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Studies on clonal propagation of plus trees of teak for identifying superior trees for future plantation programmes

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Abstract of the Project Proposal

Title of the project	**:**	**KFRI/290/98** **Studies on Clonal propagation of plus trees of teak (*Tectona grandis* L.f.) for identifying superior trees for plantation programmes.**
Principal Investigator	**:**	**T.Surendran**
Associate Investigator	**:**	**S.R.O (Kerala Forest Department)**
Objectives	**:**	**1.To propagate plus trees of teak by rooting shoot cuttings** **2. To establish a clonal garden of plus trees of teak** **3. To monitor the growth and field performance of clonally propagated plants for three years** **4. To identify superior trees for future clonal plantation programmes**
Duration	**:**	**5 Years (January 1998 – June 2004)**
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ABSTRACT

Studies on clonal propagation of plus trees of teak were carried out in Kerala Forest Research Institute (KFRI). A unique technique was developed and standardised at KFRI for clonal propagation of mature teak trees. The technique involves macro- propagation of genetically superior trees. This report describes clonal propagation technique for mass production, developed for teak. Plus trees of teak (*Tectona grandis* L. f.), 40 to 50-year-old, were cloned through the technique which involves two major steps *viz.*, production of juvenile epicormic shoots on branch cuttings obtained from Plus Trees and rooting of these juvenile shoot cuttings. Following this technique, 30 Plus Trees of teak were cloned successfully to get true-to-type rooted ramets in sufficient numbers. Through this process it takes about 120 days to produce rooted ramets from branch cuttings of plus trees. Properly rooted and hardened ramets were field planted and clonal gardens were raised in Kerala during 2000-'03 at different locations *viz.*, Emangad (Nilambur), Kalkulam (Nilambur), Decent Mukku (Quilon), and at Chettikulam(Thrissur). These ramets after 36 months of growth showed 99 percent survival and excellent growth in height and girth. By the introduction of the clonal teak plantations about 3-4 fold increase in the productivity of plantations is expected.

INTRODUCTION

Teak (*Tectona grandis* L. f.), one of the most valued timber species of the world, is being grown in plantation by at least 36 tropical countries covering about 5.7 million hectares. About 92 percent of the global teak plantations are in tropical Asia and of these about 43 percent exists in India (FAO, 2001).The annual national target for teak plantation establishment by different states of India is about 50,000 hectares.

Teak is the most important plantation species of Kerala, covering more than 70000 ha of the State's total plantation area and the annual target for raising teak plantation is about 1000 ha. Conventional method of plantation establishment is by raising seedlings in the nursery and utilizing their stumps as planting materials. Root – trainer seedlings were introduced, in place of stumps, as a step towards improvement of the planting stock of teak only very recently. Tree improvement programmes for teak were initiated in Kerala Forest Research Institute (KFRI) as well as in the state by Kerala Forest Department, as early as 1980s, by establishing clonal seed orchards, using bud-grafts of plus trees. In spite of these limited efforts, required level of improvement could not be achieved so far, due to various reasons. Selection of plus trees and production of superior planting stock by clonal propagation of these plus trees are important steps to be undertaken to achieve genetic improvement in teak.

In Kerala, KFRI had selected 50 plus trees during 1980s from plantations of teak located in Waynad, Nilambur, Konni and Thenmala Forest Divisions. Of these, about 35 plus trees are now existing and they fall in the age group of > 40 years. Successful attempts to propagate teak through vegetative means started at the beginning of the twentieth century (Fergusen, 1938), by establishing teak seed orchards using bud-grafts and this gained importance as it was aiming at the genetic improvement of teak. It is well established that a quicker and direct method for tree improvement is clonal propagation of superior trees by

rooting shoot cuttings for capturing immediate genetic gains and there by increasing the productivity of the species.

Since no convenient method for the vegetative propagation of teak have been reported so far, the main objective of the project was the development and standardization of vegetative propagation technique for teak through rooting shoot cuttings. Clonal propagation of plus trees and establishment of clonal gardens of plus trees were the other objectives. The specific objectives of the project are listed below:

1. To propagate plus trees of teak by rooting shoot cuttings
2. To establish a clonal garden of plus trees of teak
3. To monitor the growth and field performance of clonally propagated plants for three years
4. To identify superior trees for future clonal plantation programmes

REVIEW OF LITERATURE

Vegetative propagation has long been practised in the areas of Agriculture and Horticulture since this method has definite advantages over other methods of plant propagation. In the field of Forestry there has been growing interest over the past few decades in clonal propagation of important species by rooting stem cuttings. This method offers the prospects of producing high yielding, high quality clones of commercially important species like teak, by propagation of genetically superior individuals. This may also help shorten rotations and to overcome some of the biological problems hindering reforestation with hardwood species (Leakey,1987).

A number of problems connected with conventional seed propagation methods could be avoided if plants are propagated vegetatively. Also it is possible to minimise genetic variations and to attain greater uniformity in plantations of commercial tree species by selection and propagation of a small number of superior clones. Vegetative propagation can be used to exploit additive genetic gains ina relatively shorter period of time (Libby, 1983). An yield improvement of at least 10 percent is expected from the commercial plantations raised through cuttings (Mason and Gill, 1986). Eventhough, the genetic gains in productivity due to selection and clonal propagation have not yet been quantified precisely for species like teak, it is estimated that substantial enhancement in yield over that of the unselected trees should definitely be possible.

The method of clonal propagation provides possibility of establishing uniform monoclonal plantations, which will allow to introduce systematic silvicultural operations and will produce more uniform product at the end of the rotation. The possibility of rapid production of nursery stock having improved qualities, whenever needed in sufficient numbers is another important advantage of clonal propagation. However, monoclonal plantations should be well buffered against environmental fluctuations and resistance to pests and diseases. The

inclusion of required number of different clones (7 to 25) is suggested to minimise these risks (Libby,1982).

There are limited number of earlier attempts to propagate teak through vegetative propagation which started from the beginning of the twentieth century itself with very limited success (Fergusen,1938; Nautiyal *et al*., 1991; 1992 ; Monteuuis, 1994; Mahotalia, *et al*, 1995; Uniyal and Rawat; 1995. A truly successful method for clonal propagation of plus trees of teak has not been reported so far.

One of the main requirements for clonal propagation of teak is the availability or production of sufficient number of juvenile shoot cuttings for propagation, since branch cuttings of mature teak trees gave only poor rooting success in many earlier trials (Bhatnagar and Joshi,1978; Nautiyal *et al.*,1992).Rooting of juvenile shoot cuttings by providing necessary pre-treatments and conducive conditions would only lead to success in clonal propagation through stem cuttings.

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MATERIALS AND METHODS

The technique employed for the production of juvenile shoot cuttings of teak for propagation and the method of rooting them inside the mist propagation chamber are briefly described below

a. Production of juvenile shoots

Branch cuttings having diameter 3 to 10 cm were collected from the middle and lower parts of the crowns of plus trees (age >40 years) growing in different forest divisions of Kerala state. These were brought to the propagation complex as quickly as possible, without causing any damage to the bark or dormant buds on them. The branch cuttings were further sized and cuttings having a length of 50 cm were made out of these branch pieces. The side branches, if any, were carefully removed and these cuttings were immediately inserted into large polythene bags (size 30 cm X 8 cm and 250 gauge) filled with soil and sand in equal proportion (1:1). These were kept inside the mist propagation unit and intermittent misting (15 seconds misting in every 30 minutes) was provided until they sprouted and produced juvenile epicormic shoots on them. The identity of ach Plus Tree branch cuttings were maintained by properly labeling at all stages of the experiments.

Plate.1. View of a plus Tree located in Nilambur Forest DIvision

Plate. 2. Large branch cuttings of plus trees planted for the production of juvenile epicormic shoots inside the mist chamber.

b. Preparation of cuttings and hormone treatment

When the juvenile epicormic shoots produced on the branch cuttings attained growth of about 10 to 15 days and height of about 8-10 cm, having at least two or three pairs of leaves, they were harvested and cuttings were prepared after trimming away the distal 2/3 portion of the leaves, and retaining the apical bud intact. Immediately after harvesting they were subjected to hormone treatment using indole butyric acid (IBA) having a concentration of 6000 ppm prepared in talc. As a prophylactic measure, the cuttings were soaked in a solution of Bavistin w/v (0.05 percent) for about 30 minutes, before being treated with hormone powder.

c. Rooting the shoot cuttings

The treated cuttings were inserted into the rooting medium (vermiculite) filled in root trainers having a volume of 300 cm^3 and were kept under intermittent misting inside the mist propagation unit. The temperature was regulated at 28±2 ^oC and humidity at 85-90 percent. The misting frequency was controlled, so that the misting was on for 15 seconds at an interval of 30 minutes. The cuttings were kept on the mist bench for a period of 45 days, in order to allow them to sprout and root properly, after which the cuttings were removed and observations recorded. Using this technique a total of 30 plus trees located in different Forest Divisions of Kerala were successfully cloned (Table 1).

Table.1. Number and locations of Plus Trees used for Clonal Propagation.

Location in Kerala	**Total No. of Plus trees identified**	**Plus trees cloned**
Nilambur	13	10
Konni, Thenmala and Achencoil areas	25	19
Wyanad	2	1
Total	40	30

d. Hardening

The rooted ramets were removed to the hardening chamber and were kept there for about 45 days in order to allow them to harden properly. The cuttings were also hardened in the open nursery for few days before being taken to the field for planting out.

e. Field planting

The rooted ramets were field planted at different locations in Kerala *viz.* Decent Mukku (Quilon); Emangad (Nilambur); Chettikulam (Thrissur) and Kalkulam, Karulai (Nilambur), following a linear design and at a spacing of 3X 3m during the years 2000 –'02. Regular observations were recorded on their growth, survival and field performance.

RESULTS

a. Production of juvenile epicormic shoots

The branch cuttings collected from plus trees sprouted and juvenile epicormic shoots started growing with in 10-15 days. The conditions provided inside the mist chamber is conducive to sprouting of dormant buds present on the large branch cuttings and formation of juvenile shoots. With in a period of 20-30 days almost all buds present on the cuttings grew and produced juvenile shoots. In general, on an average 8-12 juvenile shoots were produced on a single branch cutting.

Plate.3.a. Production of epicormic shoots **b.** A close-up view of juvenile shoots

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B. Rooting of juvenile shoot cuttings

Within a period of 10-15 days, the planted juvenile shoot cuttings started developing roots on them. The sprouting and rooting of the cuttings were completed within a period of 30-45 days, after which the rooted ramets were removed to the hardening chamber. During rooting, the apical buds of the cuttings started growing, indicating the rooting process. The mean percentage of rooting varied from 20 to 90, between the plus trees (see Fig.1). Maximum percentage of rooting (90) was obtained with plus trees of Thenmala (T46) followed by Nilambur (T10) while it was minimum (20 percent) in some plus trees (T34, T16) (see Fig.1).

Plate .4. a. View of Mist Chamber with cuttings **b.** Cutting with emerging roots

Plate.5.a. Well rooted and sprouted cutting in root- trainer **b.** Cutting with well developed roots

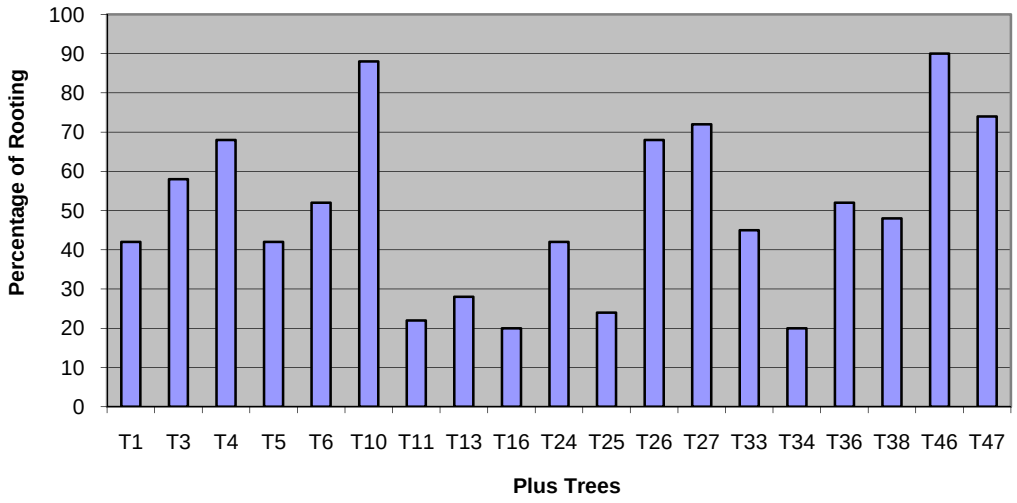

Figure 1. Percentage of rooting success of plus trees of teak (T1; T3; T4 *etc.* are numbers of plus trees)

Hardening

Plate.6. View of the hardening chamber with well rooted and hardened cuttings.

c. Field performance of rooted ramets

The growth and survival of rooted juvenile shoot cuttings during hardening was >90 percent in all the plus trees. The rooted ramets were field planted in different locations of Kerala during the year 2000-'02. Their field survival observed in the initial year was 99 percent. The height growth of ramets were 4.5 meters in some of the clones (eg. T10, T46, T47) after 11 months growth in the field at Chettikulam and almost similar rate of growth was maintained in the second year of planting (Plate.1). At the end of the 23 months' growth in the field, the maximum height growth recorded was 8.5 m and gbh 25 cm. (Table 2).

Table 2. Field performance of (Mean height and girth (GBH)) of rooted ramets planted at Chettikulam, Kerala, India 23 months after planting

Sl. No.	Clone No.	Mean ht. (m)	Mean GBH (cm)	Sl. No.	Clone No.	Mean ht. (m)	Mean GBH (cm)
1	**T1**	5.32	15.5	**10**	**T26**	6.24	19.2
2	**T4**	6.40	17.8	**11**	**T27**	6.86	22.5
3	**T5**	7.07	22.0	**12**	**T34**	5.79	17.3
4	**T6**	4.48	16.5	**13**	**T36**	7.76	23.5
5	**T10**	6.72	19.0	**14**	**T38**	6.30	19.5
6	**T11**	6.13	21.8	**15**	**T44**	6.44	20.2
7	**T13**	6.27	17.25	**16**	**T46**	8.50	25.0
9	**T24**	6.36	17.3	**17**	**T47**		

a. 11 months after planting b. 23 months after planting

Plate 7. View of the clonal garden of teak at Chettikulam

DISCUSSION

There are reports of production of juvenile shoots of teak inside the mist chamber for propagation. In the present method described, when large branch cuttings are planted vertically, the chances of sprouting and production of epicormic shoots were maximum and moreover, the shoots obtained, grew upwards showing orthotropic growth habit which is desired in the propagation programme of plantation tree species like teak. Sufficient number of juvenile shoot cuttings could be produced on the branch cuttings of plus trees by this method

There are reports on the use of juvenile coppice shoots produced on stumps of felled trees for propagation in eucalypts (Zobel and Ikemori, 1983; Lal *et al*., 1993) . However, there are no reports on production of juvenile epicormic shoots of teak inside the mist chamber. Rooting of coppice shoot cuttings and of juvenile cuttings of seedlings, within a period of 20-25 days was reported by Kaosa-ard *et al*. (1998) and the maximum percentage reported was 72 percent. In the present study, the initiation of rooting was observed within 15 days after planting.

The age of the mother tree appears to be an important factor in influencing rootability of the cuttings. Monteuuis (1994) obtained 40-60 percent rooting in cuttings of young (5-15-year-old) trees while Nautiyal *et al*. (1991) reported 60 percent rooting in cuttings collected from 16-year-old trees and only 10 percent rooting in cuttings collected from 62-year-old trees. Since the juvenile shoots are used for rooting in the present study there was no decrease in percentage of rooting observed, in relation to age, or any delay in initiation of rooting on the cuttings. The method described has very high potential for production of true to type propagules of desired plus trees.

In general, the productivity of teak in Kerala is 2.85 m^3/ha^1 /year in a 53-year rotation period which is very low as compared to the national standard (10 m^3/ha^1/year) (Subramanian *et al*.,1999). One of the reasons for low productivity appears to be the genetically inferior planting stock used for raising plantations.

Clonal propagation of plus trees and using genetically improved planting stock for raising plantations, appears to be an immediate step to increase the productivity of teak as in the case reported for eucalypts (Zobel and Ikemori, 1983; Lal *et al*., 1993). So far the technology for large-scale clonal propagation was not standardised. The technique described has great potential and offers the possibility not only to propagate large plus trees aged 40 years or more without felling them, but also to clone the superior trees on a large-scale and to raise plantations using the improved planting stock.

CONCLUSIONS

Plus trees of teak originally identified in different Forest Divisions of Kerala could be relocated and they could be cloned by a new method developed at KFRI. This new technique is an advance from earlier studies and provides a very convenient method to clone mature standing mother trees of teak.

The technique involves two steps; the first step being the production of juvenile coppice shoots on large branch cuttings collected from marked plus trees inside the mist chamber. As a second step the juvenile cuttings produced inside the mist chamber are rooted by providing pre-treatments and proper conditions to obtain well rooted cuttings of plus trees. Following this method 30 plus trees located in different forest divisions of Kerala could be conveniently cloned and their progeny produced inside the mist chamber. This ensures production of superior planting materials of teak.

The rooted cuttings are properly hardened inside the hardening chamber before being taken out for field planting. Starting from collection of branch cuttings from plus trees, it takes altogether about 120 days for production of cloned planting materials.

The rooted cuttings are field planted in different locations of kerala and clonal gardens were raised. The field survival and growth of cloned ramets were monitored for three years. The results showed excellent field survival and growth; the observed measurements in height and girth were three to four fold more than the average achieved in the plantations of Kerala.

Adoption of this technique for the production of superior plating materials through cloning of plus trees will help raising clonal plantations of teak which will substantially increase the productivity of teak plantations. This method could also be used for establishing Clonal Seed Orchards, Clonal Gardens and Clonal Multiplication Areas of teak.

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