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An Effective Sampling Procedure to Estimate Annual Yield of Rubber

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ABSTRACT. *The possibility of reducing the sampling cost involved in estimation of annual dry rubber yield for field experimentation of rubber was examined, while the conventional system of sampling comprised of 24 test tappings per year per tree. The sampling methodology employed in this study was a stratified approach using four natural strata in the annual yield cycle of rubber.*

A sample size of eight test tappings per year per tree was found to be sufficient with equal allocation in four yield strata. All possible outcomes were evaluated to obtain the 'best sample combinations' of size 8 to represent the yield estimated by the conventional system. Consequently, seven alternative combinations were recommended to estimate annual yield of rubber, which have one third of the total sampling cost, when compared to the previous system of sampling. The study suggested that selection of adjacent sampling points from neighbouring strata is an appropriate strategy for sampling in estimating annual yields for perennial crops showing seasonal variation.

INTRODUCTION

Measurement of yield is an important activity in most rubber experiments, especially in breeding, tapping and long term fertilizer trials. Methods of yield recording in these studies can be classified in various ways. One distinction in methods depends on whether yield is recorded by volume or weight of latex or by weight of coagulated rubber. The latter is widely used in experiments as an estimation of the yield potential.

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The yield per hectare per year is obviously the unit of practical interest. However, the yield per tree per tapping often provides a better measure of the relative yield capacity of the treatments under consideration. In many experiments, recording yields using two tapping days per month (24 test tappings per year) is practiced where the yield per year is the assessment of yield potential (Yogaratnam, 1984).

Recording of yields (latex sampling and subsequent chemical analysis) is generally a costly activity, and therefore, occupies a considerable portion of the experimental budget. As a consequence, to work within the budgetary constraint, researchers tend to restrict sampling frequency to one test tapping per month. It is believed that 24 test tappings would estimate the annual yield of rubber with sufficient accuracy as the sampling points are distributed evenly along the yield cycle. However, adopting a less frequent evenly distributed sampling procedure is not advisable for perennial crop species showing seasonal variation in yield, as it may lead to biased estimations.

This study attempted to identify the possible sampling alternatives to estimate annual yield of rubber for some of the *Hevea* clones popular in the wet and dry zone climatic conditions, by taking into account the variability and seasonal fluctuations of yield.

METHODOLOGY

Collection and organization of data

Yield data collected from several long term field experiments conducted by the Rubber Research Institute and tapping records available at the Dartonfield estate located in the agro ecological zone, WL_1 were employed in this study. The experimental and estate yields were recorded in grams per tree and kilograms per tapping block, respectively, for each tapping task. The extent of a tapping block varied from less than a hectare to several hectares. These yield records were employed at different stages of the study as indicated in Figure 1. The number of years of available records for the selected clones is given in Table 1.

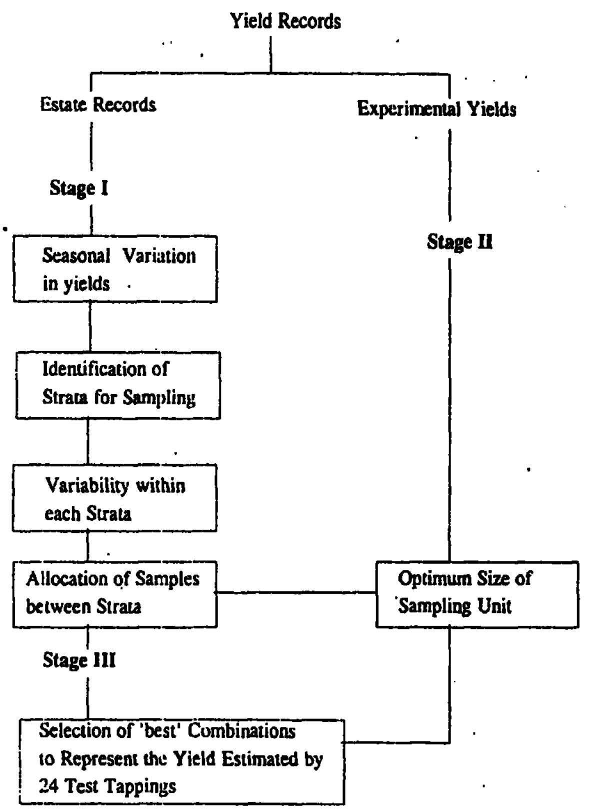

Figure 1. Use of Yield Records at Different Stages of the Study.

Table 1. Availability of Yield Records for Different *Hevea* Clones.

Clone	Record Availability (Years)	
	Experimental Yields	Estate Tapping Records
PB 86	10	12
RRIM (Mixed)	05	10
RRIC 100	08	03
RRIC 110	03	-
RRIC 121	02	-
RRIC 45	02	-
RRIC 36	02	-
PB 5/51	02	-

Stage I - Seasonal variation in yield

Being a perennial crop, the yield of rubber varies within the year as well as between years. To investigate the seasonal variation in yield of different rubber clones, the estate tapping records of PB 86 and RRIM series (panels A and B) and RRIC 100 (panel A) were used.

Statistical method

Decomposition methods are among the oldest forecasting approaches. However, they have been widely used and are most satisfactory for general use (Neiswanger, 1956; Makridakis *et al.*, 1983; Chatfield, 1984). Hence, this method was employed in calculating the adjusted seasonal indices which were averaged in the next step of the calculation to obtain a single index of "typical" seasonal variation. Mathematically, these computations accomplish the following;

$$X_t = I_t T_t C_t E_t$$

$$M_t = T_t C_t$$

$$I_t = \frac{X_t}{M_t E_t}$$

where;

X_t = Time series value at period t
I_t = Seasonal component (or index) at period t
T_t = Trend component at period t
E_t = Irregular component at period t
C_t = Cyclic component at period t
M_t = Resulting moving average at period t

The information on seasonal variation were used to identify strata for sampling. The allocation of samples between strata was determined by the variability in each strata.

Stage II - Optimum size of sampling unit

When the cost is directly proportional to the number of samples, the relative efficiency of increasing the sample size by another unit can be taken as a criterion for selecting the optimum sample size. Therefore, the relationships of coefficient of variation (CV) versus number of test tappings were established for 3 different clones, *viz.* PB 86, RRIM series (mixed) and RRIC 100 by employing the experimental yields recorded in 24 test tappings per year, equally spaced with 2 samples per month per tree. The relative efficiency was calculated using following formula.

$$Relative\ Efficiency = \frac{C_1 - C_x}{C_1} X\ 100$$

where;

C_1 - CV among single units, and
C_x - CV of samples of x single units.

Stage III - Estimation of annual yield of rubber

Systematic sampling is greatly dependant on the properties of the population. Thus, Cochran (1977) suggested that a prior knowledge of the structure of the population is a necessity for the effective usage of systematic sampling procedures. Hence, the information gathered during stages 1 and 2 of the study were employed in selecting an appropriate sampling procedure using experimental yields of PB 86, RRIM clones, PB 5/51 and RRIC series consisting of 100, 110, 121, 45 and 36, respectively.

Criteria for selecting the best combinations

As stated by Pearce (1976) and Dospekov (1984), the difficulty encountered with stratified or systematic sampling is the risk of bias. Therefore, all possible combinations were evaluated by the maximum difference (D_{max}).

$$D_{max} = \max. |X_1 - X_2|$$

where;

X_1 - average yield obtained by 24 test tappings and
X_2 - average yield obtained by selected 'optimum' sample combinations.

The combinations giving the minimum D_{max} values were chosen as the 'best' sample combinations.

RESULTS AND DISCUSSION

Seasonal variation in yield

The analysis of seasonal variation of the indices showed a similar pattern of yield variation for PB 86, RRIC 100 and RRIM clones in both panels. The four seasonal quarters of the yield cycle were identical to those reported in Malaysia by Lee and Tan (1979). As shown in Figure 2, the yields dropped below average during February to July. At the start of this period, rubber trees tend to shed leaves. Hence, February, March and April were termed as 'wintering' months with a steady drop in yield. The next period, the 'post wintering' starts from May and extends to the end of July with an increase in yield. August, September and October are termed as 'high yielding' months, followed by the 'peak yielding' period extending from November to the end of January. Therefore, the above mentioned quarters in the yield cycle were considered as the natural strata to be employed in the stratified sampling procedure to estimate annual yield of rubber.

Allocation of samples

The allocation of samples between strata is usually determined by the relative variability within each stratum. The coefficient of variation within a stratum for the clones studied were almost similar between strata (Table 2). Therefore, the sample size should be equally allocated among the four strata.

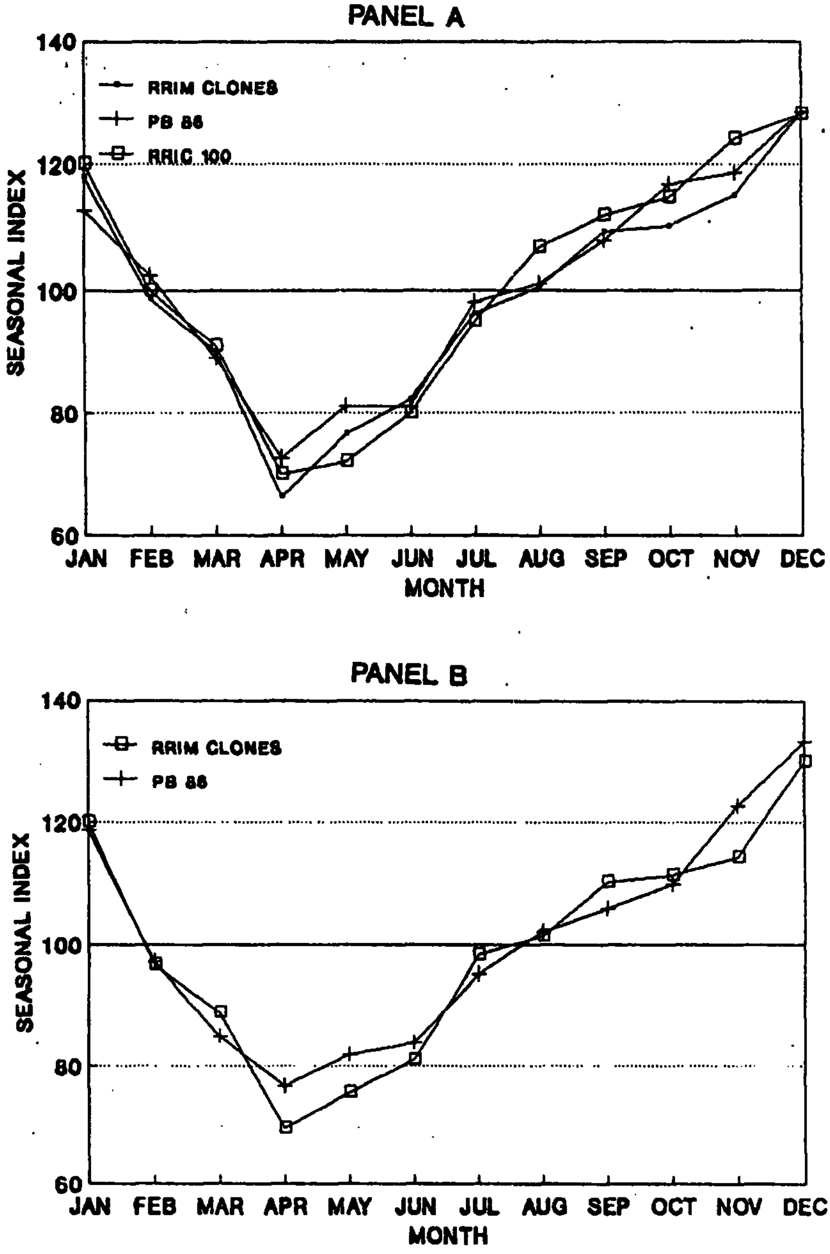

Figure 2. Typical seasonal indices for different clones tapped in panels A and B.

Table 2. Coefficients of Variation (%) within Stratum.

Season	Clone		
	PB 86	RRIM Clones	RRIC 100
Peak Yielding	16.0	16.8	14.8
Wintering	16.6	15.4	15.8
Post Wintering	15.8	16.2	15.6
High Yielding	15.2	15.1	15.1

Optimum sample size

Stratified sampling was employed based on natural strata. For all the clones studied (Figure 3), the CVs stabilized around 15 percent when the sample size approached 8. The relative efficiencies of different sample sizes based on the reduction of CVs also agreed with the sample size of 8, which can be practiced to estimate annual yield with sufficient accuracy (Figure 3). Hence, in terms of variability, a sample size of 8 can be recommended in estimating the annual yield for field experimentation of rubber. This also reduces the sampling cost to one third of that of the previous system of 24 samples.

Sampling schedule recommended for estimating annual yield of rubber

The optimum size of the sample *viz.* 8 test tappings were equally allocated among the four strata, giving an equal allocation of 2 in each. This allocation resulted in 15 combinations of 2 test tappings in one stratum, with a total of 50,625 sample combinations of size 8. Based on the analysis using the maximum difference, 7 combinations with maximum differences less than 0.4 g/tree/tapping were recommended to estimate the annual yields of rubber. The sampling schedule given in Figure 4, enables experimenters to use any particular system. As depicted in Figure 4, there is a tendency for adjacent sampling points from neighbouring strata to be selected in most of the chosen combinations.

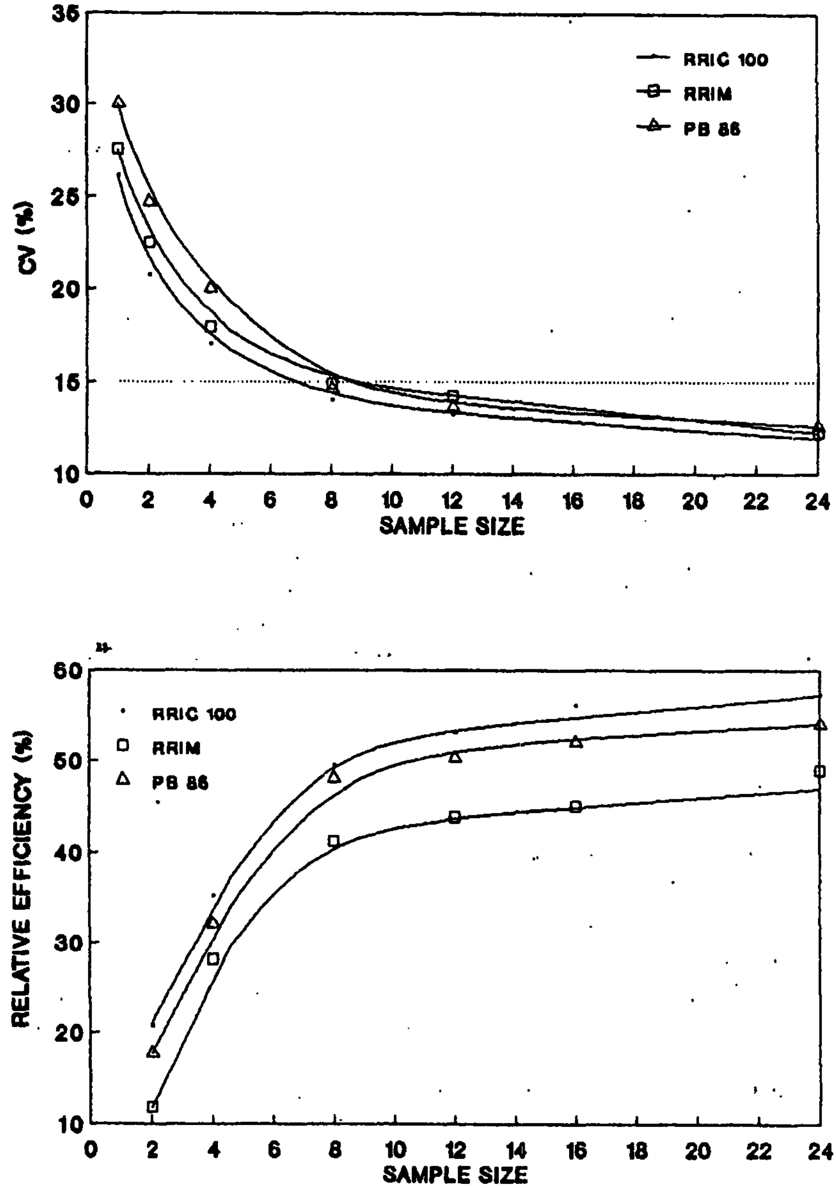

Figure 3. Coefficients of Variation and Relative Efficiencies of Different Sample Sizes.

Schedule Ranked in the ascending order of max.diff.	Test Tapping Days (1 and 2 under each month refer to 1st and 2nd halves of the month)																							
	Strata 01 (Peak Yielding)						Strata 02 (Wintering)						Strata 03 (Post Wintering)						Strata 04 (High Yielding)					
	Nov		Dec		Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
01	x				x		x	x								x		x	x				x	
02	x					x	x		x							x		x	x				x	
03					x	x	x		x							x		x	x				x	
04	x					x	x	x									x	x	x				x	
05	x					x	x	x									x	x	x				x	
06	x					x		x	x								x	x	x		x			
07	x				x		x		x							x		x	x				x	

Figure 4. Sampling Schedule for Estimation of Annual Yield of Rubber.

CONCLUSIONS

The study revealed 4 seasonal quarters in annual yield of rubber. They were employed as strata for the stratified sampling. A sample size of 8 test tappings per tree was found to be sufficient to estimate annual yields with an equal allocation among strata.

Seven combinations which had maximum differences of less than 0.4 grams per tree per tapping were recommended to estimate annual yield of rubber; and selection of "good" and "bad" neighbours in subsequent strata appeared to be a suitable strategy for stratified sampling in estimating the annual yield.

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