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Optimum Plot Size for Rubber *(Hevea brasiliensis)*

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ABSTRACT. Data collected from Eladuwa estate of the State Plantation Corporation in Kalutara district on yield (dry rubber content) of two clones (RRIC-100 and RRIM-623) were used to study the optimum plot size for rubber.

From a uniformity trial Smith's index of soil heterogeneity (which gives a single value as a quantitative measure of soil heterogeneity in an area), was estimated for both clones and used in the determination of optimum plot size. The empirical relationship between plot size and plot variance is such that variability becomes smaller as plot size becomes increasingly large. Furthermore, since higher costs are involved when large plots are used, the optimum plot size which is the plot size that balances precision and cost, was determined by taking the cost also into consideration. The optimum plot size for rubber was determined to be a minimum of 6 to 8 trees per plot.

For the analysis, a computer programme (written in BASIC) was developed to investigate the optimum plot size.

INTRODUCTION

The ability to detect existing differences among treatments increases as the size of experimental error decreases and thus a good experiment should incorporate all possible measures of minimizing the experimental error. Among the various contributions to experimental error, soil heterogeneity has been reported to be one of the greatest (Gomez and Gomez, 1983). Hence the choice of optimum plot size is essential in reducing differences in soil heterogeneity, consequently reducing the experimental error in experiments.

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MATERIALS AND METHODS

Investigation of optimum plot size is usually based on uniformity trial data. A uniformity trial involves planting an experimental site with a single crop variety and applying all cultural and management practices as uniformly as possible. *i.e.* all sources of variability, except that due to native soil differences are kept constant. Therefore the differences observed will be due to existing soil heterogeneity.

The planted area is sub-divided into small units of the same size (basic units) from which separate measurements of productivity are obtained. Hence the yield differences between these basic units are taken as a measure of soil heterogeneity.

Smith's index which gives a single value as a quantitative measure of soil heterogeneity (Narayana Reddy and Ramantha Chetty, 1982) is used primarily to derive optimum plot size. This index gives a single value as a quantitative measure of soil heterogeneity. The index is obtained from the empirical relationship between plot variance and plot size (Smith, 1938), which is given by,

$$V_x = V_1/x^b \qquad (1)$$

where, V_1 is the variance between basic units

V_x is the variance per unit area for plot size of x basic units

b is the Smith's index of soil heterogeneity

The procedure is outlined below.

1. Estimate the variance using the basic unit as the plot size, which gives the variance between basic units.

2. Simulate plots of different sizes and shapes. For each plot size and shape calculate the plot variance $V_{(x)}$,

$$V_{(x)} = [\Sigma^w_{i=1} T^2_i/x - (\Sigma^w_{i=1} T_i)^2/w] / (w-1) \qquad (2)$$

where, T_i - yield of i^{th} simulated plot

x – number of basic unit for a simulated plot
r – # of rows
c – # of columns
w – rc/x

3. For each plot size and shape compute variance per unit area as

$$V_x = V_{(x)}/x^2 \qquad (3)$$

4. Calculate coefficient of variation (CV) *i.e.*

$$CV\ \% = (V_x)/Y * 100 \qquad (4)$$

for each plot size and shape, where Y is the grand mean for unit plot size.

For different shapes of the same size *i.e.* significance of plot orientation will be determined by F test or X^2 test. If the variance differs significantly with the shape, the minimum value is taken. Otherwise the average variance is used. However, this question does not arise in the present study as plots were aggregated contour wise.

5. Plot V_x *vs* plot size and obtain the regression coefficient by least squares.

Linearizing the equation (1), we obtain

$$\ln V_x = \ln V_1 - b \ln x \qquad (5)$$

Hence, the Smith's index b is estimated as a regression coefficient. In practice a weighted regression is performed (Federer, 1955) as variances are different.

Usually, V_x decreases with the increase of plot size. But higher cost are involved with larger plots. Hence optimum plot size takes cost also into consideration.

The empirical formula widely used and developed by Smith (1938) for this purpose is

$$x_{opt} = b(K_1 + K_g A)/(1-b)(K_2 + K_g B) \qquad (6)$$

where,
- K_1 - cost associated with number of plots only
- K_2 - cost per unit area
- K_g - cost associated with borders
- A - area of plot end borders
- B - ratio of area side borders to test area
- b - Smith's index
- x_{opt} - optimum plot size in x basic units

For non bordered plots, $K_g = 0$

Therefore,

$$x_{opt} = bK_1 / (1-b)K_2 \qquad (7)$$

It is true that the estimate b varies from field to field and large number of modifications have also been suggested to improve Smith's formula in determining optimum plot size.

But still most of them are based on the b estimated from a uniformity trial or any other method. The use of Smith's formula for this purpose remains unchallenged (Lin and Binns, 1986).

Study area

This study was based on data collected from Eladuwa estate of the State Plantation Corporation for the clone RRIC-100 and RRIM-623. The collected data were from two blocks of land containing 200 trees of RRIC-100 in one block and 200 trees of RRIM-623 in the other block. The blocks were maintained as uniform as possible. For each tree, information on yield of dry rubber content of latex(g) were obtained. The total of 12 sampling days (one per month) was used as the yield of dry rubber content. All trees were 10 years old at the time of data collection. The trees were tapped in the S/2 D/2 system.

Rubber is usually planted on contours. In simulation, basic plots were combined only along the contours. One plant was considered as a basic plot, *i.e.* an area of 20 x 12 ft^2 (recommended spacing for rubber).

RESULTS AND DISCUSSION

A computer programme was written by the authors in BASIC language to calculate the Smith's index b, and the optimum plot size.

From the weighted regression the Smith's index was found out to be as 0.5264 for RRIC-100 and 0.5610 for RRIM-623 and R^2 values were 0.9250 and 0.8775 respectively.

The values are substituted in formula (7),

where, K1 = 1.1 Rs per plot

K2 = 0.19 Rs per unit area (ft^2)

Therefore, for RRIC-100,

$$x_{opt} = 0.5264 * 1.1 / [(1 - 0.5264) * (0.19)]$$

$$= 6.43 \text{ basic units}$$

and for RRIM-623

$$x_{opt} = 0.5610 * 1.1 / [(1 - 0.5610) * (0.19)]$$

$$= 7.39 \text{ basic units}$$

Note :

K_1 and K_2 were calculated on the basis of RRI recommendations.

The demarcation of K1 and K2 is extreamly difficult and cost estimated here are based on minimum costs that would be encountered in experimentation.

Table 1 gives the CV's (coefficients of variation) for different plot sizes for the two clones. From the table also it can be seen that by the time a plot size of 8 plants is achieved that the CV stabilizes around 15 – 16%. This indicates that increasing plot size beyond 8 plants is not worth.

Table 1. Change of CV with plot size.

Plot size (# of trees)	CV %	
	RRIC – 100	RRIM – 623
1	28.05	33.19
2	23.56	27.38
3	21.29	22.62
4	18.22	21.39
5	18.28	21.21
6	17.79	18.71
7	16.61	16.79
8	15.54	15.95
9	15.98	16.18
10	15.48	15.65
11	15.53	15.55
12	15.04	–

CONCLUSIONS

From these results it is possible to conclude that the optimum plot size for rubber is 6 to 8 basic units (1440 – 1920 ft^2), *i.e.* 6 to 8 trees per plot.

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