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STANDARDIZATION OF ROOT TRAINER TECHNOLOGY FOR *TECTONA GRANDIS*, *EUCALYPTUS TERETICORNIS*, *E. GRANDIS*, *E. GLOBULUS*, *E. CAMALDULENSIS*, *ACACIA AURICULIFORMIS*, *A. MANGIUM* AND *PARASERIANTHES FALCATARIA*

K.C. Chacko
R.C. Pandalai
M. Balasundaran
C. Mohanan
R.V. Varma
Jose Kallarackal
M.P. Sujatha
S. Kumaraswamy

Kerala Forest Research Institute
Peechi 680 653, Kerala, India
Website: http://www.kfri.org

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(Final Report of the Project KFRI 341/2000)

K.C. Chacko
R.C. Pandalai
Division of Silviculture

M. Balasundaran
C. Mohanan
Division of Plant Pathology

R.V. Varma
Division of Entomology

Jose Kallarackal
Division of Plant Physiology

M.P. Sujatha
Division of Soil Science

S. Kumaraswamy
Division of Plant Pathology

Kerala Forest Research Institute
Peechi 680 653, Kerala, India
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8.3.4. Conclusion

Teak plantations raised with root trainer seedlings recorded severe foliage infection caused by *Phoma* spp. and bacterial wilt caused by *Ralstonia solanacearum*. Since, teak seedlings succumb to both the diseases in nurseries, it is suspected that the disease may be transmitted from nursery to field through infected planting stock. Bacterial wilt disease encountered in eucalypts plantations also may possibly be transmitted from nursery to the field through infected seedlings. In general, eucalypts and acacia plantations recorded a good growth and were free from major foliage diseases. Incidence of *Cylindrocladium* foliage infection, the most dreadful disease affecting eucalypts in both low and high altitude areas, was very low in plantations surveyed. As most of the diseases recorded in plantations are suspected to be nursery-borne and transferred to the field through infected planting stock, prophylactic chemical treatment has to be carried out before transporting the seedlings to the field. To minimize the disease hazards in plantations and to ensure good growth and productivity, strict quality control over the planting stock is warranted.

Table 8.17. Status of diseases in plantations raised with root trainer seedlings

Sl. No.	Plantation	Age (yr)	Locality/ Forest Range	Disease recorded	% infection	Disease severity	Pathogen associated
1	*Tectona grandis*	2	Dhoni/ Olavakkode	Stem canker	8.00	L	*Corticium salmonicolor*
				Foliage infection		L	*Phoma glomerata*
2	*T. grandis*	0.9	Nellikutha, Vazhikkadavu	Foliage infection	15.28	L	*Phoma glomerata*
				Wilt	7.81	L	*Ralstonia solanacearum*
3	*T. grandis*	1.9	Nellikutha/ Vazhikkadavu	Wilt	25.68	L	*R. solanacearum*
4	*T. grandis*	0.4	Kokkathodu, Naduvathumuzhi	Foliage infection	29.86	M	*Phoma glomerata*
				Wilt	8.00	L	*Ralstonia solanacearum*
5	*T. grandis*	0.3	Chavupara/ Mannarapara	Foliage infection	7.64	L	*P. glomerata, P. eupyrena*
6	*T. grandis*	0.7	Kaprikad/ Kodanad	Wilt	13.19	L	*R. solanacearum*
7	*T. grandis*	1.4	Palakuzhy/ Mannarapara	Foliage infection	3.47	L	*P. glomerata, Phomopsis* sp.
8	*T. grandis*	1	Emangad	Foliage infection	10.00	L	*P. glomerata, Phomopsis* sp.
9	*Acacia mangium*	2	Pathupara/ Punalur	Wilt	28.76	M	*Fusarium solani.*
10	*A. mangium*	2	Kelankavu, Anchal	Stem canker	29.00	M	*C. salmonicolor Cytospora* sp. *Macrovalsaria* sp.
11	*E. tereticornis*	1.3	Thirunelly/Begur	Stem canker	4.44	L	*C. salmonicolor*
12	*E. tereticornis*	1	Perukunnu, Wadakkanchery	Wilt	8.00	L	*Ralstonia solanacearum*
13	*E. tereticornis*	1.5	Arippa/ Kulathupuzha	Pink disease	82.00	S	*Corticium salmonicolor*
14	*E. tereticornis*	2	Kulathupuzha/Kulathupuzha	Pink disease	90.00	S	*C. salmonicolor*
15	*E. tereticornis/ E. camaldulensis*	2	Pathanapuram	Foliage infection		L	*Coniella fragariae C. castaneicola*
16	*E. grandis*	0.8	Suryanelly, Munnar	Foliage infection		L	*Kirramyces* sp.

C. castaneicola (Ell. & Ev.) Sutton, *Kirramyces eucalypti* (Cooke & Massee) J. Walker was recorded in *E. tereticornis* plantations at Perukunnu and Punalur (Table 8.17). The low incidence of foliage infection in eucalypts plantations suggests the possible impact of employing quality root trainer seedlings in raising plantations in maintaining plantation health.

In *Acacia mangium* plantations, in general, disease incidence was very low. Only minor leaf infection caused by *Colletotrichum gloeosporioides, Curvularia* sp., *Cylindrocladium quinqueseptatum,* etc. was recorded. However, in a plantation at Pathupara, Punalur Forest Range, a severe incidence of vascular wilt disease was recorded. The disease affected one and half year-old plants; the disease occurred in patches affecting 10-20 plants which were mostly in slopy terrain. The affected plants showed typical external symptoms of vascular wilt, discolouration and decay of roots. *Fusarium solani* (Mart.) Sacc. was identified as the causal agent (Fig. 8.7).

Although, plantations of eucalypts and acacias raised with root trainer seedlings exhibit very high field establishment and growth performance, it is too early to make any prediction on the stand productivity. However, the present field data indicate that plantations raised with root trainer seedlings are performing much better than those raised with conventional polythene container seedlings.

application (dipping the root trainer seedlings in Streptomycin or Plantamycin (0.01% a.i.) has to given.

Incidence of pink disease caused by *Corticium salmonicolour* Berk & Br. was also noticed in 2-year-old teak plantations at Dhoni (Table 8.17). The disease was characterized by formation of canker on the affected stem. Pink encrustation, the basidial stage of the fungus, occurs on the cankered area during high humid periods. Longitudinal splitting of the bark and girdling of stem at the canker occur and the shoot becomes dried up. Pink disease in teak plants has been recorded in 1 to 5 year-old plantations raised with stumps (Sharma *et al.*, 1985). The disease has also been recorded in 1-2 year-old teak plants in homesteads and plantations under high input management (Mohanan, 2001). The disease in young plants can be controlled effectively by brush-on application of Bordeaux mixture (10% paste with sticking agent-Delaware wet).

In eucalypts plantations, incidence of stem and foliage disease was less. However, in root trainer clonal plantations, severe incidence of pink disease was recorded during the year 2000. In *E. tereticornis* clonal plantations raised at Arippa and Kulathupuzha (Kulathupuzha Forest Range), 82-90 per cent infection was recorded (Table 8.17) and severely affected plants were cut and removed from the plots. *E. tereticornis* clones viz. BC 83, BC 7, BC 130 (Badrachalam clones) and KFRI 10, KFRI 65 were found most susceptible to the disease. Interestingly, *Cylindrocladium* sp. causing foliage infection was almost nil in most of the plantations surveyed. Earlier, *Cylindrocladium quinqueseptatum* Boedijn & Reitsma, *C. ilicicola* (Hawley) Boedijn & Reitsma, *C. theae* (Petch.) Alf. & Sob., *C. clavatum* Hodges & May, *C. scoparium* Morg., etc. have been recorded as causing foliage disease havoc in eucalypts plantations in both low and high altitude areas (Sharma and Mohanan, 1991). However, mild foliage infection caused by *Coniella fragaria* (Oudem.) Sutton,

the entire leaf lamina and the affected leaves become dried up. The upper leaves become flaccid and drooped and later become necrotic. The roots of the affected plants also get discoloured and decayed. The wilt disease was caused by *Ralstonia solanacearum* (=*Pseudomonas solanacearum*) and suspected to be transmitted through nursery infected planting stock. Earlier, the disease was recorded in young teak plantations raised with stumps (Sharma *et al.*, 1985) and also with root trainer seedlings (Mohanan, 2000a,b).

Ralstonia solanacearum causing wilt of one and half-year-old *E. tereticornis* plantation was observed at Perukunnu, Wadakkanchery Forest Range. Disease incidence was low and mortality of plants due to severe infection was noticed. Diseased plants showed characteristic symptoms of vascular wilt. Yellowing and drooping of foliage and complete defoliation occur s in due course. Bacterial ooze was observed from cut ends of roots, stem and branches. Application of Streptomycin as soil drench (@ 6 g in 8 l water) controlled the disease.

To minimize the bacterial wilt disease incidence in plantations, the following remedial measures are suggested:

- Water logged areas should be avoided for planting.
- Utmost care should be taken during planting and after planting operations including soil work, fertilizer application, weeding, etc. to avoid injury to roots.
- Severely infected plants should be uprooted and burnt.
- For casualty replacement, planting pit should be taken little away from the pit of infected plant.
- Root trainer seedlings showing any apparent wilting symptoms should not be used for planting.
- If root trainer seedlings are brought from a nursery where severe bacterial disease incidence occurred, as a precautionary measure, bactericidal

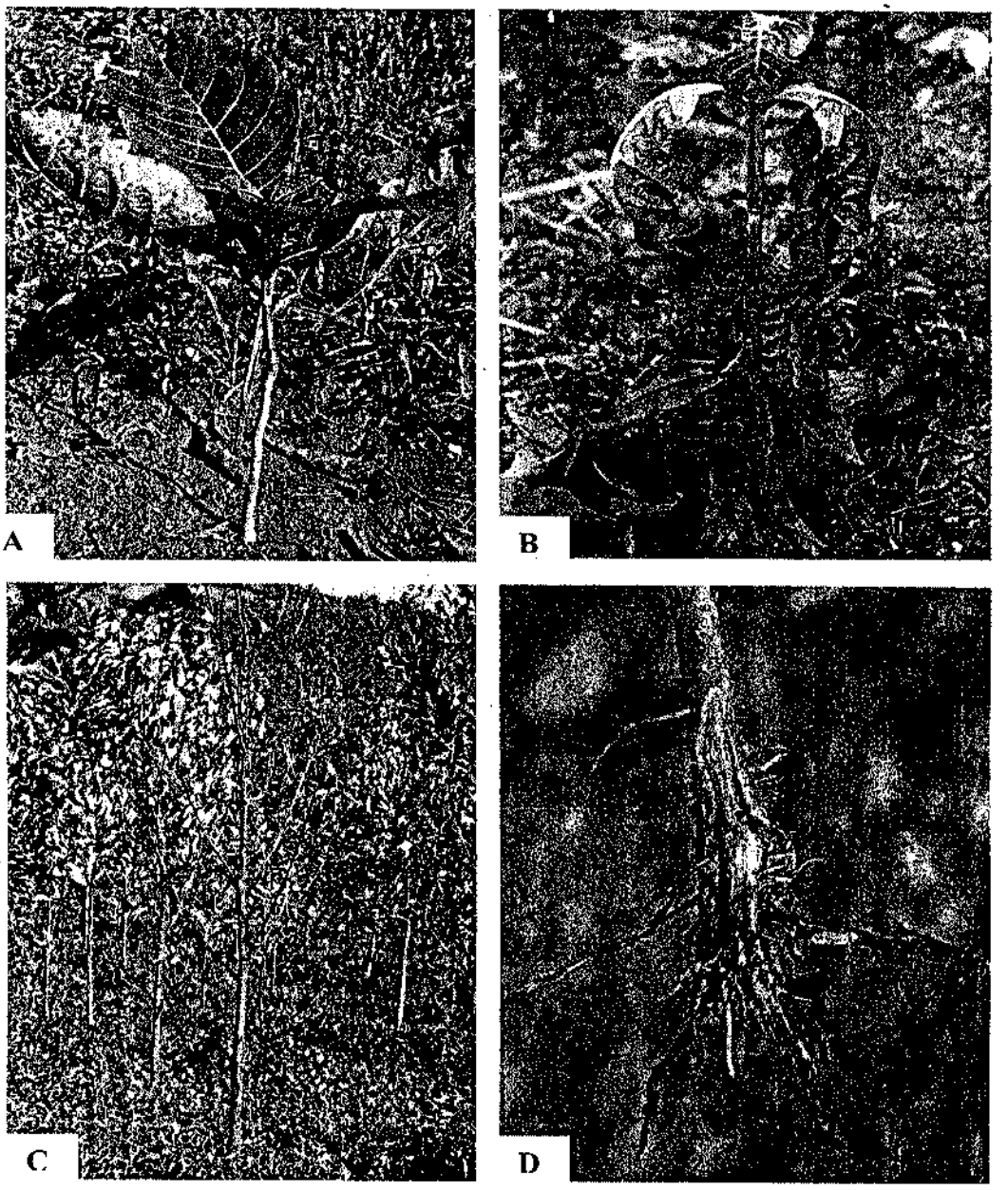


Fig. 8.7. A. *Tectona grandis* plant showing foliage infection caused by *Phoma glomerata*, B: *T. grandis* plant showing wilt symptoms caused by *Ralstonia solanacearum*, C: *Acacia mangium* plants showing wilt and root rot symptoms caused by *Fusarium* sp. D: Root rot of *A. mangium* plant caused by *Fusarium* sp.

inoculation experiments employing root trainer seedlings of the respective hosts. Detached leaf inoculation method was also used in certain cases to prove the pathogenicity of foliage disease causing fungal isolates.

8.3.3. Results and discussion

Disease survey in plantations raised with root trainer seedlings revealed that incidence of diseases was very less. However, in teak plantations raised in different parts of the State, incidence of severe foliage infection caused by *Phoma glomerata* (Cda.) Wollenw. & Hochapf was recorded (Fig. 8.7). The disease severity ranged from low to medium with 3-30 per cent infection in different plantations (Table 8.17). The pathogen was also recorded causing severe damage to root trainer seedlings in different Central nurseries. So far, *P. glomerata* has not been recorded as causing foliage infection in teak, hence the disease may possibly be introduced in the field through infected root trainer seedlings. The disease appears as large grayish brown necrotic lesions which spread to the entire leaf lamina and causes inward curling of leaf. The diseased leaves become dried up and defoliate in due course. Severe disease was recorded at Nellikutha plantation in Vazhikkadavu Forest Range and Kokkathodu plantation in Naduvathumuzhi Forest Range (Table 8.17). Application of Dithane M45 in severely affected patches controlled the disease.

Wilt of planted out teak seedlings was another disease problem recorded in teak plantations raised with root trainer seedlings. The disease was recorded in Nellikutha, Kaprikad and Kokkathodu plantations and infection ranged from 8-25 per cent (Table 8.17). The diseased plants showed the characteristic symptoms of vascular wilt. Usually, the lower leaves of the affected plants become yellowish and exhibit scorching and browning of leaf tissues in between the veins. Later the necrosis spreads to

8.3. Disease problems

8.3.1. Introduction

As the root trainer technology has been introduced in the State very recently, information on status of disease incidence in root trainer seedlings raised plantations is very limited. The present study was undertaken to investigate the disease problems, if any, in plantations raised with root trainer seedlings and to suggest appropriate disease management measures.

8.3.2.Materials and methods

Disease monitoring was carried out in eucalypts, acacia and teak plantations raised with root trainer seedlings in different parts of the State during 2000-2002. Disease incidence, severity and spread were recorded using a Disease scoring scale (Table 8.16). Disease specimens were collected and brought to the laboratory for isolation and identification of causal organisms. Information on fertilizer input, weeding and other cultural operations practiced in the plantations was also gathered.

Table 8.16. Disease scoring scale

Disease severity	Disease severity code	Disease severity scale Percentage plants affected
Nil	0	0
Low	L	1-25
Medium	M	26-50
Severe	S	51-75 or > 25% plants dead

Potato Dextrose Agar (PDA) medium was used for isolating fungal pathogens, while Nutrient Agar (NA) medium was used for isolating and maintaining bacterial pathogens. Isolation and purification of causal organisms were carried out employing standard laboratory techniques and identification of causal agents up to species level was made. As far as possible, confirmation of pathogenicity of causal agents was made through

chlorpyriphos, compared to the standard dosage of 0.5% a.i., when tested against *Paraserianthes* as a dip treatment, was found phytotoxic. Since incidence of termite attack was not observed so far in *Paraserianthes* when planted out in the field, there is no need to give a prophylactic treatment. However, the above observations emphasize the need to be careful while applying the insecticide.

During the year 1999, at Mannamangalam, a 10 ha area was planted with clones *of E. tereticornis* raised in root trainer by the Kerala Forest Development Corporation (KFDC). All the root trainer seedlings were given a dip treatment with chlorpyriphos 20 EC at 0.5% a.i. solution, before planting out in the field. Observations taken for one year period along with the field staff of KFDC, showed that the treatment was quite effective.

The treated teak seedlings were planted out at Nilambur. In this trial also the two treatments i.e. dip treatment as well as the additional granular insecticide application, did not show any difference, and both treatments were effective in preventing termite attack.

The present study has revealed that tree species such as teak, *A. auriculiformis* and *A. mangium* are also prone to attack by termites during the initial months after planting. Thus in addition to eucalypts, other crops as mentioned above would also require prophylactic treatment against termites.

three replicates of 24 plants each for each tree species. The planting of all the species, except teak was carried out at Kottappara and observations on termite attack, taken for 8 months.

The data showed no attack by termites during this period in the experimental area. The vulnerable period to attack by termites is the initial 3-4 months after planting out and the seedlings survived very well during the period.

Along with the above field trial, another experiment was also carried out to check whether, an additional treatment with a granular insecticide, in addition to the dip treatment would give added protection against termite attack. This experiment was laid out because in different locations the intensity and nature of termite attack can vary. Lindane 6G at the rate of 3 g per container was sprinkled around the plant in the potting medium, after giving the dip treatment. Three replicates of 24 plants each were planted out for this trial. There was no mortality due to termites in this experiment during the 8-months observation period. It is therefore concluded that the additional lindane granule application is not required because, the dip treatment alone would be sufficient to ward off termites during the initial establishment phase.

The dip treatment with 0.5% a.i. of Chlorpyriphos 20EC was also given to thousands of root trainer raised seedlings of eucalypts as part of an ongoing project on supply of clonal eucalypts to the Kerala Forest Department and other user agencies. While giving this treatment on a routine basis, one of the clones showed symptoms of phytotoxicity. However, when the container seedlings were watered, later on the symptoms disappeared. This casual observation indicates the need to be watchful while giving the dip treatment, because some of the clones may behave differently with the same dose of insecticide. Similarly even dosage as low as 0.125% a.i. or 0.25% a.i. of

noted that the damage intensity was less (2-23%) compared to eucalypts raised in polybags with soil as the potting medium (Nair and Varma, 1981). The low percentage of incidence of termite attack in the root trainer raised planting stock can be attributed to the plant vigour, especially with the clonal material, which increases the resistance to pest attack. It is presumed that in all the above cases, no prophylactic anti termite treatment was given before planting out in the field. One general information, which was gathered during the survey, was that in addition to eucalypts, teak and *Acacia* spp. were also susceptible to attack by termites during the establishment stage.

There was a general feeling that the compost prepared in central nurseries also promotes proliferation of organisms, both micro and macroforms. Samples were taken from the central nurseries at Kulathupuzha and Nilambur and observed for presence of insect pests or other organisms. Macroforms included white grubs and a staphylinid beetle. No other macroforms could be found. Sample observed under the microscope showed presence of mites and collembolans. In general, most of the above organisms are recognized to be associated with decaying animal and vegetable matter and cannot be regarded as harmful. It is also a common practice that the macroforms found in the compost are removed while filling up the root trainers. But once planted out in the field, whether compost can act as an attractant, especially for termites is to be confirmed.

8.2.2. Field trials

As part of the current project, the methodology already standardised (see Section 5) earlier was further field evaluated. The species selected included eucalypts, teak, *A. auriculiformis* and *A. mangium*. A 0.5% a.i. solution of chlorpyriphos 20EC was prepared and the seedlings of the above tree species raised in root trainers were given dip treatment at the nursery site. The treatment was given one day before planting out in the field. There were

8.2. Pest problems

8.2.1. Pest incidence in field planted seedlings

The incidence of various kinds of pest problems met within plantations raised through root trainer was assessed. The three major plantations surveyed were eucalypts, teak and acacia (*Acacia mangium* and *A. auriculiformis*). Details on the various plantations surveyed for pest damage together with the nature and intensity of damage at the time of field visit are given in Table 8.15.

Table 8.15. Pest problems noticed in root trainer raised plantations

Tree species	Locality	Pest	Nature of damage	Intensity/ Mortality
Eucalyptus tereticornis	Arippa Mayannur Kariem Muriem Mayannur	Termites " " *Salvyadrassus malabaricus*	Root feeding " " Stem boring	5% mortality 4% mortality 7% mortality 21% affected
Eucalyptus camaldulensis	Arissery	Termites	Root feeding	2% mortality
Acacia auriculiformis	Periyar, Puliyarkotta Nelleri Bit I Nelleri Bit II Nagrampara	Sambar deer Hare Hare Hare Termites	Cut at stem portion " " " Root feeding	40% affected Less than 5% mortality 50% affected 30% affected 2% mortality 8% mortality
A. mangium	Nilambur	Termites	Root feeding	23% mortality
Tectona grandis	Nilambur Erumeli Nellikutha Nellikutha	Termites Termites Termites Teak defoliator	Bark feeding Root feeding Root feeding Leaf damage	80% affected less than 10% mortality 20% mortality 2% mortality 60% affected

In addition to the areas visited and mentioned under Table 8.15, information on pest incidence was also gathered through other investigators in the team, during their visits to some of the other plantations. Thus an overall assessment of the pest situation in root trainer raised plantations indicates termites to be a major problem under field conditions. However, it may be

In all the three ages, stump plants produced deeper roots than root trainer plants. The increase in depth for stump plants was 1.2, 1.67 and 1.56 times for ages 1.6 year, 2.9 years and 3.7 years. Production of lateral root was also high for stump plants (1.13, 1.07 and 1.17 times respectively). Percentage of fine roots in the case of 1.6-year-old root trainer plants was 45.8 per cent as against 33.2 per cent in the case of stumps. However, in older trees fine roots were more in stump plants. Thus overall production of root system is more for stump plants.

It may be mentioned here that, for drawing statistically valid conclusions we need to sample trees covering different age and site classes. However, such destructive sampling involving removal of entire root system over a surface area of 2 m x 2 m and down to the entire root depth is labour intensive, time consuming and expensive.

Table 8.14. Lateral root dry weight (g) of 3.7 year old teak planted using root trainer* and stump** (Figures in parenthesis represents the % of total root biomass)

Depth (cm)	Root OD weight for different root diameter classes											
	0-2 mm		2-5 mm		5-10 mm		10-20 mm		20-50 mm		Total Root Biomass %	
	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump
0-15	110.93 (6.85)	103.85 (5.46)	73.31 (4.53)	69.35 (3.64)	86.42 (5.34)	64.02 (3.36)	129.67 (8.01)	161.88 (8.51)	60.15 (3.71)	195.95 (10.30)	460.48 (28.43)	595.05 (31.27)
15-30	78.44 (4.84)	181.32 (9.53)	55.15 (3.41)	130.93 (6.88)	114.19 (7.05)	156.1 (8.20)	236.93 (14.63)	130.93 (6.88)	71.3 (4.40)		566.01 (34.33)	599.28 (31.49)
30-45	45.53 (2.81)	97.76 (5.14)	29.06 (1.79)	92.1 (4.84)	58.16 (3.59)	104.22 (5.48)	43.69 (2.70)	88.05 (4.63)			176.44 (10.89)	382.13 (20.08)
45-60	37.12 (2.29)	57.87 (3.04)	26.16 (1.62)	59.52 (3.13)	53.96 (3.33)	19.81 (1.04)	53.29 (3.29)	11.35 (0.60)			170.53 (10.53)	148.55 (7.81)
60-75	34.17 (2.11)	35.3 (1.85)	7.78 (0.48)	12.63 (0.66)	32.74 (2.02)	Nil	28.48 (1.76)				103.17 (6.37)	47.93 (2.52)
75-90	27.11 (1.67)	25.03 (1.32)	13.27 (0.82)	7.11 (0.37)	20.36 (1.26)	3.26 (0.17)					60.74 (3.75)	35.40 (1.86)
90-105	23.78 (1.47)	14.54 (0.76)	14.31 (0.88)	4.88 (0.26)	2.51 (0.15)	Nil					40.60 (2.51)	19.42 (1.02)
105-120	17.35 (1.07)	18.99 (1.00)	9.99 (0.62)	3.49 (0.18)		Nil					27.34 (1.69)	22.48 (1.18)
120-135	15.04 (0.93)	5.89 (0.31)	9.15 (0.56)	0.75 (0.04)		1.95 (0.10)					24.19 (1.49)	8.59 (0.45)
135-150		6.37 (0.33)		0.52 (0.03)		1.69 (0.09)						8.58 (0.45)
150-165		8.21 (0.43)		1.43 (0.08)		Nil						9.64 (0.51)
165-180		6.79 (0.36)		0.85 (0.04)		1 (0.05)						8.64 (0.45)
180-195		10.07 (0.53)		1.55 (0.08)								11.62 (0.61)
195-210		3.43 (0.18)		2.32 (0.12)								5.75 (0.30)
Total	389.47 (24.05)	575.42 (30.24)	238.18 (14.71)	387.43 (20.36)	368.34 (22.74)	352.05 (18.5)	492.06 (30.38)	392.21 (20.61)	131.45 (8.12)	195.95 (10.3)	1619.5 (100)	1903.06 (100)

* Plant No.: 43 R3 T1 50
Plant height: 7.32 m
Basal diameter: 5.70 cm
Root depth: 135 cm
Total Root dry weight: 3.720 kg
Total Lateral Root dry weight: 0.868 kg
Total taproot: 2.100 kg

** Plant No.: 43 R3 T2 54
Plant height: 7.93 m
Basal diameter: 6.66 cm
Root depth: 210 cm (1.56 times)
Total Root dry weight: 2.710 kg
Total Lateral Root dry weight: 1.903 kg (1.17 times)
Total taproot: 0.807 kg

Table 8.13. Lateral root dry weight (g) of 2.9 year old teak planted using root trainer* and stump** (Figures in parenthesis represents the % of total root biomass)

Depth (cm)	Root OD weight for different root diameter classes											
	0-2 mm		2-5 mm		5-10 mm		10-20 mm		20-50 mm		Root Biomass %	
	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump
0-15	67.16 (3.78)	118.43 (6.23)	40.37 (2.27)	64.72 (3.41)	79.05 (4.45)	73.71 (3.88)	213.98 (12.05)	260.35 (13.70)	567.3 (31.94)	195.78 (10.30)	967.87 (54.49)	712.99 (37.52)
15-30	69.46 (3.91)	82.93 (4.36)	36.26 (2.04)	77.07 (4.06)	52.33 (2.95)	60.34 (3.18)	47.32 (2.66)	67.02 (3.53)	65.68 (3.70)	83.98 (4.42)	271.05 (15.26)	371.34 (19.54)
30-45	55.51 (3.12)	68.27 (3.59)	40.43 (2.28)	49.45 (2.60)	14.41 (0.81)	43.77 (2.30)	5.32 (0.30)	Nil	25.3 (1.42)	23.56 (1.24)	140.97 (7.94)	185.05 (9.74)
45-60	35.73 (2.01)	38.64 (2.03)	21.86 (1.23)	42.34 (2.23)	23.11 (1.30)	5.85 (0.31)	2.98 (0.17)	18.13 (0.95)			83.68 (4.71)	104.96 (5.52)
60-75	24.39 (1.37)	26.55 (1.40)	23.02 (1.30)	32.6 (1.72)	33.13 (1.87)	5.6 (0.29)	13.86 (0.78)	2.76 (0.15)			94.40 (5.31)	67.51 (3.55)
75-90	17.99 (1.01)	23.78 (1.25)	14.68 (0.83)	25.49 (1.34)	8.11 (0.46)	5.7 (0.30)	19.55 (1.10)				60.33 (3.40)	54.97 (2.89)
90-105	20.48 (1.15)	23.29 (1.23)	11.35 (0.64)	25.66 (1.35)			11.88 (0.67)				43.71 (2.46)	48.95 (2.58)
105-120	20.18 (1.14)	34.35 (1.81)	10.64 (0.60)	17.92 (0.94)			14.74 (0.83)				45.56 (2.56)	52.27 (2.75)
120-135	17.2 (0.97)	36.92 (1.94)	10.26 (0.58)	12.1 (0.64)							27.46 (1.55)	49.02 (2.58)
135-150	10.83 (0.61)	40.71 (2.14)	4.37 (0.25)	10.3 (0.54)							15.20 (0.86)	51.01 (2.68)
150-165	11.27 (0.63)	33.46 (1.76)	4.25 (0.24)	6.16 (0.32)							15.52 (0.87)	39.62 (2.09)
165-180	8.06 (0.45)	29.41 (1.55)	2.54 (0.14)	5.1 (0.27)							10.60 (0.60)	34.51 (1.82)
180-195		18.78 (0.99)		6.3 (0.33)								25.08 (1.32)
195-210		12.84 (0.68)		5.02 (0.26)								17.86 (0.94)
210-225		14.87 (0.78)		2.89 (0.15)								17.76 (0.93)
225-240		15.09 (0.79)		0.63 (0.03)								15.72 (0.83)
240-255		15.15 (0.80)		0.51 (0.03)								15.66 (0.82)
255-270		16.53 (0.87)		0.53 (0.03)								17.06 (0.90)
270-285		12.09 (0.64)		0.36 (0.02)								12.45 (0.66)
285-300		5.58 (0.29)		0.68 (0.04)								6.26 (0.33)
Total	358.26 (20.17)	667.67 (35.14)	220.03 (12.39)	358.83 (20.31)	210.14 (11.83)	194.97 (10.26)	329.63 (18.56)	348.26 (18.33)	658.29 (37.06)	303.32 (15.96)	1776.35 (100)	1900.05 (100)

* Plant No.: IM T1 20
Plant height: 6.69 m
Basal diameter: 6.15 cm
Root depth: 180 cm
Total Root dry weight: 2.327 kg
Total Lateral Root dry weight: 1.776 kg
Total taproot: 0.551 kg

** Plant No.: IM T2 14
Plant height: 7.05 m
Basal diameter: 6.05 cm
Root depth: 300 cm (1.67 times)
Total Root dry weight: 2.707 kg (1.07 times)
Total Lateral Root dry weight: 1.900 kg
Total taproot: 0.807 kg

Table 8.12. Lateral root dry weight (g) of 1.6 year old teak planted using root trainer* and stump** (Figures in parenthesis represents the % of total root biomass)

Depth (cm)	Root OD weight for different root diameter classes											
	0-2 mm		2-5 mm		5-10 mm		10-20 mm		20-50 mm		Total Root Biomass %	
	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump	Root trainer	Stump
0-15	64.12 (7.38)	26.31 (2.69)	34.41 (3.96)	15.05 (1.54)	6.29 (0.72)	44.41(4.54)	36.36 (4.19)	83.8 (8.57)	114.1(13.14)	97.88 (10.01)	255.26(29.40)	267.45(27.
15-30	71.61 (8.25)	52 (5.32)	39.18 (4.51)	39.47 (4.04)	61.64 (7.10)	33.11(3.39)	57.07 (6.57)	Nil	36.6 (4.22)	188.60(19.29)	266.10(30.65)	313.18(32.
30-45	48.81 (5.62)	37.17 (3.80)	30.41 (3.50)	29.83 (3.05)	16.02 (1.85)	14.03 (1.43)		47.87 (4.90)			95.24(10.97)	128.90(13.
45-60	27.37 (3.15)	46.42 (4.75)	18.67 (2.15)	18.89 (1.93)		5.78 (0.59)					46.04(5.30)	71.09(7.
60-75	31.4 (3.62)	19.94 (2.04)	10.49 (1.21)	6.23 (0.64)		4.64 (0.47)					41.89(4.82)	30.81(3.
75-90	29.35 (3.38)	14.33 (1.47)	7.92 (0.91)	5.62 (0.57)							37.27(4.29)	19.95 (2.
90-105	28.08 (3.23)	14.47 (1.48)	1.35 (0.16)	5.85 (0.60)							29.43(3.39)	20.32 (2.
105-120	25.12 (2.89)	22.36 (2.29)	0.23 (0.03)	4.9 (0.50)							25.35(2.92)	27.26 (2.
120-135	16.24 (1.87)	26.57 (2.72)		5.93 (0.61)							16.24(1.87)	32.50 (3.
135-150	15.25 (1.76)	13.37 (1.37)		1.48 (0.15)							15.25(1.76)	14.85 (1.
150-165	15.34 (1.77)	12.9 (1.32)									15.34(1.77)	12.90 (1.
165-180	6.35 (0.73)	12.69 (1.30)									6.35(0.73)	12.69 (1.
180-195	7.93 (0.91)	5.64 (0.58)									7.93(0.91)	5.64 (0.
195-210	6.94 (0.80)	3.15 (0.32)									6.94(0.80)	3.15 (0.
210-225	2.36 (0.27)	5.69 (0.58)									2.36(0.27)	5.69 (0.
225-240	1.26 (0.15)	3.66 (0.37)									1.26(0.15)	3.66 (0.
240-255		2.61 (0.27)										2.61 (0.
255-270		2.21 (0.23)										2.21 (0.
270-285		1.83 (0.19)										1.83 (0.
285-300		1.17 (0.12)										1.17 (0.
Total	397.53(45.79)	324.49(33.18)	142.66(16.43)	133.25 (13.63)	83.95 (9.67)	101.97 (10.43)	93.43 (10.76)	131.67 (13.47)	150.68 (17.3)	286.48 (29.3)	868.25 (100)	977.86 (1

* Plant No.: IM T1 45
Plant height: 6.52 m
Basal diameter: 4.74 cm
Root depth: 240 cm
Lateral Root dry weight: 0.868 kg

** Plant No.: IM T2 31
Plant height: 6.05 m
Basal diameter: 5.06 cm
Root depth: 300 cm (1.25 times)
Lateral Root dry weight: 0.978 kg (1.13 times)

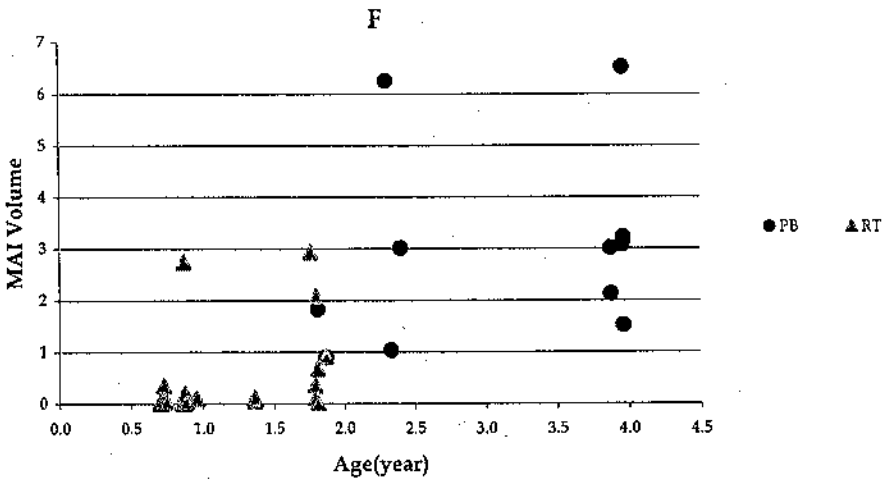


Fig. 8.6. *Acacia auriculiformis*
F. MAI (Conical volume) in KFD Plantations

8.1.3.2.3. Other species

The data on *Acacia mangium* and *E. tereticornis* are insufficient for making any comparison on survival and growth of root trainer and polybag seedlings. For *E. camaldulensis, E. grandis, E. globulus* and *P. falcataria* root trainer plantations were not available.

8.1.3.3.Root growth of *Tectona grandis*

A comparative account of root production in root trainer and stump plants in plantations of different ages (1.6, 2.9 and 3.7 years) of *Tectona grandis* in different soil layers is presented in Tables 8.12, 8.13 and 8.14.

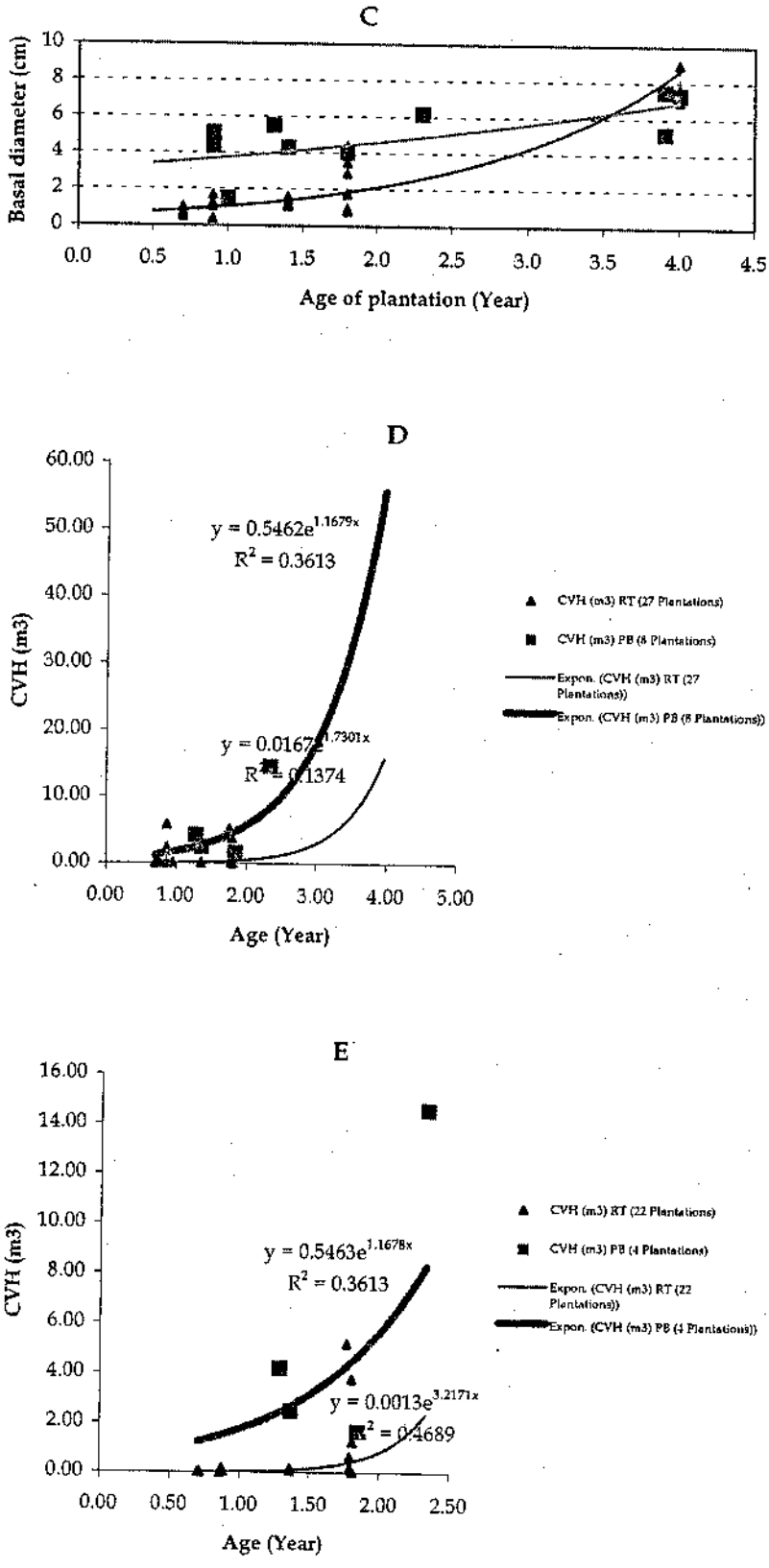


Fig. 8.6. *Acacia auriculiformis*

C. Basal diameter (All Forest circles)

D. Conical Volume per hectare (All Forest circles)

E. Conical Volume per hectare (Northern Forest circle)

8.1.3.2.2. *Acacia auriculiformis*

Survival and growth of *A. auriculiformis* did not show any useful trend to distinguish between planting stocks (Fig. 8.6).

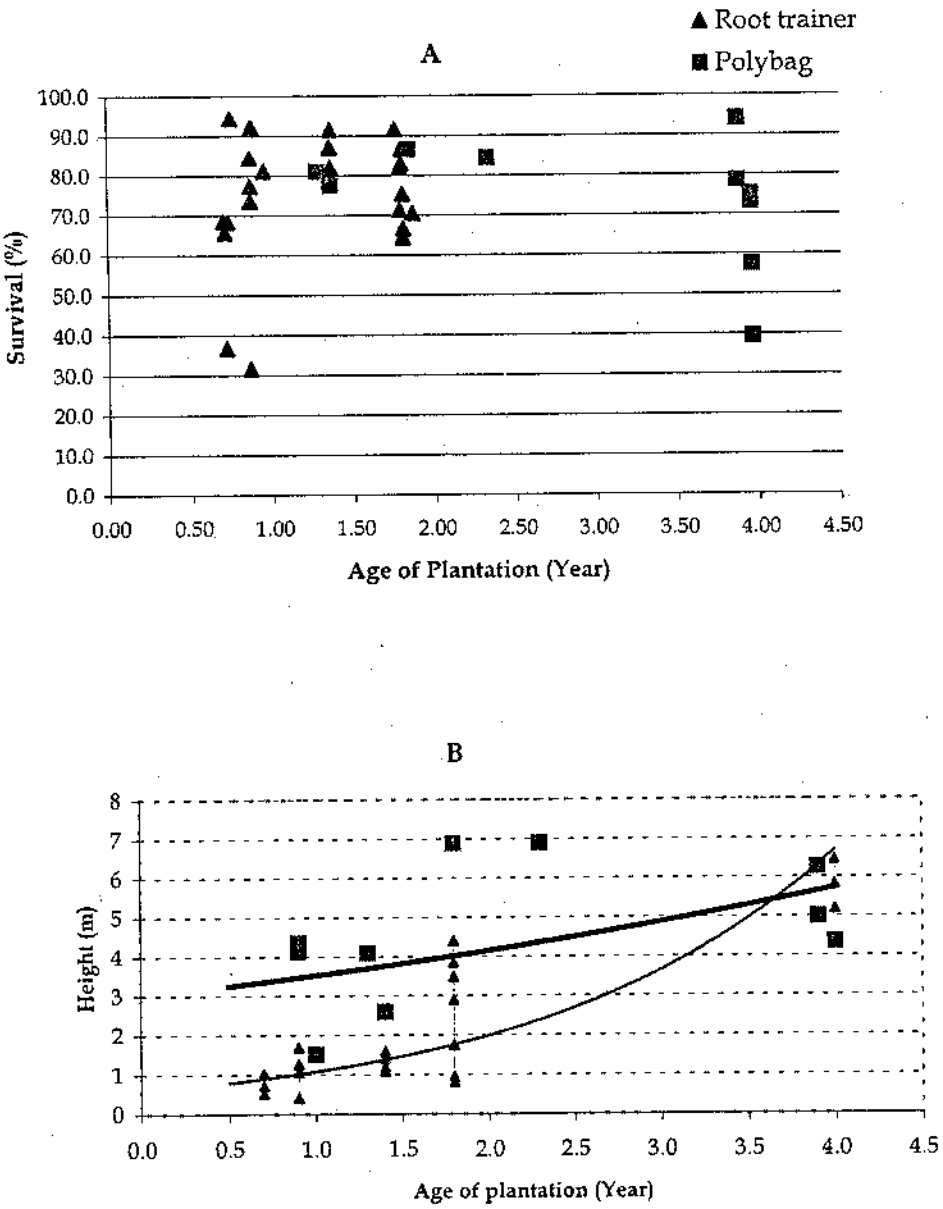
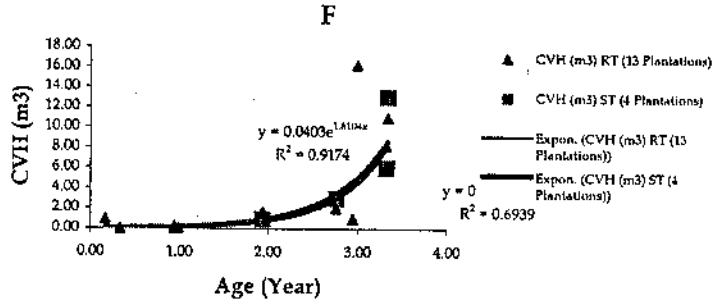


Fig. 8.6. *Acacia auriculiformis*
A. Survival percentage (All Forest circles)
B. Height (All Forest circles)



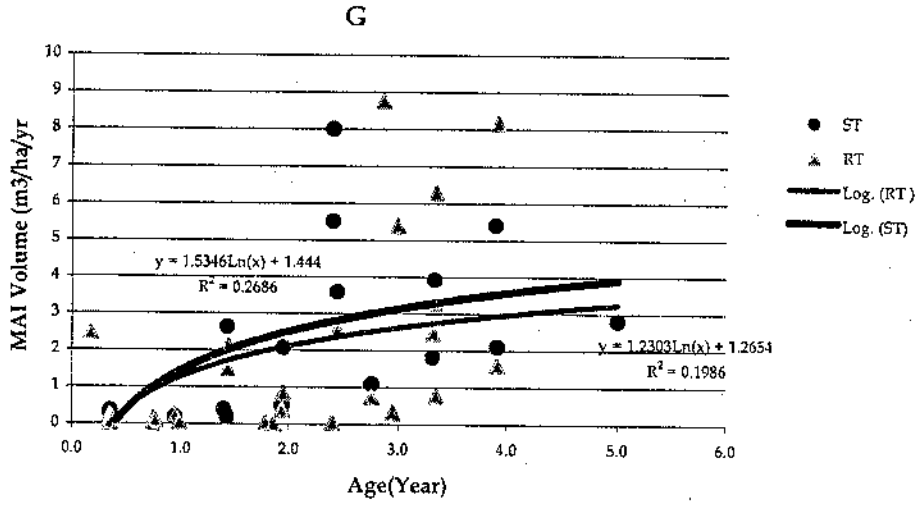


Fig. 8.5. F. Conical Volume per hectare of *T. grandis* (Olavakkod Forest circle)
G. MAI (Conical volume) of *T. grandis* in KFD Plantations

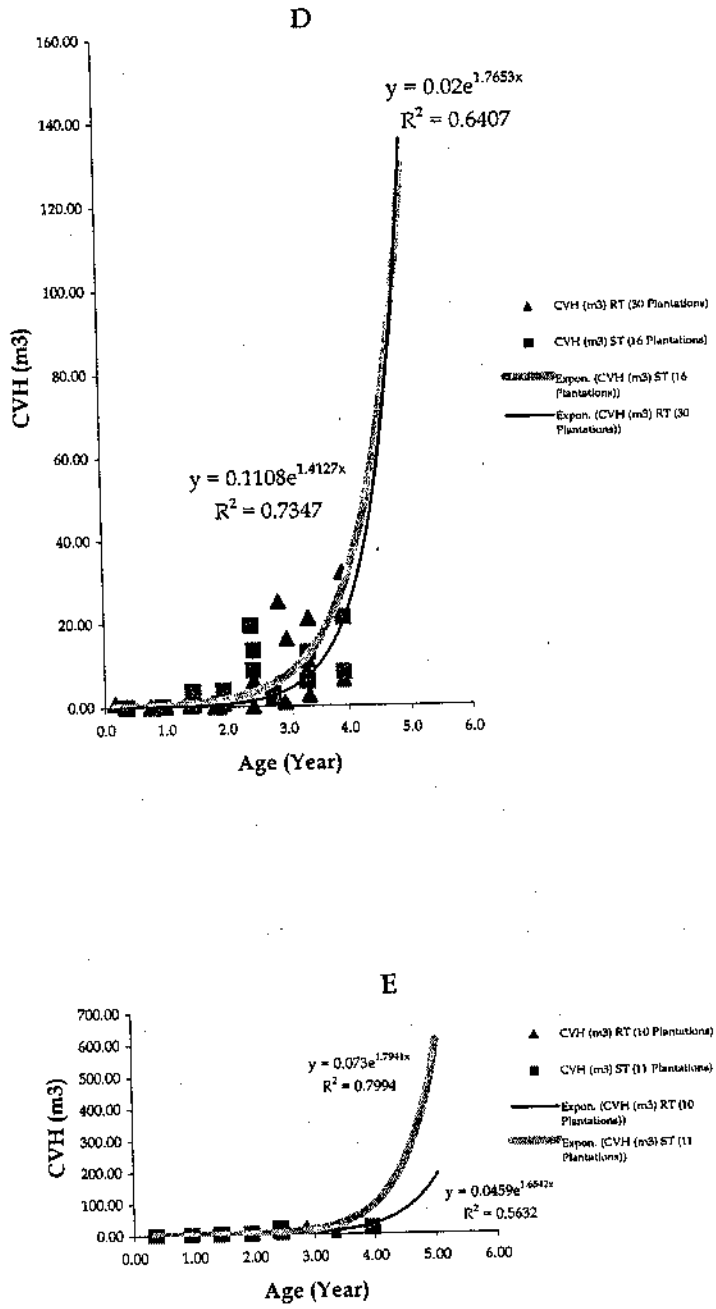


Fig. 8.5. D. Conical Volume per hectare of *T. grandis* (All Forest circles)
E. Conical Volume per hectare of *T. grandis* (Southern Forest circle)