BIOMASS AND NUTRIENT DISTRIBUTION IN YOUNG TEAK (*TECTONA GRANDIS* LINN. F) PLANTATIONS IN TARAI REGION OF UTTAR PRADESH

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Introduction

Though teak forests have been created on large scale, at present no data is available to understand the effect of these monocultures on the site. Recently, Tewari (1992) has presented a comprehensive review of the work undertaken so far on this aspect. The purpose of this paper is to present data on (i) above and below ground biomass and its distribution among various tree components, (ii) the relationship between the tree parameters and the yield expressed as dry weight, (iii) the distribution of nutrients, to understand the effect of whole tree harvesting in an age series of young teak plantations.

Study Site

The studies were undertaken in 10, 20 and 30 years old Teak (*Tectona grandis* Linn. f) plantations, in Tarai Central Division of Uttar Pradesh. These plantations are situated in the zone of tropical moist deciduous forest types. The mean annual rainfall varies from 1300 mm to 1650 mm. The soil in alluvial loam and the undergrowth consist of few herbs and grasses.

Experimental Methods

The studies were conducted in 1992 using the harvesting method of stratified tree technique for estimating the biomass. A homogeneous patch was located in each stand and two to three temporary sample plots were laid out. At least 25 m buffer strip was left around each plot to ensure that stand development is not influenced by edge effects. The diameter (DBH) of all the standing trees within the plots were recorded. In order to have a better distribution of sample trees over the population for regression analysis, the whole diameter range in each stand was divided into three diameter classes and the sample trees were selected as being nearest to the average of each class (Ovington *et al.*, 1967). One root system of the sample tree having d.b.h. close to d.b.h. of the mean tree of the crop was excavated in each plantation for estimating the underground biomass. The oven dry weight of other sample trees (Table 1, marked with asterisks) have been calculated on the basis of the ratio of root biomass to above ground biomass. In all nine trees were sampled. Immediately after felling the sample trees, the fresh weight of each of the biomass component was recorded

Table 1

Component wise dry weight of sample tree (kg / tree) at different aged Tectona grandis plantations

Age (yrs)	Density per ha	Tree Category	Wood	Bark	Leaf	Twig	Branch	Total above ground biomass	Root	Total biomass
		A	40.132	7.868	8.640	5.507	7.800	69.947	15.710*	85.657
10	570	B	64.198	9.731	5.580	6.400	10.263	96.172	21.600	117.772
		C	105.484	14.750	11.520	12.133	25.230	169.117	37.983*	207.100
		A	26.065	8.304	2.667	6.240	3.690	46.966	9.490*	56.456
20	500	B	96.181	17.394	6.750	6.390	15.990	142.705	28.835	171.540
		C	171.903	31.529	17.480	16.200	43.240	280.352	56.648*	337.000
		A	58.593	11.363	5.700	8.690	9.571	93.917	16.473*	110.390
30	494	B	202.438	25.519	15.400	10.000	26.800	280.157	49.140	329.297
		C	336.303	37.693	25.999	33.600	119.467	553.062	97.008*	650.070

Note : Figures marked with asterisks are calculated values as roots were not sampled in these trees.

and representative samples of known weight were collected for oven dry estimation and chemical analysis.

The basic data of the sample trees (Table 1) were statistically analysed to obtain a set of regression equations for prediction of biomass on a regional basis to avoid the necessity of repeated destructive sampling to a great extent. Each biomass component was considered separately. The relationship between the oven dry weight and measurable features such as diameter at breast height and total height of trees were studied. Various linear models were tried using d.b.h. and height as independent variable. DBH alone was found to give reasonably precise values of biomass.

The regression equation developed for different characters along with the value of coefficient of determination (R^2) are given below :

Bole Biomass

$Y = 0.03343\ x^{2.73532}$ $R^2 = 0.98095$

Bark Biomass

$Y = 2.45896\ e^{0.0984x}$ $R^2 = 0.8915$

Leaf Biomass

$Y = -12.49108 + 1.253875x$ $R^2 = 0.9002$

Twig Biomass

$Y = 1.592118\ e^{0.0965x}$ $R^2 = 0.8526$

Branch Biomass

$Y = 0.570279\ e^{0.1823x}$ $R^2 = 0.9717$

Total above Biomass

$Y = 0.0758\ x^{2.6135}$ $R^2 = 0.9847$

Root Biomass

$Y = 0.0241\ x^{2.45322}$ $R^2 = 0.9803$

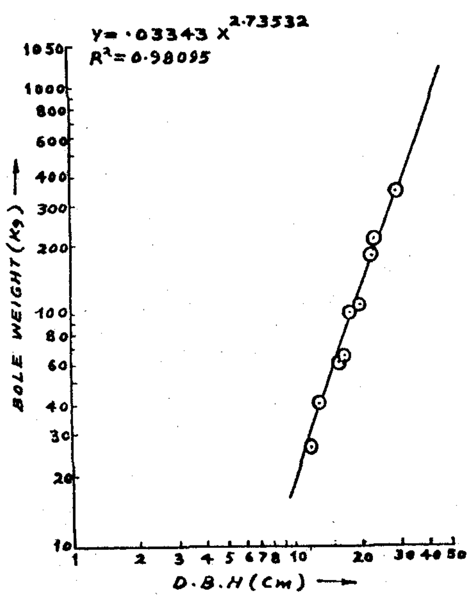
Total Biomass

$Y = 0.0982\ x^{2.5873}$ $R^2 = 0.9862$

Where Y is biomass and x is DBH

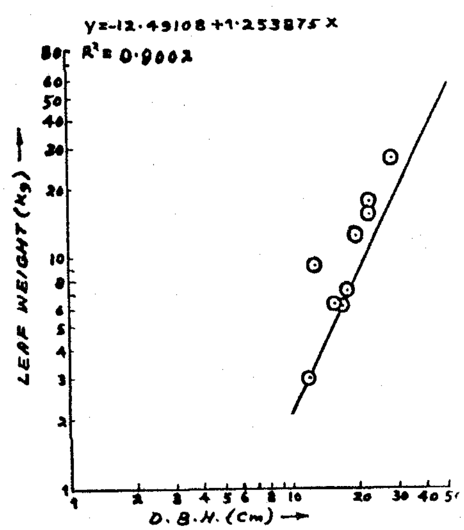
The actual figures of dry weight of different biomass components were plotted separately on log-log graph paper against DBH and above mentioned regression

Fig. 1



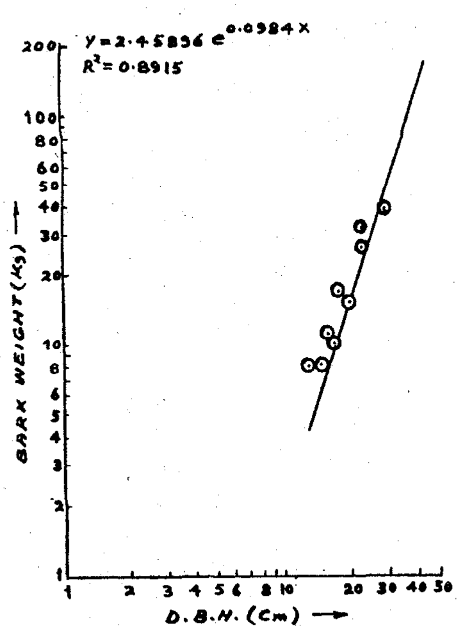
Bole weight/DBH

Fig. 3



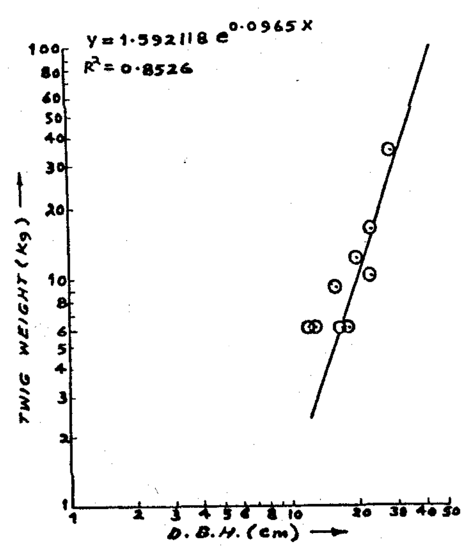
Leaf weight/DBH

Fig. 2



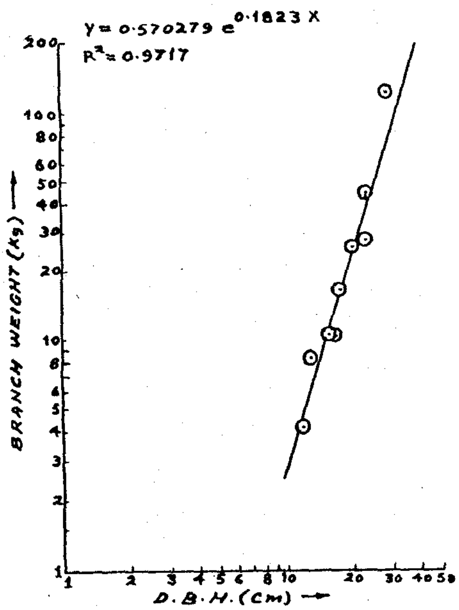
Bark weight/DBH

Fig. 4



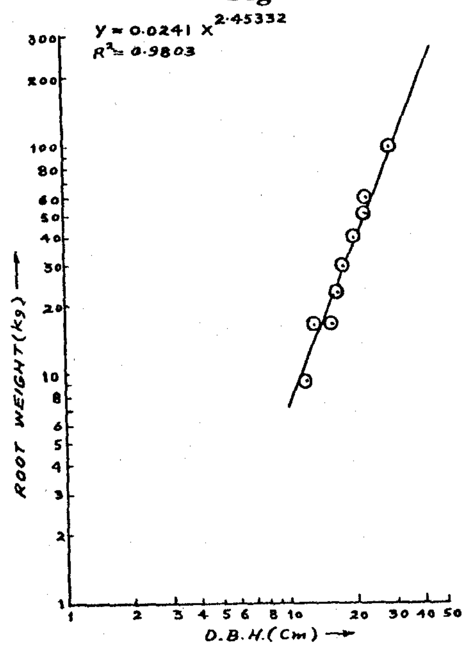
Twig weight/DBH

Fig. 5



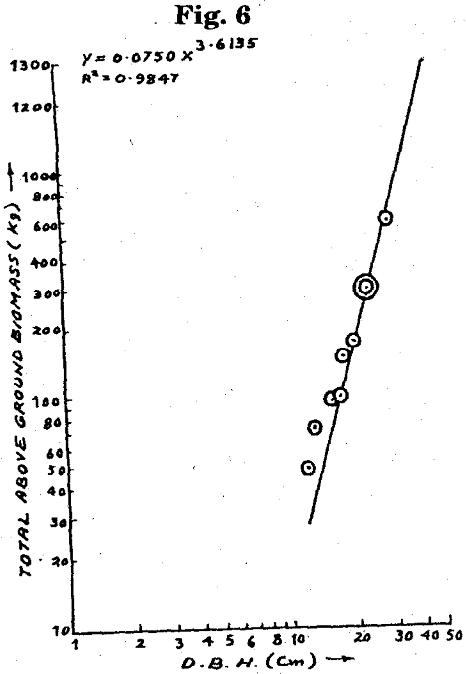
Branch weight/DBH

Fig. 7



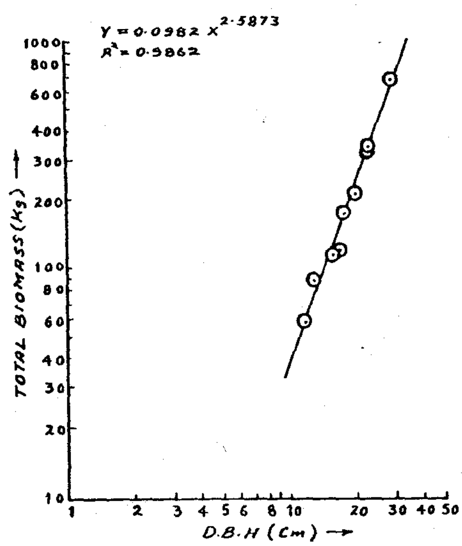
Root weight/DBH

Fig. 6



Total above-ground biomass/DBH

Fig. 8



Total biomass/DBH

equations fitted (Fig. 1 to 8). Highly significant correlations confirm that DBH can be used as reliable parameter for prediction purposes.

Biomass

The accumulation of organic matter in these stands on an unit area (t/ha) has been derived from regression on diameter at breast height (d.b.h.) and is given in Table 2. The above ground biomass of these plantation is in the order of 74.6, 90.7 and 164.1 t/ha at the age of 10, 20 and 30 years respectively, showing the growth of biomass with age. Similar trend of increasing biomass with increasing age was observed for all the biomass components. The above ground biomass increases more than twice from 74.6 t/ha at the age of 10 years to 164.1 t/ha at 30 years of age. With regard to the percentage contribution of different biomass components to the above ground biomass, bole contributes the maximum, 60 to 65 per cent and rest is attributed to other components. There is decreasing trend is percentage contribution of other biomass components except branch. The percentage of root biomass in different plantation varies between 17 to 21 per cent of the total above ground biomass.

Nutrient Distribution

The concentration of nutrients in different tree components varies considerably. Though in general, highest concentration of nutrients was observed in leaf, the accumulation of N, P and Mg was observed in bole and maximum Ca was held up in bark and roots and K in roots. The nutrients accumulated in the above ground biomass range from N 225 to 359 kg/ha; P 14 to 28 kg/ha; K 152 to 265 kg/ha; Ca 426 to 748 kg/ha; and Mg 107 to 229 kg/ha in these plantations (Table 3).

Harvesting of only utilizable biomass (148 t/ha) at the age of 30 years would result in the removal of 247, 41, 170, 632 and 198 kg/ha of N, P, K, Ca and Mg respectively.

Discussion

It is evident from the data that there is much variation in the diameter (dbh) within the same plantations. The mean tree of the highest diameter class is nearly two times the diameter of the lowest class, such variation among the population has also

Table 2

Total standing biomass (t / ha) of different aged Tectona grandis plantations

Age	Bole	Bark	Leaf	Twig	Branch	Total a.g.b	Root	Total biomass
10	48.2	7.9	5.2	5.0	8.3	74.6	15.4	90.0
	(64.6)	(10.6)	(7.0)	(6.7)	(11.1)		(20.6)	
20	58.1	8.9	5.5	5.5	12.7	90.7	17.9	108.6
	(64.1)	(9.8)		(6.1)	(14.0)		(19.7)	
30	98.8	13.9	7.8	8.5	35.1		28.5	192.6
	(60.2)	(8.5)	(4.8)	(5.2)	(21.4)	164.1	(17.4)	

Note - Figures in parenthesis indicate the percentage of the total above ground biomass.

Table 3

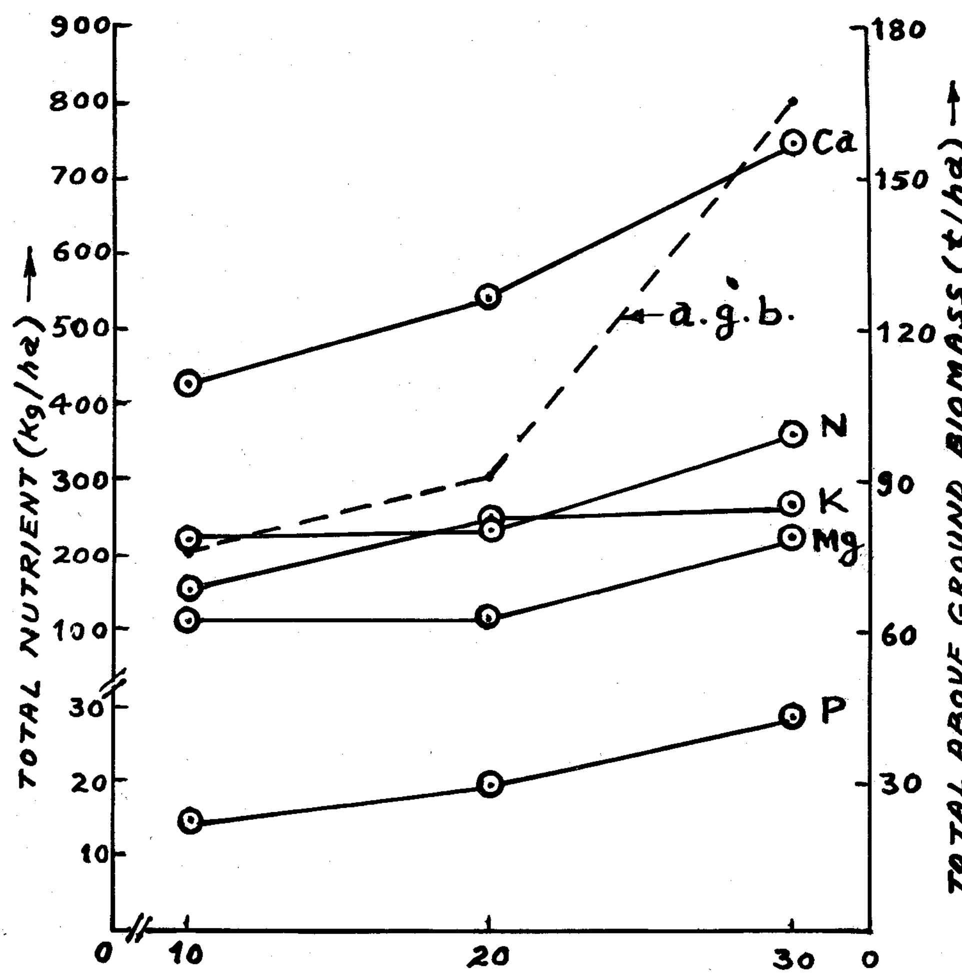
Mineral contents in biomass components (kg / ha)

Nutrients		Age (Years)		
		10	20	30
N	Bole	92.87	91.52	175.97
	Bark	27.51	35.56	28.26
	Leaf	59.54	64.39	111.32
	Twig	16.79	16.89	32.60
	Branch	28.26	19.53	43.00
	Total a.g.b.	224.97	227.89	358.55
	Root	47.46	72.32	63.57
	Total	272.43	300.21	422.12
P	Bole	4.04	10.17	18.52
	Bark	2.45	2.88	3.53
	Leaf	2.63	1.31	2.18
	Twig	1.33	0.89	2.17
	Branch	3.14	4.11	2.05
	Total a.g.b.	13.59	19.36	28.45
	Root	4.42	6.43	12.22
	Total	18.01	25.79	40.67
K	Bole	36.34	61.02	46.31
	Bark	33.62	63.43	51.80
	Leaf	35.02	48.73	61.12
	Twig	24.75	22.23	34.05
	Branch	22.76	37.01	71.67
	Total a.g.b.	152.49	232.42	264.95
	Root	83.89	144.64	190.70
	Total	236.38	377.06	455.65
Ca	Bole	80.76	101.69	185.23
	Bark	195.62	320.05	337.89
	Leaf	61.29	14.36	82.22
	Twig	51.26	38.67	34.05
	Branch	36.89	61.68	108.53
	Total a.g.b.	425.82	536.45	747.92
	Root	143.49	176.78	244.49
	Total	569.31	713.23	992.41
Mg	Bole	56.53	71.19	157.45
	Bark	17.12	7.69	8.24
	Leaf	14.01	13.92	20.37
	Twig	8.84	7.11	10.14
	Branch	10.99	13.36	32.76
	Total a.g.b.	107.49	113.27	228.96
	Root	39.74	57.86	58.68
	Total	147.23	171.13	287.64

been reported earlier in this region, *Eucalyptus* hybrid (George, 1977); *Populus deltoides* (Tandon *et al.*, 1991).

Keeping in view the contribution of diameter and height to the component plant parts and total biomass, linear relationship was established, using d.b.h. as prediction variable. Though D^2H may slightly improve the prediction, but where the trees are sampled from the same locality and for the same species, under such uniform condition, the relationship between d.b.h. and height is very close and inclusion of height does not contribute significantly to regression (Schonan and Boden, 1981). In the present study, the regression equation (equation 1 to 8), using d.b.h. as independent variable, show a highly significant correlation. The relationship for leaf and twig are slightly weaker. This may be attributed to biotic disturbances, such as lopping etc. Thus

Fig. 9



Total retention of nutrients (kg/ha) accumulated in Total above-ground biomass (t/ha) d.b.h. alone can safely be used for prediction of biomass of this species in this region, as reasonably precise value of biomass can be obtained with this parameter.

The total standing biomass increases with increasing age from 74.6 t/ha (10 years) to 164.1 t/ha (30 years). Kaul *et al.* (1979) estimated total above ground biomass 130 t/ha at the age of 38 years. Negi *et al.*, (1990) in their comparative study on Teak and Gamar carried out in Tripura estimated 114 t/ha at the age of 20 years for this species, which is higher than that recorded in the present study at the same age (90.7 t/ha). While Hase and Foelster (1983) have estimated 398 t/ha for a mature crop of teak.

The increase in nutrient content of standing crop with stand age has a direct bearing on the total biomass and stand age. As such the nutrient content accumulated in various tree component varies considerably. In general the accumulation of mineral is higher in leaf in younger plantations but as the stand increases in age, the biomass of non-photosynthetic components increases and the major portion of all the nutrients are accumulated in bole, while maximum Ca is held up in bark. In the present study, it is observed that considerable amount of Ca is accumulated in roots, Negi *et al.* (1990) have also reported higher accumulation of Calcium content (Ca) in this species. Figure 9 shows the accumulation of nutrients (kg/ha) in the above ground biomass.

Rannie (1955) probably for the first time, has drawn attention towards very considerable amount of nutrients immobilized in the crop and has questioned the ability of poorer soils to supply over prolonged period the nutrients required to maintain continuous timber production. The nutrient elements are lost from the site in a number of ways, the greatest loss being though tree removal. The perusal of the present data shows that a considerable amount of nutrients are tied up in the aerial organs of the tree (Fig. 9), some advantage, however, could be gained over several rotations by leaving foliage on the site. The present data indicate that leaving foliage at the site still results in relatively large amount of nutrients being removed. The possibility of depletion of nutrients on harvesting specially calcium content (Ca) from the soil cannot be ruled out. This is in general agreement to studies reported earlier (Negi *et al.*, 1990; Hase and Foelster, 1983). These authors have predicted that substantial amount of Ca will be removed from the site by teak harvesting and these exports may not be replenished by atmospheric imports and soil weathering. Debarking at the site is suggested. This would not only compensate the removal of Ca but also reduce the drain of the other nutrients to some extent. There is, however, an urgent need to establish the rate and amount of various nutrients that are removed from a variety of sites as a result of whole tree harvesting. Thus for proper management of these ecosystems, studies on mineral budget and cycling of mineral is important to maintain the fertility status of the soil, which would ultimately affect the productivity.

Acknowledgements

The authors are thankful to Shri Rajesh Kumar, Division of Facility, Forest Research Institute, Dehra Dun and his staff for statistically analysing the data. The invaluable help rendered by the State Forest Department, U.P. specially the Divisional Forest Officers, Tarai Central and Haldwani Divisions by providing necessary facilities during collection of field data is also gratefully acknowledged.

SUMMARY

Estimates of component wise dry matter production and nutrient distribution of 10, 20 and 30 years old plantations of Teak (*Tectona grandis* Linn. f) have been discussed. Linear regresssion analysis was carried out. Among the prediction variables tried, DBH alone was found to give reasonably precise values of biomass and can be used for prediction purposes. The total standing biomass of these stands increases with increasing age and diameter from 74.5 t/ha (10 years) to 164.1 t/ha (30 years). Maximum amount of N, P and Mg was accumulated in hole while higher accumulation of Ca was observed in bark and roots. Harvesting of only utilisable biomass (148 t/ha) at the age of 30 years would result in the removal of 247, 41, 170, 632 and 198 kg/ha of N, P, K, Ca and Mg respectively. Defoliating and debarking at the site is suggested to reduce the drain of nutrients from the soil especially Ca contents.

उत्तर प्रदेश में तराई क्षेत्र के सागौंन (*टैक्टोना ग्रांडिस* लि० वत्स) के कम उम्र रोप-वनों में जैवपुंज और पोष्याहारों का वितरण

एम०एस० नेगी, वी०एन० टण्डन व एच०एस० रावत

सारांश

सागौन (*टैक्टोना ग्रांडिस* लि० वत्स) के 10, 20 और 30 वर्षीय रोपवनों में शुष्क पदार्थ उत्पादन और पोष्याहार के अवयववार वितरण के अनुमानों का विवेचन किया गया है । रेखीय प्रतीपायन विश्लेषण किया गया है । इसमें परीक्षित भविष्यानुमान विचरों में केवल वक्षोच्चा पर व्यास ही संतोषप्रद सुतथ्यता से जैवपुंज की अर्हाओं का अनुमान देता पाया गया है और उसे भविष्य कथन के लिये उपयोग में लाया जा सकता है । इस खड़े वनों के वृक्षों का जैवपुंज रोपवन की उम्र और व्यास में वृद्धि के साथ-साथ 74.5 टन/हेक्टेयर (10 वर्ष) से 164.1 टन/हेक्टेयर (30 वर्ष) तक बढ़ता जाता है । नाइट्रोजन, फास्फोरस और मैगनीशियम की अधिकतम मात्रा तने में एकत्रित होती पाई गयी जबकि कैलशियम का अधिक जमाव छाल और जड़ो में होता पाया गया है । केवल उपयोजनीय जैवपुंज (148 टन/हेक्ट०) की ३० वर्ष की उम्र में कटाई करने का परिणाम नाइट्रोजन, फास्फोरस, पोटाशियम, कैलशियम और मैगनीशियम का क्रमशः 247, 41, 170, 632 और 198 क्रिग्रा/हेक्टेयर मात्रा निकलना होगा । मृदा से पोष्याहार निकल कर जाना विशेषकर कैलशियम, घटाने के लिए काटने की जगह पर ही पत्तियाँ और छाल उतार देने का सुझाव दिया गया है ।

References

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

Hase, H. and H. Foelster (1983). Impact of plantation Forestry with teak (*Tectona Grandis*) on the nutrients status of alluvial soils in West Venezuela. *For. Ecol. Manage* **6** (1) : 35-57.

Kaul, O.N., D.C. Sharma, V.N. Tandon and P.B.L. Srivastava (1979). Organic matter and plant nutrients in a teak (*Tectona grandis*) plantation. *Indian Forester,* **105** (8) : 573-582.

Negi, J.D.S., V.K. Bahuguna and D.C. Sharma (1990). Biomass production and distribution of nutrients in 20 years old teak (*Tectona grandis*) and Gamar (*Gmelina arborea*) plantation in Tripura. *India Forester*, **116** (9) : 681-686.

Ovington, J.D., W.G. Forrest and J.E. Armstrong (1967). Tree biomass estimation. *Symp. Pri. Pro. & Min. Cycling in Natural Ecosystem*, Maine : 4-31.

Rannie, P.J. (1955). The uptake of nutrients by Mature Forest Growth. *Plant & Soil* **VII** : 49-95.

Schonan, A.P.G. and D.I. Boden (1981). Preliminary biomass studies in young *Eucalyptus. XVII IUFRO World Congress*, Kyoto, Japan : 51-58.

Tandon, V.N., M.C. Pande, H.S. Rawat and D.C. Sharma (1991). Organic productivity and mineral cycling in plantations of *Populus deltoides* in Tarai Region of Uttar Pradesh. *Indian Forester*, **117** (8) : 596-608.

Tewari, D.N. (1992). *A Monograph on Teak* (*Tectona grandis* Linn. f) Int. Book Distributors, Dehra Dun.

Snippets ENVIRONMENT

The National Particle-board Assoc. has pledged $ 150,000 over 3 years to sponsor a program of environmental communications and advertising. The campaign, part of the Wood Works campaign, will be organized by the Wood Product Promotion Council. The particleboard industry is based on use of residues and has invested extensively in research on issues related to the environment.

Source : *Forest Products Journal,* Vol. 45, No. 5