, in the Institutional land of Oushadhi, complete removal of weeds was done using a tractor and also manually. In avenue planting, where only single-line planting was done, the distance between two plants was 2 metres. In double or triple line planting, the plant-to-plant and line-to-line distance was maintained at 2 m x 2 m. In such circumstances, staggered planting was carried out in order to derive maximum advantage of the moisture availability for better survival and seedling growth in the field. This was also aimed at controlling the soil erosion in the denuded and degraded lands.

Planting of one-year-old polypotted seedlings was initiated during the commencement of South-West monsoon in June-July, 1996. Casualty replacements were done twice during the months of September and October of the same year.

Block planting design was adopted wherever larger and contiguous areas were available for planting the tree species, especially in the private holdings of farmers. Wherever only limited areas were available, either line/avenue planting or irregular planting along the gaps were preferred. Gap planting was the method followed, especially in the case of coconut gardens of a few farmlands at Palakkad. In the Institutional lands, only block planting was done because of the availability of contiguous areas for planting the selected species of medicinal trees.

At every stages of nursery and planting activities, the farmers were involved so as to educate them on the scientific procedures to be followed in the future ecorestoration activities of degraded sites, with the same medicinal trees or any other similar species. Farmers were also impressed upon the need for protecting the outplanted seedlings from fire, grazing, diseases, pests and other anthropogenic interference's in order to make the planting programme successful.

2.5. Extension and transfer of technology

The methodology followed to transfer the technology developed in the project into action and accomplishment of the physical targets of the scheme were mainly through participatory rural appraisal (PRA), extension classes and nursery and plantation demonstrations. In the case of farmers in Palakkad District, the extension activities were

organised with the active involvement of the farmers forum called The Team Farmers, officials of the Agricultural Department, viz. Krishi-Bhavan, Muthalamada and Krishi Bhavan, Kollengodu, and local key persons identified for the purpose. In the case of Institutional lands, the idea was mooted through discussions with the executives of the two organisations. For example, in the case of the Institution Oushadhi, Managing Director and Production Manager at the planting site were appraised of the various aspects of the programme before implementation and for Sanjeevani Sanatorium, the local Member of Legislative Assembly (MLA) who is the President of the Director Board and also the Director Board Members were made fully aware about the various components of the Programme and the related activities which they agreed and were ready to co-operate and also involve, wherever necessary. The extension and training activities related to species and area selection, nursery activities and plantation raising in Palakkad District are detailed here, which were mainly centered around the participating farmers, whose land areas have been chosen for rehabilitation.

2.5.1. Species, area and farmers selection

In the first phase of the project implementation itself, both the species to be tried and the farmers and their areas to be restored were accomplished by Participatory Rural Appraisal (PRA) method. As mentioned earlier, it was already decided that only tree species will be used for the rehabilitation programme to ensure sustainability of the crop and to avoid recurring planting expenditures during and after the project period. Initially, 30 medicinally important tree species suitable for the area were selected and the land was also perambulated simultaneously. A proforma was designed with details of the species like local names, growth habit, details of product and part to be extracted and used, including marketability of the drug raw materials. This proforma included two parts to be filled by the farmers. In the first part they were to select any 10 or lesser number of the species in the list and in the second part they were also free to suggest species of their preference to be planted in their degraded lands. Some details on the extent and type of areas which they possess and willing to be rehabilitated with the species chosen or suggested by them was also to be added to the filled-up and returned proforma.

The proforma was circulated to more than 150 farmers in the Muthalamada Panchayath, Kollengode Taluk, Palakkad District, either through Krishi Bhavan, local Key persons or the farmers voluntary organization with the registered name Team Farmers. On return of

the proforma, a series of meetings were organized at three locations (schools) within the Panchayath and the farmers who attended the meetings were individually and collectively discussed about their species choices and the area available for planting. Representatives of Agricultural Department, Team Farmers and the Key persons also attended the meetings who supplemented more details about the land suitability and species preference of the farmers. By such repeated interaction meetings, a list of 10 species was finalised for the restoration programme in the farmers' land of the District and a total of 90 farmers were identified as active participants in the various activities of the programme including plantings in their wastelands.

During the interaction meetings, a feed back on the possible and practical mode of seedling transportation and distribution and details of activities related to planting were also received from the Farmers - Team farmers - Agricultural Officers - Scientists combined forum, which was acceptable to all. A detailed list of farmers, their holdings, species to be planted in each plot, approximate number of seedlings that can be planted in different plots, point of seedlings distribution, etc could also be finalised during the interaction meetings.

2.5.2. Land selection

During the PRA and species selection interaction meetings, necessary details of land availability with individual farmers were also recorded. After the species selection meetings, rehabilitation area suggested by each farmer was also visited to check and identify the area and to assess their suitability and also to gather preliminary data on their present vegetation/crop patterns, ecological details, species that are more suitable to the location and plantable number of seedlings, type of planting design like pure, intercrop, etc. Also, details pertaining to the execution of plantation activities such as seedlings transportation and points of distribution, aligning, pitting, labour availability, season or time of planting initiation and period required for the completion of pitting, exact planting dates, etc. were also gathered and recorded. As the field evaluation trips were organised along with species selection interaction meetings, on most of the occasions, representatives of the forum Team Farmers and one or two agricultural officers also accompanied along with the Scientists team consisting of a Botanist, Silviculturist and Ecologist. Several practical suggestions were also received from the farmers and agricultural officers covering various aspects of the programme which, to a great extent, facilitated the implementation of the scheme.

2.5.3. Nursery and planting demonstration

After the shade-net nursery facility was established in the Field Research Station of the Institute at Veluppadam, Thrissur District, and seeds were procured from various sources, demonstrations of the nursery activities to the farmers were organised, mainly with the help of the farmers' organisation 'Team Farmers'. A programme was chalked out to bring 15-25 farmers in a group at a time to the nursery site and to demonstrate details of nursery establishment, seed handling, seed-sowing, watering, seedlings protection, pricking, polypotting, and so on. Accordingly, within a span of 15 days, 4 such farmer groups could be brought to the nursery site and demonstration cum training imparted to almost all the 90 farmers who are to be involved in the scheme, except for a very few, who could not join any of the 4 sets of meetings. In fact, three educated and enlightened members of 'The Team Farmers' were also entrusted to impart minimum details regarding seed and nursery activities to the farmers who could not attend the demonstration classes and a write-up was given to them for circulation among all the participating farmers to fulfill the transfer of technology process, effectively.

Planting demonstration was conducted in the actual field in Muthalamada Panchayath of Kollengodu Taluk, where the planting activities were to take place. At three locations within the Panchayath, such demonstrations with details on aligning, escapement, pitting, pit-size and shape, details of transferring seedlings from polythene covers to the pits, mode of planting, pit-filling, etc. were conducted and most of the farmers including the actual pitting and planting labourers attended the demonstration classes. A demonstration of taking various pit types like V-pit, Saucer-pit, etc. were also conducted, as such pit-types are more suitable to the areas identified for planting, to facilitate for water-retentivity, seedling survival and their better growth.

3. RESULTS AND DISCUSSION

In this chapter, species-wise details of habit, world distribution, uses, etc. and the silviculture technology developed and transferred for each of them are given. The field performance of outplanted seedlings within the operational time frame of the project is also analysed and presented. With regard to the achievements in the people's participation and transfer of

technology components of the programme, the methodology followed and the outcome are already discussed earlier.

3.1. *AEGLE MARMELOS* (L.) CORR. (Rutaceae)

Local names: Koovalam, Velva, Bael.

Deciduous trees, 5-10 m high with dense or sparse crown; branches thorny with 3-foliate, aromatic leaves; leaflets ovate-lanceolate, rounded or acute towards base. Flowers greenish-white, fragrant, in axillary clusters towards the tip of branchlets. Smooth, hard and aromatic rind and sweet pulp and numerous, oblong, compressed seeds inside.

Distribution: India, Myanmar.

Useful parts: Roots, stems, bark, leaves, fruits, seeds, young shoots, wood.

Uses

The fruits are official in the Indian Pharmacopoeia. They are also valued in Ayurvedic medicine. The gummy substance surrounding the seeds serves as good adhesive and is added to water paints to improve strength and brilliancy. The gummy substance is more abundant in young fruits. The gum is also used for the stabilization of drilling fluids. The stem also contains a gum similar to gum arabic. A yellow dye is extracted from the rind of unripe fruits.

The unripe or half ripe fruit is medicinal, regarded as astringent, digestive and stomachic. The fruit is used in chronic diarrhea and dysentery, and is also used as a tonic for heart and brain. In the post treatment of bacillary dysentry, the fruit is a useful adjuvant and it helps to prevent constipation which hinders the healing of ulcerated surfaces of intestines. The preparations of the Bael fruit commonly used are the extract made from fresh unripe fruits, liquid extract from dried slices of the unripe fruits and the powdered, dry pulp. The ripe fruit is also eaten fresh. The fruit pulp, diluted with water and added with requisite amount of sugar and tamarind, forms a delicious, cooling drink. The tender green fruit is utilized for making a preserve (morabba) which occupies an important place in the preserves industry of North India.

Besides the fruits, the root, bark, leaves and seeds of Bael are valued in the indigenous systems of medicine. The root is an ingredient of the 'Dasamoola' (ten roots), a combination extensively used by the Ayurvedic medicine preparations. The roots as well as the bark are used in the form of a decoction as a remedy for melancholia, intermittent fevers and palpitation of the heart. In pharmacological trials, as in the case of fruits, the root has exhibited anti-amoebic and hypoglycemic properties. The root bark has also been used, particularly against intermittent fevers and also as a fish poison.

The young leaves and shoots are used as fodder. The bitter leaves are also used as febrifuge. Poultice made of the leaves is used to cure opthalmia and ulcers. Fresh leaves are used in West Bengal as a remedy for dropsy and beriberi associated with weakness of heart. The leaves contain biogenic stimulators which increase in quantity on storing at low temperature in dark. The diluted leaf juice is also medicinal for cataract. In clinical trials, the fresh leaf extract is reported to have significantly decreased the requirement of circulatory stimulant (1nor-adrenalin) and also reduced the period of convalescence in patients with cholera or choleric. The leaves are reported to possess cardiotonic effect, like digitalis, on amphibian and mammalian hearts. The alkaloid aegeline, present in the leaves of the species is efficacious in asthma.The astringent rind of the ripe fruit and the bark are also employed for dyeing and tanning. The timber of the tree is also commonly used for making agricultural implements, furniture, for carving and also for making sacred and religious fire. The wood is also useful for making pulp for the manufacture of wrapping paper.

3.1.1. Nursery techniques

Globose fruits of *A. marmelos* ripen during January to March and were collected from healthy trees using a long pick. Usually, when the fruits become ripe, they develop an yellowish orange color. Depending on the size, about 6 to 8 fruits weigh one kilogram. In case the fruits are not available on trees at the time of collection, fallen fruits can be gathered from the ground if they are not damaged by insects or ants. It is always better to discard the fruits fallen on the ground for gathering seeds since such fruits are usually broken open or damaged. The ripe fruits, soon after collection were broken open and the small greyish seeds, embedded in a yellowish mucilaginous mass inside the fruits, were scooped out for extraction of seeds. The seeds were developed by putting the scooped out matter into a bucket of water and soaking for atleast 12 hours to remove the mucilaginous mass. Seeds automatically get separated and those still embedded in the pulp may be separated by rubbing the pulp with the palms. After washing the

seeds thoroughly in clean water, they were sun-dried for two to three days. On an average, 9997 seeds weigh one kilogram.

Fresh seeds always gave higher germination percentage. Seeds were sown on standard nursery beds and covered with a thin layer of clean sieved soil. Approximately the same thickness of soil were sprinkled over the bed to cover the seeds and to keep them moist. Germination started after six days of sowing and continued upto 15 days. The seedlings were potted into polythene bags of 28 x 18 cm flat size and 250 mm thickness, filled with a mixture of three parts clean sieved forest soil, two parts sand, and one part clean powdered farmyard manure. Potting was done when the seedlings attained about 3 to 5 cm height and it took around 25 to 30 days for attaining this height range. Polypotted seedlings were protected from hot sun by keeping under 50% shade net and watering daily twice till the seedling established in the polythene bags. Watering was gradually reduced to once every day. Shade net were gradually removed and watering stopped during rainy days. During non-rainy seasons watering was done as and when required to avoid wilting of the growing seedlings. Usually, during the nursery stage, the seedlings are devoid of any major disease or insect problems.

Table 2. Silvicultural details of *Aegle marmelos* (Rutaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	January-March
2.	Fruits per kg	5-7
3.	Seed extraction	Break open fruits and washing off mucilage for three to four days
4.	Seeds per kg	9997
5.	Germination period	6-10 days
6.	Germination percentage	80%
7.	Plant percentage	85%
8.	Storage of seeds	Fruits can be stored up to three months

3.1.2. Planting out and after care

The polypotted seedlings of *Aegle marmelos* in the nursery attained an average height of 29 cm in eleven months. Prior to transportation, the seedlings were graded and those in the height range of 25 to 35 cm were selected and shifted to the farmers land spread over Kollengode Taluk in Palakkad District for outplanting.

Seedlings of *A. marmelos* - a draught hardy species which prefers open areas and which are capable of growing in partial shade also (Troup, 1921) - were planted in farmers landholdings. The sites were either completely exposed and barren areas receiving moderate rainfall, degraded areas with sparse vegetation in the low rainfall zone or irrigated coconut gardens. The first category of sites, ie. completely exposed open degraded areas with moderate rainfall were demarcated, aligned and staked at 2 m x 2 m spacing and pits of 30 cm x 30 cm x 30 cm were dug at the staked points during July. During the monsoon showers in August, block planting was done either in the form of square or linear plots.

The second category of degraded sites identified in the low rainfall zone having sparse vegetation were demarcated and while aligning and staking, care was taken to ensure that no existing vegetation was tampered or removed. In these sites the gaps were filled by planting the seedlings without adhering to any fixed spacing pattern.

In irrigated coconut gardens, underplanting of *A. marmelos* seedlings was carried out depending on the availability of space, without adhering to any fixed spacing or planting design. The seedlings were planted in open areas, either in the middle of four established coconut trees or along the bunds running through the compound boundaries of the farmers land. Being a plant armed with thick, long thorns, outplanted seedlings were very rarely browsed or trampled by domestic animals like cattle and goat.

Planting was done during the monsoon showers of July-August with the involvement of farmers and other local people. In highly wind prone areas, stakes were used as props for keeping the outplanted seedlings erect to avoid excess swaying during windy days which otherwise causes large scale seedling mortality in the field.

Aegle marmelos

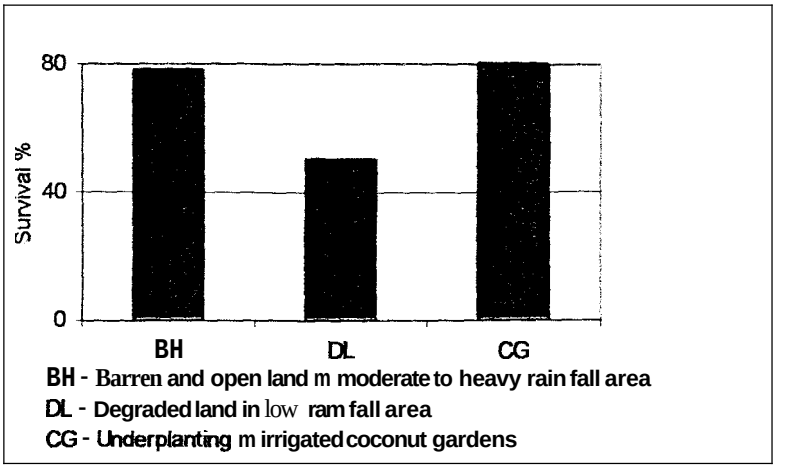


Fig. 1. Mean survival percentage of seedlings at 31 months after outplanting

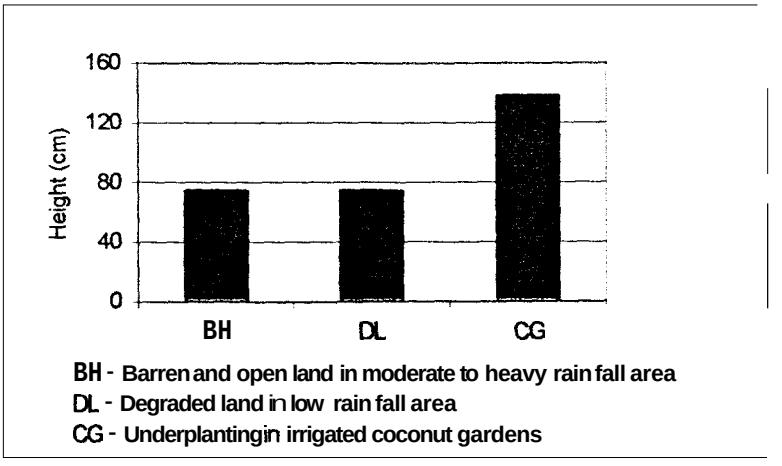


Fig. 2. Mean height (cm) of seedlings at 31 months after outplanting

3.1.3. Species performance

Eleven month old polypotted seedlings of *A. marmelos* established well and registered better growth (height and diameter) in degraded areas receiving moderate rainfall and in irrigated coconut gardens. The survival and growth performance of the species in barren areas with very low rainfall intensity was comparatively inferior and slow.

The survival percentage of outplanted seedlings after a span of 31 months in degraded land receiving moderate rainfall and in irrigated coconut gardens were 79-80% and was almost similar in both category of sites (Fig. 1). The high survival rate is probably due to the availability of water or higher moisture content in the soil during the establishment phase of the seedlings, especially during the initial two years of the growth. The outplanted seedlings in the degraded sites receiving low rainfall registered slightly lower survival rate of about 50% (Fig. 1). In addition to the meager water availability, the desiccating wind - a very common phenomenon in the degraded sites of Palakkad District - accelerated the rate of evaporation, thus reducing the soil moisture content, which naturally increased the mortality rate of outplanted seedlings. Even though the survival rate diminished slightly in low rainfall areas of Kollengode Taluk, a 50% survival after 31 months growth in a degraded zone with severe water scarcity is suggestive of the fact that *A. marmelos* is an ideal species for large scale plantation programmes in similar degraded sites.

The outplanted seedlings, after field establishment phase, exhibited only slow height growth in both categories of degraded lands receiving either moderate or low rainfall. However, the growth pattern of seedlings was almost similar in both the above categories of sites (Fig. 2). However, the seedlings underplanted in coconut gardens grew faster and registered a maximum average height of 140 cm in 31 months growth in the field. The better height growth of seedlings in this category of land can probably be due to the routine plot maintenance and care including regular fertilization and watering rendered to the agricultural crops by the farmers. The advantage of introducing medicinal tree crops as agroforestry species in such agricultural fields or coconut gardens is that the nutrition and water supply provided to the agricultural crops can be shared by the medicinal tree crops also, which will result in maximum biomass production.

3.2. *CAESALPINIA SAPPAN* L.
(Fabaceae)

Local name: Chappangam

Shrubs or small trees 2-5 m high; main stem, branches and leaves spiny. Leaves compound, paripinnate with leaflets upto 1 x 0.5 cm, oblong or linear, entire, acute or obtuse at apex and base. Flowers yellow in axillary racemes. Pods oblong 4-6.5 x 3.5-5 cm, flat and bulged in the middle with compressed, pea-shaped seeds, upto 1 cm long.

Distribution: India, Sri Lanka, Myanmar.

Useful parts: Heartwood, pod cases, leaves and stem bark.

Uses

This spiny, stunted trees are usually cultivated along the hedges. The orange-red heartwood of the tree finds its industrial use in the dyeing of cotton, silk and wool fabrics and also in calico printing. The pod-cases and bark contain tannin (ca. 40% in the former).

The wood is hard, takes shining polish and is therefore very useful for inlaying work. The wood is also used, to a limited extent, in cabinet making and for making cupboards and walking sticks.

Medically, Sappan wood is an astringent and is administered as a decoction (1 in 20). The decoction gives relief in mild cases of dysentry and diarrhoea. Given internally, it is very effective in certain skin affections. Because of its cooling effect, powdered wood is used as an ingredient in boiled drinking water and at present powered wood is manufactured and marketed widely, adding to the commercial value of the species.

3.2.1. Nursery techniques

Pods of *Caesalpinia sappan* are 5 to 10 cm long and 3 to 4 cm broad. About 100-200 of the pods weigh one kilogram. The pods are yellowish-green which turn blackish-brown when mature. Because of their thick and woody nature, usually they are indehiscent when attached to the plant. Initially, for raising seedlings, pods were collected from medium sized healthy trees using a hand-pick during the months of March to May. The pods were then dried in sun for 3 to 5 days. Most of the pods dehisced when sun-dried and those which were still intact were opened by gently tapping them with a stick to release the seeds. The seeds are 1 to 1.5 cm long, 0.5 to 0.8

cm wide and 0.4 to 0.7 cm thick, and greenish-brown in color when mature. About 1580 seeds weighed one kilogram and they can be stored in air-tight plastic containers for about 6 to 7 months without loosing much of the viability. Fresh seeds always gave maximum germination percentage.

Pre-treatment of seeds by soaking in tap water enhanced the germination percentage. Seeds were taken in a thin cloth bag and dipped in tap water for 24 hours. The water soaked seeds were sown in raised nursery beds and 500 to 700 gm of seeds were sufficient for sowing in 1 m^2 of the bed. Germination started on the 4th day and was completed by the 9th day. Fresh and pre-treated seeds usually gave very high germination rate, ie. in the range of 85 to 90% in the nursery. Seedlings were ready for pricking out when they were 2.5 to 4 cm tall, after 15 days of germination.

Table 3. Silviculture details of *Caesalpinia sappan* (Caesalpiniaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	December-January
2.	Fruits per kg	100-120
3.	Seed extraction	Sun dry pods which gets automatically opened and disperse the seeds. Those not broken may be tapped with a stick to force the pod open. Seeds dried for a day or two.
4.	Seeds per kg	1580
5.	Germination period	4-6 days
6.	Germination percentage	75-80
7.	Plant percentage	85-90
8.	Storage of seeds	4 months

Seedlings of *C. sappan* when kept at close spacings in the nursery were infected with web blight. In order to prevent this, the seedlings may be lifted once in 60 days and rearranged, leaving more space in between the polybagged seedlings. No other major disease or pest problems were encountered and a high plant percentage of 85-90% was obtained in the nursery.

Pricking out was done when the seedlings were 2.5 to 4 cm high into polythene bags of 28 cm x 18 cm flat size and 250 mm thickness, filled with a potting mixture of fine sieved forest soil (3 parts), sand (2 parts) and dried and powdered farmyard manure (1 part). Seedlings exhibited better height growth when watered twice daily and were arranged under shade-net, blocking 50% of the light intensity. Seedlings were well-established after about 30 days of potting and by then watering was reduced to once a day. The seedlings were gradually shifted to an open area in the nursery and watered as and when required only to prevent wilting of the established seedlings.

3.2.2. Planting out and after care

The polypotted seedlings of *C. sappan* registered an average height growth of 36 cm during 13 months of growth in the nursery. Seedlings in the range of 30-40 cm were distributed to the farmers from all the three selected climatic zones, ie. degraded lands in moderate to heavy rainfall zone, barren lands in low rainfall zone and underplanting in irrigated coconut gardens, for outplanting in their wasteland areas. The advantage of faster growth and presence of spines on the stem portion were features much preferred by farmers for selecting the species for large scale planting, either as live fences, boundary planting or block plantings. The seedlings were planted in closer spacing of 1.5 cm to 2 cm along compound boundaries where they served as live fences. Wherever more space was available, 2-3 rows of seedlings were planted in a staggered pattern with 1.5 m space between the two rows. In block planting, the spacing provided was 2 m x 2 m and in all the cases seedlings were planted in 30 cm x 30 cm x 30 cm pits. Planting was carried out with the participation's of farmers and local people and was completed during the monsoon showers of late July.

3.2.3. Species performance

The field performance of 13 months old seedlings of *C. sappan* in all the three land types was good with high a survival percentage (Fig. 3). The seedlings survived better in the second and third type of land, where moisture availability was better. The mortality in the plots of degraded land with moderate to heavy rainfall was mainly due to the acute grazing that was prevalent in and around the planting sites. The seedlings of *C. sappan*, even though possess a number of thorns on the stem portion, are too delicate and during the initial years of establishment, they were heavily browsed and trampled by the cattle. In other two categories of land, farmers took personal interest to check grazing the planted seedlings which helped to ensure higher survival

Caesalpinia sappan

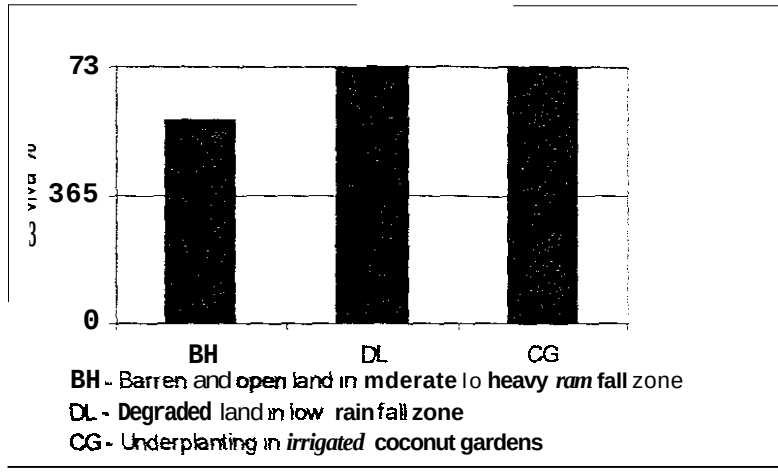
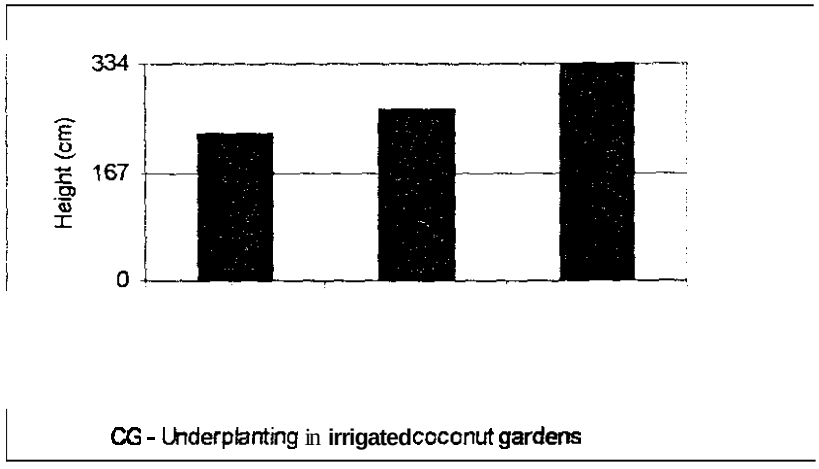


Fig. 3. Mean survival percentage of seedlings at 14 months after outplanting



rates. The seedlings survival well in drier zones also under protection during the initial stages of field establishment.

Though the seedlings established well in degraded land with low rainfall the height growth was better in coconut gardens (Fig. 4). This was probably due to the additional care farmers took for the outplanted seedlings along with adequate moisture availability during the establishment phase of the seedlings. The grazing and nibbling of the shoot tip had also resulted in slightly stunted nature of the seedlings in zones which received higher rainfall.

3.3. *CINNAMOMUM ZEYLANICUM* BREYN. (Lauraceae)

Local names: Karuva-patta, Lavanga-patta.

Evergreen trees, 10-20 m high; branches twiggy, quadrangular towards apex. Leaves aromatic, simple, petioled, 5-10.5 x 3.5-8 cm, elliptic or ovate, entire, acute at both ends with 3 prominent nerves running from base to apex. Flowers dull white in terminal panicles. Fruits upto 1 x 0.5 cm, elliptic.

Distribution: Western Peninsular India, Sri Lanka.

Useful parts: Stem-bark, roots, leaves.

Uses

The bark of the stem, as it dries, contracts and assumes the appearance of a quill which is the Cinnamon of commerce. When sufficiently dry, the bark pieces are made into bundles and assorted into different grades for export. The quills are graded into 3 or 4 qualities depending on the appearance and aroma and are used for the production of the Cinnamon oil. A less valuable oil is also distilled from leaves and petioles.

The bark, either as small pieces or as powder, is extensively used as spice or condiment. It is aromatic, astringent, stimulant and carminative. It possesses the property of checking nausea and vomiting. Powdered Cinnamon bark is a constituent of chocolate preparations. Cinnamon is also used in candy, gum, incense, dentifrice's and perfumes.

Bark-oil is extensively used for flavoring confectionery, liquors, pharmaceuticals, soaps and dental preparations. It has a high germicidal property; but on account of its irritant

properties it is not used as such. It is also used as a fungicide. The cordial and carminative properties of cinnamon makes it adjuvant in stomachic and carminative medicines. As a powerful local stimulant, it is also sometimes prescribed in gastrodynia, flatulent colic and gastric debility. A medicinal oil is also obtained from the fruits.

Cinnamon leaf-oil equals clove oil in eugenol content (70-90%) which makes it useful in perfume and flavoring industries. The oil used for flavoring sweeting and confectionery and is a common adulterant for the bark oil. It is also used as an embrocation in rheumatism.

3.3.1. Nursery techniques

C. zeylanicum possess dark, purple fruits which are single seeded, ellipsoid and 1.25 cm to 2.50 cm long. The fruits of Cinnamon ripen during August. The fully ripened fruits were either picked from the tree or allowed to drop down and then collected from the ground. Fruits were developed by keeping them immersed in water for at least 12 hours and rubbing them with the palm. Seeds were then washed properly so as to remove all the pulp and were sown without much delay, as they have very short viability. Ripe fruits also can be collected and heaped in shade until the pulp turns black and rots. The seeds can then be separated by trampling washing, drying and sowing immediately.

Seedlings were raised from freshly collected seeds. Seeds were sown in standard nursery beds under the shade-net. Watering was done twice daily and the seeds started germination after 35 days. Germination was over within 86 days and the seedlings recorded very slow initial growth. They were potted in polythene bags of 22 cm x 14 cm size with 250 mm thickness, filled with a mixture of three parts clean sieved forest soil, two parts sand and one part clean powdered farmyard manure. Potting could be initiated when the seedlings were about 3 to 5 cm height and the period taken for attaining this height range was around 70 days. The potted seedlings were retained under the shade net up to six months, watering them twice daily up to three months and then gradually reducing to once a day. Seedlings require shade and adequate moisture upto six months of development in the nursery. In this case, they were retained in the nursery up to one year before they were shifted to the field for outplanting.

3.3.2. Planting out and after care

C. zeylanicum is a hardy species which can grow on any type of soil under a wide variety of tropical conditions. The plant can withstand heavy rainfall and is also not browsed by cattle,

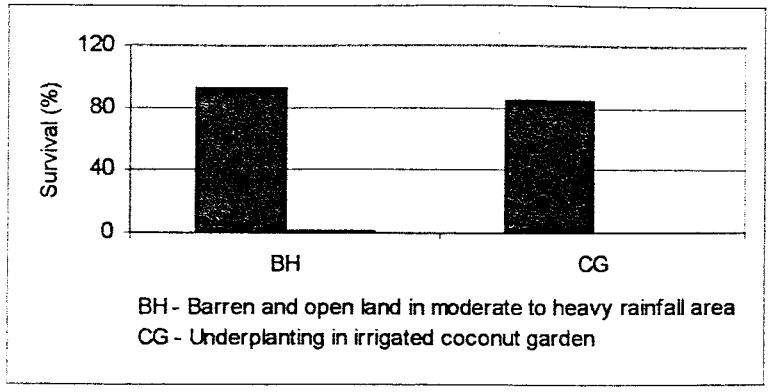


Fig. 5. Mean survival percentage of seedlings at 18 months after outplanting

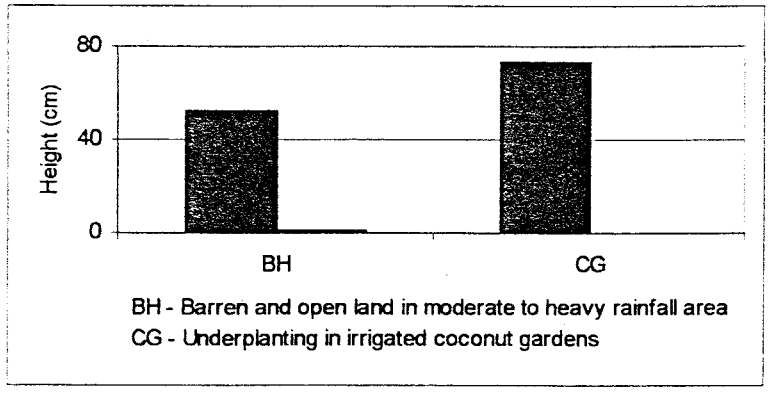


Fig. 6. Mean height (cm) of seedlings at 18 months after outplanting

Table 4. Silvicultural details of *Cinnamomum zeylanicum* (Lauraceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	May-August
2.	Seed extraction	Ripe fruits are collected and heaped in shade until the pulp turns black and rots. The seeds are then separated by trampling washed and dried.
3.	Seeds per kg	3067
4.	Germination period	2-3 weeks
5.	Germination percentage	15
6.	Plant percentage	90
7.	Storage	one week

eventhough they are susceptible to fire damage.

In the present study, Cinnamon seedlings were planted only in two types of wastelands, viz. in barren and open area which received moderate to high rainfall and in irrigated coconut gardens as underplanting. Only 15 months old seedlings were used for field planting, which was done during the month of July-August in 1996. The seedlings were planted in degraded areas with scanty vegetation in the first category of sites or in partial shade under irrigated coconut trees. The spacing adopted was 6 m x 6 m and seedlings were planted in pits of 50 cm x 50 cm x 50 cm size in both the categories of sites.

3.3.4. Species performance

Being a plant not browsed by cattle, Cinnamon proved to be a promising species for introduction in similar areas with water availability as it came up well in degraded areas with good rainfall as well as in irrigated coconut gardens. In the present study, the 15 months old seedlings used for planting showed a very high survival rate of about 93% after 18 months field growth in moderate to heavy rainfall areas and the survival rate in irrigated coconut garden was slightly

lesser ie. 85% (Fig. 5). This slight reduction in the survival rate in coconut gardens may be due to the difference in soil characteristics of both the sites.

Height growth of outplanted seedlings was poor during the initial months and it picked up considerably during the later months. The mean height growth recorded in the moderate to heavy rainfall zone was 72.8 cm in a span of 18 months field growth (Fig. 6). However, the outplanted seedlings in barren and open areas which received moderate to high rainfall was only 50.6 cm. The 30% decrease in height growth in barren and open areas may be due to the hard lateritic subsoil present in this area with moderate to heavy rainfall.

3.4. *OROXYLUM INDICUM* (L.) VENT. (Bignoniaceae)

Local name: Palaka-payyani

Trees, 3-5 m high with corky lenticels. Leaves 2-3 pinnate, upto 1.5 m long with 2-4 pairs of ovate or elliptic leaflets, acuminate at apex, rounded at base. Flowers reddish or lurid-purple, fleshy and foetid, bourne on stout, peduncled racemes. Fruits (capsules) large, sword-shaped and flat, 50-90 cm long, with woody values and flat, thin, silvery winged seeds.

Distribution: India

Part used: Almost all parts

Uses

Most parts of the tree are used in medicine. The root bark is a well known drug in the Ayurvedic system of medicine and is often prescribed fresh. Entire root is also often used, which loose their vitality after a few months. The root bark is tonic and astringent and useful in the treatment of diarrhoea and dysentery; it is diaphoretic and is used against rheumatism. Boiled in Sesamum oil, it has been recommended for otorrhoea. Tender fruits are refreshing and stomachic and the seeds act as purgative. In Malaya, a decoction of the leaves is given in stomach for rheumatism, the leaves used externally and the seeds internally, in veterinary medicine.

Young shoots and unripe fruits are edible as vegetable. Flowers and bark of the tree are also reported to be eaten. The tree is lopped for fodder. The plant parts are also reported to possess antiseptic properties.

3.4.1. Nursery techniques

Fruits attain full size by November-December but becomes ripe and starts dehiscing by February-May. The fruit is large, conspicuous, two-valved, flat and woody capsule, 30-90 cm long and 5-9 cm wide, containing a large number of seeds. The seeds are flat and surrounded by a thin transparent white papery wing, about 3.5-5 cm in diameter. About 7800 seeds weigh one kilogram and are wind dispersed. If properly stored in airtight containers the seed retains viability upto about a year.

Table 5. Silviculture details of *Oroxylum indicum*

Sl. No.	Aspects	Observations
1.	Fruit collection period	August-September
2.	Seeds per kg	7500-10500
3.	Seed extraction	Fruits collected using hand pick - dried and seeds collected after the dehiscing of the fruit wall.
4.	Germination period	15-45 days
5.	Germination percentage	80%
6.	Plant percentage	85%

Seeds were sown on standard nursery beds, 12 m long and 1.2 m broad and 30 cm high. Seeds being very light is broadcast sown on the nursery bed and a very thin layer of clean sieved forest soil spread over it. Watering with very fine rosecan is essential as the light seeds may get dislodged due to the pressure of water. During the early stages, it is advantageous to provide shade in the nursery. Germination commences by the 10th day and will be completed by 18th or 19th day. Seedlings attain potable size by 25 to 30 days after sowing and may be potted in 28 cm x 18 cm polythene bags filled with a potting mixture of 5 parts clean sieved forest soil, 3 parts

sand and 1 part dried and powdered farmyard manure. Seedlings were watered twice daily upto the establishment phase which took about 15 days after potting. Watering was reduced gradually and the seedlings were kept under shade net.

3.4.2. Planting out and after care

Thirteen-months-old seedlings of *O. indicum* attained an average height of 29 cm in the nursery when it was ready for outplanting in the field. It was planted in open degraded areas with low and medium to high rainfall at a spacing of 2 m x 2 m, in pits of 30 cm x 30 cm x 30 cm size, during July- August, at the commencement of South-West monsoon. The plants established well in the field, eventhough, initially the height growth was not appreciable.

3.4.3. Species performance

The outplanted seedlings established well in both the planted sites with low rainfall and moderate to heavy rainfall. The average height increment of seedlings outplanted in degraded area with moderate to heavy rainfall was just 6.2 cm over a span of 14 months and this was the maximum recorded height. The plant showed very poor survival rate in the low rainfall area and the drying up of seedling was mainly due to the prolonged drought prevalent in such areas.

3.5. *PHYLLANTHUS EMBLICA* L. (Euphorbiaceae)

Local names: Nelli, Amla.

Deciduous trees, 5-7 m high. Leaves linear-oblong, upto 1.2 x 0.2 cm in size, closely distichous, linear-oblong, obtuse at base, apiculate at apex. Flowers pale pinkish in axillary fascicles. Fruits (berries) upto 1.5 cm across, fleshy, juicy with six trigonous, stony seeds inside.

Distribution: India, China, Sri Lanka, Malaya

Useful parts: Fruits, seeds, stem-bark, leaves, wood.

Uses

The fruit is green when tender, changing to light yellow or brick red in color when they ripen. It is sour and astringent, and is often eaten raw. Gooseberry is also much esteemed for making pickles, preserves and jellies. The fruit is a rich source of pectin. Also, the fruit is probably the richest known natural source of vitamin C.

Fruits of *P. emblica* is extensively used in the indigenous systems of medicine. It is acrid, cooling, refrigerant, diuretic and laxative. The raw fruit is eaten as an aperient. Fresh fruits are also used successfully in the treatment of human scurvy. Dried fruit is used against hemorrhage, diarrhoea and dysentery. In combination with iron, it is used as a remedy for anaemia, jaundice and dyspepsia. A fermented liquor prepared from the fruit is used against jaundice, dyspepsia and cough. Emblica myrobalan is used in many combined medicinal preparations of which the rejuvent tonic 'Chavanaprasa' is the most important one. Acute bacillary dysentery may be arrested by drinking a sherbet of Gooseberry mixed with lemon juice. Triphala, consisting of equal parts of powdered emblica myrobalan, chebulic myrobalan (*Terminalia chebula* Retz.) and belleric myrobalan (*T. bellerica* Roxb.) is used as a laxative and to check headache, biliousness, dyspepsia, constipation, piles, enlarged liver and ascites. The exudation from incisions on the fruit is externally applied to check inflammation of the eyes. The flowers are cooling, refrigerant and aperient. The root and bark are also astringent. The seeds are used in the treatment of asthma, bronchitis and biliousness.

Gooseberry also find its use in the preparation of writing ink and also hair dyes. The dried fruit is with detergent properties and is therefore used as shampoo for washing hair. A fixed oil extracted from the fruits is reputed to have the property of promoting the growth of hair and is therefore used in the manufacture of hair oils. The twing bark is of considerable value as a source of tanning material.

The leaves and fruits are used as fodder for cattle. The leaves contain a brownish yellow coloring matter used in dyeing tusser and mulberry silks and wool, which when used with iron mordant, a black color is produced. The leaves are used as a manure, especially in arecanut and cardamom plantations of the Karnataka State. They may be employed also for ameliorating alkali soils.The wood is red, hard and close grained and is liable to split. It is used for making agricultural implements, poles and as inferior building and furniture

wood. Being durable under water, the wood is also suited for well works. It is also used as fuel and for making charcoal.

3.5.1. Nursery techniques

Fruits usually ripen during November to February or sometimes later. They are 3.4-4.2 cm in diameter, globose yellowish green, smooth, fleshy and very astringent with a 6-ridged bony endocarp containing about 4-6 dark brown, smooth, 3- gonous seeds. One kilogram will contain about 80-125 fruits and about 53000 seeds. The seeds were extracted by keeping the ripe fruits in water for a few hours and physically removing the pericarp using a sharp knife. The stony seeds were then put in a cloth bag and kept under exposed sun. After about a week of drying, the stony seed coat broke open to release the tiny seeds inside the bag, which were winnowed, cleaned and used for sowing.

Table 6. Silviculture details of *Phyllanthus emblica* (Euphorbiaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	November-February
2.	Fruits per kg	80-125/kg
3.	Seeds per kg	53000/kg
4.	Seed extraction	Fruits to be kept in water for few hours. Remove pericarp with a sharp knife. Keep the stony seeds in cloth bag under hot sun for a week. Seeds separated out by winnowing.
5.	Germination period	40-60 days
6.	Germination percentage	15-20%
7.	Plant percentage	90%

The seeds were put for germination on standard nursery beds, 12 m long 1.2 m broad and 30 cm high. The seeds were broadcast sown over the bed and a thin layer of soil sprinkled over and watered twice daily. Seeds started germination only after about 40 days and it was completed by the 60th day. Germination percentage is very low, ie. 15-20% without any pretreatment. The seedlings were potted in polythene bags of 28 cm x 18 cm size with a potting mixture of five

Phyllanthus emblica

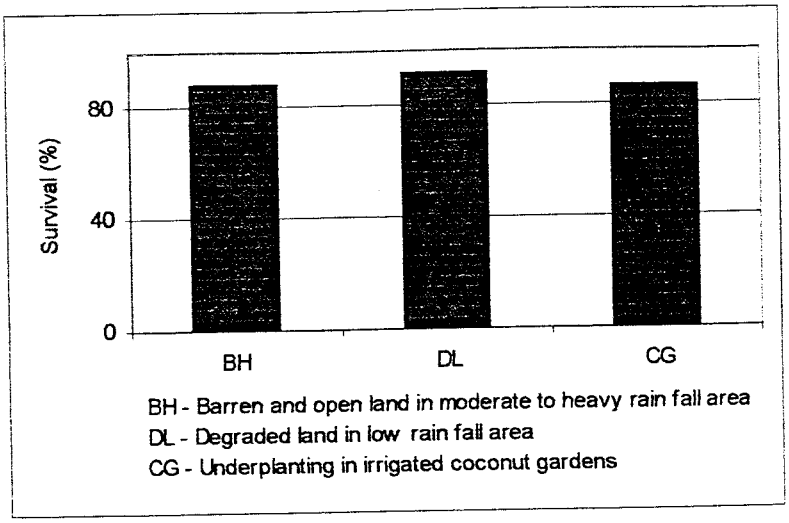


Fig. 7. Mean survival percentage of seedlings at 30 months after outplanting

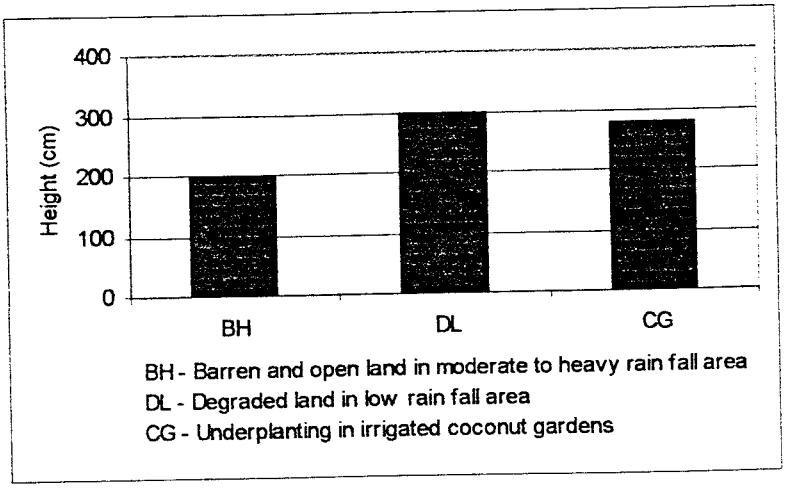


Fig. 8. Mean height (cm) of seedlings at 30 months after outplanting

parts cleaned and sieved forest soil, three parts sand and one part powdered and dried farmyard manure and the potted seedlings were kept under shade net and watered twice daily. The seedlings showed fungal infection during December-April in the nursery and were treated with Bavstin 50 wp – 2 gm per litre of water as aerial spray. One year old seedlings attained a height range of 35-43 cm and the plant percentage was around 90.

3.5.2. Planting out and after care

The seedlings were uniform in size, robust and healthy and attained an average height of 38-40 cm in 14 months growth in the nursery. They were outplanted in 30 cm x 30 cm x 30 cm pits at a spacing of 4 m x 4 m. The robust seedlings required only very little attention in the field except timely weeding. Since smothering by weeds adversely affect the seedlings growth, occasional weeding in planted areas is essential.

3.5.3. Species performance

The species established well in all the three categories of wastelands. The seedlings showed very good establishment rate and the mortality rate was negligibly low. In the degraded areas with very low rainfall, the survival rate was maximum followed by the other two categories of lands, ie. barren and open land with moderate to heavy rainfall and irrigated coconut gardens (Fig. 7). The species requires only very low moisture content in the soil for establishment and therefore is very promising for afforesting the degraded sites, especially where water is very scarce.

The species showed fast-growth in the field and within 30 months, an average height of 196 cm was recorded in the degraded land with moderate to heavy rainfall, 277 cm in coconut gardens and 297 cm in degraded site with low rainfall (Fig. 8). The robust variety of *P. emblica*, locally called as `Champakkad large' field tested in the present study seems to be an ideal species for afforesting the degraded sites, especially with very low rainfall.

3.6. *PTEROCARPUS SANTALINUS* L.f. (Fabaceae)

Local names: Rakta-chandanam, Chuvanna-chandanam, Red sanders.

Medium sized, deciduous trees, upto 10 m high; stem-bark irregular and cleft into rectangular pieces. Leaves imparipinnate, with 3 or rarely 5 leaflets, rounded, ovate or rarely elliptic, entire, leathery, obtuse at both ends. Flowers yellow in simple or rarely branched racemes. Fruits (pods) almost rounded and winged, upto 5 cm across including wings, with a central thick portion containing the reddish brown smooth seeds.

Distribution: Peninsular India.

Useful parts: Heartwood, Leaves, Stem-bark

Uses

The wood of Red Sanders tree is heavily impregnated with reddish brown gum which contains a red dye, santalin, for which the species has been much valued in the past. The timber seasons well and is also highly refractory. It is immune to white ant attack and also infestation of other insects and therefore can be used without anti-decay treatments.

Red sanders wood is considered as astringent, tonic and diaphoretic. The wood has also cooling properties and is therefore externally applied to check inflammations and headache. It is also reported to be useful in bilious affections, skin diseases and to remove scars on skin. A decoction of the fruit is also used as an astringent and tonic and to check chronic dysentery.

The coloring matter extracted from powdered wood, roots and stumps are mainly used for dyeing wool, cotton and leather and for staining other woods. The dye is also used for coloring pharmaceutical preparations and food stuffs and is also suitable for coloring paper pulp. A histological stain has been prepared from the alcohol soluble fraction of the heartwood. The bark is sometimes used in the curing of arecanuts and the leaves are used as cattle fodder.

3.6.1. Nursery techniques

Usually fruits (pods) which appear by April-June, takes about 8-9 months to ripen. The pods are almost rounded in shape, dark brown in color when ripe with single seed and flat wing all around, borne as bunches on leafless branches of mother trees. Profuse fruiting is observed almost every year. Branches with ripe pods were lopped and pods separated and sun dried for three to four days. Ripe and dried pods collected during February-March can also be stored for

about six months without loss of much viability. On an average, 1580 to 1640 dry pods with wings weigh one kilogram.

Pre-treatments like soaking the pods in boiling water, acid scarification, chipping off the wings, etc., have not much effect on the germination percentage of seeds which is usually very low. Fresh and dried seeds without any pre-treatment gave only about 26% germination. However, the pretreatment of soaking the pods/seeds in cold water for 48 hours was effective which improved the germination percentage upto 52 percent.

Table 7. Silviculture details of *Pterocarpus santalinus* (Fabaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	February-March
2.	Fruit/seed per kg	1580-1640/kg
3.	Seed extraction	Branches to be lopped and fruits/seeds/pods to be physically removed. Seeds can also be collected from the forest floor provided they are not infected or spouled. Seeds to be soaked in cold water for 48 hours before sowing.
4.	Germination period	5-26 days
5.	Germination percentage	40-52%
6.	Plant percentage	80-90%

The seeds put in gunny bags were kept immersed in cold water for 48 hours. Th soaked seeds were then broadcast sown in standard raised nursery beds of 12 m x 1.2 m x 30 cm size. A thin layer of sieved soil was sprinkled above the seeds. On an average, 2 to 2.5 kg seeds were sown on a standard nursery bed. Germination started by the 5th day and was completed by 22-26 days. The seedlings were pricked out into polythene bags of 18 cm x 28 cm size and 300 mm gauge, after about 25-30 days of germination. The potting mixture used was 5 parts finely sieved forest soil, 2 parts sand and 1 part powdered farmyard manure. Seedlings were watered twice daily soon after potting in polybags and watering was reduced to once daily and later only as and when required. The potted seedlings were kept under shade-net after pricking them out and

gradually were exposed to the sun for making them hardy. On an average 85-90% of the seedlings were plantable.

3.6.2. Planting out and after care

The growth of nursery seedlings was quite good and majority of them attained a height range of 38-45 cm by the end of fourteen months of nursery growth. Seedlings in the height range of 40-45 cm were transported to the planting sites. *P. santalinus* was preferred and by farmers and block planting of the species was done in all the three sites, viz. barren sites with low rainfall, degraded sites with moderate to heavy rains and as underplanting in coconut gardens. Planting was done during the monsoon showers in July-August with farmers participation. In the wind prone areas, stakes were used as props to avoid excess swaying of tall seedlings during windy days resulting in large scale seedling mortality in the field. The spacing followed was 2 m x 2 m and planting was done in square pits of 30 cm x 30 cm x 30 cm size.

Fourteen month old seedlings of *P. santalinus* showed maximum survival of 89% in the degraded area with low rainfall intensity. Survival was still lesser in degraded areas which received moderate to heavy rainfall and least in coconut gardens (Fig. 9). This is indicative of the fact that the species comes up well in open degraded sites even without much water availability. The species seems to be ideal for degraded sites with meagre rainfall.

3.6.3. Species performance

Fourteen month old seedlings of *P. santalinus* established well in degraded sites and are therefore suitable for introduction in similar agroclimatic zones of the State. The survival and height growth of seedlings was also very good in areas with low rainfall intensity (Fig.10). Fourteen months old seedlings of red sanders gave the maximum survival rate of 89% in the barren areas with low rainfall availability. Survival was still lesser in degraded areas which received moderate to heavy rainfall and least in coconut gardens. This is indicative of the fact that the species prefers to grow in open and its water requirement is very less. The species seems to be ideal for degraded sites which receives very little rainfall. Also, maximum height growth was recorded for the seedlings outplanted in barren areas with low rainfall. In the other two site categories, the height growth was very much similar with about 147.78 cm on an average for seedlings grown in coconut gardens and 134.38 cm for those planted in degraded sites with moderate to high rainfall intensity.

Pterocarpus santalinus

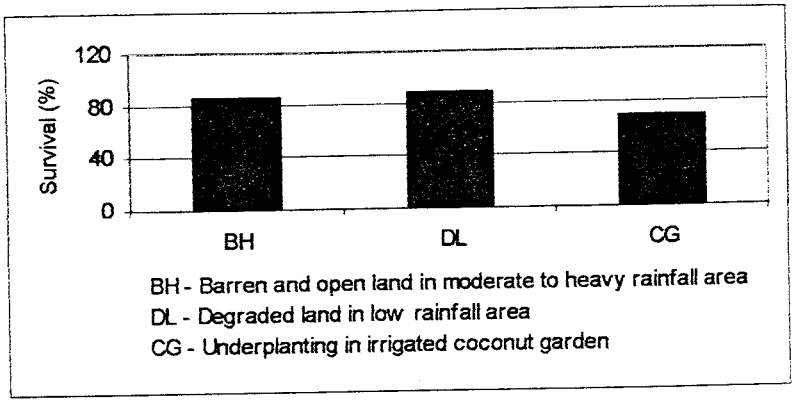


Fig. 9. Mean survival percentage of seedlings at 30 months after outplanting

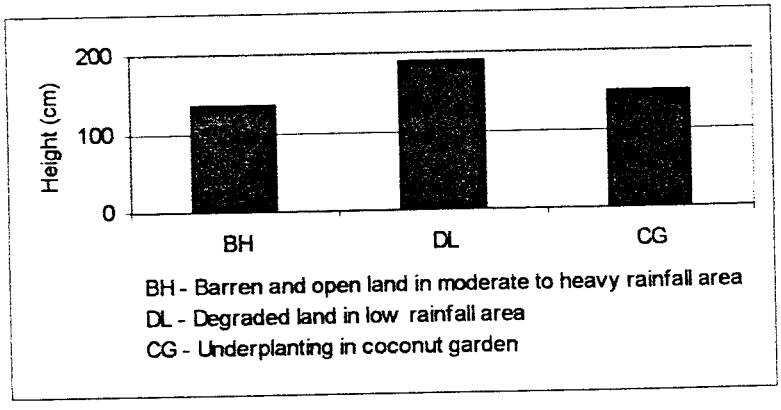


Fig.10. Mean height (cm) of seedlings at 30 months after outplanting

3.7. *PUNICA GRANATUM* L.
(Lythraceae/Punicaceae)

Local name s: Mathalam

Small trees, 5-6 m high, with branchlets sometimes spinacent. Leaves simple, upto 2 x 0.7 cm, oblong or obovate, entire, acute or obtuse at apex and base. Flowers scarlet red or yellow, axillary, solitary or 3-4 together. Fruits globose, crowned by persistent calyx with woody rind enclosing numerous angular seeds with fleshy, red, pink or whitish testa.

Distribution: Iran, Baluchistan, Pakistan, India.

Useful parts: Fruits, seeds, stem and root bark, leaves, flowers, wood.

Uses

Pomegranate is largely used as a dessert. The seeds along with the fleshy portions are dried and commercially marketed as Anardana and are widely used as condiment.

A delicious juice is prepared from the fruits. Fully ripe fruits yield sweet, deep-colored juice with a rich flavour. The fruit is a good source of vitamin C, sugars, and a fair source of iron, but is poor in calcium. The sugar content increases with age of the fruit and of the tree. The concentration of vitamin C is said to increase with maturity and ripening of the fruit, and in most cases the maximum amount is observed in the nearly ripe fruit.

Pomegranate juice can be converted into an excellent syrup. Anar rub is a product locally prepared form the juice by adding sugar and heating to a thick, viscous state. It can be stored and is used like tomato sauce or ketchup. The fruit juice easily ferments and may be used for the production of wines. The juice of wild pomegranate in Azerbaijan (USSR) is used in the manufacture of citric acid and sodium citrate of medicinal uses.

Extracts of the whole fruit is highly active against a wide range of bacteria. Alcoholic extracts of the root was found to inhibit completely the activity of Mycobacterium tuberculosis. The fresh pomegrante juice is used as an ingredient of cooling and refrigerant mixtures and of certain medicines for dyspepsia. The rind is valued as astringent in cases of diarrhoea and dysentery, the expressed juice of the leaves and young fruits and decoction of the bark are used against dysentery. The sweet types of pomegranates are said to be mildly laxative, while the less sweet types are believed to be good in inflammation of

stomach and in heart pain. The powdered flower buds are used in bronchitis. The seeds are considered to be stomachic and the pulp cardiac and stomachic. The dried bark of both the root and stem, has long been used in the treatment of tapeworm. A process for the production of an insecticidal preparation from the bark has been patented in Japan. Also, extracts of different parts of the tree exhibits antibiotic activity.

Tannin occurs in all parts of the tree, particularly in the fruit rind, stem bark, root bark and leaves. The flowers and rind of pomegranate is the source of a dye used for coloring wool and silk.

3.7.1. Nursery techniques

The fruits of *P. granatum* usually attains the size, slightly larger than a cricket ball with a light yellowish red color when ripe. Solitary fruits appear in graceful bunches and will remain attached to the mother plant till they are ripe. The ripened fruits were collected from medium-sized, healthy trees using a hand-pick during March-April and about 4-6 fruits weighed one kilogram. The fruits were opened up using a sharp knife and the seeds embedded in the fleshy pericarp was emptied into a bucket. On an average, about 6275 seeds with fleshy pericarp weighed one kilogram. The seeds were separated from the fleshy pericarp by rubbing it against a wire mesh. The seeds were then completely cleaned by repeated washes in tap water and then shade dried.

The seeds mixed with fine ash were sown in standard, raised nursery beds of 12 m x 1.2 m size and 30 cm height. A thin layer of finely sieved soil are spread over the seeds, just to cover them before watering. The seeds took 7-10 days for germination and about 65%-75% germination was obtained without any pre-treatment. Germination was completed in about 30-35 days. About 28000 cleaned seeds devoid of the fleshy pericarp weigh one kilogram.

The seedlings attained potable size of 3-6 cm within 20-25 days when they were pricked out into polythene bags of 28 x 18 cm size and 250 mm thickness, filled with a mixture of three parts clean sieved forest soil, two parts sand and one part clean powdered farmyard manure. Polypotted seedlings were kept in the shade-net nursery and watered twice daily during the initial days of establishment. Once the seedlings were established in the polythene bags, watering was reduced to once in a day. After about a month, when the seedlings were well

Punica granatum

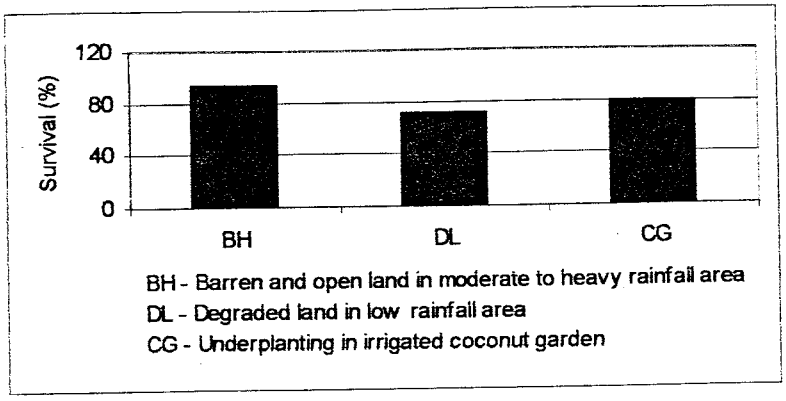


Fig. 11. Mean survival percentage of seedlings at 19 months after outplanting

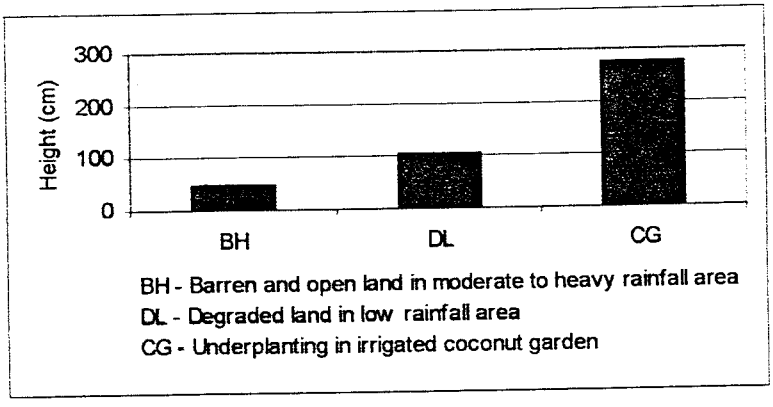


Fig. 12. Mean height (cm) of seedlings at 19 months after outplanting

established, watering was further regulated and was done only as and when required to avoid wilting of the seedling.

Table 8. Silviculture details of *Punica granatum* (Punicaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	March-April; August-November
2.	Fruits per kg	4-6 nos.
3.	Seed extraction	Fruits cut open with a sharp knife. Seeds embedded in fleshy pericarp rubbed against wire mesh to separate the pericarp. Seeds washed several times, mixed with ash and sundried for a day.
4.	Seeds per kg	28000 nos.
5.	Germination period	7-10 days
6.	Germination percentage	65-75%
7.	Plant percentage	85%

3.7.2. Planting out and after care

Polypotted seedlings of *P. granatum* reached an average height range of 30- 38 cm within 13 months of growth in the nursery and were shifted to the planting site one week prior to the date of planting. As per the preference of farmers, the seedlings were outplanted in barren areas and degraded sites receiving moderate to heavy rains, degraded sites in low rainfall region and also in coconut gardens, as underplanting. In all the three categories of sites, the seedlings were planted at a spacing of 2 m x 2 m, in pits of 30 cm x 30 cm x 30 cm size. Planting was completed by the end of July with farmers active involvement.

3.7.3.Species performance

Thirteen months old polypotted seedlings of *P. granatum* established well in all the three categories of wastelands, where they were introduced. Highest survival of 93% was obtained for the seedlings ouplanted in degraded sites receiving moderate to heavy rainfall (Fig. 11). The establishment rate of seedlings in the other two categories of lands were comparable, with a

slightly high survival rate for seedlings underplanted in coconut gardens. The partial shade in the coconut garden might have enhanced survival rate in those plots. Mortality of seedlings was more in the barren areas with very low intensity of rainfall and the plants got dried up due to the acute scarcity of water, especially during the summer months of November to August.

The height growth of thirteen months old seedling was also much higher in coconut gardens as compared to the other two types of lands. Probably, seedlings of *P. granatum* require partial shade for better establishment and faster field growth. Though, highest survival rate was observed in barren and open area which received moderate to high rainfall, height growth was minimal in these plots. Height growth of seedlings in the barren zone with low rainfall was found to be much better than the degraded zone with more rainfall (Fig. 12).

3.8. *SARACA ASOCA* (ROXB.) DE WILDE (Fabaceae)

Local names: Asokam, Hema-pushpam, Vanjulam

Evergreen trees, 5-8 m high, with dense crown. Leaves compound, paripinnate, 15-20 cm long with 4 pairs of leaflets; leaflets upto 20 x 6 cm, oblong-lanceolate, subcoriaceous, acuminate at apex. Flowers orange-yellow, slowly turning vermillions, fragrant, in dense axillary corymbs. Fruits (pods) ellipsoid-oblong, flat, woody, upto 22 x 6 cm, with 4-8, ellipsoid-oblong compressed seeds.

Distribution: India

Useful parts: Stem-bark, wood, leaves, flowers.

Uses

The Ashoka tree is one of the most sacred trees of Hindus and Buddhists, the flowers being used for religious ceremonies and temple decorations.

The stem-bark is dark brown to grey or almost black with warty surface. Aqueous extract of the bark is reported to contain two active principles one stimulating and the other relaxing the plain muscle of ileum. The drug is reported to stimulate the uterus, making the contractions more frequent and prolonged without producing tonic contraction, as the case of pituitary or ergot. The crystalline glycoside also does the same function. The drug is

reported to be useful in menorrhangia, leucorrhoea,, internal bleeding, haemorrhoids, etc. Alcoholic extract of the bark is reported to be active against a wide range of bacteria. Bark is also extensively used in various ayurvedic preparations.Bark of *Saraca asoca* is reported to cure biliousness, dyspepsia, dysentery, colic, piles, ulcers and pimples. Leaves possess blood purifying properties and their juice mixed with cumin seeds is used for stomach ache. Flowers, pounded in water, is used for haemorrhagic dysentery and dried flowers in the treatment of diabetics. Flowers are considered to make excellent uterine tonic as well as for biliousness and syphilis. In Assam, fruits are chewed as a substitute for arecanut.

3.8.1. Nursery techniques

Ripe fruits are dark purple to black in color, pendulous, long and persist on the tree for quite some time. The best period for fruit collection is during August-September and by then they may dehisce and fall. Pods will be 12-24 cm long and 4-5 cm broad, veined and compressed, tapering at both ends. Usually the seeds get infected while attached to the tree and therefore even though profuse fruiting is common every year, getting healthy, viable seeds for sowing in the nursery is difficult task. Care has to be taken to collect fruits in such a way that they are ripe and not getting infected. The fruits can be collected from the mother trees using a hand pick while they are still green in color and slight drying will make the fruit wall dehisce. Large purple to black seeds numbering 4-8 were found in a single pod. The seeds are ellipsoid oblong, 3-4 cm long and slightly compressed. About 70-90 seeds weigh one kilogram. Fresh seeds collected during September were dibbled in polybags as early as possible, as the seed viability is only around two months.

Seeds may be dibbled in polythene bags of 28 x 18 cm size 250 mm thickness filled with a potting mixture of five parts cleaned sieved forest soil, 3 parts sand and one part dried and powdered farmyard manure. The polybags were kept under shade net and watered twice till the seeds germinated. Germination started only after 15-20 days and was completed within about 40-45 days. More than 80% germination was obtained in the nursery. Seedlings were retained under the shade-net for quite some time and watering was done twice daily during the dry summer months, as the seedlings in their earlier stages of establishment and growth require shade and moisture. Since the early growth was very slow it will be ideal to plant one year old seedlings in the field. By then the seedlings will attain an average height of around 20 cm. The plant percentage was around 85 percent.

Table 9. Silviculture details of *Saraca asoca* (Caesalpinaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	August-September
2.	Seeds/kg	70-90 seeds
3.	Seed extraction	Fruits to be collected prior to the infestation sun dried and the seeds get separated from the fruit wall.
4.	Germination period	15-45 days
5.	Germination percentage	80%
6.	Plant percentage	85%

3.8.2.Planting out and after care

Twelve month old seedlings of *S. asoca* were transported to the planting site, a week ahead of planting, in July-August. The seedlings were kept under shade and watered after transporting as the species was susceptible to transporting shock and dislocation. The seedlings were planted in pits of 30 cm x 30 cm x 30 cm size, at a spacing of 2 x 2 m.

3.8.3. Species performance

The species exhibited very poor survival rate in the degraded sites with low rainfall. However, it established well in the medium to high rainfall areas and coconut gardens. The plant needs shade and high amount of water for initial establishment and if those conditions are not met with in the field, the survival percentage also declines. In the present study, after six months field growth, the survival percentage was quite high in sites with moderate to heavy rainfall intensity. However, during the course of the next 13 months mortality rate increased mainly due to intense heat and scarcity of water. The survival percentage further declined to 52% in this period (Fig. 13). Hence, it was quite evident from the trial experiment that the species requires high moisture content in the soil and also partial shade for its better establishment and growth.

Nursery grown polypotted seedlings of *S. asoca* attained an average height of 20 cm in 12 months. The seedlings were very slow growing in the outplanted sites also. During the first six

Saraca asoca

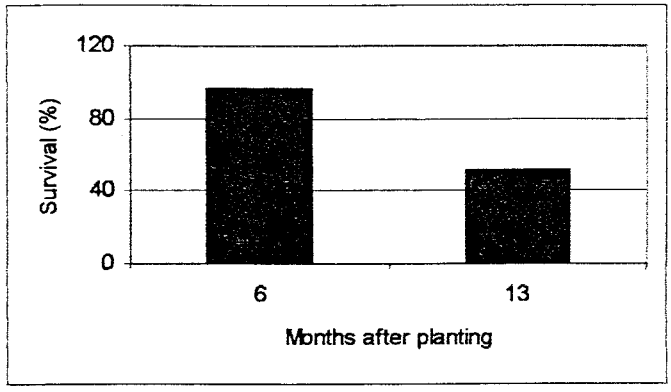


Fig. 13. Mean survival percentage of seedlings at 6 and 13 months after outplanting in the degraded land with moderate to heavy rainfall

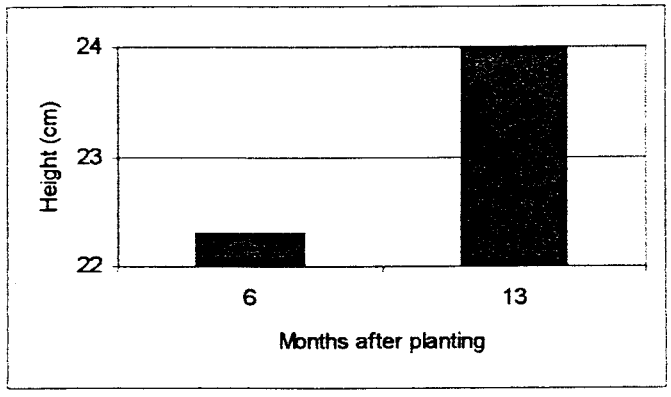


Fig. 14. Mean height (cm) of seedlings at 6 and 13 months after outplanting in the degraded land with moderate to heavy rainfall

months, seedlings planted attained an average height increment of about 22 cm and the growth rate was almost the same for another six months (Fig. 14). The species showed very poor height growth in the other two sites and the mortality rate was very high indicating the sensitive nature of the plant, especially in the degraded sites of the State.

3.9. *SYZYGIUM AROMATICUM* (L.) MERR. *ET* PERR. (Myrtaceae)

Local names: Karayampu, Krampu

Evergreen, pyramidal trees 5-7 m high with smooth-bark. Leaves simple, upto 12 x 3.5 cm, lanceolate, entire, acute at both ends, gland-dotted and aromatic. Flowers clustered at the tips of branchlets, greenish turning pink, aromatic. Fruits (drupes) dark pink, flesh-colored, upto 2 x 1 cm with oblong, grooved seeds.

Distribution: Malayan, Jawa, Singapore, Moluccas; cultivated in India and Sri Lanka.

Useful parts: Flowers buds, leaves, stem, seeds.

Uses

Only unopened flower buds are picked for preparing the clove of commerce. Clove oil is also extracted from the clove which has a strong and aromatic odour and hot, pungent and aromatic taste.

The clove is highly esteemed as a flavoring material and is extensively used, whole or in powdered form, as a culinary spice. It imparts a warming quality to food, and is used for flavoring food materials. It is used in making spiced wines and for scenting the chewing tobacco. It also forms an ingredient of betel-chew. In Indonesia, clove is used in making a special brand of cigarettes, which crackle while burning.

The chief value of clove lies in the oil that it contains. The clove-oil is highly aromatic and is extensively used for flavoring food products and in confectionery. It is also used for flavoring fermented beverages. The oil is an ingredient of dentifrice's, gargles and chewing gum. Further, it is used for scenting soap and toilet waters, in perfumery and as a cleaning agent in histological works. The oil is reported to be mosquito repellent as well. The oil

exerts action against wide range of bacteria. When added to edible fats and oils, clove impart preservative action against oxidative rancidity.

The clove is aromatic, stimulant and carminative. It is used against various types of gastric irritations and dyspepsia. It is administered either in the form of powder or as infusion to relieve nausea and vomiting, to correct flatulence and to excite languid digestion. The oil is also used as a local analgesic for hyper sensitive dentines and carious cavities. A mixture of oil and zinc oxide is used for temporary filling of tooth cavities. Used extremely, the oil is rubefacient and counter irritant. Internally, it is used as carminative and antispasmodic.

Only the oil obtained from the buds is officinal in various pharmacopoeias. The clove stem and leaf oil are valued mainly for their eugenol content and are used for the production of high grade eugenol, iso-eugenol and vanillin. The residue, after removing eugenol from the oil, is used to perfume soap.

The stem and dried buds are often distilled together to extract an oil known in the trade as anillin clove oil.

3.9.1. Nursery techniques

Fruits when fully ripe attains a purple color and is known popularly as "Mother of clove". The fruits ripen while attached to the mother plant and drops down naturally. About 650 fruits weigh one kilogram. These fruits were collected from the ground and depulped before sowing. The fruits were put in cold water for 12-24 hours and the pericarp removed by rubbing with the palms. Only fully developed and uniform sized seeds, which show signs of germination by the presence of a pink radicle, were used for sowing. One kilogram usually contains around 1063 seeds. Though ripe fruits may be stored for a few days, it is always better to sow seeds immediately after harvesting.

Seeds were sown in standard nursery beds of 12 m length 1.2 m width and 30 cm height, at a very close spacing of 2-3 cm and depth of about 2 cm. The germination commenced within about two weeks, which lasted upto six weeks. The germination percentage is very low (15%) and when the seedlings were about 3-6 cm in height they were potted in polythene bags of 30 cm x 15 cm size, containing the potting mixture of five parts clean sieved forest soil, three parts sand and one part clean dry farmyard manure. Seedlings were to be kept under shade-net and

watered once a day for better growth and vigour of the seedlings. One year old seedlings which attained a height of about 26 cm were transplanted in the field.

Table 10. Silvicultural details of *Syzygium aromaticum* (Myrtaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	January-March
2.	Fruits per kg	650 nos. (with pericarp)
3.	Seeds/kg	1063 nos. (without pericarp)
4.	Seed extraction	Purple colored ripe fruits after collection is depulped by putting in water for about 12-48 hours and rubbing with the palm.
5.	Germination period	14-45 days
6.	Germination percentage	15%
7.	Plant percentage	85%

3.9.2. Planting out and after care

It is always better to plant older seedlings in the field. Seedlings transported to the field a week in advance of planting, were planted in pits of 50 cm x 50 cm x 50 cm, at a spacing of 6 m x 6 m, during June-July along with the onset of south-west monsoon. Shade was provided for outplanted seedlings and watering done during gaps in monsoon showers and also during summer months. The plant is very sensitive to drought and sun and therefore absolute care is essential for the establishment and growth of seedlings especially in degraded sites. Proper weeding, partial shading and irrigation from October-May were the management practices followed during the initial two years of establishment.

3.9.3. Species performance

Though the germination percentage was very low, the seedlings had grown well without any disease or pest problems in the nursery, probably because of the extreme care taken during the nursery stages. The plant percent was then quite high and about 85% plantable seedlings were obtained from the nursery.

The outplanted seedlings in the degraded sites with low rainfall intensity showed declining trend in survival and in spite of intensive care the seedlings did not establish well in the field. Seedlings outplanted in the barren and open area which received moderate to high rainfall showed better survival rate initially. But, the trend reversed and they started showing stunted growth in the field. Therefore, introduction of this species in degraded areas even with much care seems to be a difficult task. Even the established plants in the field exhibited stunted growth and decline in vigour and growth characteristics.

3.10. *WRIGHTIA TINCTORIA* R. BR. (Apocynaceae)

Local names: Thonda-pala, Danda-pala, Kodaka-pala, Aiyapala.

Deciduous trees, 3-8 m high. Leaves simple, elliptic-ovate or oblong-obovate, upto 11 x 5.5 cm, entire acute at base, acuminate at apex. Flowers white, fragrant in lax, terminal cymes. Fruits (follicles) in pairs, cylindric, pendulous, upto 45 cm long, with adhering tips and linear seeds with basal coma.

Distribution: Peninsular India

Useful parts: Leaves, stem-bark, seeds, roots, latex of fruits, flowers, pods, wood

Uses

Wood of the tree is easy to saw and finishes to a surface which requires little polishing. The wood is extensively used for all classes of tennary and handicrafts.

The bark and seeds are used in flatulence and bilious affections. A decoction of the leaves and bark is taken as a stomachic. The dried and ground bark is rubbed over the body in dropsy. The seeds also possess aphrodisiac and anthelmintic properties. The fresh leaves are very pungent and are chewed for relief from tooth ache. Alcoholic and aqueous extracts of the leaves and roots possess hypotensive properties.

The flowers are used as a vegetable. They are slightly bitter and require thorough washing before use. The tender leaves, pods and seeds are also eaten.

The leaves are the source of a blue dye, indigo, called Mysore-Pala Indigo. The tree bears handsome clusters of white, jasmine-scented, star shaped flowers in profusion, which are much esteemed by Hindus for temple offerings The leaves are also used as wrappers of Bidis

3.10.1. Nursery techniques

The pods of *W. tinctoria* are 20-30 cm long, cylindrical, and pendulous with a greenish color turning straw-yellow when ripe. Fruits were available during January-April. During January-April, usually long pods get split open releasing the seeds. Hence, seeds are to be collected when the pods are greenish in color, slowly getting changed to yellowish and usually this stage is during the months of January-February. The pods collected were put in cloth bags and sun dried for releasing the seeds. The seeds are 1 cm to 1.6 cm long, linear, light yellowish grey in color with white silky hairs on the top which assists in wind dispersal. About 32250 seeds weigh one kilogram.

Table 11. Silvicultural details of *Wrightia tinctoria* (Apocynaceae)

Sl. No.	Aspects	Observations
1.	Fruit collection period	January-April
2.	Seeds per kg	32250 nos.
3.	Seed extraction	Pods sun dried for 3-7 days in cloth bags and the seeds separated and winnowed
4.	Germination period	7-21 days
5.	Germination percentage	85-90%7
6.	Plant percentage	90%

Freshly collected and winnowed seeds were broadcast sown on standard raised nursery beds of 12 m x 1.2 m x 30 cm size. Seeds were thinly covered with fine soil and watering was done twice daily. The seeds started germination after seven days and was completed in about 21 days. Germination percentage without any pre-treatment was 85-90% and the initial growth of the seedlings was slow to moderate. Seedlings were potted in polythene bags of 28 x 18 x 250 mm

size after about 36 days, when they attained a height ranging from 3-6 cm. Potting was done in a mixture of three parts clean sieved forest soil, two parts sand and one part clean powdered farm yard manure. The seedlings after potting were arranged under the shade and watered twice a day till they established in the pots. Watering was gradually regulated and was rendered as and when needed to avoid wilting of the seedlings. The plant percentage obtained was very high, ie. about 90 percent

3.10.2. Planting out and after care

Though the seedlings of *W. tinctoria* showed very good establishment rate in polythene bags, their height growth was poor to moderate in the nursery. The seedlings attained only about 22-28 cm height, even after 14 months of potting in the nursery.

W. tinctoria being a common species in the degraded areas of Palakkad District, farmers were not much interested in planting the seedlings in their wastelands. Hence, only sample plots of the species were established in the degraded area, which received moderate to heavy rainfall. The species being very typical in the degraded sites and drier tracts, gave only poor survival rate when introduced in higher rainfall areas (Fig. 15).

3.10.3. Species performance

The height growth of the seedlings was very poor during the initial 30 months after outplanting in the field (Fig. 16). Though a promising species for rehabilitation of degraded sites, it seems to be more suitable for drier tracts with lower rainfall intensities. Also, water availability is not a positive feature for the enhanced survival and height growth of the species during the initial stages in the field.

Wrightia tinctoria

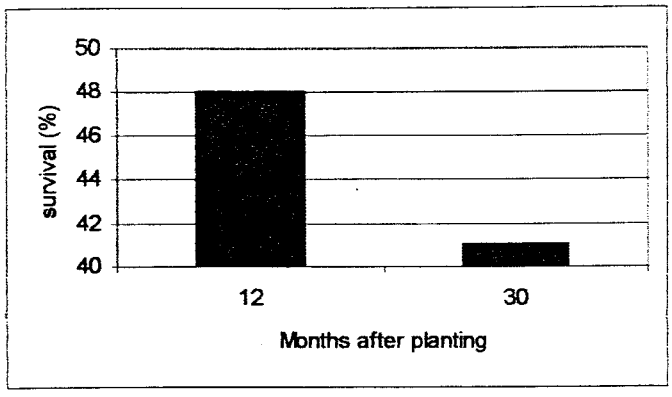


Fig. 15. Mean survival percentage of seedlings at 12 and 30 months after outplanting in the degraded land with moderate to heavy rainfall

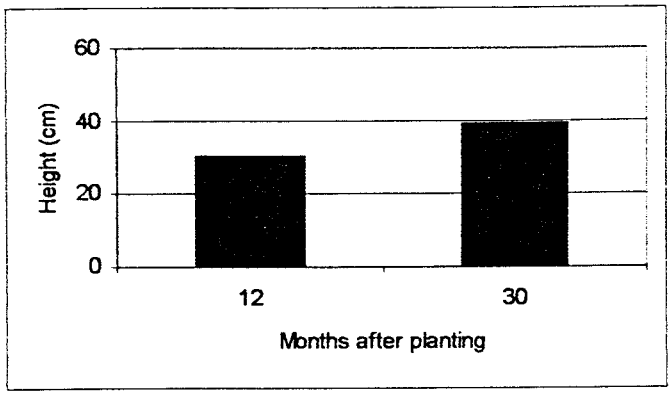


Fig. 16. Mean height (cm) of seedlings at 12 and 30 months after outplanting in the degraded land with moderate to heavy rainfall

4. PHYSICAL TARGETS ACHIEVED

The four years physical targets of the scheme envisaged to generate 1,50,000 seedlings of the ten species of medicinal plants and to plant them in a total of 75 ha of wastelands in Palakkad and Thrissur districts. As the project was operational only for about 3 years almost 2/3 of the total target could only be achieved by planting about 89,600 seedlings of the ten species in an approximate total area of 45 ha. The year-wise and species-wise details of the physical achievements of the project are given in table 12.

Table 12. Species-wise and year-wise details of seedlings raised and planted in the wastelands of Palakkad and Thrissur districts.

Sl. No.	Species name	No. of seedlings			Total
		1995-96	1996-97	1997-98	
1.	*Aegle marmelos*	3260	12245	1275	1 6780
2.	*Caesalpinia sappan*	15550	-	14475	27025
3.	*Cinnamomum zeylanicum*	170	950	310	1430
4.	*Phyllanthus emblica*	550	3200	2072	5822
5.	*Pterocarpus santalinus*	12000	-	-	12000
6.	*Punica granatum*	-	4200	-	4200
7.	*Oroxylum indicum*	1280	-	-	1280
8.	*Saraca asoca*	400	950	-	1350
9.	*Syzygium aromaticum*	450	4000	-	4450
10.	*Wrightia tinctoria*	15270	-	-	15270
	Grand total	**48930**	**25545**	**15132**	**89607**

In table 13 the details of the different categories of the benefeciaries, the area planted and the species preferred, are given. The species of medicinal plants tried in the rehabilitation programme are coded as given below in the table.

Species Name	Code No.
Aegle marmelos	1
Caesalpenia sappan	2
Cinnamonum zeylanicum	3
Oroxylum indicum	4
Phyllanthus emblica	5
Pterocarups santalinus	6
Punica granatum	7
Saraca asoca	8
Syzygium aromaticum	9
Wrightia tinctoria	10

Table 13. Details of seedlings planted by different categories of beneficiaries

a. Large-holding farmers

Names of farmers	Planted area	Species Planted
1. Joji M. Thakadi	Chulliar	1,2,6
2. Sulaiman	Chulliar	1,2,6
3. Unni	Chittoor	1,2,6
4. Suman	Chulliar	1,2,6
5. Omana	Chulliar	1,2,6
6. Vipin	Chulliar	1,2,6
7. Madhavan (Milk society)	Meenkara	2
8. Gowrisankar	Kangikodu Knassery	1,2,6
9. Mohanan	Muthalamada	1,2,5,6
10. Muraleedharan	Muthalamada	1,2,6
11. Sachithananthan	Muthalamada	1,2,6
12. A.V. Subramanian	Muthalamada	1,2,6
13. A.N. Balasubramanian	Anamari	1,2,6
14. K. Vasu	Pallam	1,2,6
15. Vinod	Chulliar	1,2,6
16. Joy	Chullair	1,2,6
17. Sivraman	Muthalamada	1,2,6

(Table cont'd….).

b. Small-holding farmers

Names of farmers	Planted area	Species
1. P.C. Velavan	Pallam, Muthalamada	1,2,6
2. Kesavan	Pallam, Muthalamada	1,2,6
3. Mayandi	Pallam, Muthalamada	1,2,6
4. Kandan	Pallam, Muthalamada	1,2,6
5. Hindumban	Pallam, Muthalamada	1,2,6
6. Padmanabhan	Pallam, Muthalamada	1,2,6
7. Balakrishnan	Pallam, Muthalamada	1,2,6
8. T. Chanthu	Pallam, Muthalamada	1,2,6
9. V. Sasidharan	Pallam, Muthalamada	1,2,6
10. K. Swaminathan	Pallam, Muthalamada	1,2,6
11. P. Sagadevan	Pallam, Muthalamada	1,2,6
12. C. Murukan	Pallam, Muthalamada	1,2,6

(Table cont'd….)

13. C. Armughan	Pallam, Muthalamada	1,2,6
14. K. Aaruchami	Pallam, Muthalamada	1,2,6
15. A.C. Narendranathan	Pallam, Muthalamada	1,2,6
16. M. Vasu	Pallam, Muthalamada	1,2,6
17. M. Aaruchami	Pallam, Muthalamada	1,2,6
18. V. Alimuhammed	Pallam, Muthalamada	1,2,6
19. V. Velayudhan	Pallam, Muthalamada	1,2,6
20. K. Velayudhan	Pallam, Muthalamada	1,2,6
21. P.S. Abdulrahman	Pallam, Muthalamada	1,2,6
22. M. Chandran	Pallam, Muthalamada	1,2,6
23. P. Pazhanimala	Pallam, Muthalamada	1,2,6
24. Athrvuthar	Pallam, Muthalamada	1,2,6
25. Sundharan	Pallam, Muthalamada	1,2,6
26. Maruthankali	Pallam, Muthalamada	1,2,6
27. Arumaghan	Pallam, Muthalamada	1,2,6
28. Saludeen	Pallam, Muthalamada	1,2,6
29. A.Swaminathan	Pallam, Muthalamada	1,2,6
30. Kandamuthan	Pallam, Muthalamada	1,2,6
31. Kittuchami	Pallam, Muthalamada	1,2,6
32. Alikutty	Pallam, Muthalamada	1,2,6
33. Mani	Pallam, Muthalamada	1,2,6
34. Sherifa	Pallam, Muthalamada	1,2,6
35. Alavudeen	Pallam, Muthalamada	1,2,6
36. Leela	Pallam, Muthalamada	1,2,6
37. Rugmini	Pallam, Muthalamada	1,2,6
38. Narayanan	Pallam, Muthalamada	1,2,6
39. M. Saithumuhammed	Pallam, Muthalamada	1,2,6
40. Aminumma	Pallam, Muthalamada	1,2,6
41. Krishnan	Pallam, Muthalamada	1,2,6
42. K.N. Hemachandran	Pallam, Muthalamada	1,2,6
43. N. Aru	Pallam, Muthalamada	1,2,6
44. Saramma	Pallam, Muthalamada	1,2,6
45. Kamarudeen	Pallam, Muthalamada	1,2,6
46. Chinna	Pallam, Muthalamada	1,2,6
47. Velayudhan	Pallam, Muthalamada	1,2,6
48. Karuman	Pallam, Muthalamada	1,2,6
49. Uruman	Pallam, Muthalamada	1,2,6
50. Ramakumari	Pallam, Muthalamada	1,2,6
51. Thillu	Pallam, Muthalamada	1,2,6
52. Sreedharan	Pallam, Muthalamada	1,2,6
53. Thajudeen	Pallam, Muthalamada	1,2,6
54. Karuppan	Pallam, Muthalamada	1,2,6
55. Shahul Hammed	Pallam, Muthalamada	1,2,6
56. Thanka	Pallam, Muthalamada	1,2,6
57. C.K. Pazanimala	Pallam, Muthalamada	1,2,6
58. P. Karuppan	Pallam, Muthalamada	1,2,6
59. Velayudhan	Pallam, Muthalamada	1,2,6
60. Shaik Musthapha	Pallam, Muthalamada	1,2,6
61. Mani	Pallam, Muthalamada	1,2,6

(Table cont'd….)

62. C. Kittu	Pallam, Muthalamada	1,2,6
63. Aruchami	Pallam, Muthalamada	1,2,6
64. Sivaraman	Pallam, Muthalamada	1,2,6
65. Velayudhan	Pallam, Muthalamada	1,2,6
66. Kittu	Pallam, Muthalamada	1,2,6
67. Chami	Pallam, Muthalamada	1,2,6
68. Visalu	Pallam, Muthalamada	1,2,6
69. Mani	Pallam, Muthalamada	1,2,6
70. Valli	Pallam, Muthalamada	1,2,6
71. Kunchan	Pallam, Muthalamada	1,2,6
72. P.S. Abdul	Pallam, Muthalamada	1,2,6
73. Shaik Musthafa	Pallam, Muthalamada	1,2,6
74. Karuman	Pallam, Muthalamada	1,2,6
75. Thaliha	Pallam, Muthalamada	1,2,6
76. Aru	Pallam, Muthalamada	1,2,6
77. Abdul Shukoor	Pallam, Muthalamada	1,2,6
78. Sadik Ravthwar	Pallam, Muthalamada	1,2,6
79. P. Velayudhan	Pallam, Muthalamada	1,2,6
80. Baduhsa	Pallam, Muthalamada	1,2,6
81. Kasi	Pallam, Muthalamada	1,2,6
82. Sharfudeen Aza	Pallam, Muthalamada	1,2,6
83. Chellan	Pallam, Muthalamada	1,2,6
84. Mayan	Pallam, Muthalamada	1,2,6
85. Hyder	Pallam, Muthalamada	1,2,6
86. Chathan	Pallam, Muthalamada	1,2,6
87. Suresh	Pallam, Muthalamada	1,2,6
88. Kannamuthan	Pallam, Muthalamada	1,2,6
89. Divakaran	Pallam, Muthalamada	1,2,6
90. Velu Chami	Pallam, Muthalamada	1,2,6

(Table cont'd….)

c. Institutional lands

Names of Institutions	Planted area	Species
1. Oushadi, Thrissur	Kuttanelloor	1,2,5,6,8,10
2. NCS, Peramangalam	Peramangalam	1,2,3,5,6,8,9
3. NSS College	Nenmara	1,2,4,6,10
4. KFRI, Peechi	FRC, Palapilly	1,2,3,4,5,6,7,8,9,10

From the table 13., it is evident that small farmers planted about 29,752 seedlings and the large farmers received more than 47,285 number of seedlings. In total, the farmers planted

more than 77,000 seedlings in their fragmented or extended waste lands as the case may be. The institutional share in the programme was planting of 12,870 seedlings.

5. CONCLUSIONS

1. Small and marginal farmers preferred to grow species like *Punica grantum*, *Cinnamomum zeylanicum* and *Syzigium aromaticum*, which are horticultural species and whose products are familiar and useful to them. In the case of large scale farmers, *Pterocarpus santalinus* and *Caesalpinia sappan* whose products form industrial raw material were the preferred species, which also do not require much attention or care for their growth. *Phyllanthus emblica* was preferred by both the categories of farmers and also institutions, whereas *Saraca asoca* was the most preferred species by the Pharmaceutical institution Oushadhi, who require its drug product in large quantities.

2. Farmers need more financial support for plantation activities and also aftercare, till they are in a position to get the returns.

3. Competition for the crop introduction by different agencies, like mango by the Agricultural Department, limits the area availability for the cultivation of medicinal plants. Also, lack of an established marketing system for the medicinal products casts doubts on the wasteland owners in introducing the medicinal plants.

4. The success of the programme points to the fact that, given more incentives, technical support and marketing facility, a sizable area of the wasteland in Kerala State can be brought under the cultivation of medicinal plants to solve the raw material scarcity and adulteration problem that pharmaceutical industries of indigenous systems of medicine now face. In this pursuit the methodology and technology evolved in this project may be of immense practical value.

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PLATES

Explanation to plates

Fig. 1. Wastelands in Kerala – how to restore ?

Fig. 2. Discussion with the beneficiaries.

Fig. 3. Centralised nursery at Field Research Centre, KFRI – for training and seedlings production.

Fig. 4. Seedlings being transported to wastelands of the beneficiaries.

Fig. 5. Planting site preparation – aligning, staking and pitting.

Fig. 6. Wastelands restored using medicinal plants.

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