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Abstract of the Project Proposal

Title of the project	:	**KFRI/439/2004** Growth of field planted teak clones at Karulai
Principal Investigator	:	Dr.T.Surendran
Objectives	:	1. To study the growth and performance of field planted rooted ramets of superior clones of teak at Kalkulam, Karulai. 2. Maintenance of clonal garden of plus trees at Kalkulam, Karulai.
Duration	:	4 Years (2004-2008)
Funding Agency	:	Kerala Forest Research Institute (Plan Fund)

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ABSTRACT

Clonal technology for mature teak trees developed at Kerala Forest Research Institute was successfully used to clone 30 plus trees of teak and clonal propagules were produced in sufficient numbers. In order to study the growth and field performance of these clonal propagules, an experimental plot was established at Kalkulam, Karulai Range, Nilambur(South) Forest Division incorporating propagules of all the 30 clones. Growth and field performance were monitored for initial three years. All the clones survived and initial growth was promising. Nilambur clones like T10, T9, T3 and T1 showed maximum growth in height and girth, while T46 and T47 clones from Thenmala Division were found promising. Silvicultural operations were carried out as and when required and this resulted in better survival and establishment of clones. Besides providing sufficient protection from wild animals, fencing also helped to a great extent in the establishment of clones. The results showed that the production of teak clones from mature elite teak trees and establishing clonal plantations are practical propositions for meeting the urgent requirements of tree improvement programme for teak.

INTRODUCTION

As part of tree improvement of teak in Kerala, KFRI had selected 50 plus trees during 1980s from various plantations in Wynad, Nilambur, Konni and Thenmala Forest Divisions. Of these, about 35 plus trees now exist and they are more than 45 years of age.

For achieving tree improvement and for capturing the genetic gains earlier, clonal propagation of identified plus trees of teak by improved technology is essential. Production of sufficient superior planting materials and raising clonal plantations are important steps to be undertaken to achieve genetic improvement and thereby enhancing productivity of teak.

Bud grafting and raising clonal orchards were carried out at various parts of the country since 1950 as part of tree improvement programmes. They were only partially successful, due to various reasons.

Since KFRI has developed a convenient method for cloning mature teak trees (Surendran, 2002), a project was undertaken to propagate promising plus trees of teak and to field plant sufficient propagules, in order to study their field growth and performances. An experimental plot was established at Kalkulam, Karulai range Nilambur (South) Forest Division as part of an earlier project (Surendran, 2008). The assessment of growth and field performance was envisaged in this project with the following objectives-

1. To study the field growth and performance of field planted rooted ramets of superior clones of teak at Kalkulam, Karulai.
2. Maintenance of the clonal garden of plus trees at Kalkulam

REVIEW OF LITERATURE

The method of clonal propagation provides the possibility of establishing uniform monoclonal plantations, which will allow to introduce systematic silvicultural operations which will produce a 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 guarded 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).

If plants are propagated vegetatively a number of problems connected with conventional seed propagation methods could be avoided. 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. An yield improvement of at least 10 percent is expected from the commercial plantations raised through cuttings of selected superior trees (Mason and Gill, 1986). Even though, 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 population should definitely be possible.

There were a few earlier attempts to propagate teak through vegetative method which started from the beginning of the twentieth century itself with very limited success (Fergusen, 1938; Nautiyal *et al*., 1991; 1992; Monteuuis, 1994). One of the main requirements of 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.

MATERIALS AND METHODS

Production of cloned ramets

Production of cloned propagules of plus trees were carried out by applying a unique technique developed at KFRI (Surendran,2000). In these method branch cuttings of plus tree was collected from its crown. Cuttings were brought safely without delay to the mist chamber and sized to 50 cm pieces. These cuttings were of 3 to 10cm diameter and with intact buds and bark. They were planted in large polythene bags filled with sand and soil (1:1 ratio) mixture and kept inside the mist chamber. The cuttings were provided conducive conditions for sprouting and producing juvenile shoots.

Harvesting and preparation of juvenile shoot cuttings

The juvenile shoots emerged on the cuttings were harvested using sterilized scissors and sized to 8 to 10 cm long cuttings with apical buds intact, having 1to 2 pair of leaves. The distal halves of leaves were trimmed off in order to reduce evapo-transpiratory loss of water during rooting period.

Pretreatments for the shoot cuttings

The prepared shoot cuttings were subjected to pretreatment with Bavistin (0.05%) fungicide for about 30-45minutes and after that treated with indole butyric acid (IBA) prepared in talc, having a concentration of 6000ppm.

Rooting

The treated cuttings were inserted into the rooting medium (vermiculite) filled in root trainers having a volume of 300 cm^3 per cell and were kept under intermittent misting inside the mist propagation unit. The temperature was regulated at 28±2 ^oC and Relative 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. At the expiry of 15 to 20 days, roots start developing and the apical buds start growing. The cuttings were kept on the mist bench for a period of 45 days, in order to allow them to sprout and root properly.

Hardening

The properly rooted cuttings of each plus tree were labeled and removed to the hardening chamber, where these were kept for about 45 days in order to allow them to harden properly. The cuttings were also hardened in the open nursery for few days in order to acclamatize before being taken to the field for planting out.

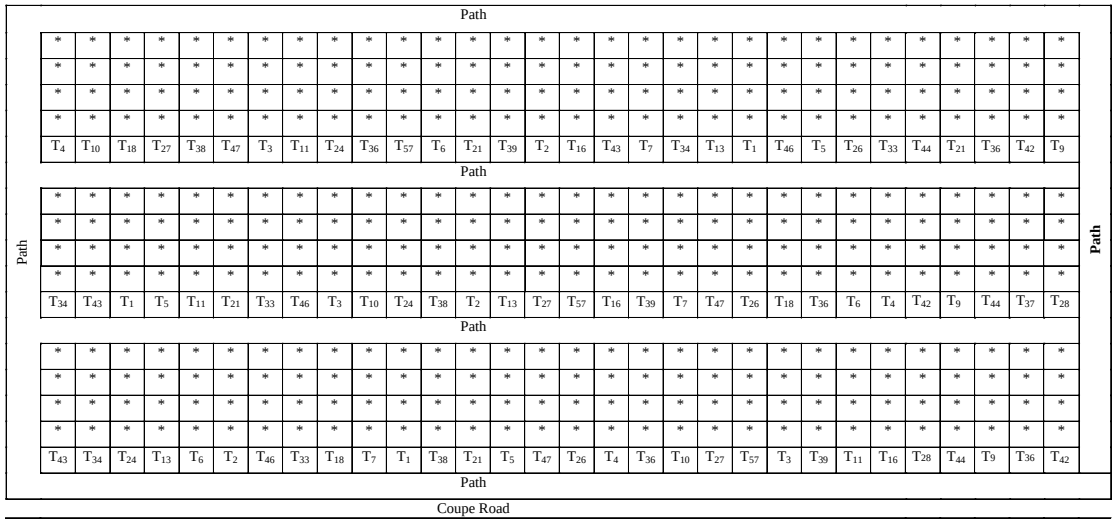
Plate.1. Cloned ramets of plus trees after open hardening ready for field planting

Field planting

The rooted ramets were transported to Kalkulam, Karulai range of Nilambur South Division and field planted at the prepared plot following a linear design having 5clones in a row at spacing of 4 X 4m during the year 2004. All the 30 clones were included in a block which is replicated three times. A one meter wide path was also provided to the garden along all the sides and in between blocks(Fig.1).

Fig 1. Design of Clonal Garden at Kalkulam, Karulai.

Location	: Kalkulam	Spacing	: 4 X 4 m
Range	: Karulai	No of clones	: 30
Division	: Nilambur South	No. of replications	: 15 (3 blocks of 5 each)



Observation and collection of data

Regular observations were recorded on their growth, survival and field performance by collecting data on increase in height growth and increase in girth at breast height (GBH).These data were collected at an interval of three months and were analysed statistically.

Silvicultural operations

Silvicultural operations like weeding, soil working and contour terracing were carried out whenever needed and according to the methods practiced by the Forest Department . The clonal garden was initially provided with conventional bamboo fencing and later with electrical fencing in order to prevent elephant damage since the area is highly prone to damages by wild elephants.

RESULTS

a. Field survival and establishment

The field planted cloned ramets of plus trees were observed regularly and their morality and field survival recorded. All the propagules of plus trees planted were established and mortality recorded was less than one percent. The casuality of ramets was replaced and plot was maintained. It took about a month for the clones to establish in the field properly. Timely silvicultural operations were provided and protection by providing fencing were highly necessary and helpful for the ramets to survive and establish in the field.

b. Silvicultural operations

Silvicultural operations like weeding, soil leveling and contour terracing were provided as and when necessary and according to the Forest Department schedule. Weeding frequency was three times in an year and contour terracing and block preparation during the time of plot establishment. There was no special treatments provided, other than the usual maintenance works. Fencing was initially provided with bamboo poles and thorns in the conventional manner for the first year of field planting. After that, when Forest Department provided electric fencing common to all the plots of teak planted in the area, the clonal garden was also given protection by the electric fencing. In spite of these efforts, elephant damage was noticed in the second year and third year. This affected the observations on the performance of few clones.

c. Height growth

Yearly height growth of field planted clones were recorded at the end of I year, II year and III year of planting respectively (Table.1). After completion of one year in the field, the clones recorded a maximum mean height of 268.25cm (Clone T44). Other clones having observed better growth in height were 260.45 cm for T24, 236.17cm for T1, and 231.41cm for T3. In general, in the initial year, clones of Thenmala and Aryankavu areas recorded better growth performance. After completion of two years in the field also the trend shown by the clones were almost same except few clones had shown improved height

Table.1. Table showing increase in height growth of clones planted at Kalkulam

Sl. No.	*Clone Number*	*Mean Height (cms.)*		
		I year	*II year*	*III year*
1	**T1**	**236.17**	**296.50**	**345.15**
2	**T2**	**140.61**	**200.15**	**280.44**
3	**T3**	**231.41**	**281.45**	**348.65**
4	**T4**	**221.35**	**271.15**	**322.30**
5	**T5**	**196.55**	**235.00**	**287.35**
6	**T6**	**214.50**	**244.12**	**301.12**
7	**T7**	**213.50**	**256.65**	**312.75**
8	**T9**	**235.38**	**280.17**	**356.15**
9	**T10**	**193.10**	**250.66**	**292.12**
10	**T11**	**103.15**	**154.18**	**201.13**
11	**T13**	**95.10**	**146.12**	**156.12**
12	**T16**	**104.18**	**156.75**	**180.45**
13	**T18**	**195.25**	**230.64**	**292.15**
14	**T21**	**230.66**	**270.15**	**343.72**
15	**T24**	**260.45**	**290.35**	**312.13**
16	**T26**	**140.15**	**174.25 ***	**214.33 ***
17	**T28**	**122.63**	**144.12 ***	**185.25 ***
18	**T29**	**195.17**	**236.28**	**287.30**
19	**T33**	**184.50**	**218.33**	**272.15**
20	**T34**	**192.12**	**33.00 ***	**40.35 ***
21	**T36**	**225.45**	**294.12**	**325.16**
22	**T37**	**215.58**	**56.25 ***	**75.00***
23	**T38**	**196.37**	**245.60**	**312.33**
24	**T39**	**230.12**	**296.75**	**326.15**
25	**T42**	**235.51**	**242.15**	**282.25**
26	**T43**	**213.75**	**280.32**	**420.23**
27	**T44**	**268.25**	**294.80**	**410.35**
28	**T46**	**220.16**	**310.45**	**380.32**
29	**T47**	**218.45**	**312.35**	**415.00**
30	**T50**	**183.25**	**218.65**	**245.75**

(*) Clones damaged due to elephant attack

growth. These included T10 (250.66cm), T24 (290.35cm), T46 (310.45cm), and T47 (312.35cm) The observation on height growth was obstructed, in the case of few clones which were damaged by wandering wild elephants. At the end of the third year growth the maximum mean growth in height was recorded for Thenmala clones T47 (415.00cm) and T43 (420.23cm), followed by T44(410.35cm), 46(380.32cm),T9(356.15cm),T3(348.65cm)and T1(345.15cm). In general, the height growth for clones was very good except for those clones which were damaged by elephants.

d. Growth in girth at breast height (gbh)

Within three years of growth the girth at breast height (gbh) also recorded proportionate increase with respect to increase in height by the different clones. The maximum mean girth recorded after completion of one year in the field were by clones T47 (8.75cm)and T46 (8.5cm) which are Thenmala clones, while this was followed by clones T24(7.23cm) and T1(7.15cm) which are Nilambur clones. The increase in girth at breast height(gbh) was also proportionate after completion of two years growth by the clones (Table.2).Maximum mean increase in gbh was recorded for the clonesT47(15.85cm) andT46(15.75cm) followed by T1(12.25cm). At the end of second year, since few clones (T20,T28,T34 andT37) suffered damages by elephants, they recorded very little increase in their growth in gbh. At the end of the third year also, the increase in gbh was showing the same trend as the previous years. Clones T47 and T46 were with mean values of gbh 25.15cm and 23.75cm respectively. Nilambur clonesT10 recorded 21.25cm and clone T1 recorded 18.50cm.All other clones recorded less values than this. The clones damaged by elephants showed only nominal increase; since their apical growth affected due to the damage.

Table.2. Table showing increase in girth at breast height(gbh) of clones

Sl. No.	***Clone Number***	***Mean girth at breast height (cms.)***		
		First Year	***Second Year***	***Third Year***
1	**T1**	**7.15**	**12.25**	**18.60**
2	**T2**	**4.87**	**8.44**	**15.25**
3	**T3**	**6.78**	**11.15**	**17.45**
4	**T4**	**6.56**	**10.82**	**20.15**
5	**T5**	**5.86**	**8.15**	**16.55**
6	**T6**	**6.40**	**9.25**	**19.50**
7	**T7**	**6.35**	**9.15**	**18.65**
8	**T9**	**6.85**	**11.28**	**20.11**
9	**T10**	**4.4**	**12.15**	**21.25**
10	**T11**	**3.12**	**7.24**	**15.75**
11	**T13**	**3.67**	**6.95**	**12.15**
12	**T16**	**3.97**	**7.15**	**15.35**
13	**T18**	**4.12**	**8.80**	**18.15**
14	**T21**	**6.35**	**10.15**	**19.12**
15	**T24**	**7.23**	**12.25**	**20.11**
16	**T26**	**5.45**	**6.45 ***	**8.15 ***
17	**T28**	**3.10**	**6.18 ***	**8.25 ***
18	**T29**	**4.25**	**8.75**	**9.25 ***
19	**T33**	**4.42**	**9.15**	**10.25 ***
20	**T34**	**5.75**	**7.25 ***	**10.25 ***
21	**T36**	**6.50**	**12.15**	**18.65**
22	**T37**	**5.90**	**7.45 ***	**14.50 ***
23	**T38**	**6.50**	**12.15**	**20.11**
24	**T39**	**7.3**	**13.25**	**19.75**
25	**T42**	**6.75**	**12.25**	**18.15**
26	**T43**	**6.85**	**12.45**	**20.23**
27	**T44**	**6.81**	**13.11**	**20.45**
28	**T46**	**8.5**	**15.75**	**23.75**
29	**T47**	**8.75**	**15.85**	**25.15**
30	**T50**	**3.36**	**9.45**	**18.75**

(*) Clones damaged due to elephant attack

DISCUSSION

Plus trees of teak were cloned following the macro cloning method developed at KFRI(Surendran,2000) and sufficient number of ramets were produced. These were field planted at Kalkulam, to study their growth and field performances, for the first time in Kerala.

The area for raising the clonal garden was located in Karulai range of the Nilambur South Forest Division of Kerala. The design selected for field planting was randomised block design (RBD) with three replications. The area selected has a gentle slope and soil is very ideal for growth of teak.

The cloned teak ramets were planted in a linear pattern in each block (Ref. Plot Chart) having five clones in a row planted at spacing of 3x3m. The clones after field planting took about one month to establish properly in the field. The silvicultural operations required were given according to the suggestions and methods followed in the Forest Department. Protection provided by fencing was highly essential and it helped the field survival of the ramets, since the area is highly prone to damages by wild animals like elephants. During the establishment period, mortality was very negligible, since the ramets used were baged and were sufficiently hardened before being taken to the field. This helped the survival and establishment in the field.

The growth of ramets were moderate in the initial year of establishment. In the subsequent years few clones of Nilambur origin (T1,T3,T9andT10) as well as Thenmala origin (T46 and T47) had very good growth in height and gbh compared to other clones. This clearly indicates that survival, growth and field performances of rooted ramets highly depends on the genetic superiority of the clone and the suitability of the area selected for planting. It is well established that the Nilambur, Karulai areas are well suited for teak growth and the soil properties are very good. This also helped the survival and growth of the clones. Timely weeding and silvicultural management operations are essential for establishment of teak clones. The area should be free from damages caused by the wild animals. The plot was initially provided with conventional fencing and later on with electric

fencing. This was also very helpful for the field establishment. Even though, the electric fencing provided maximum protection, damages caused to this type of fences by various reasons in the field could lead to lack of protection and thereby loss of valuable plants. This points out at the due care and timely repair and maintenance needed to be provided to costly protection measures like electric fencing.

By establishing a clonal garden having 30 different clones originated from various locations, assembled in the same area, the method proved to be feasible. The clones were produced by the macro- cloning technique and this also proved to be a successful method for cloning mature teak trees and establishing clonal gardens. There were no abnormalities in the growth of teak clones or any physiological problems related to development of clones into to saplings. The results are promising for the establishment of such clonal gardens and clonal orchards of plus trees of teak as well as clonal plantations in future.

CONCLUSIONS

The attempt to establish teak clones in the field and monitor their growth and performance of promising superior clones proved to be successful. The ramets were produced applying the technique developed at KFRI and this method is found suitable. The ramets produced were hardened before field planting and this helped the establishment. Spacing provided was 4x4m which is more than the conventional spacing, as this method avoids initial thinning. Providing more spacing may help field survival and growth.

The growth in height usually takes place after the proper establishment and this shows seasonality in teak. Mortality was very negligible since containerized propagules were used for field planting. Height growth and increase in gbh were moderate to good, since the field problems like elephant damage are detrimental to the initial growth of teak. The results are very encouraging and points out to the feasibility of establishing clonal plantations of teak for improved productivity. Such a trail should invariably be well protected from pest and deceases and damaging wild animals.

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