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ESTIMATION OF RUBBER WOOD VOLUME: COMPARISON OF THREE SAMPLING METHODS

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The importance of rubber wood as the timber of the present era is on the increase and therefore accurate estimation of wood available from a large population of rubber trees in a plantation has also gained much practical significance. Sampling is the ideal approach adopted in forest tree species to estimate timber volume and availability from a population. Three sampling procedures, *viz.* simple random, systematic and stratified, were adopted for estimating wood volume in a study comprising of mature trees of five clones (RRII 105, RRII 203, RRII 208, GT 1 and RRIM 600) in five locations (on-farm trials) within Kerala. Stratification was carried out based on the stable variable, the girth at the thick end of trunk. The sampling intensity required to estimate the population mean within 10% error at 95% confidence level was determined for each sampling procedure. The average sampling intensity was found to be 10, 15 and 21%, respectively for stratified, systematic and simple random sampling procedures. Error percentage was also estimated for these three methods, *i.e.* stratified (3.5), systematic (7.0) and simple random (9.0). Since the criterion for judging a sampling procedure is minimum per cent error at a minimum sampling size, stratified sampling was found to be ideal for rubber wood estimation.

The most popular clone RRII 105 recorded a bole volume of 0.24 - 0.30 m^3/tree. The highest bole volume (m^3/tree) was recorded for RRII 203 (0.52) followed by RRII 208 (0.47) at Chittar; GT 1 (0.33) at Balussery and RRIM 600 (0.32) at Ranny. Timber output was maximum for RRII 203 irrespective of regions within Kerala. In general, the trees growing in southern Kerala recorded more bole volume than that growing in central and northern Kerala.

Keywords: *Hevea brasiliensis*, Rubber clones, Rubber wood volume, Sampling methods

INTRODUCTION

The paucity of timber due to deforestation has made rubber wood an important raw material for the timber industry. It has attained increased importance with the introduction of many value-added marketable products. Rubber wood is made available on felling after the economic exploitation of latex from the trees of *Hevea brasiliensis* for a period of about 25 years. Every year large number of rubber trees with bulk quantum of wood are cleared for replanting the area with new clones. The projected availability of rubber wood during 2001-02 from 4800 ha of replanted area was 2.1 million cubic meters (Viswanathan *et al.*, 2002; Rubber Board, 2004). The quantum of wood available from plantations varies depending on clones and locality.

The efficient estimation of timber from a rubber plantation with minimum efforts assumes importance as it helps in estimating

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the upset value of the trees at the time of sale. Enumeration of large number of rubber trees (*H. brasiliensis*) for estimating wood availability at disposal prior to replanting is too tedious, labour intensive and expensive. Although during the initial years of rubber plantation in India, neither the buyer nor the seller was concerned about the accuracy of timber measurement. Today, much attention is given for the precise estimation of timber volume before its disposal because of its improved status in terms of cost and demand. Though studies were conducted on the estimation of rubber wood volume in Indian context (Viswanathan *et al.*, 2003; Thomas *et al.*, 2003) by using different methods, no attempt has so far been made to compare the efficiency of the different methods.

In forest research, different approaches are being adopted for timber enumeration, among which, sampling is found to be the ideal one for the close estimation of timber volume of the whole population (Hamilton, 1975; Philip, 1994). A sample survey is designed so that the error in the final estimates is minimum and the representative sample is selected so as to obtain information from only a part of a large population so as to infer about the whole population at a reduced cost, greater speed and improved accuracy (Jayaraman, 2001).

Even though different sampling methods are employed in forest tree species, an appropriate method has not yet been used on a comparative basis for a tree species like *H. brasiliensis*, which is cultivated commercially with great care and better cultural operations to attain good girth with uniformity for early opening of the trees for latex.

MATERIALS AND METHODS

Twenty five trees each of five clones of *H. brasiliensis*, *viz.* RRII 105, RRII 203, RRII 208, GT 1 and RRIM 600, from on-farm evaluation trials of 1973-74 planting were selected for the study from five locations in the traditional rubber growing tract of Kerala State in India. The selected locations were Koothattukulam Estate, Chittar in Pathanamthitta district; Kulathupuzha Estate (RPL), Punalur in Kollam district; Chimony Estate, Palappilly in Thrissur district (4 clones except RRII 203), Kinalur Estate, Balussery in Kozhikode district; (4 clones except RRII 203) and Central Experiment Station (CES), Chethackal in Pathanamthitta district (3 clones *viz.*, RRII 105, RRII 203 and RRIM 600). The trees were opened for tapping in 1981-82. Girth of the trunk was measured from standing trees. The height up to 30" girth was measured with a fabricated device having a basal plate to which two parallely arranged arms were fixed 24 cm apart (*i.e.*, the diameter corresponding to 30" circumference) perpendicular to the base plate. The device was screwed to the top of a 20 feet bamboo pole. The arms of the device slide around the trunk at a height and pulled downwards till it fit closely on the trunk, at a point where the circumference is 30". The height of the trunk was measured with a bamboo pole or Ravi multimeter. The bole volume was calculated by using the Smalian's formula

$$V = \frac{(b^2 + t^2)\, l}{8\pi}$$

where, V – volume

b - girth at thick end

t - girth at top

l – length of the trunk

The data on girth and bole volume of *Hevea* (Thomas *et al.*, 2003) was subjected to the three sampling methods, *viz.*, simple random, systematic and stratified, adopted

in forest inventory to select the most adaptable procedure for the estimation of available bole volume on a comparative basis. Simple random sampling is the simplest form of sampling strategy, which is the fundamental selection method where all other sampling procedures are modifications to it for achieving greater economy or precision (Husch *et al.*, 1972). In systematic sampling, the bole measurements of every particular tree after a definite interval was recorded. In stratified sampling procedure, the heterogeneous population was grouped into different strata of internally homogeneous sub-populations from which a precise estimate of any stratum mean can be obtained based on a small sample from that stratum (Sagreiya, 1967; Jayaraman, 2001). The stratification is based on a stable variable, *i.e.* girth at base, since it determines the quantum of timber available from the bole of a tree species (Tsoumis, 1968).

RESULTS AND DISCUSSION

Actual bole volume of five clones of *H. brasiliensis* at the age of 25 years from five locations in Kerala (Thomas *et al.*, 2003) is depicted in Table 1. Maximum bole volume for all the clones except GT 1 was recorded in South Kerala region. Clones RRII 203 and RRII 208 recorded the highest volume of 0.52 m^3/tree and 0.47 m^3/tree, respectively at Chittar. At Ranny, RRII 203 had 0.43 m^3/tree followed by RRIM 600 (0.32 m^3/tree), RRII 105 (0.3 m^3/tree) and RRII 208 (0.27 m^3/tree). RRII 105 showed more or less uniform pattern in bole volume which ranged from 0.22 to 0.30 m^3/tree irrespective of regions. RRII 208 had a comparatively inferior performance in Central (0.25 m^3/tree) and North Kerala region (0.23 m^3/tree) over southern region. Except at Ranny (0.32 m^3/tree), RRIM 600 recorded more or less similar values (0.22 – 0.26 m^3/tree) at other regions.

Table 1. **Bole volume (m^3/tree) of five *Hevea* clones in Kerala at 25 years age**

Region	Parameter	Clone				
		RRII 105	RRII 203	RRII 208	RRIM 600	GT 1
South	Girth (m)	0.82	1.00	0.95	0.84	0.94
Punalur	Height (m)	4.83	5.21	5.20	4.98	4.38
	Bole volume	0.24	0.33	0.31	0.26	2.46
Chittar	Girth (m)	0.92	0.97	0.96	0.90	0.98
	Height (m)	4.45	8.37	7.63	4.23	5.13
	Bole volume	0.27	0.52	0.47	0.24	0.32
Ranny	Girth (m)	1.09	1.22	1.10	1.08	-
	Height (m)	4.09	5.07	3.69	4.54	-
	Bole volume	0.30	0.43	0.27	0.32	-
Central	Girth (m)	0.76	-	0.82	0.75	0.77
Thrissur	Height (m)	4.76	-	4.98	4.83	4.95
	Bole volume	0.22	-	0.25	0.22	0.23
North	Girth (m)	0.91	-	0.85	0.90	1.03
Balussery	Height (m)	4.34	-	4.28	4.18	4.93
	Bole volume	0.25	-	0.23	0.24	0.33

GT 1 recorded maximum value (0.33 m^3/tree) in North Kerala region, followed by 0.32 m^3/tree at Chittar.

The data on bole measurements of *Hevea* were analysed with three sampling methods, *viz.* simple random, systematic and stratified, to identify a suitable method with minimum effort and greater accuracy.

a. Simple random sampling

This is a procedure where each possible combination of sampling units out of the population has the same chance of being

Table 2. **Estimation of bole volume (m^3/tree) by using different sampling methods**

Clone	Simple random			Systematic			Stratified		
	Population mean (y)	Actual bole volume	Absolute error (%)	Population mean (y)	Actual bole volume	Absolute error (%)	Population mean (y)	Actual bole volume	Absolute error (%)
Koothattukulam Estate, Chittar									
RRII 105	0.5230	6.54	3.87	0.5039	6.30	7.38	0.5541	6.80	0.01
RRII 203	0.1550	14.44	11.42	0.8679	10.85		0.9952	12.44	3.99
RRII 208	0.8412	10.52	10.53	0.9400	11.75	0.03	1.01	12.66	7.72
RRIM 600	0.4247	5.31	12.10	0.4882	8.04	1.04	0.5096	6.37	5.48
GT 1	0.7694	9.62	20.80	0.6432	6.10	1.00	0.6573	8.22	3.21
Kulathupuzha Estate, Punalur									
RRII 105	0.4742	5.93	2.71	0.5213	6.52	6.95	0.4953	6.18	1.62
RRII 203	0.6139	7.68	6.17	0.6364	7.96	2.72	0.6943	8.68	6.12
RRII 208	0.5887	7.36	5.30	0.6165	7.71	0.82	0.6151	7.69	1.05
RRIM 600	0.4907	6.14	4.20	0.5451	6.82	6.39	0.5182	6.48	1.16
GT 1	0.4608	5.76	6.30	0.4802	6.00	2.34	0.4856	6.70	1.24
Central Experiment Station, Chethackal, Ranny									
RRII 105	0.5138	6.42	14.08	0.4764	5.96	20.33	0.6280	7.85	5.03
RRII 203	0.7430	9.29	13.41	0.8560	10.70	0.24	0.8366	10.46	2.50
RRIM 600	0.7510	9.39	16.93	0.4953	6.19	22.89	0.6705	8.38	4.40
Chimony Estate, Thrissur									
RRII 105	0.3978	4.98	10.23	0.3691	4.62	16.72	0.4046	5.60	8.70
RRII 208	0.4177	5.22	16.99	0.4534	5.67	9.91	0.5336	6.67	6.03
RRIM 600	0.4577	-	3.64	0.4736	5.92	7.23	0.4439	5.55	0.52
GT 1	0.5079	6.35	8.43	0.4716	5.90	0.68	0.4623	5.78	1.31
Kinalur Estate, Kozhikode									
RRII 105	0.4873	6.09	1.39	0.4685	5.86	5.20	0.4872	6.09	1.42
RRII 208	0.4841	6.05	7.59	0.4088	5.11	9.13	0.4741	5.93	5.38
RRIM 600	0.4555	11.39	3.69	0.4935	6.17	4.35	0.4939	6.18	4.44
GT 1	0.6243	15.61	5.37	0.6475	8.10	1.86	0.6714	8.40	1.78
Mean			8.82			6.83			3.50

selected. From the 25 *Hevea* trees, a random sample of six trees was selected (24%) using random number table and the population mean was estimated. Based on the mean values, total population value, its variance and the error percentage in estimating population total were also estimated. Error per cent was recorded to be 8.82% (Table 2). The sampling intensity required to estimate the population mean within 10% error at 95% confidence interval also was determined and it was found to be 21%.

b. Systematic sampling

Out of the 24% of sample trees, an estimate of the population mean and percentage of error are depicted in Table 2. The average error in estimating the actual volume was found to be 6.83% and the sample intensity required to estimate the population mean within 10% error at 95% confidence level was also determined and was found to be 15%.

c. Stratified sampling

Based on the girth of the trunk, sample trees were stratified into three equal classes, *i.e.* low, medium and high. From each stratum, representative samples were taken and population mean and bole volume were estimated. The percentage error from the actual volume was found to be 3.5. The sample intensity required to estimate the population mean within 10% error at 95% confidence level was found to be 10%.

Among the three sampling procedures, studies conducted in forest tree species (Husch *et al.*, 1972; Thompson, 1992; Jayaraman, 2001) and also in the present study, stratified sampling procedure was found ideal over simple random and systematic methods for estimation of wood availability if the standing population is large. This method has high accuracy with ease in recording of data. Though rubber is cultivated as a monocrop, having trees of same age grown under good agro-management practices, the tree-to-tree variation exists in plantations. In such situation, stratified sampling enables to incorporate representative trees from each stratum leading to better and accurate measurements. Due to the high error range and also the inconsistency of error values from place to place, simple random method is not advisable for rubber wood estimation even though the method is easy. In forest research, this method was found to have disadvantages particularly in relocating the plots due to irregular distribution of samples in the entire area making it very expensive (Jayaraman, 2001). It was found that simple random sampling was adequate for initial survey, where the sample size was relatively small. Systematic sampling certainly has an intuitive appeal, apart from being easier to select and carry out in the field, through spreading the sample evenly over the estate and ensuring a certain amount of representation of different parts of the area.

The objective of sampling is to secure a sample which represents the population and reproduces the important characteristics of the population under study as closely as possible. The size of the sample depends on the variability of the character under study in the population (Jayaraman, 2001). The bole characteristics such as nature of girthing, bole height and pattern of branching of a particular clone are specific (Saraswathyamma *et al.*, 2000). Rubber plantations have certain specific characteristics over the timber species, *viz.* high stand per unit area, uniformity in age, cylindrical bole with low incidence of

tapering, restricted branches beyond a particular height, *etc.* The sampling procedure with smaller sample size from each stratum can be exercised with better accuracy since the variability is at a minimum level for rubber resulting in a homogenous condition over forest species where large size samples are required due to its heterogeneity.

In large rubber plantations under both private and government sectors, the estimation of wood availability has to be completed prior to its disposal through open tender, and simple random or systematic samplings are the procedures usually followed for the estimation of availability. Viswanathan *et al.* (2003) has assessed the bole volume of the entire trees of clone RRIM 600 at Central Experiment Station, Chethackal (Ranny) and was reported to be 0.37 m^3/tree. The same trees when assessed by stratified method the bole volume was found to be 0.32 m^3/tree. Considering the accuracy and the efforts taken, stratified sampling is a reliable sampling method over the other two methods tried. Though many insist on surveying the entire population for better accuracy, complete enumeration also is not free from errors (Jayaraman, 2001). Since market attraction of rubber wood logs differs based on girth (Thomas, 2003), the stratified sampling procedure can be extended effectively for the estimation of both bole and branch volume separately.

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