BIOMASS AND NUTRIENT DISTRIBUTION IN AN AGE SERIES OF EUCALYPTUS HYBRID PLANTATION IN TAMIL NADU. I. DISTRIBUTION OF ORGANIC MATTER

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The chronosequential studies can be employed to compare the pattern and processes, as well as structure and functioning of forest ecosystems. The first step in studying the processes as they relate to productivity is essentially an inventory of the lavels of dry matter (kg/ha) in each component of the ecosystem. The distribution of organic matter in an age series of *Eucalyptus* has received a considerable attention (Singh and Sharma, 1976; George, 1977; Negi, 1984; Negi *et al.*,198 4). These studies are substantially useful in predicting the fate of the younger stand to reach steady state phase on maturity.

The paper presents the estimates of the biomass in *E.* hybrid plantations at different ages established at four different sites in Tamil Nadu (Table 1). The results of this study are applicable for growing of *Eucalyptus* intensively for pulp and fuel wood production and are equally important for estimating the nutrient status in different tree components as well as nutrient drain as a result of harvesting which will be the subject matter of the forthcoming paper.

The study site

These plantations representing nine age classes are located at four different sites (Table 1). The area is situated between 10°1'-20°40'N latitude and 76°44' - 80°15'E longitude within the zone of South Indian thorn forest on sandy loam soil mixed with lateritic gravels. The mean annual rainfall is 800 to 950 mm, whilst the mean maximum and minimum temperature are 40 and 18°C respectively.

Methods

Field studies were conducted during January 1978 (Vendaloor, Pudukkottai and Pollachi) and January 1979 (Selem) using the harvesting method of stratified tree technique for biomass estimatioı (Art and Mark, 1971). In all 14 plantations (Sample Plots) (Table 2) measuring from 0.11 to 0.50 ha depending upon the variability of the crop were enumerated for its diameter at breast height (dbh). The diameter range in each plantation were devided into 3-5 classes depending upon the distribution of the trees. Height and dbh of some of the trees were also measured and diameter/height curve drawn, to get the mean height of each plantation in each diameter class and also mean height of the crop.

In each plantation 3-5 sample trees (one from each diameter class) having diameter and height close to the mean tree of each diameter class were sampled. Thus a total of 62 trees were harvested in the 14 plantations under study. One root system from each plantation was also excavated completely by making a trench around the main stem for determining the underground biomass.

Fresh weight of all components of sample trees were measured in the field by separating them into leaf, twig, branch, bark, bole and roots. Representative samples of all the plant parts were taken to laboratory for its oven dry weight and chemical analysis.

Results and Discussion

Individual tree dimensions : These were the even-aged plantations raised on the areas of South Indian dry thorn forests, apparently having similar edaphic and climatic conditions. However, the Plantation

Table 1

*Site description**

	Chinglepet Div. (Vendaloor)	Pudukkottai Div. (Aremallam)	South Coimbatore Div. (Pollachi)	Selem Div. (Krumbpatty)
Location	12°6'-12°40'N 79°12'-80°15'E	10°1'-11°3'N 76°5'-79°5'E	10°12'-10°54'N 76°44'-77°48' E	11° 8'-12°N 77°45'-78°5'E
Soil	Sandy loam	Sand to loam with mixed lateritic gravel	Sandy loam	Red sandy loam
Temp. (°C)	Coastal type			
Max.	28.3	40	28	33.8
Min.	21.4	20	18	22
Rainfall (mm)	950	800-900	916	850

*Source - Working plans of the respective Divisions.

Table 2

Details of the plantations

Plantation No.	Year of plantation	Age (yrs.)	Area of sample plot (ha)	No. of trees on the plot	No. of trees per ha	Mean dia. of the crop (cm)	Mean ht. of the crop (m)	No. of trees harvested
			CHINGLEPET DIVISION (Vendaloor)					
1	1963	15	0.50	215	430	14.5	14.2	5
2	1958	20	0.50	259	518	14.2	14.0	5
			PUDUKKOTTAI DIVISION (Aremallam)					
3	1971	7	0.25	251	1004	10.7	14.4	4
4	1970	8	0.23	225	978	11.1	14.7	5
5	1961	17	0.50	241	682	17.4	18.8	4
6	1971(c)	7	0.11	167*	1519* (836)	10.8	14.5	5
			SOUTH COIMBATORE DIVISION (Pollachi)					
7	1971	7	0.20	212	1060	14.1	18.3	4
8	1970	8	0.40	427	1068	14.2	18.5	4
9	1969	9	0.30	293	976	14.5	18.5	5
			SELEM DIVISION (Krumbpatty)					
10	1974	5	0.25	320	1284	7.7	9.8	4
11	1973	6	0.25	187	748	10.8	11.8	5
12	1972	7	0.45	237	527	12.6	13.0	5
13	1970	9	0.25	128	512	20.8	19.5	3
14	1972(c)	7	0.25	275*	1100* (480)	16.3	15.6	4

(c) = Coppiced.

* = Coppiced shoots.

Figures in parenthesis are the number of original trees.

No. 1 was mixed with Cashew later on due to the Failure of *E.* hybrid. There was wide range of variation in their growth of the trees even within the same plantations. It is quite evident from the Table 2 that the growth of the trees were very much effected by the stand density. For example the mean dbh at 7 years coppiced at Pudukkottai (10.8 cm with 1519 shoots/ha) is lower than Selem (16.3 cm with 1100 shoots/ha) though the site characteristics are almost same. While on the other hand the growth performance at Pollachi seems to be better compared to other localities, may be attributed to increasing moisture content of the soil.

Above ground biomass : The sample tree data (kg/tree) have been used to calculate the above ground biomass (kg/ha) at different ages and different localities are shown in Table 3. The above ground biomass (kg/ha) shown as increasing trend with age in all localities. The bulk of the biomass is being concentrated in the bole ranging from 52 to 74 per cent of the total above ground biomass. Whereas the per cent contribution in other components are : bark (8-15%), twigs with branch (9-23%) and leaves (4-12%). These results are in general agreement to those of comparable ages studied by Singh and Sharma, 1976; George, 1977; Hingston *et al.*, 1979 and1981 ; Bradstock, 1981 and Negi *et al.*,1984 The branch and twig percentage are more in Selem as compared to other localities which finally has effected the bole percentage which is low at Selem and high in other localities. This clearly indicates that the prevailing condition for *E.* hybrid growth at Selem is not satisfactory and is unable to provide a clean bole, whereas Pollachi seems comparatively to be ideal site for *E.* hybrid and is producing two-fold more biomass than Pudukkottai and three-fold more than Selem at age 7 (Table-3). While in contrast Selem has given the better performance (117211 kg/ha) at age 9 compared to Pollachi (90074 kg/ha) suggesting the influence of the stand density.

With regard to the above ground biomass (kg/ha) in coppiced crop (II rotation), it is 1.4 times more in Pudukkottai and 3.8 times more in Selem when compared with uncoppiced 7 year old crop of the same locality, thus indicating a vigorous growth after Ist rotation. At comparable age of 7 years (Table 3) of coppiced crop the biomass production is almost double at Selem with that of Pudukkottai. It appears that less number of shoots are providing a better chance for canopy expansion and hence more organic matter.

Underground biomass : Though there is a overall increase in the root biomass with the increaseing age (Table 3) but the percent contribution of the root biomass to above ground biomass decreases with the advancing age. While comparing the root biomass at 7 years of age (Table 3) Pollachi is producing more (15616 kg/ha) as compared to Pudukkottai (7124 kg/ha) and Selem (6079 kg/ha), this could be attributed to the better site characteristic for root development

Table 3

Dry matter production (kg/ha) in E. hybrid plantations

Plantation No.	Age. (yrs.)	Trees/ ha	Leaf	Twig	Branch	Bark	Bole	Total above ground	Root	Total Biomass
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	15	430	2154 (6.0)	1543 (14.7)	3736	5143 (14.3)	23451 (65.0)	36027	8719 (24.2)	44746
2	20	518	2292 (5.9)	1383 (15.5)	4667	4881 (12.5)	25842 (66.1)	39065	7060 (18.1)	46125
3	7	1004	3753 (7.8)	2952 (16.2)	4818	6045 (12.6)	30401 (63.4)	47969	7124 (14.9)	55093
4	8	978	2794 (6.1)	2297 (13.1)	3763	6385 (13.8)	30893 (67.0)	46132	6083 (13.2)	52215
5	17	682	3765 (4.2)	3278 (12.5)	8300	9874 (10.6)	67130 (72.7)	92351	12818 (13.9)	105169
6	7*	1519	3340 (4.8)	3546 (13.5)	5776	7452 (10.8)	49103 (70.9)	69217	30495 (44.0)	99712
7	7	1060	4505 (4.7)	4465 (14.8)	9604	10315 (10.8)	66278 (69.7)	95167	15616 (16.4)	110783
8	8	1068	5855 (6.1)	3070 (9.5)	5969	9900 (10.4)	70696 (74.0)	95490	17016 (17.8)	112506

(Contd.)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
9	9	976	4981 (5.6)	3553 (15.2)	10177	11257 (12.5)	60106 (66.7)	90074	13927 (15.5)	104001
10	5	1284	2828 (11.0)	2671 (26.5)	4098	3802 (14.9)	12194 (47.6)	25593	7666 (30.0)	33259
11	6	748	3465 (11.5)	2337 (22.6)	4482	4240 (14.0)	15673 (51.9)	30197	7467 (24.7)	37664
12	7	527	2979 (9.8)	2394 (22.1)	4368	3373 (11.0)	17450 (57.1)	30564	6079 (19.9)	36643
13	9	512	6350 (5.4)	9373 (19.9)	14010	11799 (10.0)	75679 (64.7)	117211	18254 (15.6)	135465
14	7*	1100	6594 (5.7)	5337 (12.1)	8711	12824 (11.1)	82566 (71.2)	116032	46193 (44.0)	162225

* Coppiced.

Figures in parenthesis are percentages of total above ground biomass.

to commensurate with the above ground biomass as noted earlier. With regard to the root/shoot (R/S) ration the low productivity at Selem has been attributed to high R/S ratio. It appears that Selem is comparatively drier than the other localities. Therefore, most of the net production accumulates in the root system. In case of coppiced crop the percentage contribution of roots is between 40-44 per cent of the above ground biomass. The obvious reason for this increment is the remains of the original root system. The original root system supplies the easily available reserve food to the coppicing shoots resulting to a vigorous growth which leads to higher biomass production. Further it is interesting to note that there is a proportionate increment in the above ground biomass with that of under ground biomass. For example at Selem and Pudukkottai the ratio between above ground and under ground biomass is nearly 1.6 times (Tabel 3).

Leaf efficiency : Mean Annual Leaf Efficiency (MALE) which has been obtained deviding the total biomass by foliage biomass and age of the crop. It is observed that MALE (Table 4) at Pollachi and Pudukkottai is more at the age of 7 years as compared to Selem indicating the better site index for the *Eucalyptus* planting. Though the leaf efficiency is conditioned not only by site factor but also by genetic factors (of species and race), age or rotation, by the biotic history of the stand density. For example the Vendaloor being a poor site the leaf efficiency is also affected by the age. This can also be coupled with the fact that there is a tendency for lavelling off in leaf production at older age and hence the lower rate of biomass accumulation. This is in conformity with the result reported for biomass in an age series of *E. grandis* plantation in Australia where the foliage biomass exhibits the tendency of lavelling off at older age (Bradstock, 1981). It is also quite evident from Table 4 that the leaf efficiency increased in coppiced crop indicating that the leaves become more efficient after Ist rotation to produce higher biomass (Table 4).

Productivity : The Mean Annual Production (MAP) of various plantations in different localities is shown in Table 5. The MAP of non-photosynthetic component was obtained by dividing the total biomass of each component by the age of the plantation. It is evident from Fig. 1 that there is a consistent decease in the MAP with the increasing age in almost all localities. Similarly the rate of accumulation of dry matter (kg/tree/year) in non-photosynthetic components also follows the same trend, excepting Selem where the site has not yet achieved the maximum MAP. This can be supported by the MAP (kg/tree) (Table 5) which is also increasing consistently from 5 to 9 years of age. It is most probably that a stand of a given species of a given age on a given site will produce the same amount in a year at various densities as long as

Table 4

Mean annual leaf efficiency in E. hybrid

Locality	Aged (yrs.)	Stand density (trees/ ha)	Leaf biomass (kg/ha)	Total biomass (kg/ha)	Mean annual leaf efficiency* (kg/ha)
		ORIGINAL PLANTATIONS			
Chenglepet Division	15	430	2154	44746	1.38
	20	518	2292	46125	1.00
Pudukkottai Division	7	1004	3753	55093	2.10
	8	978	2794	52215	2.33
	17	682	3765	105169	1.64
South Coimbatore Division	7	1060	4505	110783	3.51
	8	1068	5855	112506	2.40
	9	976	4981	104001	2.32
Selem Division	5	1284	2828	33259	2.35
	6	748	3465	37664	1.81
	7	527	2979	36643	1.76
	9	512	6350	135465	2.37
		COPPICED PLANTATIONS			
Selem Div.	7	1100	6594	162225	3.51
Pudukkottai Division	7	1519	3340	99712	4.26

*Mean annual leaf efficiency = $\frac{\text{Total biomass}}{\text{Leaf biomass x age}}$

Table 5

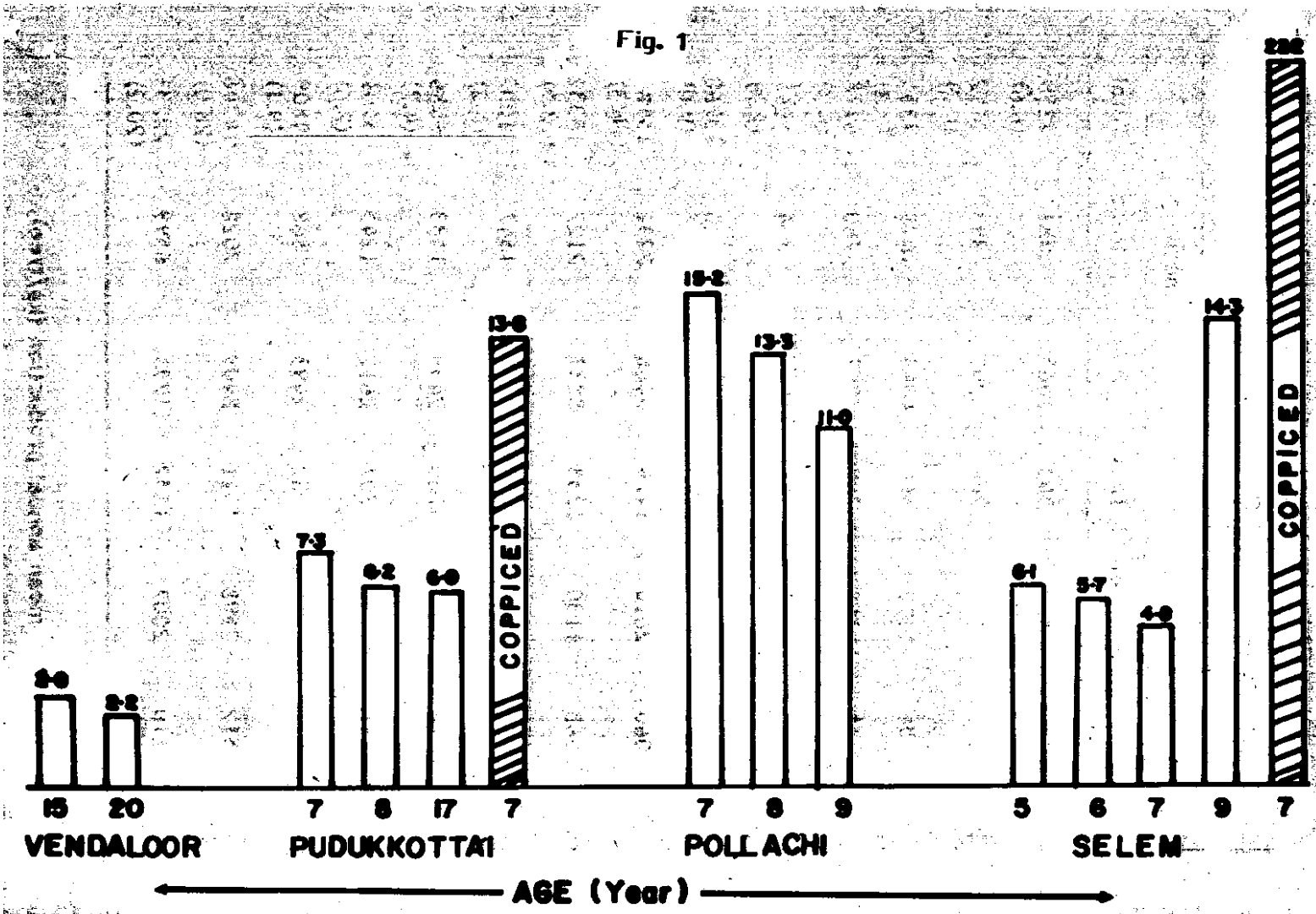
Mean annual production (kg/ha) in E. hybrid plantation

Plantation No.	Age (yrs.)	Trees/ha	Non-photosynthetic				
			Branch	Bark	Bole	Root	Total
1	15	430	352	343	1563	581	2839 (6.6)
2	20	518	303	244	1292	393	2192 (4.2)
3	7	1004	1110	864	4343	1018	7335 (7.3)
4	8	978	758	798	3862	760	6178 (6.3)
5	17	682	681	581	3949	754	5965 (8.7)
6	7*	1519	1332	1065	7015	4356	13768 (9.0)
7	7	1060	2010	1474	9468	2231	15183 (14.3)
8	8	1068	1130	1238	8837	2127	13332 (12.5)
9	9	976	1526	1251	6678	1547	11002 (11.2)
10	5	1284	1354	760	2439	1533	6086 (4.7)
11	6	748	1137	707	2612	1245	5701 (7.6)
12	7	527	966	482	2493	868	4809 (9.1)
13	9	512	2598	1311	8409	2028	14346 (28.0)
14	7*	110	2007	1832	11795	6599	22233 (20.2)

*Coppiced.

Figures in parenthesis are mean annual production (kg/tree).

Fig. 1



Mean annual production (t/ha) in Eucalyptus hybrid plantations.

the site is fully occupied. It can thus be safely concluded that the rotation at Pudukkottai and Pollachi can be fixed at age 7. These results are somewhat similar to those reported earlier for *E. globulus* grown in Tamil Nadu where the maximum MAP was observed at age 7 (Negi *et al.*, 1984). However, the same cannot be predicted for Selem as it appears (Fig. 1) that the MAP is consistently declining with increasing age upto 7 years. Further a spurt in growth at 9 years of age could be due to the variability between sites of the same locale. With regard the MAP in coppiced crop Selem is producing nearly 1.5 times more with that of Pudukkottai (Fig. 1), because a thinned stand or even in open stand, trees would be in advantageous position to utilize the available environmental resources, otherwise shared by the individuals of the same species. Further, the leaf efficiency at both the locales is almost same but the lower stand density (1100 shoots/ha) at Selem has given a better chance for high leaf production (6594 kg/ha) and consequently the higher biomass production (162225 kg/ha) as well.

Thus, it could be concluded on the basis of above results that (i) the rotation age for *E.* hybrid can be fixed at 7 years where the mean annual production is at the maximum, (ii) Pollachi seems comparatively better site and (iii) to increase the productivity in a coppiced crop; thinning is essential.

Summary

The distribution of organic matter in an age series of Eucalyptus hybrid plantations in Tamil Nadu has been discussed. It was observed that (i) the rotation age for E. hybrid can be fixed at 7 years where the Mean Annual Production (MAP) is at the maximum, (ii) Pollachi seems to be comparatively better site for E. hybrid planting presumably due to higher leaf efficiency and (iii) to increase the productivity in a coppiced crop thinning is essential as the lower stand density gives a better chance for high leaf production and consequently higher biomass.

तामिलनाडु के संकर युकेलिप्टस रोपवन की आयु संश्रेणी में जैवपुंज और पोष्याहार वितरण—I, जैवपदार्थ का वितरण

जे० डी० एस० नेगी व एस० सी० शर्मा

सारांश

तामिलनाडु के संकर – युकेलिप्टस रोपवन की आयु संश्रेणी में जैवपदार्थ के वितरण का विवेचन किया गया है। इसमें यह देखा गया है कि, 1– संकर युकेलिप्टस की आवर्तन उम्र 7 वर्ष रखी जा सकती है जहां कि पोलाची और पुदुकोट्टाई में माध्यवार्षिक उत्पादन अधिकतम है, संभवत: अधिक पर्ण कार्य क्षमता के कारण क्योंकि ये स्थल संकर युकेलिप्टस लगाने के लिए अधिक अच्छे हैं, 2–उत्पादकता बढ़ाने के लिए स्थूलकल्प वनों में विरलन कराना आवश्यक है क्योंकि कम घनत्व रखने से पत्तियां अधिक उत्पन्न होती हैं और फलत: जैवपुंज भी अधिक होता है।

References

Art, H.W. and *P.L. Marks* (1971). A summary table of biomass and net annual primary production in forest ecosystems of the world. *Forest Biomass Studies* (Ed. H.E. Young). Life Science and Agri. Exp. Sta. University of Maine, Orono, Maine, U.S.A.

Bradstock, R. (1981). Biomass in an age series of *Eucalyptus grandis* Plantations. *Aust. For. Res., 11:* 111-27.

George, M. (1977). Organic productivity and nutrient cycling in *Eucalyptus* hybrid plantations. *Ph. D. Thesis,* Merrut Univ., Meerut.

Hingston, F.J., A.G. Turton and *G.M. Dimmock* (1979). Nutrient distribution in Karri (*Eucalyptus diversicolor* F. Muell.) ecosystems in South West Western Australia. *For. Ecol. Manage.,* 2: 133-158.

.....(1981). Nutrient distribution in Jarrah (*Eucalyptus marginata* Donn. ex Sn.) ecosystems in South West Western Australia. *Forest Ecol. Manage.,* 3: 183-207.

Negi, J.D.S. (1984). Biological productivity and cycling of nutrients in managed and man-made ecosystems. *Ph. D. Thesis,* Garhwal Univ., Srinagar, Garhwal.

Negi, J.D.S., N.K.S. Bora, V.N. Tandon and *H. D. Thapliyal* (1984). Distribution of organic matter in an age series of *E. globulus* plantations in Tamil Nadu. *Indian For.,* 110 (8): 802-813.

Singh, R.P. and *V.K. Sharma* (1976). Biomass estimation in five different aged plantations of *Eucalyptus tereticornis* Smith. in Western Uttar Pradesh. *Oslo Biomass Studies.* College of Life Science and agriculture, Univ. of Maine, Orono, U.S.A.