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ESTABLISHMENT OF A SEMI-PERMANENT FIELD CLONAL PROPAGATION UNIT FOR *EUCALYPTUS*

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[Final Report of the Project KFRI 280/97]

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ABSTRACT OF PROJECT PROPOSAL

1.	Project No.	:	KFRI 280/97
2.	Title of the Project	:	Establishment of a semi-permanent field clonal propagation unit for *Eucalyptus*
3.	Objectives	:	i. To establish a semi-permanent field clonal propagation unit (FCPU) for clonal multiplication of eucalypt for experimental purpose ii. To work out the economics of the production of ramets
4.	Date of commencement	:	July 1997
5.	Scheduled date of completion	:	June 2000
6.	Funding Agency	:	Indian Council of Forestry Research and Education (ICFRE)
7.	Project Team		
	Principal Investigator	:	J. K. Sharma
	Associates	:	M. Balasundaran E. J. Maria Florence
8.	Study Area	:	Kottappara, Malayattoor Forest Division
9.	Duration of Study	:	3 years

CONTENTS

ABSTRACT

Vegetative propagation technique is an important component of tree improvement programme through which mass production of true to type progenies of superior parent trees is made possible. Sophisticated mist chambers with automatic control systems for maintaining humidity and temperature are in vogue for large scale multiplication of eucalypt clones. Field mist chambers which can be established close to a group of candidate plus trees are useful for research and development of new clones in the field and for multiplication of superior trees, in places where facilities like electricity is lacking or the permanent clonal multiplication facilities are distantly located.

Preliminary trials were conducted in order to design appropriate field clonal multiplication facility to suit Kerala conditions. Initially, an above-ground polytunnel where humidity was maintained through a channel of water kept stagnant over black polythene sheet all around inside the chamber was tried. The efficiency of the mist chamber was improved by designing a below-ground level mist chamber. Such a mist chamber consisted of two trenches, each of 11 m x 1.35 m x 0.60 m size, provided with 15 nozzles in the middle of each trench for producing mist. The mist was produced through operating a kerosene pump of 1.5 HP. Each trench had a protective tunnel type polythene cover and two such trenches of a mist chamber were provided with a hut type shed covered with polythene sheet, for protection from rain. To reduce intensity of heat and light falling over the shed, a covering of 50% shade net was provided.

Single-node cuttings kept in the trench, rooted and sprouted within three weeks. The sprouted cuttings were transferred to hardening units where watering was reduced gradually for hardening the ramets. The ramets attained plantable height of 45–60 cm within four months.

Three clonal propagation units with a total of six propagation trenches to accommodate 18,000 cuttings of *Eucalyptus tereticornis* and *E. camaldulensis* were established at a cost of approximately Rs.1.9 lakhs. Rs.2.88 lakhs were required for purchase of root trainers and root trainer stands, Rs.0.22 lakhs were spent towards the cost of vermiculite, chemicals, etc. and Rs.0.62 lakhs towards the labour charges. Thus, a total of Rs.5.62 lakhs were spent for the production of 48,000 ramets within eight months. The average cost of one ramet during the first year works out to be Rs.12/-. However, cost of production of ramets during the subsequent years will be

considerably less as no expenditure will be required towards infrastructure development. Considering 10% increase in recurring expenditure, including labour charges and the cost of replacement of damaged root trainer, root trainer stand, etc, the cost per ramet during the subsequent years is worked out to be Rs.3/- approximately. This clearly shows that FCPU standardised is highly economical as compared to other clonal propagation units provided with modern gadgets and amenities.

1. INTRODUCTION

Clonal propagation is an important component of tree improvement programme. The technique is used for mass production of true to type planting stock in which all the genetic superiority of the parent tree is retained. The mean annual increment (MAI) of *Eucalyptus grandis* plantations in Brazil before attempting genetic improvement and clonal forestry in 1967 was 15 $m^3 ha^{-1} yr^{-1}$. But when selected clones were introduced, the yield increased to 70 $m^3 ha^{-1} yr^{-1}$ in industrial plantations. Such clones under intensive management have yielded even upto 100 $m^3 ha^{-1} yr^{-1}$ (Zobel, 1993).

Clones are used not only for raising superior plantations but also for establishing seed orchards for production of high quality seeds and establishing clonal gene banks which will be useful in future tree improvement programmes. Clonal propagation consists of conventional vegetative propagation technique collectively called as macro-propagation and unconventional techniques which involve micropropagation or tissue culture. The advances made in clonal propagation techniques have been discussed in various national (ICFRE, 1989) and international seminars (Davidson, 1993; Lal, 1993; Kulkarni and Lal, 1995).

Tissue culture method of clonal propagation require specialized laboratory facilities where plant tissues are handled and incubated in aseptic and controlled environment until the tissues develop into plantlets. This entails heavy investment, specialised laboratory facilities and highly skilled personnel. But techniques of macro-propagation which consists of vegetative propagation, grafting, air layering, etc. do not require sophisticated facilities.

For mass propagation of forest tree species, the vegetative technique through rooting of cuttings is more efficient and less labour intensive than other methods. However, for rooting and sprouting of the cuttings, suitable environmental conditions such as high humidity, optimum temperature and adequate light conditions are required. These essential environmental conditions are provided in facilities known as mist chambers.

For clonal propagation of tree species through cuttings, providing high humidity and continuous water supply are essential. Therefore, usually mist chambers where misting frequencies can be controlled electronically, are used for large scale vegetative propagation of tree species in economical scale.

For large scale clonal propagation of eucalypts, sophisticated mist chambers are in vogue which provide high humidity and controlled leaf wetness employing fine nozzle sprinklers and humidifiers regulated using electronic sensors and timers. Even the light intensity and temperature regime are electronically controlled to provide conducive climatic conditions for growth. Such mist chambers and associated structures have been established in India (Lal, 1993; Kulkarni and Lal, 1995) and abroad (Davidson, 1993) for production of millions of planting materials for raising pulpwood plantations. However, such facilities require not only huge financial investment but also large area, substantial manpower and organized management.

Often the candidate plus trees (CPT), which provide clonal material, are scattered and located far away from the permanent mist chamber facility. Transportation of clonal material over long distances not only poses practical problems but also increases chances of loosing the precious clonal material as it may not be able to withstand the long transportation time, even if carried in ice boxes with high humidity. Considering this, an urgent need was felt to develop an economical field propagator which can be established in the field in close proximity of a cluster of candidate plus trees where facilities like electricity is not available. Efforts were directed towards developing such a field propagator, and subsequently a Field Clonal Propagation Unit (FCPU) was standardized which gave almost up to 100% rooting success depending upon the clones.

2. CRITICAL FACTORS FOR SUCCESSFUL VEGETATIVE PROPAGATION

For vegetative propagation of tree species, there are certain factors, which affect considerably the rooting of shoot cuttings, sprouting of axillary buds and shoot growth. Some of the most important factors are environmental parameters, maturity of shoot cuttings, potting medium and hormone treatment. If optimum conditions of any of these factors are not met, the vegetative propagation efforts are likely to get set back resulting in total failure. These factors are reviewed by several authors (Markus Wallenberg Foundation, 1984; ICFRE, 1989; White, 1993; Zobel, 1993; Kijkar, 1995; Vivekanandan *et al.*, 1997). Based on the resources available and the production target, various types of mist chambers are suggested (Jayachandran *et al.,* 1997).

(i) Environmental factors

Three environmental factors are important in a high humidity field propagator for successful production of rooted cuttings. They are (1) maintenance of high humidity throughout (2) uniform and appropriate temperature regime, and (3) appropriate light conditions.

High humidity around the plant cuttings directly affect the rate of transpiration which will be minimal if the intracellular vapour pressure of leaves is equal to vapour pressure in the mist chamber. Under such a situation, the energy synthesized by the plant would be in excess of the energy consumption and that excess energy would be used for rooting of cuttings.

Similarly, another important factor is the leaf wetness regulated through a film of water covering the leaf surface, which not only affects evaporation of water from the leaf surface but also reduces the temperature due to cooling. Thus, cooling reduces the transpiration rate and slows down the overall metabolic rate of the cut-shoot and prevents the shoots from desiccation. At the same time it enhances the photosynthetic activity and thereby promoting rooting of cuttings.

The ambient temperature in the propagation unit also controls the rate of transpiration. Higher temperature may result in excessive rate of transpiration resulting in desiccation and wilting of cuttings. Therefore, it is essential to maintain diurnal temperature range within ambient temperature ± 5°C. Any increase or decrease in temperature outside the chamber reflects upon the temperature inside the propagator. The required temperature range and light conditions are regulated by providing overhead diffused shade to decrease the temperature and light intensity.

(ii) Coppice shoot cuttings of desired maturity

The maturity of coppice shoots utilized for vegetative/clonal propagation is another critical factor. Usually, the mother trees to be cloned are felled at 30-40 cm above ground to produce coppice shoots which increase the juvenility of the host tissue and consequently rooting. In the case of eucalypts, 45-to 60-day-old coppice shoots root well. With increase in maturity, the coppice shoot becomes woody and the rooting ability of cuttings decreases. For each species, optimum age/maturity of coppice shoots has to be standardized through experimentation. For the present study, 45-to 60-day-old coppice shoots of *Eucalyptus tereticornis/E. camaldulensis* were utilized. Coppice shoots were converted into one-noded cuttings with a pair of leaves; the leaf blade was cut to 3 cm to half size before converting to single node-cuttings. All the cuttings were dipped in 0.05% carbendazim solution to prevent fungal infection.

(iii) Growing medium

Growing medium used for rooting of cuttings is another important factor which affects rooting behaviour. Some of the characteristics of the growing medium which influence rooting are water retention ability, porosity, nutrient content and pH. Therefore, before embarking upon clonal/vegetative propagation programme of a particular species, the type of growing medium needs to be standardized for obtaining optimum rooting. In the present study, vermiculite of grade II (Keltech Energies Ltd., Bangalore) was utilized.

(iv) Rooting hormone

Rooting hormone which promote rooting ability of tree species are central to rooting performance of cuttings. Hormones such as indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), etc. have been used widely for rooting of various tree species. For maximum rooting, a particular hormone and its concentration need to be standardised. For eucalypt cuttings 4,000 ppm IBA in talc was employed.

3. DEVELOPMENT OF A FIELD PROPAGATOR

The following two types of field propagators were tried initially to standardize a most efficient and economical Field Clonal Propagation Unit (FCPU) suitable for Kerala conditions. The experiments were carried out at Kottappara (Malayattoor Forest Division) during February - June 1998 when the temperature ranges between 24-36° C and RH 20-90 percent.

1. Above ground FCPU (AG-FCPU)

On an experimental basis, an above ground field propagator was tried. The propagator was provided with a channel all around a raised platform on which a black polythene sheet of 250 gauge was spread. The cuttings taken in HIKO trays/single-celled root trainers were kept over the platform and the channel was filled with water (Fig. 1, 2).

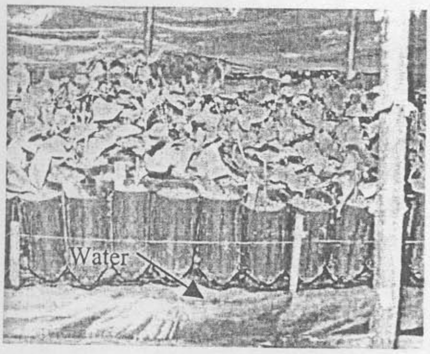

Fig. 1. Above-ground FCPU with single Celled root trainers

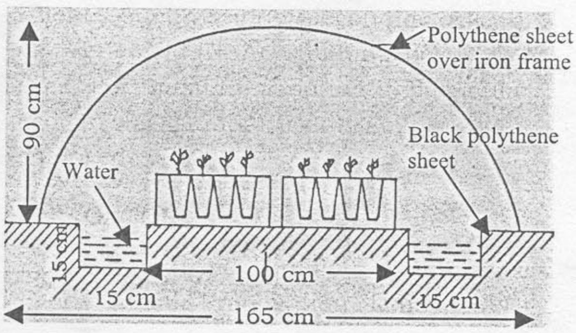

Fig.2. A diagrammatic sketch of above-ground FCPU

The cuttings were covered with a UV-stabilized, transparent polythene sheet 200 gauge over a steel wire, 6 mm dia, frame, making a polytunnel with very high humidity inside. The undersurface of the polytunnel and the shoots were sprayed profusely with water using a fine sprayer. Water was sprayed over the cuttings as and when required and water level maintained in the channel.

The shoots started rooting and sprouting with in 15-25 days. A dose of Hoagland's nutrient solution was applied to cuttings at the rate of 10 ml per cutting after 15 days to meet the nutrient requirement for uniform rooting and sprouting. Though, the growth of shoot appeared to be normal, the maximum rooting of cuttings was found to be 30-50% depending upon the eucalypt clones. Possibly, high temperature reaching up to 42° C in this type of polytunnel FCPU during the day affected the rooting percentage. Since the rooting percentage in the above-ground FCPU (AG-FCPU) or polytunnel was quite low, no further experiments was carried out to standardize this type of FCPU.

2. Below-ground level FCPU (BG-FCPU)

A trench type FCPU was designed and its efficacy in rooting and sprouting was studied. A trench of 10 m x 1 m dimension was dug and filled with medium sized granite metal and river sand each in layers of 15 cm thickness (Fig.3, 4).

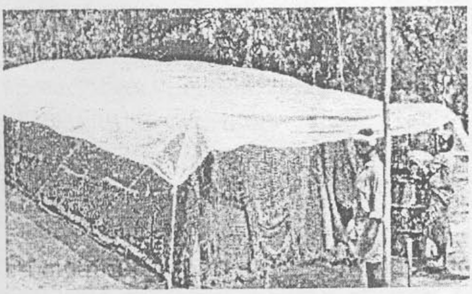

Fig. 3. Below-ground level FCPU – external view

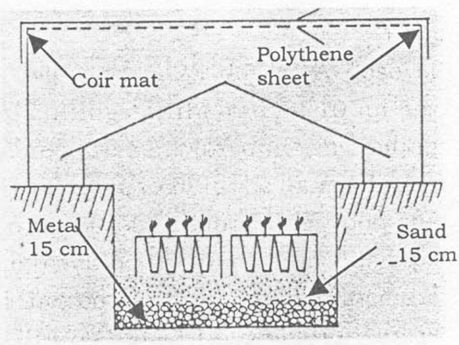

Fig. 4. Diagrammatic sketch of below –ground level FCPU with one trench

The trench was provided with a polythene cover to maintain high humidity using improvised frame made up of bamboo splints and wire. The trench was covered with overhead coir mat (1/4" mesh) to provide diffused light inside (Fig. 4). The sand was drenched with water and eucalypts cuttings placed in root trainers filled with vermiculite as growing medium. The trench and cuttings were sprayed with water (Fig. 5) every hour to maintain high humidity inside, which is required for rooting and sprouting. The cuttings started to sprout and root within 15-21 days depending upon the clone (Fig. 6, 7).

Maximum rooting of 95 per cent was observed in some clones such as KFRI 14, KFRI 16 and KFRI 25 (Fig. 7). High percentage of rooting and sprouting showed a great promise for using this type of FCPU for vegetative

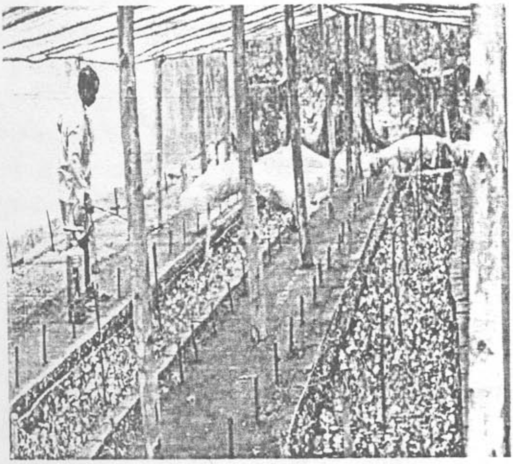

Fig. 5. The trench and cuttings being sprayed with water

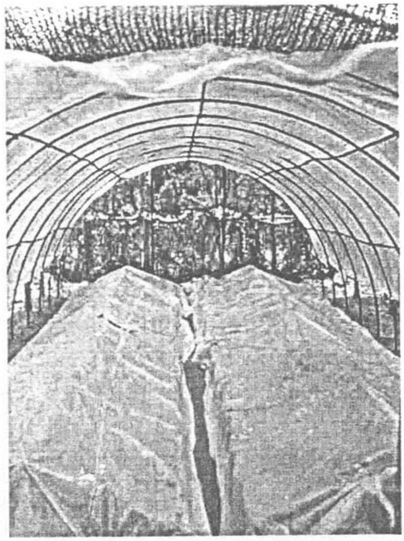

Fig.6. Below-ground FCPU with two trenches

propagation. After the onset of pre-monsoon shower, a polythene sheet had to be spread over the coir mat to protect the cuttings from rain splash and flooding in the trench (Fig. 3). But polythene sheet spread over the coir mat posed practical problems such as sagging of poly-thene sheet due to rain water collection, and hence it was decided to provide polythene covering over the propagator trenches (Fig.6). Certain other modifications were made in the prototype to increase the efficiency and easy workability in the FCPU.

The coir mat was replaced by agro-shade net (50%), fixed at a height of 2 m above ground level, spread over a semi-permanent frame made of G.I. pipes (Fig.8). Improvised wire frames over

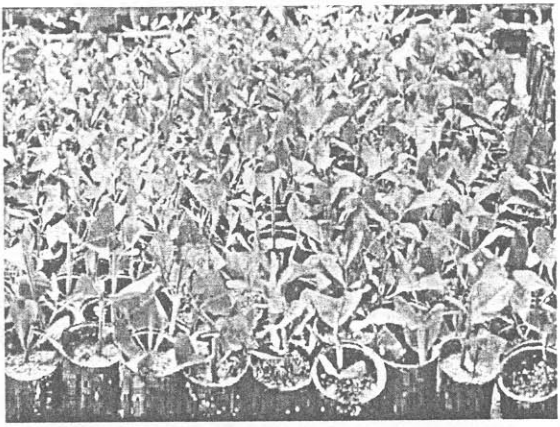

Fig. 7. Clone No. KFRI 25 which gave 90% success

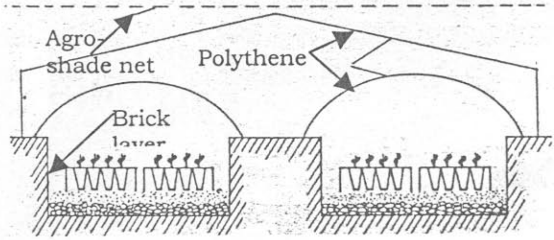

Fig.8. Below-ground FCPU with two trenches

the propagator trenches were replaced with semi-circular steel frame for making the polytunnels. For providing protection from rain, another semi-permanent steel frame, either hut type or tunnel type, were made about 1.75 m in height from ground level, covered with UV-stabilized polythene (Fig. 6, 8). The hut type protective structure was found to be more practical from the point of view of movement inside the mist chamber. These structures were constructed so as to include two propagation trenches in a single unit. The other changes made were, providing a brick lining in the trenches to conserve water and a water pump set to operate the misting system.

4. DESCRIPTION OF STANDARDISED FCPU

Following are the main requirements and components of a standard FCPU fabricated for clonal production of eucalypts (Fig.9).

Fig.9. A view of the field clonal propagation unit at Kottappara

1. Shade net (50%) to provide shade to the cuttings in order to reduce intensity of light and temperature under it.

2. UV-stabilized polythene sheet, 200 gauge (optional in high rainfall area) to prevent rain water flooding the trenches.

3. High humidity chamber/ trench

   i. Trench (12 m long, 1.35 m wide, 0.6 m deep) lined with bricks at sided and granite metal and river sand as two layers on the floor (Fig.10).

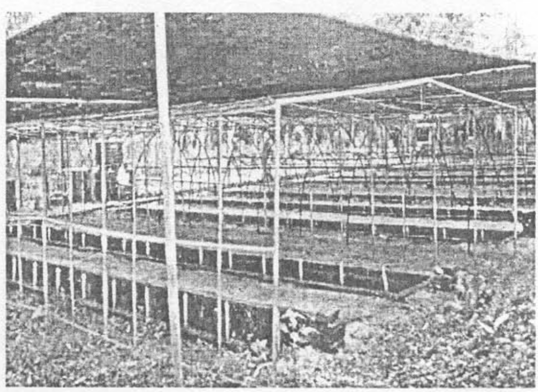

Fig.10. A view of the FCPU showing trenches

ii. UV-stabilized polythene cover (150 gauge) for the propagator trenches on steel wire frame (6 mm dia).

iii. Capacity -150 root trainers (20-celled, each cell with 150 ml volume) kept on 30 stands per chamber.

4. Pressurised fine nozzle spraying system, 15 Numbers, PVC pipes, valves, etc. (Fig. 10, 12).

5. Vermiculite (horticultural grade) as potting medium.

6. Root trainers and root trainer stands or HIKO trays with stands.

7. One-noded 2-leaf cuttings treated with 4000 ppm IBA preparation (Indole butyric acid in talc).

8. Well, water storage tank, buckets, mug, etc. Two pump sets - one 1-HP pump for operating the misting system and one 5-HP pump for pumping water from the well to the overhead tank. PVC tank: Two; one overhead and one underground (Fig.11).

Fig. 11. Water tanks and pump – part of misting system

Fig.12. A trench with misting

9. Plastic trays, scissors, secateurs, weighing balance, measuring cylinder, marking pen, labels, etc.

10. Bavistin for controlling Cylindrocladium leaf blight and stem infection, and Chlorpyriphos for controlling termites.

11. Hoagland's solution as mineral nutrient supply.

Propagation trenches

Each Field Clonal Propagation Unit (FCPU) designed for Kerala conditions consists of two sunken trenches (12 m x 1.35 m x 0.6 m) lined with one layer of bricks on all the side walls (Fig.10, 13). The trench is filled with granite metal of medium size up to a depth of 15 cm which is over layered with river sand up to a height of 15 cm thus leaving 30 cm of space for root trainers and stands.

Each trench is provided separately with a frame made up of steel rods, over which a clear polythene sheet of 150 gauge is spread in such a way that at least 15 cm of the excess sheet rests on the ground all around. Another structure covered at the top with transparent ultraviolet resistant polythene (200 gauge) is provided over the trenches at a height of about 1.75 m to facilitate protection from rain.

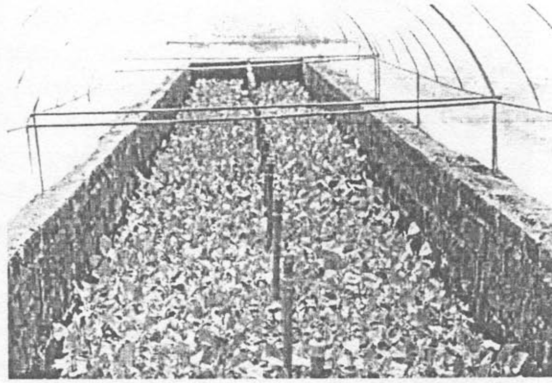

Fig.13. Rooted and sprouted cuttings ready to be transferred to hardening unit

To reduce the light intensity, black plastic shade net is provided over the polythene shed. Instead of plastic shade net, coir mat can also be used with appropriate mesh size so as to allow desired light. All the cuttings are applied with a measured quantity (10 ml) of nutrient (Hoagland's) solution at third week.

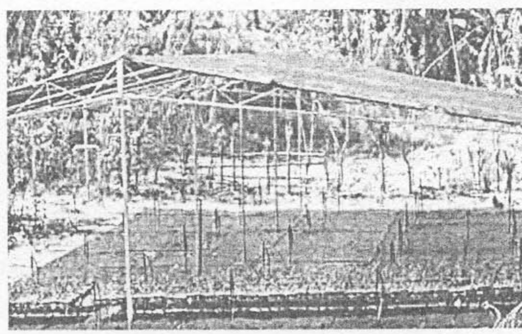

Fig.14. Four-week-old rooted cuttings transferred to hardening shed (unit I)

Hardening unit: After the rooting and sprouting of cut shoots have occurred (Fig.13) in propagation trenches, the root trainers with the cuttings are transferred to hardening unit to promote further growth and hardening of ramets (Fig.14).

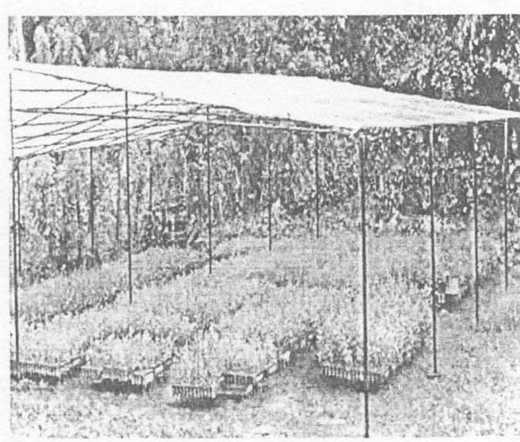

Fig.15. Hardening unit II without agro-shade net

Hardening of rooted cuttings involves three stages. Initially, the cuttings are transported to a hardening shed provided with UV-stabilized polythene sheet over laid with a black agro-shade net (50%). The hardening unit is provided with sprinklers which are used intermittently to provide sufficient moisture on the leaf surface to avoid shock and drying up.

Watering is regulated and gradually reduced over a period of two weeks to promote rooting. Another dose of Hoagland's solution (15 ml) is applied to each ramet to promote luxurious growth of shoot. After two to three weeks, the ramets are transferred to another hardening unit provided with a protective roof of UV-stabilized thick gauge polythene sheet to allow more light penetration for healthy shoot and root development (Fig. 15, 16). The watering frequency is further reduced to promote root growth to form root plug and to reduce growth of shoot (Fig.17). The ramets are retained here for 3-4 weeks; subsequently, they are kept out in open until planting.

Fig.16. A ramet with well developed root plug

5. FUNCTIONING OF FCPU

Stage 1

The sand in each trench is drenched with about 250 l of water and then treated with about 10 l of 0.2% chlorpyriphos solution to control termite attack. The brick lining of the trench is also drenched with water. The polythene sheet is spread over the steel frame of each trench in such a way that the trench is completely covered with the sheet all around. The propagation trench is left covered with polythene sheet for about one hour with intermittent misting before transferring the root trainers with the cuttings into the trench. Two-leaf shoot cuttings treated with 4000 ppm talc preparation of IBA (indole butyric acid) by dipping the lower root tip into the hormone preparation is transplanted into each cell of the root trainer. The root trainer stands carrying root trainers are transferred to the trench.

The cuttings are sprayed with water using the misting system at frequent intervals 3-6 minutes depending upon the local climatic conditions. The misting system is operated through pump manually for 5-10 seconds. After the initiation of roots, the frequency of misting during the day was reduced to every one hour and during night once or twice if required. At this stage, 10 ml of nutrient solution (Hoagland's solution) was given to each cutting by pouring at the collar region. The cuttings remained inside the propagator for about three to four weeks until the sprouts started to appear.

For best results, preparation and planting of cuttings into the root trainer is done during early morning or evening or after the sunset. The harvesting of coppice shoots, preparation of cuttings and treating them with Bavistin solution (0.1% a.i.) were done during early morning or the late afternoon.

Stage II

After the sprouting of the axillary buds, the root trainers were taken out from the propagator and transferred to a hardening shed provided with sprinklers. The cuttings were frequently (every one hour for the first few days) sprayed with water to keep the leaf surface wet. The cuttings remained here for about one to two weeks during which time the shoots elongated and roots got air pruned while trying to grow out of the root trainers. All cuttings were supplied with di-ammonium phosphate (DAP) solution (0.25%) to improve growth and root development. The frequency of watering was gradually reduced to once or twice daily.

Stage III

The cuttings were then shifted to another hardening unit provided with UV-stabilized polythene roof but without black plastic shade net for further hardening.

The frequency of watering was gradually reduced to three to four times in a week in order to further harden the ramets and to promote root plug formation (Fig.17).

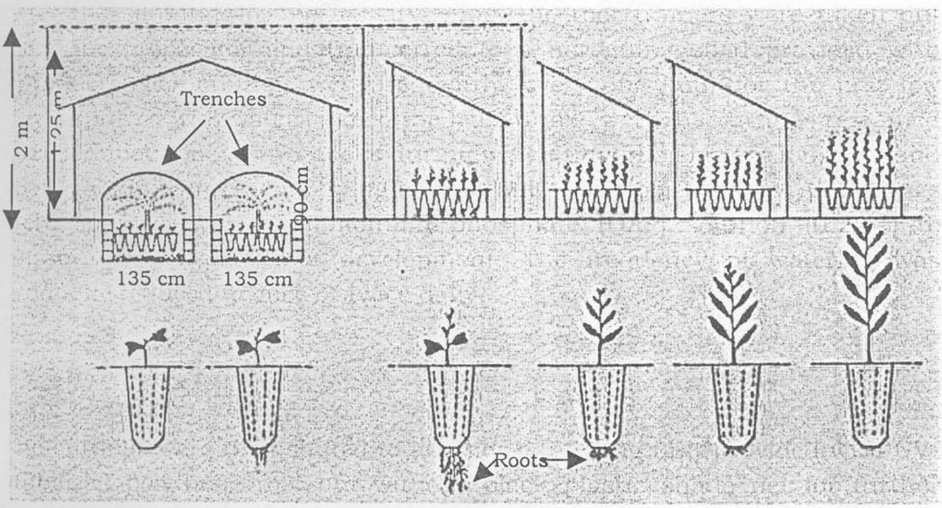

Fig.17. Diagrammatic sketch showing FCPU and hardening units

Stage IV

The ramets were then removed from the hardening unit and kept in the open and watered two to three times in a week depending upon the prevailing climatic conditions. Fertilizer (0.2% NPK mixture solution) and micro-nutrient solutions were applied at this stage.

Thus it took about three months to produce approximately 4,000 hardened ramets of Eucalypts from two trenches of a single unit of the propagator. Coppice cuttings of *E. tereticornis, E. camaldulensis, E. urophylla, E. pellita* and *E. grandis* have been successfully rooted using the FCPU established at Kottappara, under Kodanad Range of Malayattoor Forest Division in Kerala.

6. REGULATION OF ENVIRONMENTAL FACTORS IN FCPU

High humidity: High humidity is maintained in the below-ground trench through wet sand and intermittent misting in closed atmosphere.

Temperature: Intermittent misting is intended to keep the leaf surface moist and cool and also to keep the humidity in the chamber up to or 80% ± 10%. Favourable temperature of 32 ± 3°C is regulated through the black shade net which cuts down light by 50%.

Light: Light conditions, which are very important for sprouting of axillary buds, and shoot elongation are regulated through black plastic shade net and UV- stabilized polythene sheet.

7. LARGE SCALE PRODUCTION OF CLONAL PLANTING STOCK

The success of rooting and sprouting depended upon i. genotype of the clone, ii. age of the tree iii. maturity of the coppice shoot iv. temperature, humidity and light conditions inside the mist chamber, and v. moisture of the growing medium (vermiculite). However, as far as the field mist chamber is concerned, temperature, humidity, and light intensity are most important for achieving maximum rooting and sprouting.

The temperature inside the mist chamber ranged from a minimum of 22° C (at 8 AM during January) to a maximum of 38° C (at 2 PM during March-May). The temperature was highest during the months of March-May; the maximum temperature in a day was observed at noon. However, such high temperature remained only for one or two hours. Generally the atmospheric temperature ranged between 26 ± 3°C in the morning to 36 ± 3° C during noon from February to May. If the temperature remained at the highest point during a few successive days, it affected the freshness of the leaves. Such leaves showed yellowing and wilting and fell off prematurely. Even if rooting took place, sprouting was absent or very weak. But, such a situation arose very rarely; increasing the frequency of misting reduced the temperature during the period of high temperature.

Maintenance of optimum humidity was a key factor for success in rooting. Persistence of extremely fine drops of water as mist inside the chamber was the most ideal condition. Except during noon, the relative humidity was at least 85%. However, during 12 noon to 3 P.M., the RH came down to around 50%. Increasing the frequency of misting generally improved RH and brought down the temperature. The quantity of water accumulation inside the potting medium was judiciously controlled through regulating the duration of misting. An extremely damp vermiculite reduced rooting percentage. In such situations, the lower tip of the stem including root primordia and the collar region of the cuttings rotted with in a few days.

Light is one of the most important requirement for rooting and sprouting, especially sprouting. Leaves are required for photosynthesis, through which the plant gets nutrients and energy to the growing tips. However, excess light and the consequent heat turned the leaves yellow in colour and such leaves fell off prematurely inhibiting rooting and sprouting. Occasionally, cuttings rooted efficiently, but did not sprout. When such cuttings were brought out and kept in increased light, most of them sprouted and established into healthy ramets.

As mentioned earlier, the success percentage depended upon the genotype, age of the tree and maturity of the coppice shoots. The success in rooting and sprouting in mist chamber reached up to 65-90%. When all the environmental conditions were favourable, a minimum of about 2000 sprouted cuttings were available from each trench within a period of four weeks, and almost all of them survived during hardening. Thus, about 8,000 ramets could be produced from each trench during one season (January - April) and about 48,000 ramets could be produced during a season from three mist chambers with six trenches.

8. COST OF FCPU AND THE RAMETS PRODUCED

The cost of establishing a temporary FCPU with three mist chambers, each having two trenches and its maintenance for 8 months from November to June is given in the following table. During this period it will be possible to start with new cuttings every 3-4 weeks completing 3-4 cycles during 3 months duration covering stage I to IV, thus producing a maximum of 48,000 healthy ramets sufficient for about 30 ha at 2.5 m x 2.5 m spacing or 40 ha at 3 m x 3 m spacing.

Establishment cost of three FCPU with twin propagation trenches and two hardening units at Kottappara (Malayatoor Division) in 1998

Sl. No.	Particulars	Amount (Rs).
I.	**Non-recurring expenditure**	
A.	***Construction cost***	
1.	Construction of Propagation trenches (6 Numbers)	29,000
2.	Steel frames for trenches (18 Numbers)	15,000
3.	UV-stabilized polythene sheet 60 kg	6,000
4.	Cost of fabrication of steel frame for the structure to Protect trenches from rain and for spreading UV-stabilized polythene sheet over the structure	45,000
5.	Cost of fabrication of GI pipe structure to spread black agro-shade net	18,000
6.	Cost of hardening unit for stage II with agro-shade net and UV-stabilized plastic sheet (to accommodate 35,000 ramets during the season)	40,000
7.	Cost of hardening unit for stages III with UV-stabilised plastic sheet to accommodate 35,000 ramets during the season	37,000
	Total	190,000
B.	***Cost of root trainer and stand***	
1.	Cost of 2400 Nos. Root trainers @ Rs.100/-/piece	240,000
2.	Cost of 400 Nos. Root trainer stand @ 400 Nos. @ Rs.120/-/piece	48,000
	Total	288,000
II.	**Recurring Expenditure**	
A.	***Growing medium, hormones, etc.***	
1.	Cost of vermiculite	12,000
2.	Cost of hormone, fungicide, mineral nutrient, etc.	5,000
3.	Cost of implements and tools such as secature, scissors, etc.	5,000
	Total	22,000
B.	***Labour charges***	
1.	Wages for one nursery man @ Rs.125/- day for 8 months	30,000
2.	Wages for two women labours @ Rs.90/- day/women for six months	32,400
	Total	62,400
	GRAND TOTAL	**562,400**

Cost of production of 48,000 ramets during the first year Rs.562,400/-
The mean cost of production of one ramet works out to be Rs.12/-(approx.)

Cost of production of 48,000 ramets during subsequent years

Sl. No.	Particulars	Amount (Rs.)
I.	**Non-recurring expenditure**	Nil
II.	**Recurring expenditure**	
A.	***Growing medium, hormone, etc.***	
1.	Cost of vermiculite	13,200
2.	Cost of hormone, fungicides, mineral nutrients, etc.	5,500
3.	Cost of implements	2,000
	Total	20,700
B.	***Labour charges***	
1.	Wages for nursery man @ Rs.140/-/day for eight months	33,600
2.	Wages for two women @ Rs.105/-/day for six months	37,800
	Total	71,400
C.	***Replacement of damaged and broken items such as polythene sheets, shade net, root trainers, etc.***	40,000
D.	***Annual repair and maintenance work of FCPU***	10,000
	GRAND TOTAL	**142,100**

Cost of production of 48,000 ramets during second year Rs.142,100/-.
The mean cost of production of one ramet during second year Rs.3/- (approx.)

If 10% yearly hike in labour and other recurring costs are considered during the subsequent years, the mean cost of production of a single ramet is likely to remain below Rs.4/- at least for a few years.

9. PRACTICAL UTILITY

The field clonal propagation units established under this project are being utilized for mass multiplication of fast growing, disease resistant eucalypt clones developed by KFRI. So far about 80,000 ramets belonging to 23 clones of *E. tereticornis* and *E. camaldulensis* have been supplied to the Kerala Forest Department and several other pulpwood industries for establishing their clonal multiplication areas and clonal plantations. The structure of field clonal propagation unit can be adopted by Forest Department and other agencies for establishing clonal propagation units in areas lacking facilities like electricity inside the forest plantations.

10. CONCLUSION

An efficient and economical field Clonal Propagation Unit (FCPU) was designed and established at Kottappara in Malayattoor Forest Division. Such FCPU will be very useful for research and development of new clones in field, and commercial production of clones in a small scale.

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12. ACKNOWLEDGEMENTS

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