IDENTIFICATION OF SITE SPECIFIC EUCALYPTUS *CAMALDULENSIS* CLONES FOR TIRUPATHI (ANDHRA PRADESH) BASED ON ITS PRODUCTIVITY

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Abstract

Eucalyptus camaldulensis and *Eucalyptus tereticornis* clones were shortlisted based on individual tree superiority observed in the multilocational clonal trial for growth attributes like height, girth at breast height and volume. Clonal trials were planted with commercial clones, seedlings from seed orchard, IFGTB and local seedlings during the year 2009-10 to identify the best performing and site specific clones. The clones were planted at the experimental site of Andhra Pradesh Forest Department (KFD) at Tirupathi. The growth parameters like height, girth at breast height and its volume were recorded at its half rotation (2010 to 2014). Ranking of the 22 commonly planted clones and two seed lots showed that Clone C-10 and C-19 were consistently superior in their growth performance when compared to all other clones, seed lot and the commercial clones with respect to height, girth and volume although the performance changed with each characters. Based on the study it was concluded that the clones viz., C-10 and C-19 are best suitable for the area in and around Tirupathi and also for having the same soil characteristics (sandy clay loam). The results confirm that the clones selected and tested in test environments will perform similarly in similar site conditions if deployed.

Key words: *Eucalyptus camaldulensis*, clone, site specific, repeatability, deployment

INTRODUCTION

Natural forests are diminishing as a result of over dependence on them. Government and non-government agencies worldwide are taking measures to bring more area under green cover by planting valuable trees in both private and government lands. Despite the increasing afforestation activities, the supply of forest products doesn't meet the demands of the ever increasing population (Dhillon *et al.,* 2010). The projected requirement of forest products in 2020 is 437 million tons of fuel wood and charcoal, 37 million m^3 of industrial wood, 33 million

m^3 sawn timbers, 5.7 million m^3 pulp and paper wood and 1.3 million tons of wood based panels to mention a few (Parveen *et al.*, 2010).

A manmade forest which capitalizes the tree improvement strategies is an economic realistic option and the only way forward. Clonal forestry is a feasible alternative to seedlings based forestry in planting programs, particularly in case of tropical species like eucalypts, where cloning constitutes a valuable tool in most improvement programs (Libby and Rauter, 1984). The greatest contribution of tree improvement programs is to create superior individuals that help effectively obtain gains in product quality and help transform these gains for farmers' benefit and prosperity. In this context, the greatest challenge to a forest breeder is the use of efficient breeding strategies to obtain individuals which have high growth potential and wood quality.

Eucalyptus is the most common tropical forest plantation species (Evans, 1992) and is often chosen because of high growth rate, short rotation and favorable pulpwood properties. The genus Eucalyptus belongs to the family Myrtaceae, comprising about 700 species (Eldridge *et al.*, 1993). It was introduced to India around 1790 (Wilson, 1973). Studies reveal that, it sequesters about 10-14 tons of carbon/ha/yr and has several wood properties favorable for paper, pulp, furniture and cellulose. It helps diminish global warming by reducing the emission of green house gases and fixing on an average 1.8 tons of CO_2 and generating 1.3 tons of O_2 for every ton of dry wood (Vennila *et al.*, 2017).

Eucalyptus of seedling origin cannot meet the expected yield due to genetic variability which leads to variation of wood traits within the clones. The variability is reduced by establishing clones via vegetative propagation using coppice shoot cuttings which has received lot of attention for true to type progeny (Nanda and Kochhar, 1987). The tree improvement exercised through clonal trials envisages deployment of outstanding individual selections via replicated tests in different targeted environments for several years to provide high genetic gain within a short period of time when compared to those of seedling origin. Institute of Forest Genetics and Tree Breeding (IFGTB) selected 126 clones of *Eucalyptus camaldulensis* from the seed orchards established since 1995 and these were studied in three different places viz., Sathyavedu in Andhra Pradesh, at Karunya in Tamil Nadu and Panampally in Kerala to select best performing clones. The clonal trials revealed that some clones perform better than even the widely cultivated and popular commercial clones. 18 superior clones from IFGTB seed orchard

were selected and trialed in Tirupathi (Andhra Pradesh) for the development of site specific clones.

These short listed IFGTB clones along with three commercial clones and also seedlings (from IFGTB seed orchard) were tested for their performance and productivity to identify the clones suitable for Tirupathi afforestation programme by the SFDs, forest corporations, wood based industries and farmers. This study also aims to develop site specific clones for Tirupathi (Andhra Pradesh).

MATERIALS AND METHODS:

18 promising clones were shortlisted from the first generation provenance trials and seed orchards established during 1996 with the seeds received from Commonwealth Scientific Industrial and Research Organisation (CSIRO), Australia. The CPT selections were carried out through overall performance in which the height, diameter at breast height and bole straightness were prominence. The selected clones were multiplied by developing ramets from coppice shoots using IBA for rooting in mist chamber during 2009. Clonal trial was established at Tirupathi (Andhra Pradesh) during September 2010.

All the selected 18 Clones viz., C7, C9, C10, C14, C19, C63, C66, C100, C101, C111, C115, C123, C124, C186, C187, C188, C196, C198 were tested along with three of the commercially planted clones viz., ITC- 3, ITC-7, TNPL-103; a single *Eucalyptus tereticornis* clone (402) and two seed lots of *Eucalyptus* 301 (Orchard seeds) and 302 (local seed source). Trial was laid in Randomized Block Design with about four replications and 16 ramets (4 x 4 blocks) in each replication in the trial (Fig-1).

The site for trial establishment was selected based on parameters like amount of rainfall, humidity, temperature and soil characteristics. It was ensured that the trial was laid on even grounds.

Ramets were planted at 3 x 2 meter spacing after a disc plough using heavy duty tractor. Weeding was carried out twice a year before the rain. Watering, fertilization and soil amendments were restricted for 4-6 months during initial period of establishment. Every year, growth traits were recorded before rain. Periodic inspections were carried out once in six months for observing pest and disease incidence.

Results

Analysis of Variance

The growth data was recorded after 12 months of plantation and was repeated for three years at 12 months interval i.e., 12, 24 and 36 months. The data includes growth parameters viz., height and girth at breast height. Haga altimeter was used to determine the height of trees and girth was measured using measuring tape (Table 1). Volume was estimated using the measured height and the girth at breast height. The cylindrical volume was calculated by multiplying the cross section area with the height and further multiplying with form factor (0.55) to establish the actual volume. The data was analysed using GENSTAT 5. The soil is sandy loam, pH 5.6, EC 0.03ds/m, organic carbon 1.5, Bulk density 0.8, N-202.6 kg/ha, P-21.7 kg/ha and K -111.6 kg/ha.

The trial data was analyzed separately for every year growth traits to calculate the variance of replication, ramet and clonal spectrum. Clonal mean was calculated and statistical significance was tested. Standard Error (SE) of mean and Least Significant Difference (LSD) were also calculated for all three years and given in (table-1). Clones with high mean values and their relative superiority over other clones were established using LSD values given in table (1). The clones were significantly different among themselves for all the observed traits and years.

Table 1. Growth attributes of Eucalyptus Clonal Trial at Tirupathi

Clone	Height 1 (m)			Girth (cm)			Volume (Cu. m).		
	I year	II Year	III Year	I year	II Year	III Year	I year	II Year	III Year
7	3.35	4.86	6.44	12.83	13.08	18.58	0.0028	0.004	0.010
9	3.61	5.52	6.88	13.05	14.38	20.28	0.0036	0.006	0.014
10	4.33	7.01	**7.83**	14.86	16.10	**22.21**	0.0046	0.009	**0.018**
14	3.50	5.81	6.87	11.76	14.96	20.73	0.0025	0.007	0.014
19	3.89	5.83	**7.40**	14.91	13.29	**21.94**	0.0043	0.005	**0.017**
63	2.82	4.89	5.32	10.14	11.94	13.02	0.0020	0.004	0.007
66	3.95	6.04	6.75	13.42	15.63	20.08	0.0037	0.007	0.015
100	3.15	4.86	5.78	11.28	12.75	18.17	0.0022	0.004	0.010

101	3.35	5.57	5.73	10.12	12.85	16.69	0.0020	0.005	0.011
111	2.58	3.71	4.61	9.44	10.54	12.40	0.0014	0.002	0.004
115	2.68	4.76	5.37	8.83	10.78	14.12	0.0013	0.003	0.006
123	3.40	4.67	5.79	13.01	12.15	15.98	0.0034	0.004	0.010
124	3.12	5.69	6.14	10.94	14.28	17.70	0.0021	0.006	0.010
186	3.30	5.40	6.37	12.70	13.38	18.90	0.0027	0.005	0.011
187	3.51	5.40	6.48	10.76	13.56	20.03	0.0023	0.006	0.014
188	3.19	5.47	6.55	10.96	14.35	19.18	0.0019	0.006	0.012
196	3.50	5.32	6.56	11.60	13.02	17.45	0.0027	0.005	0.010
198	2.43	4.14	5.06	8.59	10.60	14.18	0.0015	0.003	0.006
301	2.75	4.26	5.21	10.09	11.89	14.58	0.0017	0.003	0.008
302	2.64	3.93	4.97	9.18	10.56	13.39	0.0015	0.002	0.005
303	2.71	3.98	5.62	9.11	10.03	14.72	0.0020	0.003	0.008
304	2.46	4.37	4.66	8.33	11.23	14.12	0.0014	0.003	0.005
307	2.47	4.20	4.81	7.82	10.52	12.99	0.0013	0.003	0.006
402	4.25	6.05	**7.03**	13.50	16.30	**22.72**	0.0041	0.009	0.020
Mean	3.21	5.08	6.02	11.14	12.86	17.30	0.0025	0.005	0.011
SEd	0.17	0.29	0.26	0.70	0.67	0.89	0.0004	0.001	0.004
LSD	0.33	0.57	0.51	1.38	1.31	1.74	0.0008	0.002	0.009

Table 2: ANOVA for growth traits - Tirupathi

Locality	df	Treatment SS	Treatment MS	EMS	F Value	F Pro.
Girth (I year)	23	6185.84	268.95	15.73	17.10	<.001
Girth (II year)	23	5138.21	223.40	14.19	15.75	<.001
Girth (III year)	23	15342.78	667.08	667.08	26.62	<.001
Height (I year)	23	457.1938	19.8780	0.8868	22.41	<.001
Height (II year)	23	979.791	42.600	2.683	15.88	<.001
Height (III year)	23	1176.072	51.134	2.194	23.31	<.001
Volume (I year)	23	0.146E-02	0.634E-04	0.409E-05	15.50	<.001
Volume (II year)	23	0.00516519	0.00022457	0.00001302	17.25	<.001
Volume (III year)	23	0.02645729	0.00115032	0.00005477	21.00	<.001

The result depicted that clone no 10, 19 and 14 are having maximum girth at breast height (gbh) i.e., 22.21, 21.94 and 20.73 respectively when compared to all other clones in this location. The height of clones 10, 19 and 9 was found to be greater than all other clones with the values 7.83 m, 7.40 m and 6.88 m respectively. The wood quantity is determined by volume of timbers, the clones C10, C19 and C66 expressed maximum volume and were the best suitable clones for Tirupathi area as they recorded maximum volume of about 0.018, 0.017 and 0.015 cubic meter respectively. ANOVA results also depicted the superiority of these clones over other clones, the genetic variation among superior clones is as shown in Table 2.

DISCUSSION

Clonal plantations promise vigorous uniform planting stock for afforestation programmes. New clones need to be regularly developed through selection. Clone selections coupled with multi locational trials brings out the provenances having better phenotype, genotypic characters and uniformity in growth especially for introduced species like *Eucalyptus*. The present study aimed to select best clones from broad genetic base at a particular location accounts for the deployment of same clones to similar locations owing to the identification of superior clones for the particular location.

The phenotypic characters such as Girth, Height and Volume are the most important traits to identify the superior provenance in a clonal trial and this trial at Tirupathi showed that clones C10 and C19 performed better than other clones including commercial clones. The clone C19 exhibited similar performance in a clonal trial at Tiyagadurgam (Vijayaraghavan *et al*., 2017). C 19 shows better adaptability in different soil conditions (Vijayaraghavan *et al*., 2018). Apart from this Clone C 10 also showed similar performance which suggests that this clone also is suitable for Tirupathi and surrounding areas. The study revealed that the clones (C 9, C 10 and C 19) were highly adapted to the dry environments and generates high wood volume and pulp. Higher volume content than the commercially planted clones showed that these clones have traits suited for small scale as well as large scale farmers especially in dry climatic conditions.

Oballa *et al*., 2005 indicated that clones have to be tested in target environments before deployed as site specific clones and clonal trial at Tirupathi showed that many clones outperformed the seedlots and commercial clones. The survival percentage of clonal plantation was observed to be over 90 percent, similar to what was reported by Kulkarni and Lal, 1995. The

difference in survival between the clones within the site was probably due to the genetic difference which interacts differently in the various climatic conditions and showed strong environment clone interaction which supported by Wamalwa *et al*., 2007. Evaluation of clones across diverse environments has identified suitable provenances for low and medium rainfall sites of central and southern India (Varghese *et al*., 2008). Superior clones of *E. camaldulensis* identified in the trial reported here are likely to play an important role in future breeding programme.

Conclusion

This study clearly shows that selection of clones for a particular site is very important to get maximum productivity from *Eucalyptus camaldulensis*. In addition, this study demonstrates that the farmers would be benefitted from high productivity due to the deployment of site specific and highly productive clones. Although implementing such a strategy would require significant investments for field trials, the benefits with respect to increased yield and economic returns with deployment of site specific clones ensures better economic returns to farmers and wood yield to industries. The present ranking of the 18 IFGTB clones, commercial clones, two seed origin seedlings and one genetic gain trial showed that Clone C-10 and C-19 were consistently superior with respect to height, girth and volume although the performance changed for each parameters. All these clones are observed to be superior in their growth when compared to commercially cultivated clones. The results confirm that the clones C10 and C9 are best for the specific location of Tirupathi and that they can be deployed to larger areas having similar environmental conditions.

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REFERENCES

Dhillon, G. P. S., Singh, A., Singh, P. and Sidhu, D. S. (2010). Field evaluation of Populus deltoids Bartr. ex Marsh. at two sites in Indo-gangetic plains of India. Silvia genetica, 59(1): 1-7.

Eldridge, K., Davidson, J., Harwood, C. and Van Wyk, G. 1993. Eucalypt domestication and breeding. Clarendon Press, Oxford.

Evans, J. (1992): Plantation forestry in the tropics. Oxford Science Publications. 2nd Edition. 403 pp.

Kulkarni, H. D. and Lal, P. (1995). Performance of eucalyptus clones at ITC Bhadrachalam India. In: Potts, B. M., et. al., (Ed.). Eucalyptus plantations: improving fiber yield and quality. Proc. CRCTHF – IUFRO Cong., Hobart, Australia. pp.: 274 - 275.

Libby, W. J.; Rauter, R. M.(1984). Advantages of clonal forestry. The Forestry Chronicle 60 (3): 145-9.

Nanda, K. K. and Kochhar, V. K.(1987). Vegetative propagation of plants: principles and practices. New Delhi: India Book Trust.

Oballa, P., Chagala Odera, E., Wamalwa, L., Oeba, V., Mutitu, E. and Mwangi, L. (2005). The performance of Eucalyptus hybrid clones and local landraces in various Agroecological zones in Kenya. www.easternarc.org/biotechnology.eucalyptus.

Parveen, A. Kumar, V.K. Sharma and H.S. Ginwal. 2010. Sustained Hybrid Vigor in F1 Hybrids of Eucalyptus torelliana F.v.Muell x E. citriodora Hook. World Applied Sciences Journal 11 (7): 830-834.

Varghese, M., Harwood, C. E., Hegde, R. and Ravi, N.(2008). Evaluation of Provenances of Eucalyptus camaldulensis and Clones of E. camaldulensis and E. tereticornis at Contrasting Sites in Southern India. Silvae Genetica, 57:170-179.

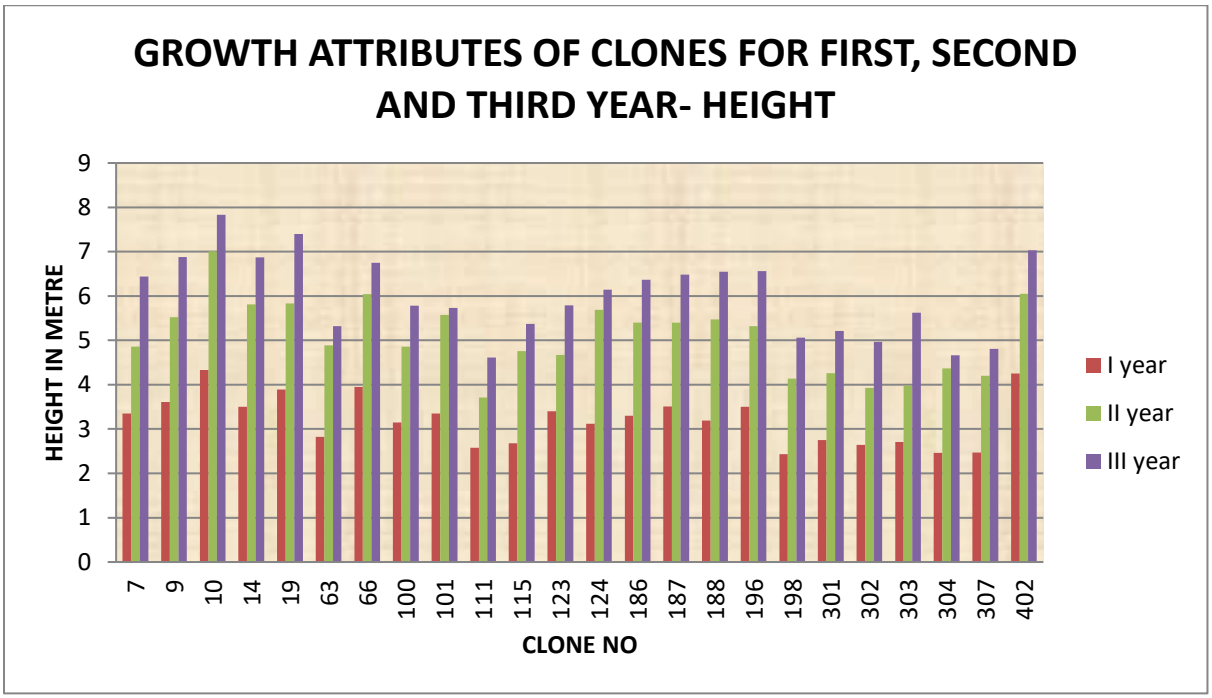
Vennila, S., K.T. Parthiban and Palanikumaran, B. 2017. Clonal Evaluation of Eucalyptus Genetic Resources for Pulping Quality. Int.J.Curr.Microbiol.App.Sci. 6(7): 4021-4031.

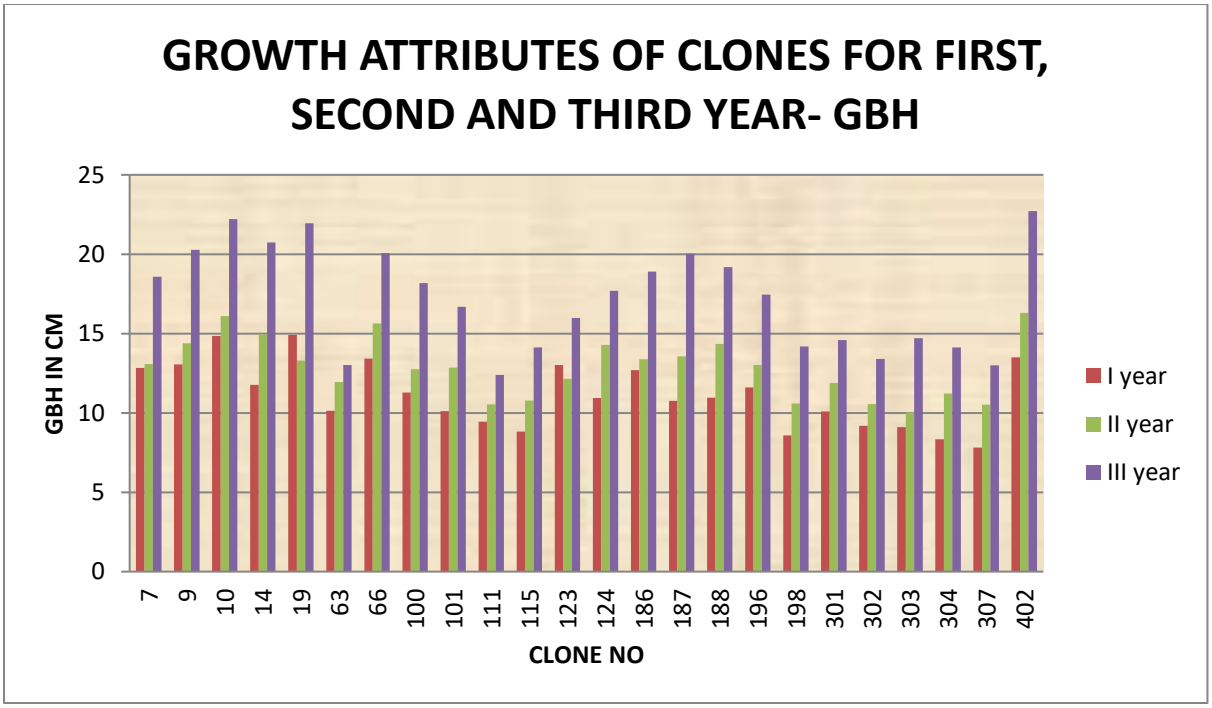
Vijayaraghavan A. and Sivakumar V.(2017). Selection of site specific Eucalyptus camaldulensis and Eucalyptus tereticornis clones for Ariyalur region (Tamil Nadu) based on its higher productivity. International Journal of Research & Development Organisation (IJRDO- Journal of Applied Science 3(2):40-57.

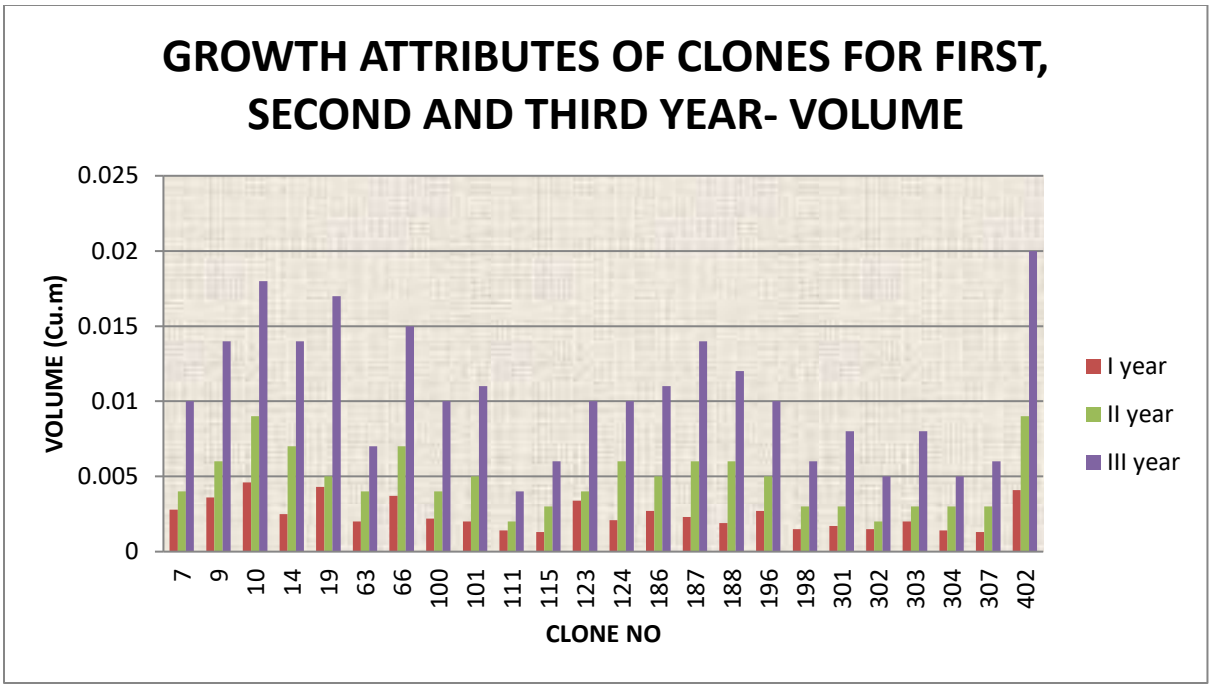
Vijayaraghavan, A., Sivakumar, V., Anees, A., Madhanraj, A and Suresh, G. (2018). Identification of suitable Eucalyptus camaldulensis and Eucalyptus tereticornis clones for Karaikudi (Tamil Nadu) based on productivity. Proceedings of National Conference on Biodiversity and its Conservation: Priorities and Challenges- 2018. ISBN : 978-93-84234-71-3: 74-78

Wamalwa, L., Chagala-Odera, E., Oeba, V and Oballa, P. O.(2007). Adaptability of four-year old Eucalyptus species and clones in Kenya.Discovery and Innovation ***19****(4): 326 – 334.*

Wilson, J. (1973). Rational utilization of the Montane Temperate Forests of South India. Indian Forester, 99(12): 707-716.






GROWTH ATTRIBUTES OF CLONES FOR FIRST, SECOND AND THIRD YEAR- VOLUME
VOLUME (Cu.m)
0.025
0.02
0.015
0.01
0.005
0
7
9
10
14
19
63
66
100
101
111
115
123
124
186
187
188
196
198
301
302
303
304
307
402
CLONE NO
I year
II year
III year