KFRI Research Report 63

STUDIES ON STUMP AS PLANTING MATERIAL FOR EUCALYPTUS TERETICORNIS PLANTATIONS

K.C.Chacko
V.V.Sudheendrakumar
C.Mohanan
T.Surendran
E.Muhammad

KERALA FOREST RESEARCH INSTITUTE
PEECHI, THRISSUR

February 1990 Pages: 29

CONTENTS

ABSTRACT

A field study was conducted at Nilambur, Kerala, during 1981-'84 to standardise the practices for raising *Eucalyptus tereticornis* Sm. plantation with stump as planting material. The effect of planting season and method, length and diameter of stump, different methods of stump storage and sealing of shoot end of stump prior to planting on sprouting, rooting, survival and growth of the stumplings were investigated. Effect of some growth regulators as well as insecticidal and fungicidal treatments was also evaluated. The study led to the following conclusions.

The survival of stump planted during the period between the pre-monsoon and the intense monsoon (latter half of May) was found better than those planted during the first premonsoon showers in early May and intense monsoon in June. Variations in stump dimensions - tap root length, 10 to 15 cm; root diameter at 15 cm below collar, 0.5 to 1.I cm; shoot length, 2.5 to 5 cm; and shoot diameter at 2.5 cm above collar, 0.8 to 1.6 cm - had little influence on sprouting and survival of stumps. Treatment of stumps with boric acid 90 ppm prior to planting enhanced rooting percentage and abundance. Storage of stumps either in pits or under shade enhanced callusing at root end. Stumps wrapped in moist gunny bags and stored under shade for 4 days or stored in pits in bundles for 11 days before field planting registered better survival. Drenching the planting hole (2 cm dia and 15 cm deep) with 100 ml of 0.1 % Aldrin 30 EC solution before planting ensured protection of stumps from termite attack. Drenching the planting hole with carbendazim (Bavistin) 0.1 a. i. (2 g of Bavistin 50 WP per litre of water) and application of fertilizer (NPK 8:8:16. 100 g per stump) in two holes dug close to the planting hole ensured protection against fungal infection, better survival and height increment. Sealing of shoot-end of the stump prior to planting either with wax or coaltar did not increase survival or growth. The study showed lower percentage of survival in stump planting as compared to planting of polypotted seedlings in pits. However, this method is suitable for raising plantations making use of older seedlings from previous year's nursery beds.

INTRODUCTION

Reduction in expenditure on plantations has always been a topic of great interest in production forestry. One of the ways to achieve this is by planting stumps[1] in crow-bar holes unlike the practice of planting polypotted or bare-rooted seedlings in pits. Stump planting method is widely employed in raising teak plantations. There are reports of stump planting in *Grewia tiliifolia, Bombax ceiba. Pterocarpus marsupium* etc. (Joshi 1981, 1983). However, the success of stump planting varies considerably with species.

Eucalyptus tereticornis Sm. is a fast growing species highly suitable for production of good quality paper and rayon pulp grown extensively in lowland tropics. The total extent of eucalypt plantations in Kerala alone is about 38,000 ha. Of this 23,800 ha are under *E, tereticornis* (Chand Basha, 1986). *E. tereticornis* plantations are generally raised by planting 6-months.old polypot seedlings in pits of 30x30x30 cm. (Nair, 1968).

Seedlings of *E.tereticornis* are characterised by the presence of lignotubers at the collar region which appear in most eucalypt species during the first year of life of the plant as two globular swellings in the axil of the cotyledons. Additional pairs of tubers may occur in the axils of the first and second and even the third pairs of leaves. With time, they grow and if there are more than the cotyledonary pair, they coalesce to form a quite large woody tuber upto several centimetres in diameter. The lignotuber consists of a mass of vegetative buds together with vascular tissues and substantial food reserves. If the shoot portion of a seedling, which has developed a lignotuber is destroyed by fire, drought or grazing, growth is vigorously renewed by the development of new shcots from lignotuber (Pryor, 1976). Evidently lignotuber is of considerable survival value for the plant in an environment where fire and drought are frequent. This property of plant is advantageous in using its stump as the propagule for planting. Nursery trials by Chinnamani and Gupta (1966) demonstrated that *E. rereticornis* cculd be raised from stump. Preliminary trials with *E. tereticornis* stump at Nilambur during 1978-'79 also yielded an overall sprouting of 57-100% and a survival of 39 - 94% at the end of 9 months (Chacko, *et al.*, 1985). Encouraged by fhis result, the present study was undertaken with the object of standardising the stump planting practices for raising *E. tereticornis* plantations.

All the trials were laid out at Nilambur (1I° 17' N. 74° 4' E) situated at 50 m above mean sea level, The average rainfall during the study period (1981-'84) was 2200 mm. The site was well drained. The soil was sandy

---

1. Stump = a young plant with a pruned tap-root and severed stem used for planting (a root shoot cutting)

loam with pH 5.8, organic carbon 0.77% and exchangeable bases 11%. Stumps prepared from 18-months-old *E. tereticornis* were used in all the trials.

This report is organised in 5 sections. Sections 1 to 4 deal with different trials. General conclusions are presented in section 5.

1. PLANTING PRACTICES

Fig. 1.1 A stump of *Eucalyptus tereticornis* showing lignotuber around collar.

1.1 *PLANTING METHOD*

A field trial was laid out in 1981. to compare the performance of stumps planted in crowbar holes and pits with that of potted seedlings planted in pits.

1.1.1 *Materials and Methods*

Stumps with 15 cm tap root and 2.5 cm shoot (Fig. 1.1) were used in the trial. In all, three planting methods were tried. They were, (A). Planting stumps in crowbar holes of 2 cm diameter and 15 cm deep, **(B)** planting stumps in pits of 30x30x30 cm size and (C). planting 6-month-old polypotted seedlings in pits of 30 x 30 x 30 cm size.

While preparing the stumps, adequate care was taken so that the lignotuber was not damaged. Prior to planting, the planting holes and the polypotted seedlings were drenched with 0.1% aldrin 30 EC solution as a prophylactic treatment against termite damage.

Randomised block design with three replicates and 50 plants (or stumps) in a replicate was employed for layout. Regular observations on survival of stumplings%, height and number of shoots per stump were recorded at 1, 12 and 35

---

2 Stumpling = a young plant which has developed from a stump months after planting and the 12th and 35th month data on survival and 36th month data on height were subjected to analysis of variance. Analysis of variance for survival percentage was done after angular transformation of the data. The significance of differences between treatment means was tested using cluster analysis method. The same design and analysis were followed for all the trials dealt with under the heading "Planting practices". The observations in the case of the "Planting season" trials were recorded only for the first four months.

1.1.2 *Results and discussion*

Survival and height of the plants in different treatments at different months are presented in Table 1.I.

At the end of the first month after planting, treatment C, where polypotted seedlings were planted in pits, recorded highest survival (99%) followed by A (77%) and B (74%). Even at 12 and 35 months the survival values in treatment C (72% and 67% respectively) were significantly higher than those in A and B.

Table 1.I Effect of different planting methods on survival, height and number of shoots per stump at 1, 12 and 35 months after planting.

Treatment	Mean survival % at months 1	12	35	Mean height of leading shoot (cm) at months 1	12	35	Mean number of shoots per stump at months 1	12	35
A Stump planting in crowbar holes of 2 cm dia. and 15 cm deep	77	23[a]	21[a]	13	129	487[a]	9.1	3.3	1
B Stump planting in pits of 30 x 30 x 30 cm size	74	32[a]	29[a]	14	137	426[a]	9.7	2.4	1
C Planting polypotted seedlings in pits of 30x30x30 cm size	99	72[b]	67[b]	42	176	457a	1	1	1

Figures superscribed by the same letter in a column are not significantly different at P = 0.05. Figures without superscript were not subjected to statistical analysis.

At the end of the first month after planting the seedlings in C recorded maximum height as compared to other treatments only because the potted seedlings had an initial height advantage over stumps. This initial difference decreased over time and at the end of 35 months there was no significant difference between the three treatments. The mean number of shoots per stump in treatments A and B decreased from the initial number of 9.1- 9. 7 to 2.4-3.3 in 12 months and by the end of 35 months it came down to 1 in both the treatments.

Stump planting in crowbar holes and pits showed a low survival percentage as against planting of polypotted seedlings in pits. This was either due to the total failure in rooting of stumps or inadequate formation of root system

1.2 *STUMP LENGTH*

In this trial, performance of stumps with different root and shoot lengths was studied.

1.2.1 *Materials and methods*

Stumps of lengths viz. 17.5, 20, 12.5 and 15 cm, were used for the trial. The root shoot lengths in each case were 15/2.5. 15/5. 10/2.5 and 10/5 centimetres respectively. Periodic observations on survival, height and number of shoots were taken and data analysed as indicated under 1.1.1.

1.2.2 *Results and discussion*

The results are presented In Table 1.2

Table 1.2 Effect of different stump lengths on survival, mean height of leading shoot and number of shoots per stump at 1, 12, & 35 months after planting.

Treat-men1	Length of tap root & shoot (cm)	Mean survival %			Mean height of leading shoot (cm)			Mean number of shoots per stump		
		at months			at months			at months		
		1	12	35	1	12	35	1	12	35
A	15/2.5	37	5[a]	5[a]	9	124	516[a]	9.7	3.3	1
B	15/5.0	69	25[a]	27[a]	12	111	460[a]	9.3	2.9	1
C	10/2.5	78	25[a]	23[a]	10	99	442[a]	9.2	2.5	1
D	10/5.0	75	25[a]	23[a]	10	124	534[a]	10.1	2.8	1

Figures in a column superscribed by the same letter are not significantly different at P = 0.05. Figures without superscript were not subjected to statistical analysis

One month after planting, highest survival was recorded in in C (78%) followed by D (75%) and B (69%). Statistical analysis of the survival figures at the end of 12 and 35 months and the height figures at 35 months showed no significant difference between the treatments. The mean number of shoots per stump in all the four treatments decreased from the initial number of 9.2 – 10.1 to 2.5 - 3.3 in 12 months and it further came down to 1 at the end of 35 months.

1.3. *STUMP DIAMETER*

Standardisation of the diameter of the root and shoot of the stump was the objective of the trial.

1.3.1 *Materials and methods*

Stumps with 15 cm tap root and 2.5 cm shoot having different diameters were used in the trial. The stumps were classified into four grades based on shoot diameter at 2.5 cm above collar and tap root diameter at 15 cm below collar. The mean shoot / root diameters for the four grades were 1.6 / 1.1, 1.3 / 0.8, 1.2 / 0.8 and 0.8 / 0.5. Periodical observations on survival, height, and mean number of shoots per stump were recorded and the data analysed as indicated under 1.1.1.

1.3.2 *Results and discussion*

Results are presented in Table 1.3

Statistical analysis of the survival values at 12 and 35 months and the height values at 35 months revealed no significant difference between the four treatments. There was a considerable reduction in the mean number of shoots per stump. At the end of 35 months the mean number of shoots per stump was 1 in all the treatments.

Table 1.3. Effect of different stump diameters on survival, height and number of shoots per stump at 1, 12 and 35 months after planting.

Treatment	Shoot dia. at 2.5 cm above collar (cm) / root dia. at 15 cm below collar (cm)	Mean survival % at months 1	12	35	Mean height of leading shoot (cm) at months 1	12	35	Mean number of shoots per stump at months 1	12	35
A	1.6 / 1.1	63	13[a]	13[a]	16	100	446[a]	10.2	3.3	1
B	1.3 / 0.8	63	13[a]	12[a]	15	111	480[a]	10.3	2.9	1
C	1.2 / 0.8	69	14[a]	13[a]	16	108	507[a]	8.6	3.1	1
D	0.8 / 0.5	59	21[a]	20[a]	11	99	500[a]	7.9	2.9	1

Figures in a column superscribed by the same letter are not significantly different at P = 0.05. Figures without superscript were not subjected to statistical analysis.

7.4 *SHOOT-END SEALING PRIOR TO PLANTING*

In vegetative propagation technique, sealing the end of a branch cutting helps to reduce desiccation and increase their survival and hence enhance establishment of cutting. To examine this aspect in the stump planting of *E. tereticornis,* a trial was laid out.

1.4.1 *Materials and methods*

The trial had the following three treatments :

A. Sealing the shoot end with coal tar
B. ,, *, paraffin wax
C. Control (no shoot-end sealing)

The treatments A and B were administered by quick dip of shoot end of the stumps in coal tar and melted paraffin wax respectively. Regular observations on survival, height of the tallest shoot and the number of shoots per stump were recorded for 35 months and the data subjected to analysis of variance as indicated under 1.1.1

1.4.2 *Results and discussion*

The results are presented in Table 1.4. Statistical analysis of the survival values at 12 and 35 months as well as the height values at 35th month did not proclaim the observed differences as statistically significant at P = 0.05. The mean number of shoots per stump at the end of 35 months was also the same (1) in all the treatments.

Table 1.4. Effect of shoot-end sealing of stumps prior to planting on survival, height and number of shoots per stump at 1, 12 and 35 months after planting.

Treatment	Mean survival %			Mean heights of leading shoot (cm)			Mean number of shoots per stump		
	at months			at months			at months		
	1	12	35	1	12	35	1	2	35
A Coaltar sealing	48	17[a]	17[a]	11	106	561[a]	10.7	3.2	1
B Paraffin-wax sealing	75	28[a]	27[a]	17	111	431[a]	10.1	3.1	1
C Control	75	31[a]	30[a]	12	127	433[a]	12.0	3.0	1

Figures in a column superscribed by the same letter are not significantly different at P = 0.05. Figures without superscript were not subjected to statistical analysis.

1.5 *STORAGE OF STUMPS PRIOR TO PLANTING*

Preparation and storage of teak stumps well in advance of the planting season is practiced for teak in some of the teak growing countries. In Thailand the practice is to store teak stumps in covered pits protected from the rains. During the planting season the stumps are taken out of the pits and planted in the field. This practice, to a great extent, overcomes the difficulty in arranging labour who would be mostly engaged in agricultural works during the planting season. However, in Kerala, this practice is not in vogue and the case of *E. tereticornis* such a practice is unknown. Hence, a field trial was laid out to study the effect of different storage methods on establishment of plantation.

1.5.1. *Materials and methods*

The following storage treatments were administared to the stumps prior to planting.

A. Control (fresh stumps without any storage)

6. Stumps stored in pit for 4 days

C. Stumps stored in pit for 11 days

D. Stumps wrapped in moist gunny bag and stored under shade (in a thatched shed) for 4 days

E. Stumps wrapped in moist gunny bag and stored under shade (in a thatched shed) for 11 days.

For storage of stumps in pit the following procedure was followed. A pit of 50 x 50 x 5G cm size was dug. Stumps were bundled together in 50s and arranged horizontally in pits. Sand was sprinkled over the bottom layer of bundles before placing another layer over it. The pit was covered with a 2 cm layer of sand and 10 cm soil. The storage pit was protected from rain by providing a temporary shed thatched with coconut leaves. The field planting was done in crow bar holes at 1X 1 m spacing during June. The planting date was the same for all the treatments. Regular observations on survival of stumplings, number of sprouts and height growth of shoots were taken for 35 months and the data analysed as indicated under 1.1.l.

1.5.2 *Results and discussion*

The results are summarised in Table 1.5.

Table 1.5. Effect of different stump storage treatments on survival, height and number of shoots per stump at 1, 12 and 35 months after planting.

Treatment	Mean survival %			Mean height of leading shoot (cm)			Mean number of shoots per stump		
	at months			at months			at months		
	1	12	35	1	12	35	1	12	35
A Control (fresh stumps)	21	5	3[a]	3	99	434[a]	5.8	3.0	1
B Stored in pit for 4 days	29	11	9[a]	5	83	440[a]	7.1	2.7	1
C ,, 11 days	75	45	41[bc]	7	97	443[a]	7.7	2.4	1
D Wrapped in moist gunny bags and stored under shade for 4 days	85	51	49[c]	8	96	411[a]	7.2	2.7	1
E ,, 11 days	79	38	33[b]	9	80	428[a]	8.0	3.9	1

Figures superscribed by different letters in a column are significantly different at P = 0.05. Figures without superscript were not subjected to statistical analysis.

The treatments D, E and C recorded better initial sprouting percentage viz. 85, 79 and 75, respectively. Survival percentage at the end of the 12 months in these treatments were 51, 38 and 45 respectively. The stored stumps developed callus (less in 4 days and more in 11 days) at the root end and this formation probably promoted rooting and increased the chances of survival. However, there was no significant difference in height growth as well as the mean number of shoots per stump.

The study showed that the treatments D and E where the stumps were wrapped in moist gunny bags and stored under shade for 4 and days respectively enhanced their survival in the field. Storage of stumps in pits for 11 days also gave encouraging results. In the case of storage in pits the chances of stumps getting dried due ro adverse climatic conditions are less and, hence, may be preferred in areas where above ground storage conditions are not ideal. However, satisfactory explanation for low survival in treatment B could not be offered.

1.6 *SEASON OF PLANTING*

It is a normal practice to plant polypotted or bare-root seedlings of most of the tree species after the onset of monsoon showers (June-July in Kerala). On the otherhand in tne case of stump planting of teak, field planting is recommended during prernonsoon showers (March-May) as teak stumps do not tolerate excess moisture at the time of rooting. By the time the monsoon becomes active, the stumps develop sufficient root system helpful for successful establishment. Since success of establishment of stumps depends upon rooting, the time of planting appears to be very crucial. With this in view, the effect of season of stump planting of *E. tereticornis* was studied in two field trials.

1.6.1 *1981 Trial*

1.6.1.1. *Materials and methods*

Stumps were planted in crow bar holes in late May corresponding to premonsoon season and in mid June corresponding to active monsoon season at a spacing of 2 x Im. The survival, height of leading shoot and number of shoots were recorded for 4 months.

1.6.1.2 *Results and discussion*

The data presentsd in Table 1.6 reveals that the percentage survival was higher in the case of stumps planted just after the premonsoon showers (late May) than in those planted during monsoon (mid June). However, the treatments did not differ with regard to mean height of leading shoot (30 & 29) and number of shoots per stump (3 in both).

Table 1.6. Survival percentage, average height of leading shoot and average number of shoots per stump at the end of 4 months after planting-1981 Trial

Time of planting	Survival	Mean height of leading shoot (cm)	Mean number of shoots per stump
Late May	55	30	3
Mid June	29	29	3

1.6.2 *1982 Trial*

1.6.2.1 *Materials and methods*

This trial was laid out in Nilambur in 1982 on an area close to the 1981 trial plot. The site characteristics were comparable to that of the 1981 plot. Stump planting was done during four different times representing premonsoon and monsoon seasons viz. early May, mid May, late May and mid June. Observations on survival of stumps, height of leading shoot and number of shoots were recorded for 4 months.

1.6.2.2 *Results and discussion*

Results are presented in Table 1.7. Survival was significantly higher in the case of plantings done during mid and late May (64% and 87% respectively) compared to those planted in early May 9% and late June 1% The mean height of leading shoot and mean number of shoots per stump also were higher in these two cases.

Table 1.7. Survival pecentage. mean height of leading shoot and mean number of shoots per stump - 1982 Trial.

Time of Planting	Survival %	Mean height of leading shoot (cm	Mean number of shoot per stump
Early May	9^{a}	16^{a}	2
Mid May	64^{b}	27^{a}	3
Late May	87^{b}	29^{a}	3
Late June	1^{a}	9^{a}	1

Figures in a column superscribed by the same letter are not significantly different at $P = 0.05$. Figures without superscript were not subjected to statistical analysis.

In both 1981 and 1982 trials better survival of stumps was recorded in the case of stumps planted between premonsoon and intense south-west monsoon, i.e. during second half of May.

2. INDUCTION OF ROOTING

A well developed root system is necessary for the survival and good growth of plants. The low survival was suspected to be due to the failure of stumps to root or development of inadequate root system. In the trials conducted to find out suitable planting method, (Part-1) large - scale mortality of stumps was noticed. Treatments with plant growth regulators are known to induce rooting of stem cuttings of many tree species (Nanda, 1970). Pre-treatment with growth regulating substances to induce and enhance rooting of stumps was thought to reduce mortality of stumps when used as planting material. Hence, studies were carried out to find out the efficacy of different plant growth regulators to induce rooting of stumps.

2.1 *Materials and methods*

2.1.1 *Preparation of stumps* :

Stumps with 15 cm tap root and 2.6 cm shoot made out of 18 months old seedlings were used for the trials. The upper cut end of the stump was sealed with paraffin wax to reduce desiccation.

2.1.2 *Preparation of solutions* :

Stock solutions of indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA) and coumarin were prepared separately by dissolving weighed quantities of each chemical in 2 ml of ethyl alcohol and subsequently diluting them to appropriate concentrations by adding water. Boric acid (BA) was disolved directly in water and made up *to* the required concentration.

2.1.3 *Experimenr - I Treatment with different Growth Regulating Substances*

Stumps were grouped homogeneously into 11 lots of 10 stumps each and the following eleven treatments were given.

1. Control (water)
2. IAA 10 pprn
3. IAA 100 ppm
4. IBA10ppm
5. IBAl00ppm
6. NAA 10 ppm
7. NAA 100 ppm
8. Coumarin 10 ppm
9. Coumarin 100 ppm
10. Boric acid 10 ppm
11. Boric acid 100 ppm

The chemicals were applied by dipping lower 5 cm portion of the stumps in the respective solution for 24 hrs., before planting. The treated stumps were planted in polythene bags, filled with quartz sand and kept in shade. The bags were watered regularly to keep the stumps sufficiently moist. Observations on sprouting and rooting responses were recorded. Based on the result obtained in the experiment - 1, in the next set of experiments, only boric acid was tried in three different seasons.

2.1.5 *Experiment - Treatment witn boric acid* :

Total 10 different concentrations of boric acid (10 ppm to 100 ppm) were used to study its efficacy to induce rooting of stumps. Watar was used as control. Stumps grouped into 11 lots of 10 stumps each, were treated with various concentrations of boric acid solutions for 24 hrs., by using dip method as mentioned in experiment-I and planted in polythene bags, filled with quartz sand, kept in shade and were watered regularly. The experiments were carried out during February, June and October in order to study the seasonal effect, if any, on induction of rooting.

Periodic observations were recorded on sprouting and rooting. The data were statistically analysed using analysis of variance to find out the significant differences between the treatments and seasons.

2.2 *Results and discussion*

2.2.1 *Experiment* I

Highest percentage of rooting (60%) was obtained in treatment with boric acid 10 ppm followed by coumarin 10 ppm *(50%)* (Fig. 2.1). Stumps treated with IBA 100 ppm failed to root while control and IBA 10 ppm recorded 40% rooting. Treatments with IAA 100 ppm and coumarin 100 ppm showed maximum mean number of roots while the treatments with boric acid 10 ppm and NAA 10 ppm produced maximum length of roots. As regard the sprout number and vigour, NAA 10 ppm. IAA 10 ppm, coumarin 10 ppm and IAA 100 ppm gave maximum mean values respectively (Table 2.1). Interestingly none of the treatments employed seemed to favour both sprouting and rooting.

Table 2.1 Sprouting/rooting responses of *E. tereticornis* stumps to various treatments (N=10).

Treatments (ppm)	**Mean No. of stumps rooted**	**Mean No. of sprouts / stump**	**Mean length of sprouts (cm)**	**Mean No. of leaves / stump**	**Mean No. of roots / stump**	**Mean length of roots (cm)**
Control	4	4	9	30	4	4
IAA_{10}	4	7	6	37	4	5
IAA_{100}	2	3		18	7	5
IBA_{10}	4	3	7	24	5	2
IBA_{100}	0	0	0	0	0	0
NAA_{10}	4	3	5	19	3	7
NAA_{100}	3	10	6	28	3	3
$Coumarin_{10}$	5	3	19	20	3	4
$Coumarin_{100}$	4	5	8	29	5	5
Boric $acid_{10}$	6	3	6	34	2	7
Boric $acid_{100}$	3	3	3	18	4	5

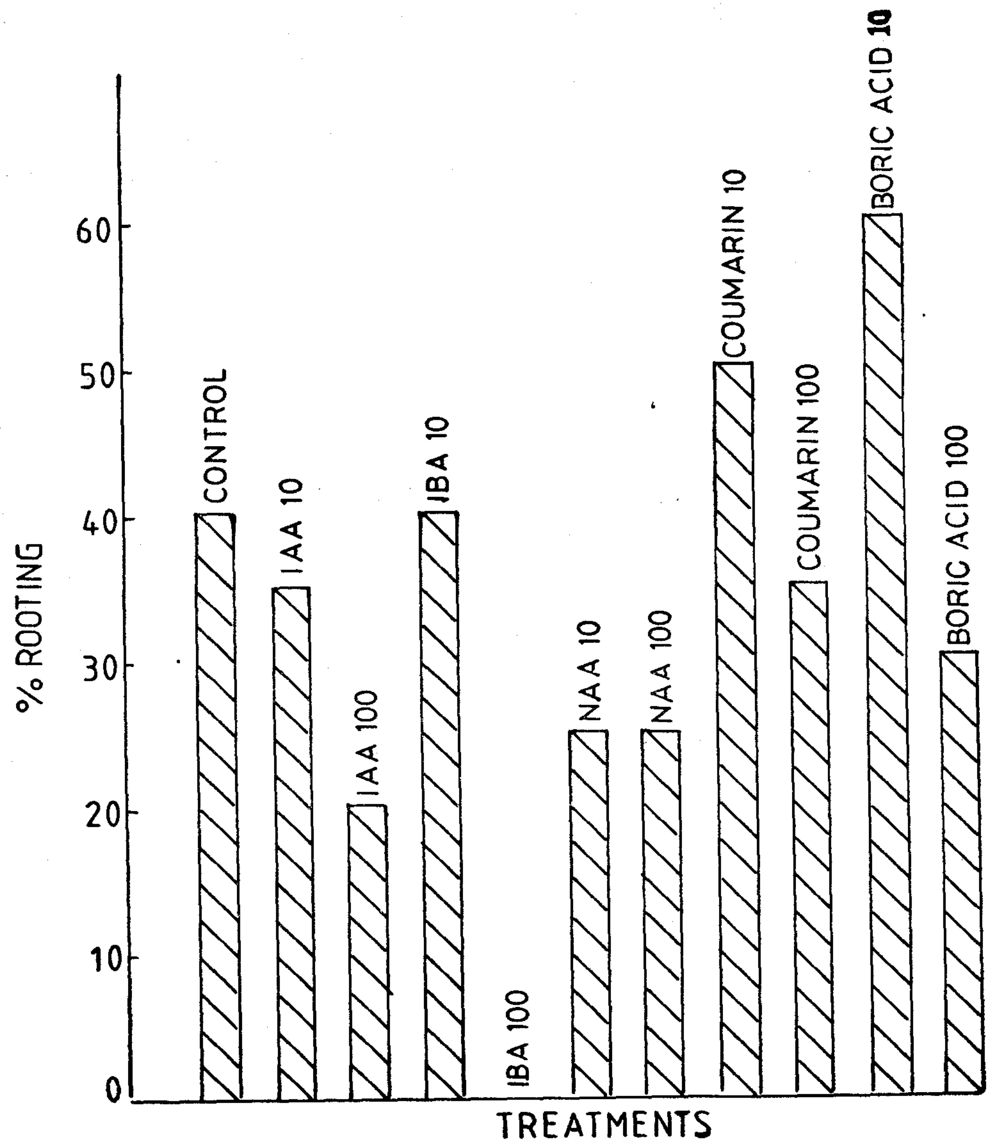

Fig. 2.1 Effect of various growth regulating substances on rooting of stumps.

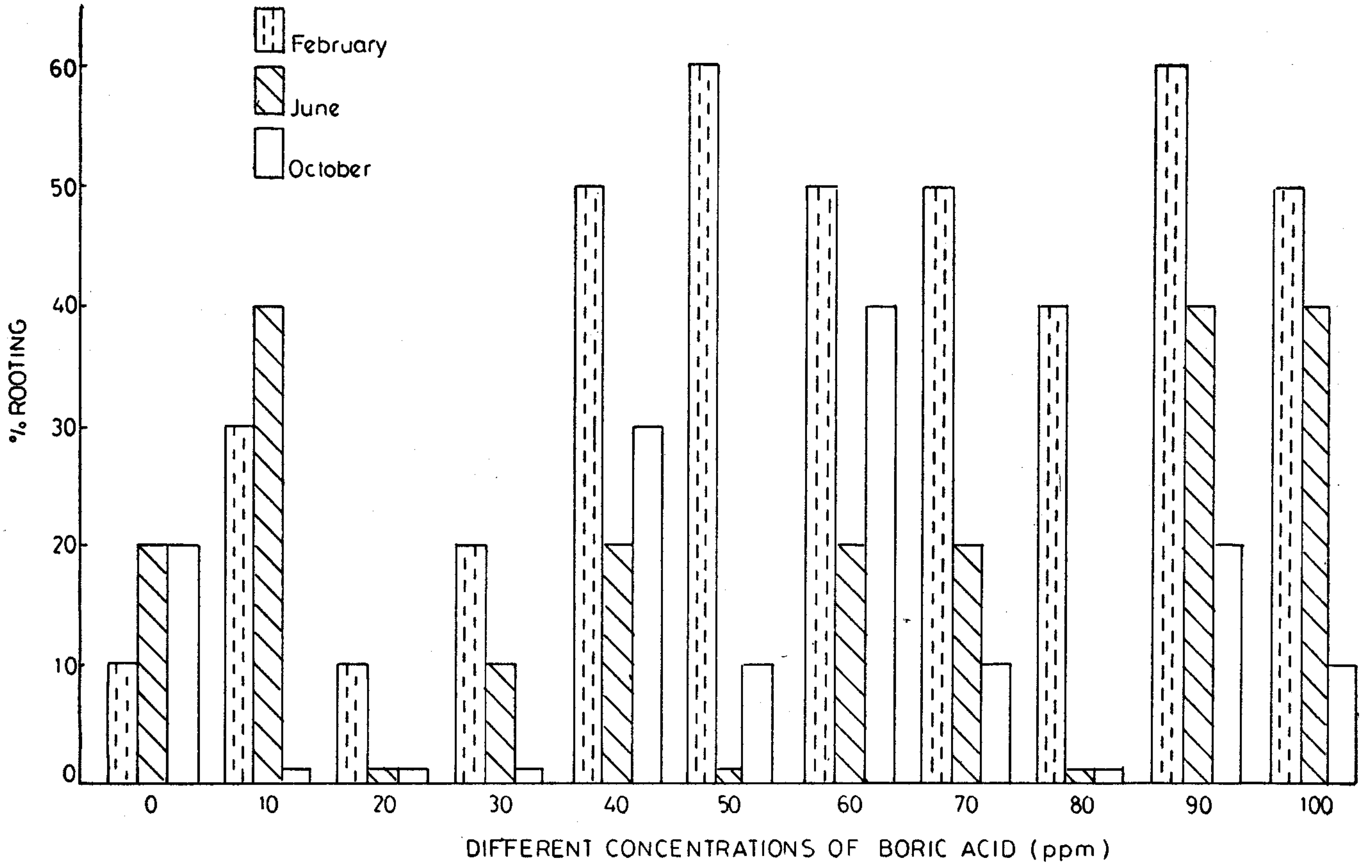

Fig. 2.2 Effect of various concentrations of boric acid on rooting of stumps in three seasons.

2.2.2 *Experiment* II

Results of the experiment showed significant ($P > 0.01$) differences in rooting response between seasons (Table. 2.3). In general, trials conducted in February appeared to give better rooting response. However, there was no significant difference between trials conducted in June and October. Nevertheless, this clearly shows that month of planting (season) is an influencing factor in the rooting ability of *E. tereticornis* stumps. There were no significant differences between treatments in rooting responses. This may be attributed to the treatment X season interaction which may be more influencing than interaction between treatments. However, treatment with boric acid 90 ppm and 50 ppm gave 60% rooting while in control only 10% rooting occurred during February (Fig. 2.2.). In June trials boric acid 90 ppm gave 40% rooting, while in October the rooting response was minimum (20%). As far as the sprouting responses such as number and height of the sprouts and mean number of leaves, no appreciable differences between different treatments and seasons were observed (Table 2.2.)

Table 2.2 Sprouting/rooting responses of *E. tereticornis* stumps to various concentrarions of boric acid (BA) in three different seasons. ($N = 10$)

Treatments (ppm)	Mean No. of sprouts/stump			Mean length of sprouts (cm)			Mean No. of leaves/stump			Mean No. of roots/stump			Mean length of roots (cm)		
	Feb.	Jun.	Oct.	Feb.	Jun.	Oct.	Feb.	Jun.	Oct.	Feb.	Jun.	Oct.	Feb.	Jun.	Oct.
Control	5	4	3	15	16	13	17	40	23	7	7	9	4	10	6
T1 BA_{10}	2	2	0	23	14	0	20	26	0	6	8	0	3	8	0
T2 BA_{20}	4	0	0	21	0	0	42	0	0	8	0	0	5	0	0
T3 BA_{30}	2	10	0	10	16	0	57	8	0	3	9	0	8	5	0
T4 BA_{40}	2	4	2	17	10	20	11	18	28	6	6	9	2	6	7
T5 BA_{50}	3	0	1	17	0	22	21	0	15	4	0	3	4	0	21
T6 BA_{60}	5	2	2	17	14	30	12	23	17	3	3	5	11	7	10
T7 BA_{70}	2	4	2	18	16	24	11	34	15	3	6	5	11	10	10
T8 BA_{80}	3	0	0	21	0	0	17	0	0	5	0	0	24	0	0
T9 BA_{90}	2	3	2	16	13	17	15	23	15	5	4	4	5	8	13
T10 BA_{100}	3	4	1	15	11	19	12	19	8	4	4	10	6	5	

Table 2.3. Analysis of variance of percentage of rooting of *E. tereticornis* stumps.

Sources	D. F.	S. S,	M. S. S.	F
Total	32	8370.5784		
Season	2	2647.4313	1323.7156	10.8336**
Treatment	10	3279.4220	327.9422	2.6840^{ns}
Error	20	2443.7252	122.1863	

** Significant at 1% level
ns = not significant

Pretreatment of *E. tereticornis* stumps with boric acid 90 ppm enhanced the rooting percentage of stumps during the month of February. As field plantings are not usually undertaken during February, this result has relevance only in the case of plantings done under irrigated conditions. During the month of June, a treatment with broic acid 90 ppm favoured rooting and increased the length of roots which has an added advantage on the survival rate. Boric acid is a comparatively cheaper and easily available chemical. This study recommends dipping of 5 cm portion of the root end of the stump in 90 ppm boric acid for 24 hours before planting.

3. INSECTICIDAL TREATMENT AGAINST TERMITE DAMAGE

Termite damage is a serious problem during the initial periods of establishment of eucalypts in Kerala. Based on the studies conducted during 1976 - 1980, and further large-scale field trials, Nair and Varma (1981) recommended group drenching of polypotted seedlings with liquid formulation of aldrin (0.12g (a. i) of insecticide per container (18 x 12 cm) as the most effective method in controlling termite damage in young plantations. In the present trial, since stumps are the planting material, directly planted in the field the above method of insecticidal application could not be adopted. Hence, this study was undertaken to standardise a suitable method of insecticidal application and also to find out an effective and safe dosage of the insecticide against termites. Both liquid and dust formulations of aldrin, one of the effective insecticides in termite control, were tested.

One field trial and three nursery trials were carried out.

3.1 *Field experiment*

Stumps of one and half year old with 15 cm tap root and 2.5 cm shoot were used. Planting was done in crow-bar holes at a spacing of 1x1 m. The design followed was RBD with 3 replicates and fifty stumps for a treatme'nt in a replicate. Planting was in June after the onset of monsoon. The treatments were as follows.

TI - Control

T2 - 100 ml of 0.1% aldrin 30 EC solution applied in each crowbar hole (2 cm dia., 15 cm deep) before stump planting.

T3 - Stumps rolled in aldrin 5% dust formulation at the rate of 2g per stump.

T4 - Stumps rolled in aldrin 50% dust formulation at the rate of 2g per stump. (50% dust formulation prepared by mixing equal quantity of 5% dust and technical material)

T5 - Dipping stumps in 2% solution of aldrin 30 EC for one minute. To the insecticide solution fresh cowdung was added to form a slurry which left a visible coating on the stump.

Regular observations on sprouting, and termite infestation were taken for one year. Plants died due to reasons other than termite attack were also recorded. The data were statistically analysed using X^2 test of independance of factors.

3.2 *Nursery trials*

3.2.1 *Nursery trial* I

This trial was undertaken to study the effect of insecticidal application on sprouting of the stumps. Fifty stumps were used in each treatment. Planting was done in polythene bags filled with quartz sand. The treatments were as follows.

TI - Control

T2 - Dipping stumps in 2% aldrin 30 EC solution for one minute before planting.

T3 - Dipping stumps in 10% aldrin 30 EC solution for one minute before planting.

T4 - Rolling the stumps in 5% aldrin dust formulation at the rate of 2g of dust per stump.

Observation on sprouting was taken for a period of $1^1/_2$ months.

3.2.2 *Nursery trial*

The trial was undertaken to find out a safe dosage of the insecticide. The methodology was the same as that followed in the previous trial. The treatmentc were as follows.

T1 - Control

T2 - Dipping the stumps in 0.03% aldrin 30 EC solution.

T3 - Dipping the stumps in 0.1% aldrin 30 EC solution.

3.2.3 *Nursery* trial *Ill*

The effect of insecticidal treatment on rooting in the case of callused stumps was studied. The stumps were prepared and planted in vermiculite which was kept moist. After 5 days the stumps were pulled out. The stumps that had developed callus at the root end were used in the trial. Thirteen stumps were used per treatment. The treatments were as follows.

T1 - Control.

T2 - Dipping the callus formed stumps in 0.01% aldrin 30 EC solutlon.

3.3 Results and Discussion

The results of the field trial are summarised 'in Table 3.1. Mortality of seedlings due to termite infestation was observed only in the case of un-treated stumps (24%) which suggested the effectiveness of aldrin in cont-rolling termite attack of stumps irrespective of the formation, methods or application and dosage. However, the high percentage of mortality of the stumps in all treatments (80-92%) in comparison with control (58%) due to causes other than termite attack indicated the possiblity of an harmful effect of insecticidal treatment on their establishment.

Tabie 3.1 Effect of aldrin treatment on sprouting and incidence of termite attack - 1981 field trial.

Treatment	% sprouting+	% mortality due+ to unknown reason	% mortality duel+ to termite
T1 - Control	81[a] *	58[a]	24
T2 - 0.1% aldrin EC-crowbar hole drenching	80[a]	80[a]	0
T3 - Rolling stumps in 5% aldrin dust	72[ab]	94[b]	0
T4 - Rolling stumps in 50% aldrin dust	68[ab]	86[b]	0
T5 - Stump dip 2% aldrin EC	59[b]	91[b]	0

+ Average of three replicates

Figures superscribed by same letters are not significantly different at 5% level of significance

The results of the nursery trials I and II (Tables **3.2;3.3)** indicated that sprouting is significantly inhibited, only when aldrin is applied at a dosage as high as 10 per cent. Significantly low percentage *of* rooting in the case of treated stumps (30-42%) in comparison with control (62%) indicated the phytotoxic effect of the higher dosages tested (Table 3.2). The data obtained

Table. **3.2** Effect of aldrin treatment on sprouting and rooting-Nursery trial I.

Treatment	% sprouting	% rooting
TI - Control	**96[a]** *	**62[a]**
T2 - Stumps dipped in 2% aldrin EC	**84[a]** ,	**42[b]**
T3 - Stumps dipped in 10% aldrin EC	**68[b]**	**30[b]**
T4 - Stumps rolled in 5% aldrin dust	**80[a]**	**34[b]**

* Figures superscribed by same letters are are not signifificantly different at 5% level of significance.

from nursery trials II and III indicated that a dosage ranging between **0.03** to 0.1% of aldrin **30** EC has no inhibitory effect on rooting and sprouting of the stumps (Table **3.3):** The results of nursery trial III (Table **3.4)** showed that percentage of rooting of the callused stumps is not affected by aldrin when used at a dosage as low as 0.1%.

Table. **3.3** Effect of lower dosages of aldrin on sprouting and rooting-Nursery trial II.

Treatment	% sprouting	% rooting
T1 - Control	**93[a]** *	**6 1[a]**
T2 - Stumps dipped in 0.3% aldrin EC	**96[a]**	**63[a]**
T3 - Stumps dipped in 0.1% aldrin EC	**91[a]**	**59[a]**

* Figures superscribed by same letters are not significantly different at of significance.

Table. 3.4 Effect of insecticide on rooting of callused stumps

Treatment	% sprouting	% rooting
T1 - Control	100	85
T2 - Stump dipped in 0.1% aldrin EC	100	92

The study suggests drenching of the planting holes (2 cm dia,' 15 cm deep) with 100 ml of 0.1% aldrin 30 EC solution before planting, as a prophylactic treatment for protecting *E.* tereticornis stumps from termite attack.

4. FUNGICIDAL FIELD TRIALS AGAINST DISEASES

In Kerala, eucalypts are found to be susceptible to various fungal diseases in their early establishment phase in plantations. Large-scale mortality of *E. tereticornis* saplings due to fungal infections has been recorded in plantations situated both in low and high altitude areas of the State. Sapling root collar canker caused by *Botryodiplodia theobromae* Pat., root rot caused by *Calonectria floridana* Sobers and *Cylindrocarpon lucidum* Booth, root and shoot infection caused by *Cylindrocladium* spp., wilt caused by *Fusarium oxysporum* Schlecht are the important diseases in young plantations (Sharma et al., 1984, 1985). Of these, Cylindrocladium leaf blight (CLB) caused by different species of *Cylindrocladium* is posing major threat to the establishment of young saplings. *Cylindrocladium.* a soil-borne fungus has been recorded causing multiple infection at various growth phases of seedlings and also in young coppice crop. Repeated infections of young coppice sprouts of *E. tereticornis* by *Cylindrocladium* spp. resulting in complete failure of the coppice regeneration have been recorded in Kerala. Since, there is considerable disease pressure on eucalypts in the State and some diseases of roots are already known to cause mortality of saplings in plantations, to protect the sprouting stumps from the threat of fungal infection, various fungicides were tested for their efficacy against the major pathogens in the field. As boosting the initial growth of seedlings possibly helps in disease escape, a fertilizer application was also included the trial.

4.1 *Materials and methods*

Freshly cut stumps of 18-month-old *E. tereticornis* saplings with 15cm tap root and 2.5 cm shoot were employed for the study. Solutions of appropriate concentrarions of various fungicides were prepared for dipping the stumps and for drenching the planting holes. For dip treatment, 35 stumps each were dipped in the respective fungicidal solutions for one hour. Fungicidal drenching in the crowbar holes was carried out by using a rose can. The shoot end of the stump was sealed by molten paraffin wax. As a prophylactic measure against termites, aldrin 30 EC (0.1 % a.i.) was applied in each planting hole.

The fungicidal trial had a total of 18 treatments with two systemic (carbendazim, benomyl) and a non-systemic (mancozeb) fungicides involving three different methods of application (dipping, drenching, dipping + drenching) (Table 4.1). Fertilizer (NPK 8-8-16) was applied at the rate of 100g per stump in two holes dug closely to the planting hole in two treatment sets (TI2-TI6) with fungicidal application mode as drench or dip. Waxed and nonwaxed shoot ends of the stumps were tried in some of the treatments; two controls (TI7, TI8) with waxed and nonwaxed shoot ends were also provided. Each treatment was replicated in two rows of 35 stumps each. Planting was done in crowbar holes at espacement of 1x 1 m.

Observations on sprouting of stumps, their survival, disease incidence and severity, shoot height, etc. were recorded at various intervals upto 10 months. The sprouted stumps showing advanced symptom of die-back and also with dried up sprouts were uprooted and examined and isolations of causal organisms were made on potato dextrose agar medium (PDA). In certain cases sections of root and lignotuber of the apparantly infected stumps were cut and observations made.

Statistical analysis : ANOVA was carried out after appropriate transformation of data on sprouting, survival, shoot height, *Phaeoseptoria* and *Cylindrocladium* foliar infections. Multiple comparison test was also done.

4.2 *Results and discussion*

4.2.1 *Effect of treatment on sprouting*

Stumps in drenching treatment of benomyl and mancozeb (T4, T5, and T7) showed high percenatge of sprouting (Table 4.1). Furthermore, treatment TI2 where carbendazim was drenched along with fertilizer application also showed high sprouting percentage (83). Sprouting was low in stumps which were dipped in carbendazim (T1) and benomyl (T2) and also had NPK treatment (T15, T16). Interestingly, the treatments T9, T10 and T11, a combination of dipping the stumps in fungicidal solution and drenching the fungicides in the planting hole, gave the lowest sprouting. Treatment T14, where *NPK* alone was applied gave better sprouting percentage (76) but did not differ significantly from treatments T12 and T13. In both the control sets sprouting was slightly higher than that of treaments T9, T10 and T11. Treatments where shoots were pretreated with and without paraffin wax did not differ significantly in sprouting. Dipping of stumps in benomyl apparently had deleterious effect on sprouting. The same trend was also noticed in treatments T9, T10 and T11, where the stumps were dipped in benomyl (0.05% a. i.) followed by a drenching with either carbendazim(0.05%).or benomyl (0.05%) or mancozeb (0.1%). Significant difference in sprouting was found in treatments where stumps were dipped in benomyl (T2) and drenched with benomyl (T4 and T7). Similarly the dipping (T1) and drenching (T3 and T6) with carbendazim showed significant difference in sprouting. The treatment T12, where fertilizer was also applied along with carbendazim, differed significantly from the treatment T1. Since the fungicidal solution was used in low concentration (0.05%), the adverse effect on sprouting may be due to the long duration of the dipping treatment.

4.2.2 *Disease incidence*

Initially, the percent infection of the stumps was very low ranging from 0-28.. Shoot diseases caused by *Cylindrocladium* spp. and *Phaeoseptoria eucalypti* (Hansf.) Walker were recorded after 20 days of sprouting. *Cylindrocladium* spp. causing both stem and leaf infections of the sprouts persisted throughout the period of this study. The infection caused defoliation and general weakening of the sprouts. Moderate foliar infection caused by *Cylindrocladium quinquesepratum* Boedjn & Reitsma was recorded in treatments T12, T13 and T17 (Table 4.1). *P. eucalypti;* foliar infection was also recorded in plants of most of the treatments. Moderate infection was recorded in treatments T1, T2, T7 and T17. But none of the treatments differed significantly. (Table 4.2) Eight to thirteen percent mortality was recorded after 40 days of sprouting in treatments T1, T8. T14 and T18. In most cases the affected stumps shrivelled and had poor root systems with browning of lignotubers. Isolations from some of these affected stumps yielded two fungi viz. *Botryodiplodia theobromae* Pat. and *Scytalidium* state of *Nattrassa toruloidea* (Nattrass) Dyke & Sutton. *B. theobromae* has earlier been reported to cause large scale mortality of *E. tereticornis* saplings in plantations and *N. toruloidea* causes stern canker of young *E. tereticornis* plants (Sharma *et al.,* 1984, 1985). High mortality was also observed in other treatments after 40 days of sprouting, but no pathogen could be isolated from the dying stumps. Possibly the cause of mortality of the stumps was due to poor development of the root system and drought.

Tabla 4.1 Effect of various fungicides and fertilizer treatments on stumps of *E. tereticornis*

Treatment No.	Mode of treatment	Pretreatment	Chemicals	% Conc. (a. i.)	% Sprouting	% Infection Ph.*	% Infection Cyl.**	% Survival	Mean height (cm)
	Dipping	Wax coating							
T_1			Carbendazim	0.05	67.14	21.43	—	0	—
T_2			Benomyl	0.05	65.71	20.54	—	8.69	46.17
	Drenching the crowbar hole	,,							
T_3			Carbendazim	0.1	78.57	19.35	—	8.99	47.31
T_4			Benomyl	0.1	85.71	7.74	5.36	11.67	46.48
T_5			Mancozeb	0.1	82.86	14.07	7.14	5.11	38.65
		No wax coating							
T_6			Carbendazim	0.1	72.86	6.52	8.0	15.69	48.48
T_7			Benomyl	0.1	81.43	22.77	—	19.06	59.59
T_8			Mancozeb	0.1	77.14	10.52	5.26	16.66	58.0

	Dipping in 0.05% a. i. Benomyl and drenching the crowbar hole	wax coating							
T_{9}			Carbendazim	0.05	58.57	7.14	—	0	—
T_{10}			Benomyl	0.05	52.85	13.85	—	8.04	22.45
T_{11}			Mancozeb	0.1	57.14	—	10.0	6.52	12.92
	Drenching the crow bar hole and NPK (100g/stump)	,,							
T_{12}			Carbendazim	0.1	82.85	6.66	13.33	27 04	94.73
T_{13}			Benomyl	0.1	67.14	4.55	34.09	21.26	96.48
T_{14}			N P K	1oog	75.71	19.17	4.16	19.68	85.24
	Dipping and NPK (100gm/stump)	,,							
T_{16}			Carbendazim	0.05	64.29	—	10.0	6.25	46.43
T_{16}			Benomyl	0.05	54.29	—	1.0	2.78	22.7
T_{17}	Control		—	—	67.14	28.57	17.28	23.91	47.89
T_{18}	Control	No wax	—	—	68.66	12. 5	6.25	10.31	62.78

* Phaeoseptoria infection

** Cylindrocladium infection

Table 4.2 Analysis of variance table

Variable	Source	Sum of squares	DF	Mean squares	F.valees
	Total SS	1588.4219	35		
Sprouting	Treatment SS	1207.3672	17	71.021599	3.3548696*
	Error SS	381.05469	18	21.169704	
Survival	Total SS	84.277313	35		
	Treatment SS	65.720154	17	3.8658912	3.7498217*
	Error SS	18.557159	18	1.0309533	
Phaeose-	Total SS	60.907791	35		
ptoria	Treatment SS	43.403275	17	2.5531337	2.6254027ns
Infection	Error SS	17.504517	18	0.92724731	
Cylindro-	Total SS	67.639847	35		
cladium	Treatment SS	40 845108	17	2.4026532	1.6140392ns
infection	Error ss	26.794739	18	1.4885966	
Shoot	Total SS	331.01135	35		
height	Treatment SS	255.07898	17	15.004645	3.5568969*
	Error SS	75.932373	18	4.2184649	

* Significant at P = 0.05

ns : not significant.

4.2.3 *Effect on growth*

Maximum shoot height was recorded in treatment T13 (96.48 cm) and in some other treatments viz. (T12, T14) where NPK was applied alone or with fungicides. But, in T16 which also had NPK and stumps were dipped in benomyl, curiously the height growth was poor (22.7cm). This may possibly be due to the benomyl dip treatment as is also evident in other treatments, T2 and T10.

4.2.4 *Effect on svrvival*

In general, the initial sprouting percentage was in the range of 52-85. However, due to dry spell of 10 days after the premonsoon showers, ie. 30days after planting 1-28% of sprouts of stumps in various treatments dried up. Only treatments T12, T13 and T17 gave *>20%* survival after 300 days of sprouting and were differred significantly from other treatments (Table 4.1). In all the treatments a declining trend in the percent survival was noticed after 20 days of sprouting. The decline was sudden in treatments T1, T2, T15, T16 gradual in treatments T4,T5,T7,T8 and intermediate in others. Dipping stumps in fungicides apparantly had deleterious effect on the survival as noticed in treatments T1, T2, T9, T10 and T11.

Drenching carbendazim and application of NPK in the planting hole 'was the best treatment for obtaining high percentage of sprouting, survival of stumps, shoot height and comparatively low incidence of disease. Drenching was found to be better than the dipping in terms of sprouting and survival. Disease incidence was very low in most of the treatments as compared to the controls. Fertilizer application boosted the growth of the sprouts and highest shoot height was recorded in these treatments. Stumps pretreated with and without wax did not differ significantly in sprouting, disease incidence survival and height growth.

The study suggests drenching of carbendazim (Bavistin) (0.1% a.i.) in the planting hole and application of fertilizer (NPK 8-8-16 @ 100g per stump) as a prophylactic measure for protecting the sturnps against fungal infection and for maximum survival of stumps and growth of the sprouts.

5. GENERAL CONCLUSIONS

The results of the studies on various aspects of stump planting of *Eucalyptus tereticornis* undertaken during 1981-'84 and dealt with in parts 1 to 4 lead to the following conclusions.

1. In Nilambur. the period between the pre-monsoon and intense monsoon (latter half of May) showers was found best for field planting of *Eucalyptus tereticornis* stump.

2. Variations in stump dimensions - tap root length, 10 to 15 cm; root diameter at 15 cm below collar, 0.5 to 1 cm; shoot length, 2.5 to 5cm; and shoot diameter at 2.5 cm above collar, 0.8 to 1.6 cm - had little influence on sprouting and survival of the stumps.

3. Treatment of stumps with boric acid 90 ppm prior to planting enhanced rooting percentage and abundance. For field treatment, the stumps could be made into bundles of convenient size and the lower 5cm of the root portion dipped in the solution for 24 hours.

4 Storage of stumps in pit or shade enchanced callusing at the root. Stumps wrapped in moist gunny bags and stored under shade for 4 days or stored in pits for 11 days before field planting registered better survival. For storing the stumps in pits the following procedure was followed. The stumps were made into bundles of 50 and arranged horizontally in layers alternating with layers of sand in a pit of 1x1x1 m. The top of the pit was covered with sand and layer of soil, and well protected from rains by providing a thatching.

5 Drenching of the planting hole (2cm dia and 25cm deep) with 100ml of 0.1% aldrin 30 EC solution before planting ensured protection of *E. tereticornis* stumps from termite attack.

6 Drenching of carbendazim (Bavistin) 0.1% a.i. (2gm of Bavistin W. P. per litre of water) in the planting hole and application of fertilizer (NPK 8:8:16 @ l00g per stump) in two holes dug close to the planting hole ensured protection against fungal infection, better survival and height increment.

7 Sealing the shoot-end of the stump prior to planting either with wax or coaltar did not increase survival or growth.

8 The study showed lower percentage of survival 'in stump planting as compared to planting of polypotted seedlings in- pits. However, this method is ideally suited for raising plantations (Fig. 5.1) using older seedlings from nursery beds raised in the previous year.

Fig.-5.1 A trial plantation of *Eucalyptus tereticornis* raised using stumps

REFERENCES

Alexander, T. G. 1987. Soils of the Nilambur Sub Centre campus : An interpretive study (Table 27). Division of Soil Science, Kerala Forest Research Institute, Peechi.

Chand Basha, S. 1986. Performance of Eucalypts in Kerala. In: Eucalypts in India: Past, Present and Future (eds. J. K. Sharma *et a/.),* Kerala Forest Research Institute, Peechi : 71-76.

Chacko, K. C. Sudheendrakumar V. V. and Balagopalan M. 1985. Studies on the feasibility of stump planting of *Eucalypts tereticornis. Malayslan Forester,* 48: 330-338.

Chinnamani, S. and Gupta, S. *C.* 1966. A note on stump planting of some Eucalypts and Black Wattle in the Nilgiris. *Indian Forester,* 92: 667-668.

Joshi, H. B. 1981. (Ed.) Troup's the Silviculture of 1ndian trees. Vol. 3, 311p.

Joshi, H. B. 1983. (Ed.) Troup's the Silviculture of Indian trees. Vol. 4, 344p.

Nair. P. N. 1968. Eucalyptus planting in Kerala. Publ. No.2, Kerala Forest Department, Silvi Res. Off., Govt Press, Trivandrum, 23p.

Nair, K. S. S. and Varma, R. V. 1981. Termite control in Eucalypt plantations. K F R I Research Report, No. 6. Kerala Forest Research Institute, Peechi, 43p.

Nanda, K. K. 1970. Investigations on the use of Auxins in Vegetative Reproduction of Forest Plants. Final Report of PL 480 Research Project, A 7-FS-11 (FG-In-255).

Pryor, L. **D.** 1976. Biology of Eucalypts. Arnold, London, 82p.

Sharma, J. K., Mohanan, C. and Maria Florence, E. J. 1984. A new stem canker disease of *Eucalyptus* caused by *Botryodiplodia theobromae* in India. *Trans. Br. Mycol. Soc.,* 83: 162-163.

Sharma, J. K., Mohanan, C. and Maria Florence, E. J. 1985. Disease'survey in nurseries and plantations of forest tree species grown in Kerala. KFRl Research Report, No. 36, Kerala Forest Research Institute, Peechi, 275p.