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International Journal of Current Research
Vol. 7, Issue, 07, pp.17652-17658, July, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

GROWTH PATTERN, WOOD PRODUCTION AND GENOTYPIC CLUSTERING OF THE CLONES OF *EUCALYPTUS TERETICORNIS*, SM

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ARTICLE INFO

Article History:
Received 22nd April, 2015
Received in revised form
26th May, 2015
Accepted 19th June, 2015
Published online 28th July, 2015

Key words:

Eucalyptus tereticornis,
Mean Annual Increment (MAI),
Current Annual Increment (CAI),
Over-bark volume, Under-bark volume,
Diameter at breast height (Dbh),
Clinometer, Increment core, D^2h,
D^2 analysis.

ABSTRACT

Clonal plantations are gaining more attention in recent years as they are more profitable than seed raised plantations. The main objective of industrial forest management is to get optimum return for a given investment and it can be achieved only with clonal forestry programmes. E*ucalyptus tereticornis* clones are commercially planted as a source of paper pulp and volume tables are available to understand per year growth of clones. However, most of the volume table shows only over-bark wood volume undermining the actual volume of wood available for pulping. The present study was carried out to understand the MAI, CAI, over-bark and under-bark wood volume of thirty clones of E*ucalyptus tereticornis* raised at Vantimomidi, Secunderabad, Andhra Pradesh for a period of three years. Significant variation has been observed for all the growth traits studied. Bark thickness varied considerably among the clones and it showed insignificant correlation with growth traits. Clones such as Et 03, Et 07, Et 10, Et 71, Et 93, Et 99, Et 105, Et 122 and Et 130 were identified as promising clones in terms of productivity. Twelve clusters could be identified based on D^2 analysis and the result will help the farmers to select the best planting stock for optimal productivity.

***Citation*:** Ajith Kumar, K.G., Sunil Kesavadeth, G., Pratheepkumar, V., Bindumole, V.R. and Aswathy, P.J., 2015. "Growth pattern, Wood production and Genotypic clustering of the clones of *Eucalyptus tereticornis*, sm.", *International Journal of Current Research*, 7, (7), 17652-17658.

INTRODUCTION

Eucalyptus tereticornis, Sm is an exotic fast growing tree species commercially planted as a source of paper pulp and timber. The species has been introduced to many tropical countries including India to meet the ever increasing demand for paper pulp. The astonishing growth characteristics and wide range of adaptability make it a promising one, capable of reducing wide gap between demand and production of wood in shortest possible time (Chandra and Yadava, 1986). Currently, eucalypts constitute a major portion of pulpwood plantations, comprising 10-15mha of land throughout the world, ranking second to pines (Neilson, 2000). In India alone more than one million hectare area is under eucalypts plantations and it is estimated to increase in coming years in view of the demand of the wood (Turnbull, 1999). Among all the species, *Eucalyptus tereticornis* is an astonishing one in terms of height and biomass accumulation (Rakesh Kumar *et al.,* 2010; Gomes and Correia., 1995; Kumar and Bangarwa2006). Clonal plantations are gaining more attention recently as they are more profitable than seed raised plantations. Eucalypts clonal plantations have been found successful in many parts of the world (Libby and Ahuja, 1993; Ikemori, 1986; Ciancio and Hermanin, 1976). Realizing the potential of clonal forestry in India, Lal *et al.* (1997) carried out extensive studies to develop fast-growing, genetically superior and comparatively disease resistant clones of eucalypts at Bhadrachalam Paperboards Limited, Andhra Pradesh. There are reports of the productivity of clonal plantations three to four times more than that of seed raised plantations (Lal, 2005). Currently, there is a significant rise in the plantation area and the number of farmers taking up eucalypts plantations especially *Eucalyptus tereticornis* that clearly indicates the popularity of clonal plantations among farmers. Higher yields combined with better quality of produce and lower per unit production costs have improved the profitability of eucalypts clonal plantations substantially. The main aim of industrial forest management is to obtain highest net value for a given investment. This goal is obtainable only by planting with superior clones having faster growth and optimum wood production. Volume table preparation is therefore a key aspect in clonal plantation programme so as to get information about the growth pattern and volume increment of different genotypes. However, many of the volume tables are prepared based on over-bark volume undermining the fact that the bark does not have any utility for pulping and the proportion of bark varies significantly with genotypes.

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The study was mainly intended to understand the growth pattern and annual volume increment of the clones of *Eucalyptus tereticornis* and to make a comparison between over-bark wood volume and under-bark wood volume.

MATERIALS AND METHODS

The *Eucalyptus tereticornis* clonesraised by ITC, Bhadrachalamviz, Et 01, Et 03, Et 04, Et 06, Et 07, Et 10, Et 27, Et 32, Et 71, Et 74, Et 82, Et 84, Et 86, Et 93, Et 99, Et 100, Et 105, Et 111, Et 114, Et 122, Et 128, Et 130, Et 132, Et 135, Et 137, Et 138, Et 142, Et 147 and Et 148, planted at Vantimimidi, near Secunderabad, Andhra Pradesh were screened for the growth characteristics. The clones were raised in block design with a spacing of 3mx3m. The soil was red sandy loam with a pH of 5.71. The maximum temperature during summer, ranged from 28^0C to 37^0C and the minimum ranged from 16^0C to 26^0C. The maximum winter temperature ranged from 28^0C to 30^0C and the minimum temperature ranged from 16^0C to 20^0C. The summer rainfall was between 79 to 130mm, the monsoon rainfall between 500 to 700mm and the winter rainfall between 90 to 120mm. The relative humidity was 50% to 60% in summer and 70% to 80% in winter during the study period.

As it was clonal plantation, twenty percent of population from each clone was sampled for studying the growth characteristics. Height was measured using a clinometer, diameter was taken at breast height level (Dbh) using vernier calipers as per standard procedures (IUFRO, 1965). The clones were assessed for a period of three years right from fourth year of their establishment. The volume growth (v) was calculated from the formula D^2h and the volume on hector basis (V) was estimated by multiplying average volume (v) of each clone and total number of trees per hector (1111, on the assumption of full stocking without thinning. Mean Annual Increment (MAI) was estimated by dividing total over-bark stem volume from ground to tip to the age and Current Annual Increment (CAI) was estimated by subtracting each year's volume to the previous year's (IUFRO, 1965). The bark was taken using an increment core and the thickness was measured using a screw gauge. The value for double bark thickness was subtracted from the Dbh for estimating under-bark wood volume.

Statistical Analysis

The growth traits of the clones of *Eucalyptus tereticornis* were subjected to one-way variance analysis and correlation studies using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). The analysis of genetic divergence was done using Mahalanobis (1936) D^2 statistics and the genotype clustering was carried out based on the D^2 values.

RESULTS AND DISCUSSION

Analysis of variance showed significant differences among the clones of *Eucalyptus tereticornis* in the morphological traits such as height, diameter, bark thickness and volume. The coefficient of variation was higher for height (16.33) followed by bark (13.40), diameter (11.76) and volume (11.04). The estimated volume, MAI and CAI are presented in the Table (1). At the age of four, the MAI ranged from $13.93m^3ha^{-1}yr^{-1}$ in Et 135 to $35.31m^3ha^{-1}yr^{-1}$in Et03 with excellent volume growth in clones such as Et 05 ($33.96m^3ha^{-1}yr^{-1}$), Et 10 ($32.50m^3ha^{-1}yr^{-1}$), Et 128 ($30.85m^3ha^{-1}yr^{-1}$), Et93 ($30.31m^3ha^{-1}yr^{-1}$) whereas the clones Et82 ($14.88m^3ha^{-1}yr^{-1}$), Et 111 ($14.89m^3ha^{-1}yr^{-1}$), Et123 ($17.64m^3ha^{-1}yr^{-1}$), Et138 ($15.58m^3ha^{-1}yr^{-1}$), Et137 ($14.60m^3ha^{-1}yr^{-1}$), Et84 ($17.67m^3ha^{-1}yr^{-1}$), Et04 ($17.77m^3ha^{-1}yr^{-1}$)showed poor volume growth. At the age of five, the MAI varied from a minimum of $17.43m^3ha^{-1}yr^{-1}$in Et 111 to a maximum of $42.73m^3ha^{-1}yr^{-1}$in Et 105. The clones Et 03 ($40.82m^3ha^{-1}yr^{-1}$), Et 93 ($35.63m^3ha^{-1}yr^{-1}$), Et 10 ($32.88m^3ha^{-1}yr^{-1}$), Et 99 ($32.11m^3ha^{-1}yr^{-1}$), Et 71 ($31.06m^3ha^{-1}yr^{-1}$), Et 07 ($32.49\ m^3ha^{-1}yr^{-1}$), Et 06 ($30.26m^3ha^{-1}yr^{-1}$), Et 122 ($32.21m^3ha^{-1}yr^{-1}$), Et 128 ($32.73m^3ha^{-1}yr^{-1}$), Et 130 ($33.22m^3ha^{-1}yr^{-1}$), Et 132 ($30.55m^3ha^{-1}yr^{-1}$) exhibited better volume growth while Et 82 ($18.94m^3ha^{-1}yr^{-1}$), Et 138 ($22.92m^3ha^{-1}yr^{-1}$), Et 137 ($19.30\ m^3ha^{-1}yr^{-1}$), Et 135 ($18.52m^3ha^{-1}yr^{-1}$) showed poor volume growth. MAI varied from $21.77m^3ha^{-1}yr^{-1}$in Et 111 to $48.17m^3ha^{-1}yr^{-1}$in Et 105 at six years of age. Clones such as Et 03 ($42.31m^3ha^{-1}yr^{-1}$), Et 71 ($40.34m^3ha^{-1}yr^{-1}$), Et 93 ($40.32m^3ha^{-1}yr^{-1}$), Et 105($48.18m^3ha^{-1}yr^{-1}$), Et 122($38.57m^3ha^{-1}yr^{-1}$) showed excellent growth whereas poor growth was recorded in Et 135 ($24.23m^3ha^{-1}yr^{-1}$), Et 138 ($24.92m^3$/ha/yr^{-1}), Et 82 ($23.75m^3ha^{-1}yr^{-1}$), Et 137 ($26.24m^3ha^{-1}yr^{-1}$), Et 04 ($26.12m^3ha^{-1}yr^{-1}$), Et 01 ($26.13m^3ha^{-1}yr^{-1}$).

Significant variation has been observed in the CAI for all the clones (Table 1/Fig. 2) and three patterns could be identified. Most of the studied clones showed an increasing trend in MAI over the study period. However, a few clones such as Et 03, Et 04, Et 06, Et 105, Et 132, Et 147 and Et 148 showed a decreasing trend in CAI. Clones such as Et 07, Et 114 and Et 123 were found to maintain the CAI over the years. Analysis of variance showed significant differences in bark content among the clones and the estimated percentage of bark in six year old clones are shown (Table 1/Fig.4). It ranged from a minimum of 10.14% in Et 06 to a maximum of 22.28% in Et 71. This indicates that the amount of actual wood available for pulping varies according to the clones because the bark forms a significant amount in some clones. More bark content was observed in clones such as Et 142 (22.10%), Et 100 (20.79%), Et 137 (20.61%), Et 138 (20.2%), Et 123 (18.09%) and Et 07 (18.07%) whereas Et 32 (11.73%), Et 147 (13.78%), Et 01 (11.83%), Et 03 (11.40%), Et 84 (12.49%), Et 122 (11.03%) and Et 4(13.55%) were found to have thinner bark. Another significant finding was the variation of bark content in some of the faster growing clones. Et 71 was found to be an excellent clone in terms of volume growth but with thicker bark whereas Et 03 was another superior clone but with thinner bark. Correlation studies have been carried out to understand any relation between growth parameters and bark content. It was found that bark did not have any significant correlation either with height (r=0.31), diameter (r=0.08) or volume (0.04). As this character is highly heritable (Pederick *et al.,* 1970) and independent in its inheritance with other morphological traits, it should be given more importance during the selection plus trees in tree improvement programmes. In order to understand the actual wood available for pulping, a comparison has been made between volume of wood over-bark and volume of under-bark for each clone at the age of six and the result has been shown (Table 3/Fig 3).

Table 1. Volume, MAI and CAI of the clones of *E.tereticornis* for a period of 3 years (4th year to 6th year)

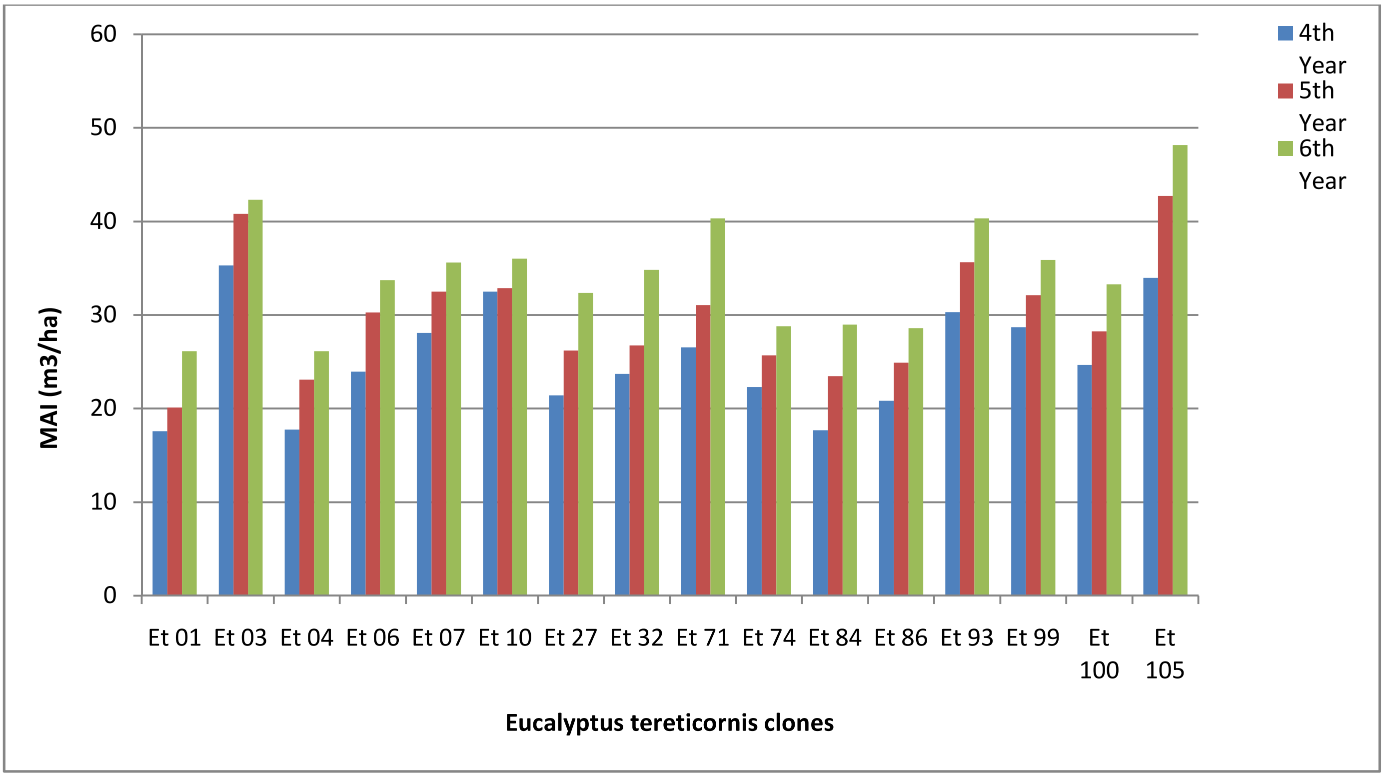
Sl.No	Clone No.	Age (Yrs.)	Height (m)*	DBH (m)*	Volume (v) (m^3/tree)	Volume (V) (m^3/ha)	MAI (m^3/ha)	CAI (m^3/ha)
		4	10.54 ± 1.37	0.0775 ± 0.003	0.0633	70.33	17.58	
1	1	5	12.22 ± 1.78	0.0861 ± 0.004	0.0906	100.66	20.13	30.33
		6	14.31 ± 2.02	0.0993 ± 0.005	0.1411	156.76	26.13	56.11
		4	13.94 ± 1.52	0.0955 ± 0.004	0.1271	141.21	35.30	
2	3	5	15.78 ± 1.98	0.1079 ± 0.004	0.1837	204.09	40.82	62.88
		6	18.15 ± 2.68	0.1122 ± 0.006	0.2285	253.86	42.31	49.77
		4	10.02 ± 1.17	0.0799 ± 0.003	0.0640	71.10	17.78	
3	4	5	11.66 ± 1.39	0.0944 ± 0.005	0.1039	115.43	23.09	44.33
		6	13.91 ± 1.89	0.1007 ± 0.006	0.1411	156.76	26.13	41.33
		4	11.05 ± 1.55	0.0883 ± 0.003	0.0862	95.77	23.94	
4	6	5	12.91 ± 2.00	0.1027 ± 0.004	0.1362	151.32	30.26	55.55
		6	14.34 ± 2.42	0.1127 ± 0.006	0.1821	202.31	33.72	50.99
		4	12.42 ± 1.63	0.0902 ± 0.004	0.1010	112.21	28.05	
5	7	5	14.08 ± 2.11	0.1019 ± 0.005	0.1462	162.43	32.49	50.22
		6	16.21 ± 2.85	0.1089 ± 0.005	0.1922	213.53	35.59	51.11
		4	11.63 ± 1.77	0.1003 ± 0.004	0.1170	129.99	32.50	
6	10	5	12.9 ± 2.05	0.1071 ± 0.005	0.1480	164.43	32.89	34.44
		6	14.43 ± 2.11	0.1161 ± 0.006	0.1945	216.09	36.01	51.66
		4	10.69 ± 1.12	0.0849 ± 0.003	0.0771	85.66	21.41	
7	27	5	12.11 ± 1.62	0.0987 ± 0.005	0.1180	131.10	26.22	45.44
		6	13.88 ± 1.95	0.1122 ± 0.006	0.1747	194.09	32.35	62.99
		4	9.61 ± 1.02	0.0942 ± 0.004	0.0853	94.77	23.69	
8	32	5	11.11 ± 1.43	0.1041 ± 0.004	0.1204	133.76	26.75	39.00
		6	12.8 ± 1.76	0.1212 ± 0.006	0.1880	208.87	34.81	75.10
		4	10.48 ± 1.21	0.0955 ± 0.004	0.0956	106.21	26.55	
9	71	5	12.3 ± 1.77	0.1066 ± 0.004	0.1398	155.32	31.06	49.11
		6	14.1 ± 2.16	0.1243 ± 0.006	0.2179	242.09	40.35	86.77
		4	10.19 ± 1.33	0.0888 ± 0.003	0.0804	89.32	22.33	
10	74	5	11.85 ± 1.79	0.0988 ± 0.004	0.1157	128.54	25.71	39.22
		6	13.34 ± 2.12	0.108 ± 0.004	0.1556	172.87	28.81	44.33
		4	11.25 ± 1.65	0.0752 ± 0.003	0.0636	70.66	17.66	
11	84	5	12.89 ± 2.17	0.0905 ± 0.005	0.1056	117.32	23.46	46.66
		6	14.56 ± 2.53	0.1037 ± 0.005	0.1566	173.98	29.00	56.66
		4	10.19 ± 1.31	0.0858 ± 0.003	0.0750	83.33	20.83	
12	86	5	11.65 ± 1.77	0.0981 ± 0.004	0.1121	124.54	24.91	41.22
		6	13.1 ± 2.01	0.1086 ± 0.004	0.1545	171.65	28.61	47.11
		4	12.22 ± 1.87	0.0945 ± 0.004	0.1091	121.21	30.30	
13	93	5	14.3 ± 2.32	0.1059 ± 0.004	0.0160	17.82	3.56	-103.39
		6	16.21 ± 3.01	0.1159 ± 0.005	0.2177	241.86	40.31	224.04
		4	13.37 ± 1.86	0.0879 ± 0.003	0.1033	114.77	28.69	
14	99	5	15.2 ± 2.44	0.0975 ± 0.004	0.1445	160.54	32.11	45.77
		6	17.54 ± 3.45	0.1051 ± 0.005	0.1937	215.20	35.87	54.66
		4	12.2 ± 1.66	0.0853 ± 0.003	0.0888	98.66	24.66	
15	100	5	14.12 ± 1.98	0.0949 ± 0.003	0.1272	141.32	28.26	42.66
		6	16.31 ± 2.68	0.105 ± 0.005	0.1798	199.76	33.29	58.44
		4	13.05 ± 1.88	0.0968 ± 0.004	0.1223	135.88	33.97	
16	105	5	15.14 ± 2.53	0.1127 ± 0.005	0.1923	213.65	42.73	77.77
		6	17.74 ± 3.55	0.1211 ± 0.005	0.2602	289.08	48.18	75.44
		4	10.3 ± 1.27	0.0893 ± 0.003	0.0821	91.21	22.80	
`17	114	5	11.98 ± 1.88	0.1037 ± 0.005	0.1288	143.10	28.62	51.88
		6	13.5 ± 2.14	0.1146 ± 0.006	0.0177	197.05	32.84	53.95
		4	10.95 ± 1.36	0.0938 ± 0.004	0.0963	106.99	26.75	
18	122	5	12.45 ± 1.77	0.1079 ± 0.004	0.1449	160.98	32.20	53.99
		6	14.11 ± 2.12	0.1215 ± 0.006	0.2083	231.42	38.57	70.44
		4	11.38 ± 1.49	0.0988 ± 0.004	0.1111	123.43	30.86	
19	128	5	13.01 ± 1.99	0.1064 ± 0.004	0.1473	163.65	32.73	40.22
		6	14.44 ± 2.53	0.1141 ± 0.006	0.1880	208.87	34.81	45.22
		4	12.67 ± 1.73	0.0916 ± 0.005	0.1063	118.10	29.52	
20	130	5	14.01 ± 2.45	0.1033 ± 0.005	0.1495	166.09	33.22	48.00
		6	16.21 ± 3.32	0.1113 ± 0.006	0.2008	223.09	37.18	56.99
		4	9.92 ± 1.12	0.0935 ± 0.004	0.0867	96.32	24.08	
21	132	5	11.2 ± 1.37	0.1108 ± 0.005	0.1375	152.76	30.55	56.44
		6	13.31 ± 1.98	0.1152 ± 0.005	0.1766	196.20	32.70	43.44
		4	9.36 ± 1.23	0.0732 ± 0.003	0.0502	55.77	13.94	
22	135	5	11.01 ± 1.67	0.087 ± 0.003	0.0833	92.55	18.51	36.77
		6	12.8 ± 1.89	0.1011 ± 0.005	0.1308	145.32	24.22	52.77
		4	10.46 ± 1.39	0.0709 ± 0.003	0.0526	58.44	14.61	
23	137	5	12.22 ± 1.94	0.0843 ± 0.003	0.0868	96.43	19.29	38.00
		6	13.89 ± 2.15	0.101 ± 0.005	0.1417	157.43	26.24	60.99
		4	10.27 ± 1.30	0.0739 ± 0.003	0.0561	62.33	15.58	
24	138	5	12.32 ± 1.88	0.0915 ± 0.004	0.1031	114.54	22.91	52.22
		6	14.1 ± 2.33	0.0977 ± 0.005	0.1346	149.54	24.92	35.00
		4	10.53 ± 1.31	0.0855 ± 0.004	0.0770	85.55	21.39	
25	142	5	12.14 ± 2.10	0.0968 ± 0.005	0.1138	126.43	25.29	40.88
		6	14.35 ± 2.88	0.1041 ± 0.006	0.1555	172.76	28.79	46.33
		4	9.61 ± 1.02	0.0884 ± 0.003	0.0751	83.44	20.86	
26	147	5	11.15 ± 1.33	0.1054 ± 0.005	0.1239	137.65	27.53	54.22
		6	12.75 ± 1.91	0.1151 ± 0.006	0.1689	187.65	31.27	50.00
		4	10.12 ± 1.21	0.0898 ± 0.003	0.0816	90.66	22.66	
27	148	5	11.93 ± 1.88	0.1063 ± 0.005	0.1348	149.76	29.95	59.11
		6	13.13 ± 2.15	0.1163 ± 0.006	0.1776	197.31	32.89	47.55
		4	9.33 ± 1.00	0.0825 ± 0.003	0.0635	70.55	17.64	
28	123	5	10.85 ± 1.48	0.0987 ± 0.005	0.1057	117.43	23.49	46.88
		6	12.45 ± 1.86	0.1088 ± 0.005	0.1474	163.76	27.29	46.33
		4	9.87 ± 1.31	0.0737 ± 0.003	0.0536	59.55	14.89	
29	111	5	11.36 ± 1.88	0.0831 ± 0.003	0.0784	87.10	17.42	27.55
		6	12.81 ± 2.23	0.0958 ± 0.004	0.1176	130.65	21.78	43.55
		4	9.55 ± 1.01	0.0749 ± 0.003	0.0536	59.55	14.89	
30	82	5	11.21 ± 1.57	0.0872 ± 0.005	0.0852	94.66	18.93	35.11
		6	12.65 ± 2.45	0.1007 ± 0.006	0.1283	142.54	23.76	47.88

* Standard deviation is shown

Volume = Stem volume over-bark from ground level to tip

N = 1111/ha (Assumes full stocking without thinning)

Spacing = 3m x 3m



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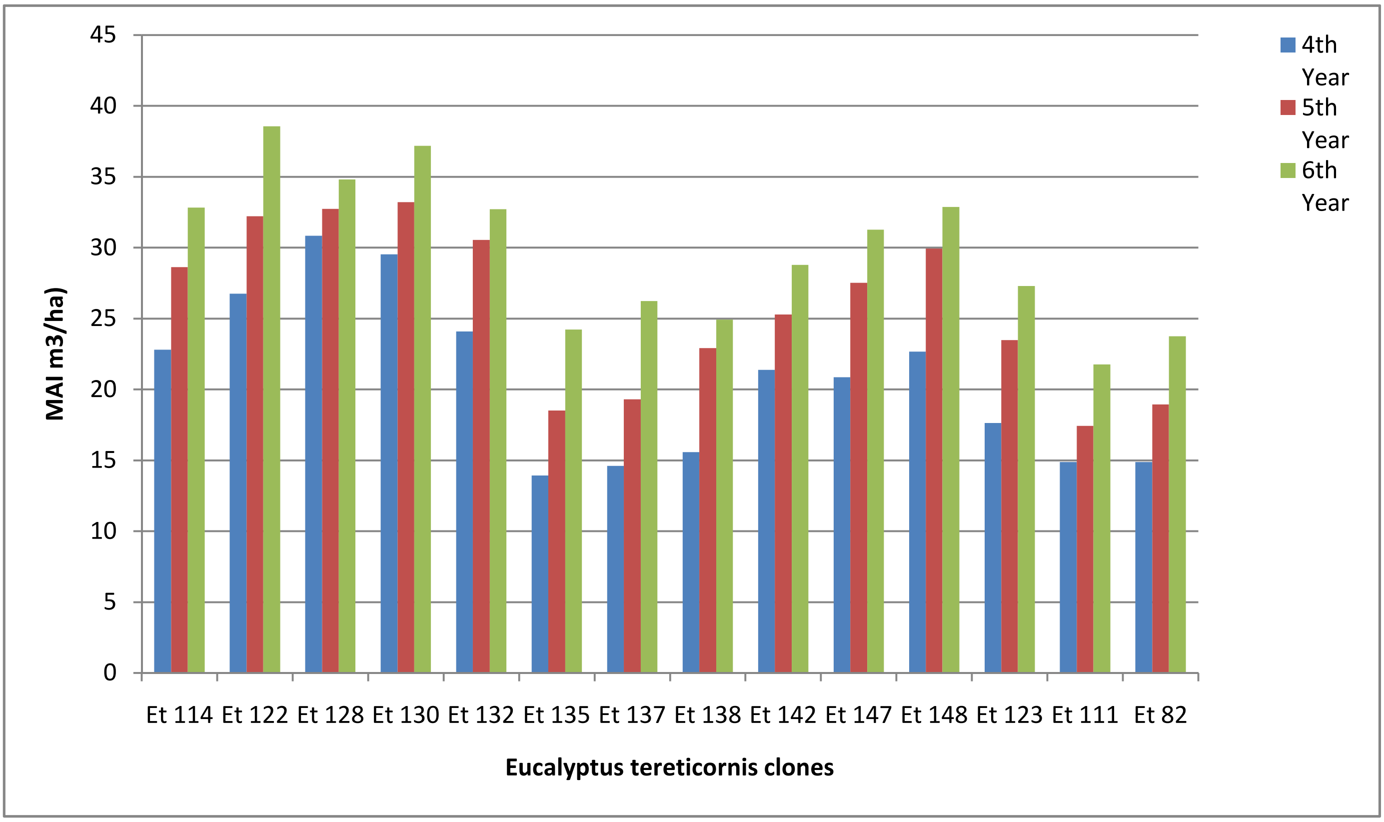

The clone Et 03 was identified as an excellent clone in terms of both over-bark and under-bark wood volume. It was followed by clones such as Et 93, Et 130, Et 122, Et 07, Et 99, Et 105 and Et 10. Et 04, Et 71, Et 82, Et 111, Et 123 and Et 135were found to be highly inferior for pulping due to their lower actual wood.

D^2 analysis was carried out for genetic clustering of the clones based on morphological traits such as height, diameter, bark content and volume collectively and twelve clusters could be identified (Table 4). Cluster I, the largest group, containing seven clones viz., Et 06, Et 132, Et 74, Et 32, Et 148 and Et 114. This cluster was highly divergent from cluster XI (Et 99 and Et 105) and cluster XII (Et 03) but it was genetically closer

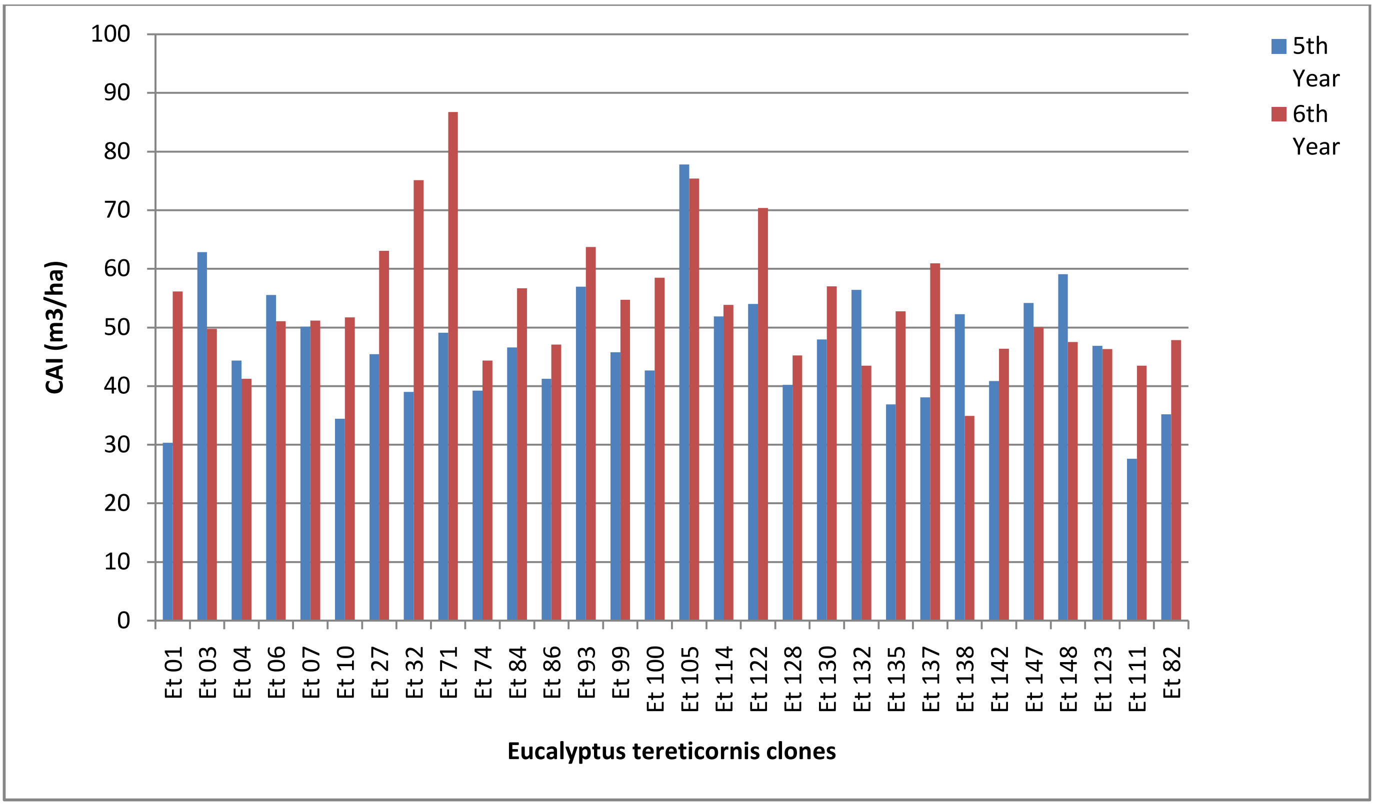

Fig. 2. CAI *of Eucalyptus tereticornis* clones for two consecutive years (5^{th} year to 6^{th} year)

Table 2. Over-bark volume and under-bark volume of six year old *E.tereticornis* clones

Sl.No	Clone No.	Height (m)	DBH (m)	Bark thickness (mm)*	Bark volume (%)	Over-bark volume (V) (m^3/ha)	Under-bark volume (V) (m^3/ha)
1	1	10.55	0.077	4.7 ± 0.222	11.83	69.49000	61.27
2	3	13.95	0.093	5.46 ± 0.234	11.4	134.05000	118.77
3	4	10.03	0.076	5.34 ± 0.299	13.55	64.36000	55.64
4	6	11.05	0.085	4.42 ± 0.222	10.14	88.70000	79.71
5	7	12.42	0.091	8.63 ± 0.356	18.07	114.27000	93.62
6	10	11.64	0.094	7.12 ± 0.318	14.58	114.27000	97.61
7	27	10.69	0.089	6.95 ± 0.312	15	94.07000	79.96
8	32	9.62	0.091	5.5 ± 0.211	11.73	88.51000	78.13
9	71	10.49	0.071	8.41 ± 0.385	22.28	58.75000	45.66
10	74	10.19	0.087	7.5 ± 0.329	16.5	85.69000	71.55
11	82	9.56	0.069	5.06 ± 0.234	14.14	50.57000	43.42
12	84	11.25	0.074	4.78 ± 0.213	12.49	68.44000	59.89
13	86	10.12	0.085	6.43 ± 0.300	14.55	81.23000	69.41
14	93	12.23	0.089	7.54 ± 0.322	16.23	107.63000	90.16
15	99	13.37	0.09	8.03 ± 0.388	17.05	120.32000	99.81
16	100	12.21	0.083	9.13 ± 0.369	20.79	93.45000	74.02
17	105	13.06	0.093	7.41 ± 0.312	15.3	125.49000	106.29
18	111	9.87	0.073	6.12 ± 0.312	16.07	58.44000	49.05
19	114	10.31	0.088	6.49 ± 0.299	14.21	88.70000	76.10
20	122	10.96	0.09	5.11 ± 0.277	11.03	98.63000	87.75
21	123	9.33	0.07	6.65 ± 0.296	18.09	50.79000	41.60
22	128	11.38	0.081	6.98 ± 0.321	16.49	82.95000	69.27
23	130	12.68	0.088	7.25 ± 0.322	15.79	109.09000	91.86
24	132	9.92	0.088	7.06 ± 0.305	15.41	85.35000	72.20
25	135	9.36	0.075	6.13 ± 0.302	15.68	58.49000	49.32
26	137	10.46	0.085	5.9 ± 0.268	20.61	83.96000	66.66
27	138	10.28	0.085	8.98 ± 0.378	20.02	82.52000	66.00
28	142	10.53	0.087	10.17 ± 0.421	22.01	88.55000	69.06
29	147	9.62	0.089	6.36 ± 0.287	13.78	84.66000	72.99
30	148	10.12	0.085	6.6 ± 0.301	14.92	81.23000	69.11
	CV	16.33	11.76	13.4	* Standard deviation is shown		
	SE	0.26	0.0094	0.18			
	LSD	0.73	0.0192	0.37			

Table 3. Average intra-cluster and inter-cluster D^2 values

Cl. No	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
I	1.96	7.92	5.24	3.97	6.96	10.1	5.47	6.88	12.43	17.96	24.27	28.54
II		2.12	10.49	6.4	4.32	5.49	9.03	7.84	7.84	11.66	17.82	22.04
III			0	4.93	9.04	12.87	4.01	8.61	14.32	20.79	27.19	31.57
IV				0	4.66	8.27	3.66	5.2	10.09	16.24	22.72	26.99
V					1.78	5.08	6.87	4.33	6.87	12.14	18.55	22.88
VI						2.01	9.53	6.81	6.64	9.55	15.61	19.61
VII							2.12	5.98	11.7	18.28	24.67	29.01
VIII								2.45	8.89	13.85	20.11	24.4
IX									0	8.1	14.44	18.45
X										2.11	7.19	11.15
XI											2.52	5.88
XII												0

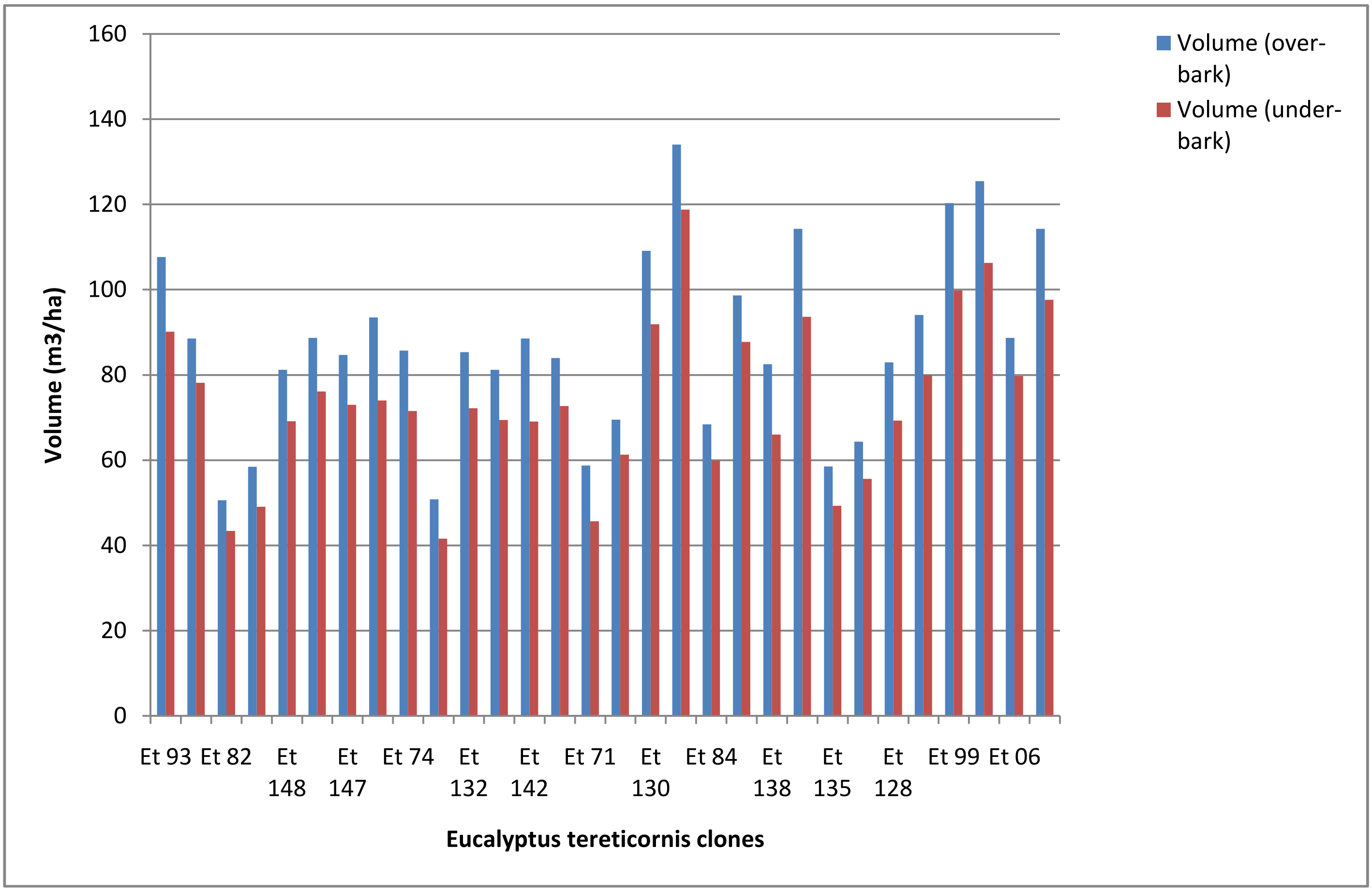

Fig. 3. Volume over-bark and volume under-bark of six year old clones of *Eucalyptus tereticornis*

Table 4. Clusters with their respective clones

Sl. No	Cluster No.	Clones
1	I	Et 06, Et 132, Et 74, Et 32, Et 148, Et 114
2	II	Et 10, Et 122, Et 71
3	III	Et 123
4	IV	Et 86
5	V	Et 27, Et 142
6	VI	Et 128, Et 06
7	VII	Et 111, Et 135
8	VIII	Et 04, Et 01, Et 138, Et 137, Et 82
9	IX	Et 84
10	X	Et 130, Et 07, Et 100, Et 93
11	XI	Et 99, Et 105
12	XII	Et 03

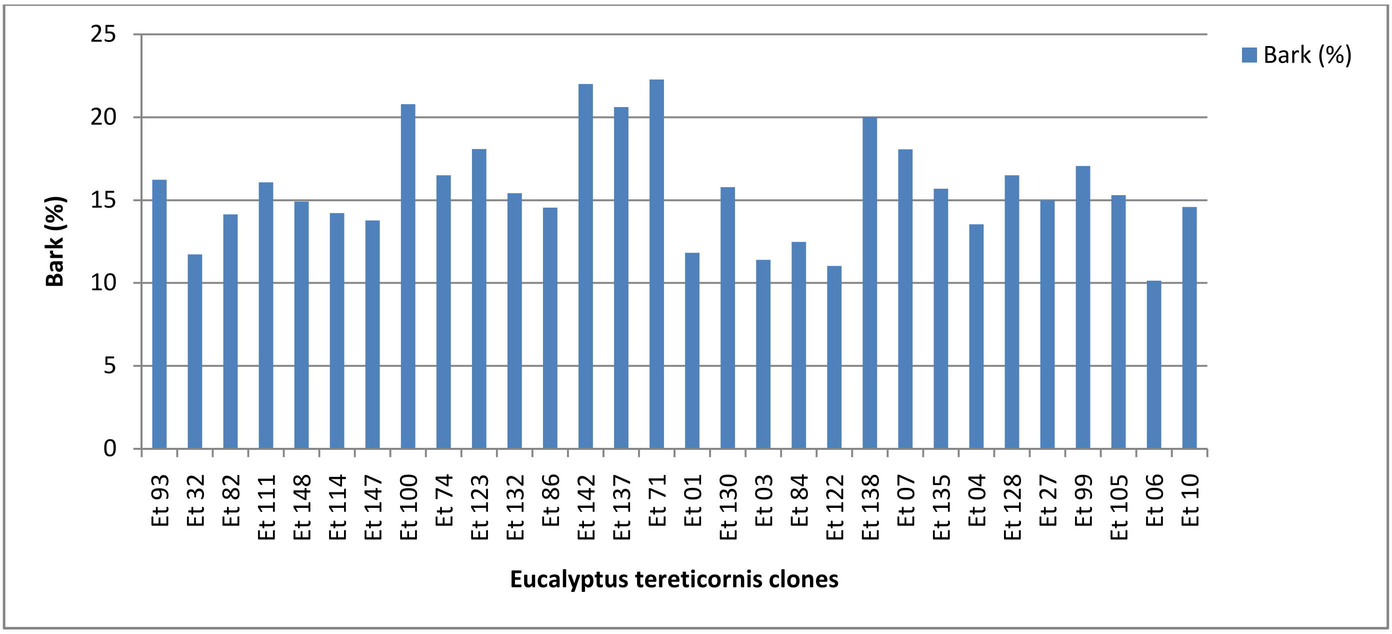

Fig. 4. Variation in the percentage of bark of six year old clones of *Eucalyptus tereticornis*

to cluster IV (Et 86), cluster III (Et 123) and cluster VII (Et 111 and Et 135). Similarly, cluster II with three clones, Et 10, Et 122, Et 71, was highly divergent from cluster XI and XII but closer to cluster V and VI. There are four clusters, cluster III (Et 123), cluster IV (Et 86), cluster IX (Et 84) and cluster XII (Et 03) containing only one clone each. The cluster diagram and the genetic distance between the clusters will definitely help the tree breeders to select the right choice of parents for their future tree improvement programmes.

Conclusion

The study shows that a significant variation in growth rhythm among the clones of *Eucalyptus tereticornis*. Coefficient of variation is higher for all the growth traits studied. Significant variation in bark thickness among the clones and it is insignificantly correlated with growth traits. Clones such as Et 03, Et 07, Et 10, Et 71, Et 93, Et 99, Et 105, Et 122 and Et 130 are identified as promising clones in terms of productivity. Twelve clusters are identified based on growth traits taken together using D^2 analysis and the genetic clustering will be useful for the tree breeders for further tree improvement programmes.

Acknowledgment

The authors greatly acknowledge the financial assistance and the support provided by the Institute of Forest Genetics and Tree Breeding, Coimbatore, Tamil Nadu, India for the successful completion of the work.

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