RAISING PLANTING STOCK OF EUCALYPTUE CLONES FOR THE KERALA FOREST DEPARTMENT

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ABSTRACT

Clonal forestry has been accepted as a strategy to improve productivity of eucalypt plantations in Kerala under the Kerala Forestry Project funded by the World Bank. Establishment of clonal multiplication areas (CMA) in central nurseries at Kulathupuzha and Nilambur and also plantations using clonal planting materials were the activities planned initially under the clonal forestry programme. For the establishment of CMA and plantations of the Kerala Forest Department, Kerala Forest Research Institute (KFRI) was requested to supply fast growing disease resistant clones. Utilizing the fund provided by the Department, KFRI supplied 16,600 ramets of 15 KFRI clones of *E. tereticornis* and *E. camaldulensis* and 800 ramets of four ITC Bhadrachalam clones of eucalypt 'hybrid' in 1998. Out of this 11,450 ramets were planted at Kulathupuzha and 5,950 ramets at Nilambur in 1.5 x 1.5 m spacing. In 1999, approximately 16,000 ramets were supplied for raising plantations in Kodanad Range under Malayattoor Division and 12,000 ramets to Arienkavu Range under Thenmala Division. Infrastructural facilities required for clonal multiplication of eucalypt such as mist chamber and hardening units were upgraded at the Eucalypt Clonal Nursery of KFRI at Kottappara. This project was an action oriented programme to supply clonal planting stock to the Kerala Forest Department and KFRI supplied a total of 45,500 ramets of 28 clones to the Department.

1. INTRODUCTION

1.1 GAINS OF EUCALYPT CLONAL FORESTRY

Exploitation of the potentials of clonal forestry has resulted in increased productivity of eucalypt in countries like Brazil, Congo and South Africa, and in the state of Andhra Pradesh in India. The Mean annual increment (MAI) of *Eucalyptus* plantations, especially that of *E. grandis* in Brazil prior to embarking on genetic improvement and clonal forestry in 1967 was 15 m^3 $ha^{-1}yr^{-1}$ at 7 year rotation. But when selected clones were introduced, the yield increased to 70 m^3 ha^{-1} yr^{-1} in industrial plantations. With use of improved clones under intensive management, the yield reached even up to 100 m^3 ha^{-1} yr^{-1} in moderately good sites. Such growth is not so far obtained from seedlings (Zobel, 1993).

Similarly, in Congo, yield from selected clones increased up to 35 m^3 ha^{-1} yr^{-1} compared to 20-25 m^3 ha^{-1} yr^{-1} from selected provenances and about 12 m^3 ha^{-1} yr^{-1} from unselected seed lots, the gain ranging from 40 to 192 % (Lal, 1993). These achievements were possible primarily through continuous genetic improvement of planting stock, especially through selection and use of disease resistant and high yielding clones.

1.2 EUCALYPT CLONAL FORESTRY IN INDIA

In India, clonal forestry on an industrial scale was pioneered by ITC Paper Boards Ltd., Bhadrachalam in Andhra Pradesh. The Company selected plus trees from plantations of Mysore gum commonly known as *Eucalyptus* 'hybrid' and distributed ramets (vegetatively propagated plants from clones) in large scale among farmers as farm forestry crop and also to the Andhra Pradesh Forest Department. Clones from 35 fast growing disease resistant trees are being multiplied on a large scale through rooting of cuttings. Productivity is expected to be 20-25 m^3 ha^{-1} yr^{-1} by 7th year which is nearly four-fold increase in yield over eucalypt plantations raised from unimproved seeds (Lal, 1993).

1.3 PRODUCTIVITY OF EUCALYPT IN KERALA

In Kerala, over the years, the average productivity of eucalypt plantations has come down drastically. A study conducted by KFRI recently (Jayaraman *et al*., 1997, unpublished) indicated that the MAI of seedling

crop of *Eucalyptus* hybrid is 7.65 m^3 ha^{-1} at 8 years and for the first coppice crop 2.54 m^3 ha^{-1}. The MAI for seedling crop of *E. grandis* at 10 years is 10m^3 ha^{-1}. This clearly indicates the extremely low yield of eucalypt plantations in Kerala as compared to clonal plantations in Brazil or even in Andhra Pradesh.

Besides the low density of the growing stock in the plantations, the genetically poor seed quality caused by generations of inbreeding, and serious outbreak of diseases especially Cylindrocladium leaf blight, and pink disease caused by *Corticium salmonicolor* are the two major reasons for the low yield.

1.4 WORK DONE BY KFRI FOR PRODUCTIVITY IMPROVEMENT

To overcome this situation, Kerala Forest Research Institute (KFRI) with financial support from Kerala Forest Department initiated a research programme to develop genetically improved disease resistant planting stock. As a short-term strategy to identify seed source of improved quality, four multilocational provenance trial plots comprising about 75 provenances of *E. tereticornis*, *E. camaldulensis*, *E. urophylla and E. pellita* were established during 1990, 1992 and 1993 in approximately 28 ha area using provenance seeds from Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia. Based on the observations on growth and disease resistance of these provenances in the field, promising provenances with improved growth and disease resistance were identified and recommended to the Kerala Forest Department for raising plantations during 1998 under the World Bank aided Kerala Forestry Project.

As the next step towards the long-term strategy for improving the eucalypt planting stock for higher yield, the technology of clonal forestry through multiplication and planting of superior clones of Eucalypt was perfected by KFRI during the last few years. Candidate plus trees, selected from superior provenances were mass multiplied in semi-permanent field clonal propagation unit established at Kottappara under Malayattoor Forest Division. A clonal gene bank (CGB) using ramets from 85 clones and Clonal Multiplication Area (CMA) comprising potential clones have been established.

1.5 CLONAL EUCALYPT PLANTATION UNDER THE KERALA FORESTRY PROJECT

Under the World Bank aided Kerala Forestry Project, Clonal Forestry has been recommended the strategy to improve productivity of eucalypt

plantations. Though *Eucalyptus* 'hybrid' clones are available from other states they are actually developed and tested under an entirely different agro-climatic condition. Such clones may or may not be suitable for Kerala conditions having very high rainfall (> 2500 mm) and warm humid weather, which are conducive for severe disease incidence. The KFRI clones are identified and tested for local climatic conditions of very high disease pressure, especially against Cylindrocladium leaf blight and pink disease. Moreover, KFRI clones are selections from provenance trees introduced from Australia and hence, genetically superior to selections from existing inbred plantations of *Eucalyptus* 'hybrid'.

1.6. OBJECTIVES OF THE PROJECT

To achieve the target of clonal plantation under the Kerala Forestry Project, the Forest Department had to establish Clonal Multiplication Area (CMA) during 1998 which would produce clonal material by year 2000. For establishing CMA in Central Nurseries at Kulathupuzha and Nilambur and also to raise clonal plantations at Kodanad and Arienkavu, KFRI raised ramets of eucalypt clones during 1997-'98 and 1998-'99. This report provides the details of infrastructure developed such as field clonal propagation facility, ramet hardening units, etc. at Kottappara and details of the ramets raised and supplied to the Forest Department during 1998 and 1999. A brief description of the method adopted for production of ramets is also provided.

2. MATERIALS AND METHODS

In this section, a brief description of the earlier work done for selection of clones, facilities established at Kottappara for vegetative multiplication of clones, and the methodology adopted for large scale production of ramets are described.

2.1 PROVENANCE TRIAL AND IDENTIFICATION OF CANDIDATE PLUS TREES (CPTs)

The provenance trial plots, clonal gene bank, clonal multiplication area and clonal multiplication facility are located at Kottappara under Kodanad Range of Malayattoor Forest Division. Kottappara was selected as the location for establishing provenance trial plots because of the conducive environment for very high incidence of Cylindrocladium leaf blight and pink disease. Provenance trial plots were established in 1990 (1.5 ha), 1992 (3 ha) and 1993 (6 ha). Growth, disease incidence and survival percentage monitored for a minimum period of four years formed the criteria for selection of candidate plus trees (CPTs) from the best performing provenances. A total of 75 CPTs were identified as potential ortets (mother trees) for exploitation as clones. These ortets were either felled or partially girdled to produce coppice shoots, which were utilized for clonal propagation. A small number of ramets of each clone were planted in clonal gene bank and majority of ramets in clonal multiplication area (CMA) (1 ha) established during 1996 and 1997.

2.2 MANAGEMENT OF CLONAL MULTIPLICATION AREA (CMA)

The CMA also acted as a clonal testing area. Clones which proved to be disease susceptible or of low rooting percentage were uprooted and removed, and newer clones introduced instead during the subsequent years. A clonal testing area was established during 1997 using some of the best performing clones.

Successful clonal programme depends upon production of healthy coppice shoots. The clonal plants were cut at a height of 20-30 cm from the ground for the production of coppice shoots. The stumps were watered at least once/twice a week after fertilizer application to improve the quality of coppice shoots, thereby increasing percentage in rooting and sprouting of cuttings.

2.3 FIELD CLONAL PROPAGATION UNIT

The initial clonal multiplication facility established at Kottappara comprised a field clonal propagation unit (FCPU) with five propagation trenches with provision for misting, established under a research project funded by the Indian Council of Forestry Research and Education (ICFRE). However, this facility was insufficient to produce enough ramets for the Kerala Forest Department. Hence, part of the fund obtained from Kerala Forest Department under the project was utilized to upgrade the infrastructure such as construction of more propagation trenches, purchase of root trainer, fabrication and production of root trainer stand and construction of hardening sheds necessary for proper hardening of the ramets.

2.3.1 Root trainers and stand

Root trainer technology was adopted for mass clonal production of eucalypt planting stock. UV stabilized root trainers of 20-cells (Compo-150 VA, 150 ml capacity) and 40-cells (Compo-110 VA, 110 ml capacity) were utilized. The root trainers were obtained from M/s. Niveditha Plastics Industries Pvt. Ltd., Nagpur 440 012. Root trainers were kept on a specially fabricated stand. Each stand accommodated four to five root trainer blocks depending upon the size of root trainer. The root trainers were retained on the stands during hardening for proper air-pruning of roots of growing ramets.

2.3.2 Expansion of mist chamber facility

As the number of trenches in the existing Field Clonal Propagation Facility was insufficient to produce the required number of ramets, four more trenches of 10 m x 135 cm x 60 cm were constructed. Misting facility and protection from rain were also provided to these trenches. Each trench, provided with 15 fine nozzles for misting, accommodated 30 root trainer stands each carrying four or five numbers of 40/20-celled root trainers. Thus a total of 3000 to 4800 cuttings can be kept in each trench.

2.3.3 Hardening unit

After the initiation of rooting and sprouting of shoot cuttings, the root trainers were transferred to hardening sheds. Hardening sheds are extremely important for proper hardening of the ramets coming out of mist chamber facility. One of the units was provided with a 50 per cent agro-shade net just below the silpaulin covered roof and sufficient quantity of

sprinklers to irrigate the cuttings at pre-determined intervals. The rooted and sprouted cuttings from mist chamber were transferred first to this unit. The second shed was provided only with UV stabilized silpaulin as a protective cover against rain. In both the hardening units, watering of ramets was regulated depending upon the prevailing climatic conditions so as to promote profuse root system as well as stout shoot.

2.4 METHODOLOGY

2.4.1 Selection of clones for multiplication

Based on overall performance, 22 clones were identified for mass clonal propagation and supply of ramets to the Kerala Forest Department during 1998 and 1999. Six clones obtained from ITC Paperboards, Bhadrachalam (BCM clones) were also multiplied at Kottappara and supplied to the forest department. The details of the clones including the name of the provenance to which it belonged are provided below.

Eucalyptus tereticornis

Sl. No.	Clone No.	Provenance Name	Seed lot No.
1	KFRI 14	Kennedy River, Qld[1]	14802
2	KFRI 16	Morehead River, Qld	13444
3	KFRI 28	80 Km NNW Cook town	15198
4	KFRI 38	East of Kupiano, PNG[2]	13398
5	KFRI 43	Ravenshoe, Qld	14424
6	KFRI 47	Kennedy Creek Pen Dev Road, Qld	15827
7	KFRI 49	Morehead River, Qld	13444
8	KFRI 56	Ravenshoe, Qld	14424
9	KFRI 58	Kennedy River, Qld	14802
10	KFRI 62	Palmer River, Qld	13847
11	KFRI 65	Kennedy Creek Pen Dev Road, Qld	15827

Eucalyptus camaldulensis

Sl. No.	Clone No	Provenance Name	Seed lot No.
1.	KFRI 7	Katherine Nt [3]	13801
2.	KFRI 10	Cape River, Qld	13815
3.	KFRI 22	West of Irvine Bank	15234
4.	KFRI 23	West of Normanton,Qld	13695
5.	KFRI 24	Daly Waters, Nt	13943
6.	KFRI 25	Katherine, Nt	13801
7.	KFRI 41	Victoria River, Nt	13928
8.	KFRI 54	Cape River, Qld	13815
9.	KFRI 55	Victoria River, Nt	13928
10.	KFRI 59	Region East of Petford, Qld	14338
11.	KFRI 68	Cape River, Qld	13815

Qld[1] - Queensland; PNG[2] - Papua New Guinea; Nt[3] - Northern Territory

ITC Bhadrachalam clones

1	BCM 3
2	BCM 6
3	BCM 7
4	BCM 10
5	BCM 83
6	BCM 130

2.4.2 Processing of coppice shoots and production of ramets

Clones established in CMA in 1996 were coppiced about 20-30 cm above ground level during December 1997-March 1998 and February - March 1999. Sprouts started to appear within 15-20 days of felling the plants. Each stump produced varying number of shoots. Forty five- to sixty-day-old coppice shoots were harvested and brought to mist chamber facility for processing (Fig.1). Two-leafed, single-node cuttings were prepared from healthy coppice shoots, leaves cut to about quarter to half length to reduce transpiration. The cuttings were kept in 0.1% Bavistin 50 WP (fungicide)

solution for 10 minutes for protection from Cylindrocladium infection. The lower portions of cuttings were treated with 4000 ppm indole butyric acid (IBA), the rooting hormone, mixed with talcum powder, and then planted in root trainers containing wet horticultural grade vermiculite (Keltech Energies Limited, Perlite Division, Bangalore) (Fig. 2). The root trainers (5 each) were kept on a root trainer stand, and then transferred to the trenches (Fig. 3). Misting was provided for about half to one minute duration with an interval of 30-60 min depending upon the weather conditions (Fig. 4). Bavistin 50 WP (0.05 % a.i.) was sprayed on to the cuttings once in 10 days. The identity of each clone was maintained by proper labeling. Coppice shoots were harvested two-three times from each stump at periodical intervals for production of ramets (Fig. 1).

The cuttings rooted within 2-3 weeks and sprouted within 4-5 weeks (Figs. 5,6). The percentage of success ranged between 20 and 90 percent. After initiation of sprouting, all the cuttings were transferred to the first hardening unit provided with sprinklers and shade net to reduce sunlight and temperature (Fig. 7). Nutrient solution was also added to rooting medium during this period. After two weeks of hardening, the root trainers along with stands were transferred to the second hardening unit provided with UV stabilized polythene sheets, where the frequency of watering was reduced step by step as the age of ramets increased (Fig. 8). Fertilizers (DAP or NPK mixture) was also supplied to the growing ramets.

Fig.1 Harvesting coppice shoots from eucalypts stumps. Fig. 2 Preparation of 2-leafed single node cuttings and planting in root trainers. Fig. 3 Arranging root trainers in trenches. Fig. 4 Misting to maintain high humidity inside the trenches. Fig. 5 Three-week-old cuttings with new sprouts. Fig. 6 Clones undergoing hardening.

3. RESULTS AND CONCLUSION

3.1 SUPPLY OF RAMETS TO KERALA FOREST DEPARTMENT

By the middle of June 1998, 26,000 hardened ramets of 19 clones of eucalypt were produced. Of these, 16,600 ramets of 15 KFRI clones and 800 ramets of 4 ITC Bhadrachalam clones were supplied to the Kerala Forest Department (Figs. 9, 10). The details of clones supplied to the Central Nursery Kulathupuzha and Central Nursery Nilambur in 1998, and to Kodanad and Arienkavu range for raising plantations in 1999, are provided in Table 1.

The number of ramets of different clones supplied varied because of the difference in age of stumps and percentage of rooting and sprouting. The ramets in root trainers were transported in lorries fitted with stands suitable to carry root trainers. The average height of ramets supplied ranged between 30-45 cm. Before transporting, a prophylactic spray of Bavistin 50 WP 0.1% (2g in 1 litre of water) was given to the ramets for protection against Cylindrocladium infection during transportation and field planting.

3.2. CONCLUSION AND FUTURE WORK

Vegetative propagation of eucalypt through rooting of cuttings from coppice shoots can be successfully carried out in field clonal propagation unit, by proper manipulation of light, moisture, aeration and nutrients. The method can be adopted successfully for mass production of true-to-type ramets from high yielding disease resistant superior clones.

In order to sustain the high productivity of eucalypt, the clonal forestry programme should be made dynamic incorporating new clones. Clonal seed orchard has to be established using proven clones to obtain superior seeds. Candidate plus trees (CPTs) can be selected from plants raised using these seeds and multiplied vegetatively for addition of clones to the improvement programme.

Table 1. Details of eucalypt clones multiplied at Kottappara and supplied to the Kerala Forest Department during 1998 and 1999

Clone No.	Number of ramets supplied				
	1998		1999		Total
	To central nursery Kulathupuzha	To central nursery Nilambur	To Kodnad range	To Arienkavu range	
E.tereticornis					
KFRI 14	1200	500	160	540	2400
KFRI 16	1300	300	3460	2060	7120
KFRI 28	300	100		200	600
KFRI 38			200	280	480
KFRI 43	150	150		70	370
KFRI 47				80	80
KFRI 49			400	320	720
KFRI 56	400	200	100		700
KFRI 58				140	140
KFRI 62	500	300		200	1000
KFRI 65	200	300	600	780	1880
Total	**4050**	**1850**	**4920**	**4670**	**15490**
E.camaldulensis					
KFRI 7	400				400
KFRI 10	1000	500	560	300	2360
KFRI 22				60	60
KFRI 23	600	300	300	1040	2240
KFRI 24	200	100	200	100	600
KFRI 25	2500	1500	7116	3410	14526
KFRI 41	500	100			600
KFRI 54	1500	1000	1200	760	4460
KFRI 55			200	390	590
KFRI 59	400	100		190	690
KFRI 68			540	200	740
Total	**7100**	**3600**	**10116**	**6450**	**27266**
Bhadrachalam clones					
BCM 3		100	200	80	380
BCM 6		200			200
BCM 7			200		200
BCM 10		100			100
BCM 83			200	600	800
BCM 130	300	100	400	320	1120
Total	**300**	**500**	**1000**	**1000**	**2800**
Grand total	**11450**	**5950**	**16036**	**12120**	**45556**

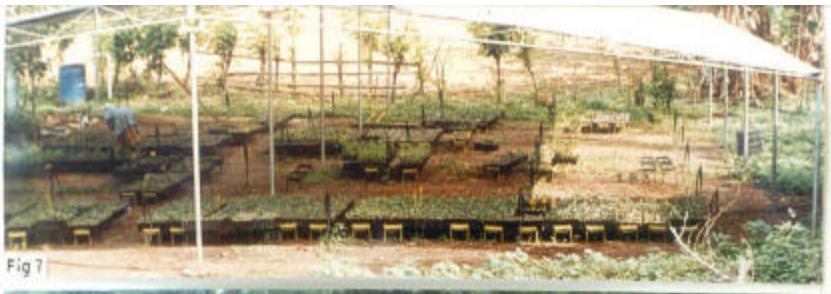
Fig 7


Fig 8


Fig 9


Fig 10

Fig. 7 Clones growing in hardening unit provided with sprinklers. Fig. 8 Two-month-old clones in hardening unit II. Fig. 9 Clones raised in 20-celled and 40-celled root trainers ready for transportation. Fig.10 A lorry loaded with clones arranged on specially made stands.

4. RESEARCH RESULTS OF PRACTICAL/FIELD APPLICATION

About 17,400 ramets of 15 KFRI and 4 ITC Bhadrachalam clones were supplied to Kerala Forest Department to raise clonal gene bank in Central nurseries at Kulathupuzha and Nilambur during 1998. In 1999, approximately 28,100 ramets of 20 KFRI and 4 Bhadrachalam clones were supplied to Kodanad Range in Malayattoor Forest Division and Arienkavu Range in Thenmala Forest Division for raising clonal plantations. This project, apart from producing clonal planting stock of eucalypt for Kerala Forest Department, was a demonstration of the suitability of trench type field clonal propagation unit designed by KFRI for vegetative multiplication of eucalypt.

6. REFERENCES

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