The Planter, Kuala Lumpur, 79 (925): 253 -261 (2003)

Timber Yield Potential of *Hevea* Clones in India: A Preliminary Assessment

VISWANATHAN P K; THARIAN GEORGE K AND TOMS JOSEPH
Economic Research Division, Rubber Research Institute of India, Kottayam 686 009, Kerala, India

The objective of the paper is to examine the timber yield potential and related aspects of three Hevea *clones,* viz., *a) irradiated clones; b) RRIM 600 and c) RRII 200 series grown in India. Based on the final stand of the trees per hectare at the time of felling, the total green wood volume has been found to be the highest for RRII 200 series (183 m^3/ha) followed by RRIM 600 (124 m^3/ha) and irradiated clones (93 m^3/ha). The clone RRII 200 series has also been identified as the top yielder in terms of the utilisable wood volume and timber yield per tree with an average yield of 0.43 m^3 per tree in relation to RRIM 600 (0.37 m^3/ tree) and the irradiated clones (0.24 m^3/ tree). The analysis of girth class-wise variability in timber yield showed lower levels of variability for RRII 200 series in all the girth classes compared to RRIM 600 and Irradiated clones, which is suggestive of the consistent growth of the clones of RRII 200 series. The relationship between and the influence of basal area on timber volume has also been examined to detect the tapering effect on the trees among the three clones and it was found to be in the negative, which validates that tapering effect will be minimum in even-aged mono-clonal plantations. The paper highlights the importance of promoting an integrated breeding and planting policy for natural rubber (NR) in India with the priority on maximisation of net income per unit area rather than the hitherto followed unilateral focus on latex yield potential. Although the analysis is confined to timber yield potential and related aspects of the three experimental trials, it is indicative of the importance of undertaking detailed multi-disciplinary analysis of clone-specific and region-specific latex timber potential of the popular as well as the pipeline clones in India.*

Keywords: *Timber yield, full circular volume, quarter girth volume, basal area, latex timber clones.*

The unique advantage of rubber plantations *vis-à-vis* other major plantation crops is the higher salvage value arising from the commercial exploitation of rubberwood suitable for various industrial applications. The evolutionary dynamics of rubberwood during the past three decades from a source of fuel wood to a raw material for value added furniture and panel products has been remarkable and the current estimated size of the world market for rubberwood based products is more than US$ 2 billion. In this regard, the pioneering research and development efforts initiated by Malaysia since the 1970s in developing not only rubberwood based value added products but also the subsequent development of latex timber clones (LTC) with higher timber yield potential are commendable. The reported timber yield potential of the latex timber clones (LTCs) at 14 years of planting varied from 0.81 to 1.87 m^3 per tree (Malaysian Rubber Board, 1998). Though India is a net importer of wood and wood products amounting to US$458.82 million during 1999-2000 (DGCIS, 2000), its efforts towards the promotion of rubberwood in general and development of LTCs in

e-mail: vishwa33@rediffmail.com

particular are only in the preliminary stages. It is also important to note that there are no realistic estimates based on empirical studies as regards the clone-wise availability of timber from rubber plantations in India except the estimates at the aggregate level on the total availability of rubberwood in the country, sector-wise consumption, price trends, *etc*. Although the systematic collation of statistics on timber yield potential of *Hevea* clones in India is a cumbersome process, initiatives in this direction deserve due attention in the context of the emerging challenges posed on the economic viability of NR cultivation.

It is in this backdrop that the present paper is perceived with a view to highlight certain important aspects of timber yield and related attributes of three *Hevea* plantations, which were experimentally planted as part of the clone evaluation trials at the Central Experimental Station (CES) of the Rubber Research Institute of India (RRII) in the early 1970s primarily for latex yield evaluation. The objectives of the study were to:

(a) assess the timber yield of three *Hevea* clones and its composition;
(b) examine the variability in timber yield across clones and girth classes; and
(c) determine the influence of basal area and girth on timber volume across the clones.

MATERIALS AND METHODS

The analysis is based on an assessment of field level data on timber volume of three *Hevea* planting materials *i.e.* three plots, *viz*., irradiated clones, RRIM 600 and RRII 200 series (*i.e.* RRII 201 to 208). While RRIM 600 and RRII 200 series are reported to have distinct attributes in terms of their origin, secondary characteristics, yield and related aspects, enabling their potential use in future hybridisation programmes, the genetic as well as yield related attributes of the irradiated clones are not so promising. The commercial yield of rubber is reported to be higher in the case of RRII 200 series compared to that of RRIM 600. For instance, the commercial yield of RRII 208 was reported at 1250 kg per hectare against 1123 kg per hectare in the case of RRIM 600 during the first five years of tapping (Joseph *et al.*, 1999: 35). As the plots under discussion were intended for clear felling for further experimental planting, the field level data on girth and height of 1058 trees have been collected by employing census method. The measurement of girth was taken at breast height, which is generally accepted as the standard height. Height of the trees was recorded by using a bamboo pole with a calibrated length of 5 metres.

The per tree timber volume has been estimated by using the full circular method and the quarter girth method as suggested in Chaturvedi and Khanna (1982: 99). Basal area is the cross sectional area of a tree at breast height and is estimated to understand the clonal differences in taper, which is the rate of change in girth over a specified length or height of trees (Philips, 1994: 45). The cross sectional area, which is internationally denoted as 'g' was estimated based on Philips (1994:18). A log linear function was used to determine the influence of basal area on timber volume of the three clones.

RESULTS AND DISCUSSION

The salient features of the three plots considered for the analysis are shown in *Table 1*.

All the three plots were of almost 30 years of age with the plot planted with irradiated

TABLE 1
PROFILE OF THE SAMPLE EXPERIMENTAL PLANTATIONS AT THE CES

Clone	*Year of planting*	*Area planted (ha)*	*Initial planting density*	*Age at clear-felling (years)*	*Final stand at clear-felling (no. of trees)*
Irradiated	1972	0.78	312	30	162
RRIM 600	1974	1.00	395	28	186
RRII 200 series	1973	3.00	1170	29	710
Average/ total		4.78	1882	29	1058

clones being the oldest. The total area planted was 4.78 ha with an average initial planting density of 394 trees per hectare and the final stand of all the three plots taken together was 221 trees per hectare, indicating casualty of almost 44 per cent caused by wind damages, natural decay and replacement of trees with abnormal growth pattern. The exploitation system followed was 1/2 S d/2 for all the three plots with a tapping intensity of 100 per cent.

Timber yield and its composition

The volumetric yield of *Hevea* logs per unit area planted may vary due to the differences in agro-management practices, agro-climatic conditions, variety of clones, initial planting density, casualty due to wind and other damages, genetic and physiological characters of the tree, method of logging, *etc*. The average timber yield varies across rubber planting regions from 140 to 200 m^3 per hectare, based on the manner in which plantations are managed (ITC, 1993). It is estimated that in India, the yield of green wood (including branches greater than 5 cm girth) per hectare is of the order of 180 m^3 in the estates sector and 150 m^3 in the smallholdings (Joseph & George, 1996). In Malaysia, the green wood yield is estimated at 190 m^3 and 180 m^3 respectively (Arshad, *et al.*, 1995: 74).

Volume estimation of a tree is generally based on the measurement of girth and length of the tree and the measurement can be made either as standing volume or felled volume/ cross cut volume. The choice of the positions to cross cut trees into logs is determined by the bole shape, taper and markets (Philips, 1994:57). In the present analysis, the measurement of girth and length has been taken on standing trees, as the immediate objective was to estimate the upset value of rubber trees for sale by auction. However, due allowance was given for root wood, bole wood, branch wood and the canopy of the individual trees while estimating the commercial potential of the trees. For this, two measures of volume have been estimated based on the girth and length of individual trees and they are:

i) full circular volume (FCV); and
ii) the quarter girth volume (QGV).

The full circular volume and quarter girth volume have been estimated using the following formulae respectively.

1) *Full circular volume* = $V_1 = (g^2/4\pi) \times l$ ....(1)

2) *Quarter girth volume* = $V = (g/4)^2 \times l$ or $(g^2/16) \times l$ ......(2)

Where: V = volume derived in cubic feet (cft) and expressed as m^3;

g = girth in feet;
l = height in feet;
$\pi = 3.1416$

Though the full circular volume gives the true volume of the tree including branch wood of smaller dimensions, the marketable volume of logs amenable for various industrial and commercial applications was arrived at using the quarter girth volume method. In principle, the volume estimated using quarter girth method gives only 78.5 per cent of the true volume of the tree as indicated below:

$$V/V_l = 4\pi/16 = 0.785, \text{ i.e.}, 78.5\%$$

However, the log volume based on quarter girth formula cannot be taken as the actual saleable volume as the sawn timber content of the log depends on the taper or girth at the thinner end of the log. Even if the log had no taper, the volume of the squared timber would be 63.6 per cent of the full circular volume, which means that the loss in conversion is 36.4 per cent (Chaturvedi & Khanna, 1982: 99). Thus, the total timber yield of a tree may be regarded as an additive function of the stemwood as well as branchwood, which are internationally known as bole (stemwood) volume and canopy (branch wood) volume respectively. In respect of rubber plantations in India, the proportion of available stemwood is estimated to be 60 per cent and that of branchwood at 40 per cent (Joseph & George, 1996).

Clone-wise timber yield and utilisable volume

The estimates of the clone-wise timber volume in terms of full circular and quarter girth volume and the actual industrial volume are presented in *Table 2*. The table indicates that the overall average greenwood volume is 157 m^3 per hectare, the highest being in the case of RRIM 200 series (183 m^3/ ha), followed by RRIM 600 (124 m^3/ ha) and irradiated clones (93 m^3/ ha). The utilisable volume is the actual volume of timber that could be used for secondary processing and the estimates are based on the proportion of stemwood with girth above 35 inches available from the felled stock. It is evident that higher rate of utilisation is achieved in the case of RRII 200 series at 56 per cent compared to RRIM 600 (54 %) and irradiated

TABLE 2
CLONE-WISE TIMBER YIELD AND ACTUAL UTILISABLE VOLUME

Clone	*Full circular volume (FCV)*					
	Total (m^3)	*Per tree (m^3)*	*Per ha (m^3)*	*QGV# (m^3 / ha)*	*Utilisable volume* (m^3/ ha)*	*Utilisable volume (m^3/per tree)*
Irradiated	72.76	0.45	93.46	73.22	49.40	0.24
RRIM 600	124.12	0.67	124.62	97.49	67.99	0.37
RRII 200 series	549.26	0.77	183.03	143.87	102.41	0.43
Total	746.14	0.71	157.15	122.64	86.56	0.39

Notes
(a) #QGV – Quarter girth volume;
(b) * Indicates the actual volume of stemwood suitable for secondary processing;
(c) Figures in parentheses are the respective utilisable volume of timber per tree.

clones (53 %).

In general, almost 45 per cent of the volume of wood is not usable, as it constitutes branchwood and is lower in girth. The clone RRII 200 series was found to be the top yielder in terms of the utilisable wood volume and timber yield per tree with an average yield of 0.43 m^3 per tree in relation to RRIM 600 (0.37 m^3/ tree) and the irradiated clones (0.24 m^3/ tree).

The composition of the total timber volume in terms of stemwood (bole) volume and branchwood (canopy) volume was estimated based on the measurements of height of the stemwood and branchwood taken from a sub-sample of the three clones separately. It was found that in the case of RRII 200 series, the stemwood was over and above that of the other two types, as revealed by the higher proportion of bole volume (62 %) compared to irradiated clones (58 %) and RRIM 600 (56 %). This brings out a clear advantage for RRII 200 series in terms of utilisable timber yield over RRIM 600 and it may also be observed that the total average wood volume of RRIM 600 grown in Indian conditions is almost comparable to that in Malaysia, where, the average per tree wood volume of 25-year old RRIM 600 series has been reported to be 0.4 m^3, 0.59 m^3 and 0.59 m^3 respectively for RRIM 600, RRIM 605 and RRIM 623 (Razali *et al.*, 1993). However, though RRII 200 series also show highest bole volume to the extent of 0.42 m^3 compared to RRIM 600 (0.23 m^3) and irradiated clones (0.20 m^3), it is considerably lower than the clear bole volume reported in Malaysia for some of the potential latex timber clones (LTCs), *viz.*, RRIM 900 series and RRIM 2000 series. While the clear bole volume for RRIM 2000 series ranged between 0.41 m^3 and 0.57 m^3 per tree, that for some of the RRIM 900 series clones was 0.61 m^3 (Othman *et al.*, 1996).

The maximum greenwood volume per tree was observed in the case of RRII 200 series at 1.78 m^3 against 1.62 m^3 in the case of RRIM 600 and 1.58 m^3 in irradiated clones. While significant variability measured in terms of coefficient of variation in timber volume per tree was noticed in the irradiated clones, the variability has been almost uniform across the bole and canopy volumes of trees in the case of RRII 200 series and RRIM 600. There were also differences in the most frequently occurring timber volume in the tree population among the three clones as revealed by the value of the mode. For instance, the value of the mode was the highest in respect of RRII 200 series at 0.51 m^3, compared to RRIM 600 (0.35 m^3) and irradiated clones (0.09 m^3).

Thus, the above analysis brings out that the clones, RRIM 600 and RRII 200 series show uniform pattern as regards the variability in timber yield among the trees, though there are differences in terms of average timber yield per tree as well as the value of the mode of the timber volume in tree population. The proportion of the stemwood is also found to be much higher in the case of RRII 200 series in relation to RRIM 600 and the irradiated clones.

Variability in tree girth and timber volume

The classification of timber yield of *Hevea* trees according to girth classes is highly relevant in view of its importance as an industrial raw material. This is based on the logic that higher the proportion of logs belonging to larger girth classes, greater will be the potential for manufacturing options and the resultant value addition. The clone-wise composition of trees according to girth classes is shown in *Figure 1*. The girth-wise composition of the trees as given in *Figure 1* shows the highest

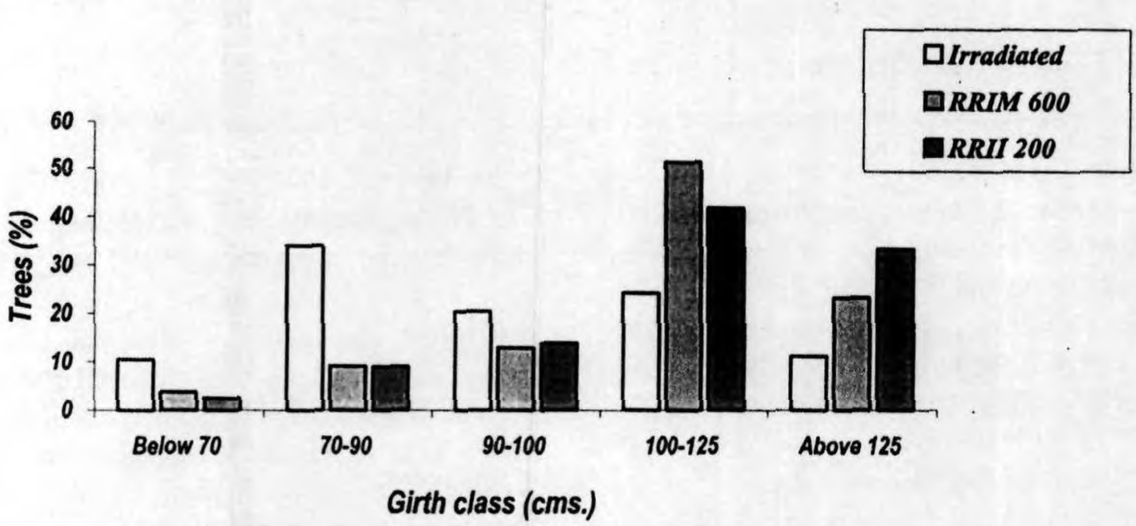

Figure 1 Girth-wise distribution of trees

concentration of trees in the girth class 100 - 125 cm. In the case of RRIM 600 (51%) and RRII 200 series (42%) compared to irradiated clones where 34 per cent of the trees fall in the 70 – 90 cm.

The girth-class wise mean girth of the trees, variability in girth and utilisable timber volume are examined separately for the three clones and the results are shown in *Table 3*.

Among the three clones, RRII 200 series stands out in terms of the higher proportion of trees falling in the higher girth classes above 90 cm, which highlights the superiority of RRII 200 series over the other two clones in terms of more availability of logs suitable for secondary processing enabling higher value addition and net income realisation. While the mean girth values are almost comparable across the three clones, mean wood volume showed minor variations across girth classes, highest mean volumes being observed in respect of RRII 200 series (except the first girth class) compared to the other two clones.

Variability in girth was found to be lower and almost uniform across the three clones except the lowest girth class below 70 cm in the case of RRII 200 series (16 %). In sharp contrast to the lower levels of variability in girth across the girth classes among all the three clones, the variability in timber volume was reportedly higher among all the clones, which may be explained in terms of the wide variations in height and stemwood content of the trees. However, higher variability in per tree timber volume was noticed in the case of irradiated clones and RRIM 600 compared to RRII 200 series, where the variability has been considerably lower in higher girth classes, which is suggestive of the consistent growth of RRII 200 series clones.

Basal area and its relationship with girth and timber volume

The basal area is a good measure of site potential (Philip, 1994: 117) which measures the uniformity in growth in girth, stand and height of even-aged plantations. The basal area for each plot is calculated by summing the basal areas of the trees of different girth classes. The basal area per tree has been estimated using the equation:

TABLE 3
VARIABILITY IN TREE GIRTH AND TIMBER VOLUME OF *HEVEA* CLONES

Girth class (cm)	*Proportion of trees (%)*	*Mean girth (cm)*	*Variability in girth (CV %)*	*Mean timber volume (m^3/ tree)*	*Variability in timber volume (CV %)*
I. Irradiated clones					
Below 70	10.49	64.79	7.79	0.10	49.17
70-90	33.95	81.58	6.64	0.21	50.61
90-100	20.37	90.19	3.07	0.30	50.55
100-125	24.07	110.08	6.31	0.53	44.73
Above 125	11.11	131.52	6.48	0.86	36.93
II. RRIM 600					
Below 70	3.76	62.17	7.15	0.13	38.54
70-90	9.14	80.80	7.87	0.20	39.14
90-100	12.90	96.26	2.96	0.31	42.19
100-125	51.08	112.62	5.56	0.52	39.20
Above 125	23.12	136.95	8.18	0.86	29.15
III. RRII 200 series					
Below 70	2.54	66.06	16.36	0.11	13.79
70-90	9.01	82.27	6.62	0.21	37.47
90-100	13.80	95.26	2.81	0.36	34.89
100-125	41.55	113.03	6.04	0.61	25.62
Above 125	33.10	138.48	7.29	1.03	28.16

Basal area $= g = (\pi/4) \times d^2$

Where: g = basal area expressed in m^2;
d = girth of the tree, recorded in centimeters.

The basal area is otherwise expressed as cross sectional area and is normally expressed in square meter. It is expected that in even-aged plantations of a single crop, volume of timber will be closely related to basal area. The higher the variability in basal area of the trees, greater will be the tapering effect on the trees, leading to wide variations in timber yield. The above logic of the influence of basal area on timber volume and the variability in basal area, girth and timber volume across the three clones are examined and the results are shown in *Table 4*. As evident, there is a significant relationship between the basal area and timber volume, as indicated by the correlation coefficients between basal area and timber volume of the three clones.

Among the three clones, the highest coefficient value was noticed for RRII 200 series. The variability in basal area, girth and timber volume was the highest in the case of irradiated clones at 47, 23 and 79 per cent respectively compared to the other two clones. Among the three clones, the variability in basal area, girth and timber volume has been found to be the lowest in the case of RRII 200 series. The highly significant positive relationship

TABLE 4
EFFECT OF BASAL AREA ON TIMBER VOLUME AND THE VARIABILITY IN BASAL AREA, GIRTH AND LOG VOLUME

Clones	*Correlation coefficient**	*Basal area (m^2/tree)* Mean	*Basal area (m^2/tree)* CV (%)	*Girth (cm)* Mean	*Girth (cm)* CV (%)	*Log volume (m^3/tree)* Mean	*Log volume (m^3/tree)* CV (%)
Irradiated	0.826	0.80	47.05	97.10	22.87	0.36	78.66
RRIM 600	0.860	1.04	36.31	111.33	19.13	0.53	56.13
RRII 200 series	0.877	1.13	34.94	116.13	17.96	0.68	51.25

Note: * Between basal area and timber volume and is significant at 1 per cent level.

between basal area and timber volume denotes the absence of taper in the tree population of all the three clones and validates that tapering effect is minimum in even-aged monoclonal plantations.

Influence of basal area on timber volume

In order to determine the extent of influence of basal area on timber volume of the three plots, the most commonly used log-linear function was used and the function was of the form:

$$V = a\,(g)^{b}; \quad i.e.,\ \log(v) = \log(a) + b\log(g)$$

Where: v = volume of the timber expressed in m^3;
g = basal area expressed in m^2;
a, b are the constant and coefficient respectively, to be estimated.

The results of the analysis are shown in *Table 5*. The analysis shows that the basal area has almost uniform influence on the timber yield of the three clones as evident from the regression coefficients. Among the three clones examined, highest influence of basal area on timber yield was noticed in respect of RRII 200 series as also revealed by the R^2 values and DW statistic. The negative values of the constants estimated signify the absence of the influence of basal area on timber volume in the case of small dimension trees. The negative values of the constants estimated in the equation signify that trees of zero basal area have negligible timber volume.

The influence of girth on timber volume among the three clones has also been examined and it was observed that there is a positive relationship between girth and timber volume for all the three clones in lower girth classes up to 120 cm. However, a declining trend in timber volume is observed for higher girth classes above 120 cm especially in the case of RRIM 600 and RRII 200 series, which may be attributed to casualities in the field due to natural causes.

CONCLUDING OBSERVATIONS

The study brings out some important aspects of the *Hevea* clones grown in India with respect to the timber yield and related attributes despite the limitations due to the analysis being confined to experimental clones. An important aspect emerging from the study is the potential timber yield of these clones. Based on the final

TABLE 5
INFLUENCE OF BASAL AREA ON VOLUME OF TIMBER OF CLONES

Clones	*Constant*	*Coefficient**	*R Square*	*Adj. R^2*	*DW Stat.*
Irradiated	-0.858	0.997	0.631	0.628	1.401
RRIM 600	-0.754	1.152	0.737	0.736	1.435
RRII 200 Series	-0.648	1.449	0.739	0.739	1.482

Note: * Estimates are significant at 1 per cent level.

stand at the time of felling, the timber yield was highest for RRII 200 series (183 m^3/ha) followed by RRIM 600 (124 m^3/ha) and irradiated clones (93 m^3/ha), with an average timber yield of 157 m^3 per hectare. The present analysis though confined to the analysis of timber yield potential and variations in its different components, it highlights the importance of undertaking detailed multi-disciplinary empirical investigations on the clone and region-specific potential timber yield of the popular as well as the pipeline *Hevea* clones in India. The future priority should be oriented towards maximisation of both latex and timber yield per unit area so as to ensure economic viability and sustainability of rubber based farming systems.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the help and support rendered by Mr Jacob Pothen, Deputy Director, Central Experiment Station (CES), Chethackal in undertaking the census of the three plots. Thanks are also due to Dr K Jayaraman, Head, Division of Statistics, Kerala Forest Research Institute (KFRI), Peechi for clarifying the technical issues in the measurement of timber volume. The usual disclaimers apply.

REFERENCES

ARSHAD, N L B; OTHMAN, R B and YAACOB, W A R B W. 1995. *Hevea* wood availability in Peninsular Malaysia. *Planters Bulletin*, 224 and 225: 73-83.

CHATURVEDI, A N and KHANNA, L S. 1982. *Forest Mensuration*. International Book Distributors, Dehra Dun. 95-129.

DGCIS 2000. *Monthly Statistics on Foreign Trade*, Vol. 2, Imports, Directorate General of Commercial Intelligence and Statistics, Ministry of Commerce, Government of India, Calcutta, 1464 pp.

INTERNATIONAL TRADE CENTRE 1993. Rubberwood: A Study of the World Development Potential, Market Study, International Trade Centre, UNCTAD/GATT, Geneva. 99 pp.

JOSEPH, T and GEORGE, K T. 1996. Primary processing of rubberwood in Kerala: Report of a sample survey, *Wood News*, January- March, 1996: 39-43.

JOSEPH, T; CHANDY, B; VISWANATHAN, P K and LEKSHMI, S. 1999. Commercial yield performance of *Hevea* clones in India: A comparative analysis. Monograph, Rubber Research Institute of India, Kottayam. 66 pp.

MALAYSIAN RUBBER BOARD. 1998. LGM Planting Recommendations 1998-2000. *Planters' Bulletin*, 3: 22.

OTHMAN, R; ARSHAD, N L; HUAT O S; OTHMAN, H; MOHD. M B; WANCHIK, G; AZIZ, M Z A; GHANI, Z A and GHANI, M N A. 1996. Potential *Hevea* Genotypes for Timber Production. In: *Ensuring Sustainability and Competitiveness of the NR Industry* (Kadir, S.A. Abdul Aziz, ed)). Rubber Research Institute of Malaysia, Kuala Lumpur. 340-360.

PHILIP, MICHAEL, S. 1994. *Measuring Trees and Forests*. Wallingford, CAB International, 310 pp.

RAZALI, W M; MOHD ALI SUJAN, R M and ZAIN, T M. 1993. Double entry volume table equations for some RRIM 600 series clones of *Hevea braziliensis*. *Malaysian Forester*, 46-58.