The Pharma Innovation Journal 2022; SP-11(3): 1548-1551

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(3): 1548-1551

www.thepharmajournal.com
Received: 17-01-2022
Accepted: 20-02-2022

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Assessing the biomass productivity of *Eucalyptus* plantations at different age gradations

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Abstract
This experiment was carried out in one to five years old *Eucalyptus* plantations located at Tamil Nadu Newsprint and Papers Limited, Kakithapuram, Tamil Nadu. To study the growth and biomass potential of *Eucalyptus* plantation of different ages *viz*., from one year to five years. The main objective was to elucidate the above and below ground biomass of *Eucalyptus* plantations of different ages. The analysis on growth characteristics revealed that the tree height, girth at breast height and diameter at breast height, the tree productivity in term of volume of standing and felled trees of *Eucalyptus* (1 to 5 years) depicted an exponential growth with an increase in age of trees. The mean tree height in different ages of *Eucalyptus* was ranged from 6.00 m to 15.50 m. The above ground biomass of *Eucalyptus* trees *viz*., stem, branch and leaf and the below ground biomass component *viz*., root increased with an increase in age of trees. The stem fresh weight of individual tree ranged from 7.60 kg tree^{-1} to 46.99 kg tree^{-1} and the total fresh weight varies from 16.88 t ha^{-1} to 104.41 t ha^{-1} in one year and five years old trees. The increase in total biomass of different components contributed to a gradual increase in total biomass with an increase of age. In the current study above ground biomass contributed in 73.62% and below ground biomass contributed in 26.37% to the total biomass of *Eucalyptus* plantation. In this study, we concluded that there was a significant increase in growth and biomass of trees as the age increases. This exponential increase in incremental growth and biomass due to age would occur up to certain age and slow growth in current annual increment.

Keywords: Biomass, productivity, age gradation, above ground biomass and below ground biomass

Introduction
Eucalyptus originates from Myrtaceae family and it is native to Australia, Tasmania and near islands. Economically, *Eucalyptus* trees constitute one of the most valuable groups in the order Myrtales. This species has high economic value, as it is major source of paper and plywood industries. It is one the most adapted species under agroforestry plantations in India due to the assured market price and high returns. Biomass of *Eucalyptus* plantation which includes both the above- and belowground of trees for example, leaves, twigs, branches, boles, as well as roots of trees. Biomass is often reported as a mass per unit area (g m^{-2} or Mg ha^{-1}) and usually as dry weight (water removed by drying). In worldwide, the biomass has become important and presently, is an important tool in implementation of emerging carbon credit mechanism (Mugasha *et al.* 2013) [5]. The estimation of biomass and the biomass studies are time consuming, expensive and applicable to localized conditions. Typically, biomass comprises measureable tree variables such as DBH, height, canopy spread, etc. that are closely correlated to biomass (Chave *et al.* 2014) [2]. DBH is the most important variable used for predicting biomass (Verma *et al.* 2014 and Rizvi *et al.* 2011) [10, 8]. Few allometric models for biomass of *Eucalyptus* hybrid have been previously developed. Biomass has an essential role in the energy sector of the world due to applications in bioenergy. The aim of this study was to assess the biomass production of *Eucalyptus* plantation of different age gradation in that biomass was determined by weighing different component of the trees after harvesting and it is differing from age to age. Plant spacing affected biomass production of forestry trees at different ages after planting. Mature tress produces larger quantities of biomass compared to the younger trees. Wood biomass represented the biomass component with the largest production over time, which showed an increasing proportion throughout the age groups, followed by branch, leaf and bark biomass.

Materials and Methods
The *Eucalyptus* clonal plantation established at the fields of Tamilnadu Newsprint and Papers Limited, Kakithapuram (11º 3' N latitude and 77º 59' E longitude) were formed base material for the current study.

The laboratory studies were conducted at Silviculture and Agroforestry laboratories of Forest College and Research Institute, Mettupalayam, Tamil Nadu. The present study was undertaken in 1 to 5 year old *Eucalyptus* plantation. The field experiment was conducted in factorial randomized block design. The *Eucalyptus* plantations of 1, 2, 3, 4 and 5 year old were selected for the present study. The total height of trees was measured by using Haga altimeter in all ages of plantations randomly and expressed in metre (m). All the experimental trees were marked at 1.37 m from ground level with a band of 1 cm around the stem using orange paint. The DBH of trees was arrived at by using the formula *viz*., G/3.14 and expressed in centimetre. The volume of standing trees was estimated using the formula $V = \pi r^2 h$ and expressed in m^3. The volume of felled trees was calculated using the quarter girth formula i.e., $V = (g/4)^2 x\ l$ and expressed in m^3.

The above ground biomass estimation was done by destructive sampling method. The trees were felled at ground level using a mechanical chain saw (Poulan/Pro, USA). After recording the total height and girth at breast height of the standing trees, the above ground portions were separated into stem, branches and leaves. Fresh weights of all the above ground tree components were recorded immediately after felling using appropriate spring scales.

A small sample (500 g) of wood, branches and leaves were immediately transferred to the laboratory in double sealed polythene bags. The collected samples were dried at 80 ºC till constant weight is obtained and dry weight of the tree biomass was estimated. For below ground biomass estimation, pits were excavated and complete recovery of roots was done at 1 m distance from tree base. The roots were separated and weight was recorded immediately using appropriate spring scales. A small sample (500 g) of roots was immediately transferred to the laboratory in double sealed polythene bags. The collected samples were dried at 80º C till constant weight is obtained. The results were subjected to an analysis of variance and tested for significant difference according to Panse and Sukhatme (1967) [9].

Results and Discussion

Tree growth

In the present study, the growth of *Eucalyptus viz*., height, GBH, DBH and volume increased with an increase in age. The results revealed that there was a gradual increase in height, GBH, DBH and volume when the age of trees increases. The mean tree height in different ages of *Eucalyptus* was ranged from 6.00 m to 15.50 m. The GBH and DBH of trees were ranged from 16.00 cm to 25.50 cm and 5.10 cm to 8.12 cm respectively at first year and fifth year. They observed that the growth and biomass of any stand is mainly influenced by stand age, stand density and other management regimes. Bertomeu and Sungkit (1999) [1] recorded an increasing growth rate in *Eucalyptus deglupta* plantation when age increases (Table. 1).

Table 1: Growth and volume of *Eucalyptus* plantations at different ages

Age of plantations (yrs)	Mean height (m)	Mean girth (cm)	Mean diameter (cm)	Mean volume of standing trees (m^3 $tree^{-1}$)	Mean volume of standing trees (m^3 ha^{-1})	Mean volume of felled trees ($m^3$$tree^{-1}$)	Mean volume of felled trees ($m^3$$ha^{-1}$)
1	6.00	16.00	5.10	0.017	37.77	0.010	22.22
2	10.50	20.50	6.53	0.030	66.66	0.022	48.88
3	13.00	21.50	6.85	0.047	104.43	0.039	86.65
4	14.60	23.50	7.48	0.063	139.98	0.046	102.21
5	15.50	25.50	8.12	0.077	171.09	0.058	128.87
SEd	0.254	0.312	0.294	0.003	0.268	0.002	0.342
CD (0.05)	0.539	0.661	0.624	0.006	0.567	0.004	0.726

Volume of trees

The volume of standing trees differed significantly due to ages and the mean volume of individual trees ranged from 0.017 m^3 $tree^{-1}$ in one year old to 0.077 m^3 $tree^{-1}$ in five years old tree and the total volume of standing trees ranged from 37.77 m^3 ha^{-1} to 171.09 m^3 ha^{-1}. The results showed that the volume of felled trees varied significantly due to ages and the value ranged from 0.010 $m^3$$tree^{-1}$ in one year old to 0.058 m^3 $tree^{-1}$ in five years old plantation. The total volume varied from 22.22 m^3 ha^{-1} to 128.87 m^3 ha^{-1} at first and fifth year respectively (Table 1).

The result revealed that there was a gradual increase in volume of both standing and felled trees with an increase in age of plantations. The increase in volume over the years of plantation might be due to increase in dbh and height of the trees over the years. Since both of these factors have direct positive effect on volume, direct proportionate increase was observed.

Tree biomass

The stem fresh weight of individual tree ranged from 7.60 kg $tree^{-1}$ to 46.99 kg $tree^{-1}$ and the total fresh weight varied from 16.88 t ha^{-1} to 104.41 t ha^{-1} in 1st and 5thyr old trees respectively. The stem dry weight differed from 4.75 kg $tree^{-1}$ to 34.90 kg $tree^{-1}$ and the total stem dry weight varied from 10.55 t ha^{-1} to 77.54 t ha^{-1} in 1st and 5th year old trees respectively. The stem fresh weight and stem dry weight increased with an increase in age of trees. The result of the present study was in accordance of Mugasha *et al.* (2013) [5] and they stated that the biomass of shisham in energy plantation of three-year age and record 52.17 t ha^{-1} with 31.6 per cent bole biomass (Table 2).

Table 2: Above and below ground biomass of *Eucalyptus* plantations at different ages (Kg $tree^{-1}$)

Age of plantations (yrs)	Above ground biomass (Kg $tree^{-1}$)						Below ground biomass (Kg $tree^{-1}$)	
	Stem fresh weight	Stem dry weight	Branch fresh weight	Branch dry weight	Leaf fresh weight	Leaf dry weight	Root fresh weight	Root dry weight
1	7.60	4.75	5.20	3.29	3.40	1.99	5.80	3.59
2	12.70	8.00	6.10	4.19	4.30	2.89	7.60	4.85
3	21.00	13.50	7.00	4.30	5.80	3.40	13.49	8.99
4	28.99	19.00	8.23	6.99	8.50	6.39	16.50	11.25
5	46.99	34.90	10.99	8.00	10.00	7.40	22.89	16.99
SEd	0.260	0.142	0.135	0.171	0.235	0.003	0.003	0.034
CD (0.05)	0.552	0.300	0.287	0.363	0.497	0.006	0.005	0.072

Similarly, the branch fresh weight of *Eucalyptus* trees varied due to ages and ranged from 5.20 kg tree^{-1} to 10.99 kg tree^{-1} and the total branch fresh weight from 11.55 t ha^{-1} to 24.42 t ha^{-1} The same trend was observed in branch dry weight as that of branch fresh weight (Table 2 & 3).

There was a gradual increase in branch fresh weight and dry weight with an increase of age of plantation. As the stem weight of trees increase with ages, one of the components of biomass i.e., branch weight also increases over the years.

The data depicted that the leaf fresh weight and dry weight increased with an increase of age. But the contribution of branch and leaf weight was less when compared to stem weight. Similarly, Vidyasagaran and Paramathma (2014) [11] also reported that *Eucalyptus* hybrid among different components, comparatively lesser variations are explained in case of leaf and branch weight (Table 3).

In the present study, the contribution of root was 25 per cent to the total biomass which was concomitant with the result of Lodhiyal and Lodhiyal (2003) [4] who reported that different biomass components, bole contributed the maximum (65 to 73 %) and root contributed (10 to 21%).

The results depicted a significant difference in total biomass due to ages. In the present study there was increase in biomass over the age which was clearly supported by Ravi (2012) [7] who reported that there was increase in biomass with increase in age of *Casuarina equisetifolia*. The total biomass dry weight differed from 30.31 t ha^{-1} to 149.51 t ha^{-1} in 1st and 5th year old trees respectively. The similar biomass increment was observed by Kraenzel *et al.* (2003) [3] in teak plantations and estimated that the total tree dry biomass varied from 122 to 1365 kg. (Table. 4)

The average percent contribution of different biomass components to the total above ground fresh biomass varies as: stem, 69.12 per cent to 46.91 per cent, branches, 31.96 per cent to 16.17 per cent and leaf, 20.98 per cent to 14.71 per cent. The per cent contribution of root to the total below ground fresh biomass varies from 28.52 per cent to 24.83 per cent. The average per cent contribution of different biomass components to total above ground dry biomass varies as: stem, 63.66 per cent to 47.27 per cent, branches, 32.84 per cent to 11.77 per cent and leaf, 19.98 per cent to 10.88 per cent. The per cent contribution of root to the total below ground dry biomass varies from 29.79 per cent to 24.32 per cent.

The average per cent contribution of different biomass components to the total above ground biomass by different ages shows that the percentage contribution of branches and leaf were decreasing with increasing ages. But the percentage contribution of stem was increasing with ages. In the current study above ground biomass contributed 73.62 per cent and below ground 26.37 per cent contributed to the total biomass. This was clearly evident from the results of Sangha *et al.* (2005) [9] who reported that three-year-old *Eucalyptus tereticornis* trees had above ground biomass of 9.99 t ha^{-1} to 21.69 t ha^{-1} and below ground biomass of 2.6 t ha^{-1} to 5.3 t ha^{-1} and constituted about 81 per cent and below ground 19 per cent of above ground and below ground respectively. The per cent contribution of tree components in the present study were in the order bole > root > branch > leaf.

It is concluded that there was a significant increase in growth and biomass of trees as the age increases. This exponential increase in incremental growth and biomass due to age would occur upto certain age and slow growth in current annual increment. Hence, optimum age for obtaining maximum growth and biomass is to be determined for each tree species as per the objective of the plantation.

Table 3: Above and below ground biomass of *Eucalyptus* plantations at different ages (t ha^{-1})

Age of plantations (yrs)	Above ground biomass (t ha^{-1})						Below ground biomass (t ha^{-1})	
	Stem fresh weight	Stem dry weight	Branch fresh weight	Branch dry weight	Leaf fresh weight	Leaf dry weight	Root fresh weight	Root dry weight
1	16.88	10.55	11.55	7.33	7.55	4.44	12.89	7.99
2	28.21	17.77	13.33	9.33	9.56	6.44	16.88	10.78
3	46.67	29.99	15.55	9.56	12.89	7.56	29.97	19.99
4	64.42	42.21	18.28	15.55	17.00	14.22	36.66	25.00
5	104.41	77.54	24.42	17.78	22.22	16.44	50.86	37.77
SEd	0.094	0.314	0.303	0.381	0.521	0.005	0.004	0.074
CD (0.05)	0.199	0.665	0.642	0.807	1.103	0.010	0.009	0.15

Table 4: Total biomass of *Eucalyptus* plantations at different ages (t ha^{-1})

Age of plantations (yrs)	AGB fresh weight (t ha^{-1})	AGB dry weight (t ha^{-1})	BGB fresh weight (t ha^{-1})	BGB dry weight (t ha^{-1})	Total biomass fresh weight (t ha^{-1})	Total biomass dry weight (t ha^{-1})
1	35.98	22.32	12.89	7.99	48.87	30.31
2	51.10	33.54	16.88	10.78	67.98	44.32
3	75.11	47.11	29.97	19.99	105.08	67.1
4	99.70	71.98	36.66	25.00	136.36	96.98
5	151.05	111.76	50.86	37.77	201.93	149.51
SEd	0.294	0.379	0.004	0.074	0.654	0.371
CD (0.05)	0.623	0.804	0.009	0.157	1.387	0.787

Conclusion

From this study there was a significant increase in growth and biomass of trees as the age increases. This exponential increase in incremental growth and biomass due to age would occur upto certain age and slow growth in current annual increment.

Acknowledgement

The authors are greatful to the Tamil Nadu Agricultural University, Coimbatore for granting permission to conduct the experiment and Tamil Nadu Newsprint and Papers Limited, Karur, Tamil Nadu providing facilities.

References

1. Bertomeu MG, Sungkit RL. Propagating *Eucalyptus* species–recommendations for smallholders in the Philippines. For Farm Comm Tree Res Rep. 1999;4:68-72.
2. Chave J, Réjou-Méchain M, Búrquez A, Chidumayo E,

Colgan MS, Delitti WB, *et al*. Improved allometric models to estimate the aboveground biomass of tropical trees. Global change biology. 2014;20(10):3177-90.
3. Kraenzel M, Castillo A, Moore T, Potvin C. Carbon storage of harvest-age teak (*Tectona grandis*) plantations, Panama. Forest Ecology and Management. 2003;173(1-3):213-25.
4. Lodhiyal N, Lodhiyal LS. Biomass and net primary productivity of Bhabar Shisham forests in central Himalaya, India. Forest Ecology and Management. 2003;176(1-3):217-35.
5. Mugasha WA, Eid T, Bollandsås OM, Malimbwi RE, Chamshama SA, Zahabu E, *et al*. Allometric models for prediction of above-and belowground biomass of trees in the miombo woodlands of Tanzania. Forest Ecology and Management. 2013;310:87-101.
6. Panse VC, Sukhatme PV. Statistical methods for agricultural workers. 2nd edition, ICAR, New Delhi. 1967, 328p.
7. Ravi R. Carbon sequestration potential of Casuarina equisetifolia in coastal tracts of Tamil Nadu (Doctoral dissertation, Ph. D. Thesis, FRI University, Dehra Dun).
8. Rizvi RH, Dhyani SK, Yadav RS, Singh R. Biomass production and carbon stock of poplar agroforestry systems in Yamunanagar and Saharanpur districts of northwestern India. Current science, 2011, 736-42.
9. Sangha KK, Jalota RK. Value of ecological services of exotic *Eucalyptus tereticornis* and native *Dalbergia sissoo* tree plantations of north-western India. Conservation and Society. 2005, 92-109.
10. Verma A, Kaushal R, Alam NM, Mehta H, Chaturvedi OP, Mandal D, *et al.* Predictive models for biomass and carbon stocks estimation in *Grewia optiva* on degraded lands in western Himalaya. Agroforestry systems. 2014;88(5):895-905.
11. Vidyasagaran K, Paramathma M. Biomass Prediction of *Casuarina equisetifolia*, Forest. Plantations in the West Coastal Plains of Kerala, India. Indian J Sci. Res. Technol. 2014;2:83-89.